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**EXPERIMENTAL STUDY OF DEPENDENCIES DURATION OF
MANAGEMENT OF HEALTH & SAFETY FROM RESOURCE ENSURING**

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**ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ ЗАЛЕЖНОСТІ ТРИВАЛОСТІ
ДІЙ З УПРАВЛІННЯ В УМОВАХ НАДЗВИЧАЙНИХ СИТУАЦІЙ**

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**ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ЗАВИСИМОСТИ
ПРОДОЛЖИТЕЛЬНОСТИ ДЕЙСТВИЙ ПО УПРАВЛЕНИЮ В
УСЛОВИЯХ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ**

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Abstract. In recent years there has been widespread acknowledgement of the significance of managerial and organisational failures in the causation of accidents. Assess the contribution of safety management in achieving the ultimate goal of creating a safe working environment at the present stage of development of management theory and practice relevant forces and means there is enough challenge. The activities and processes involved in managing safety have come under increasing scrutiny via the development of approaches for safety management and safety culture assessment.

A lot of human, material and technical resources should be used to eliminate consequences of emergencies. Prevention of emergencies, elimination of their consequences, reduction of losses and damages became a national problem and one of the most important tasks for executive authorities and management at all levels.

The main indicator of effectiveness for tasks solving in case of elimination of emergencies or it's consequences depends on responsiveness and time taken for decision making process.

The subject of the research is the decision making process during control in emergency situations.

Keywords: emergency, safety, danger, control, effectiveness.

Анотація. Щорічно на території України та інших держав спостерігаються природні та техногенні катастрофи. Це призводить



екологічних, суспільних та матеріальних втрат та головне створюють загрозу життю та здоров'ю населення або навіть викликають смерть.

До ліквідації наслідків надзвичайної ситуації необхідно залучати значну кількість людських, матеріальних і технічних ресурсів. Запобігання надзвичайним ситуаціям, ліквідація їх наслідків, максимальне зниження масштабів втрат та збитків перетворилося на загальнодержавну проблему і є одним з найважливіших завдань органів виконавчої влади і управління всіх рівнів.

Тому оперативність реагування у надзвичайних ситуаціях та оперативність при прийнятті рішень у таких випадках, головні показники рівня ефективності виконання задач з ліквідації надзвичайних ситуацій або їх наслідків.

Предметом дослідження є оперативність прийняття рішень при управлінні у надзвичайних ситуаціях.

Метою дослідження є розроблення методу визначення часу оперативності реагування при прийнятті управлінських рішень у разі виникнення надзвичайних ситуацій.

Ключові слова: надзвичайна ситуація, безпека, небезпека, оперативність, управління, ефективність системи.

Анотація. Ежегодно на территории Украины и других государств наблюдаются природные и техногенные катастрофы. Это приводит к экологическим, социальным и материальным потерям и главное создают угрозу жизни и здоровью населения или даже могут вызывать смерть.

К ликвидации последствий чрезвычайной ситуации необходимо привлечь значительное количество человеческих, материальных и технических ресурсов. Предотвращение чрезвычайных ситуаций, ликвидация их последствий, максимальное снижение масштабов потерь и убытков превратилось в общегосударственную проблему и является одной из важнейших задач органов исполнительной власти и управления всех уровней.

Поэтому оперативность реагирования в чрезвычайных ситуациях и оперативность при принятии решений в таких случаях, главные показатели уровня эффективности выполнения задач по ликвидации чрезвычайных ситуаций или их последствий.

Предметом исследования является оперативность принятия решений при управлении по чрезвычайным ситуациям.

Целью исследования является разработка метода определения времени оперативности реагирования при принятии управленческих решений в случае возникновения чрезвычайных ситуаций.

Ключевые слова: чрезвычайная ситуация, безопасность, опасность, оперативность, управление, эффективность системы.

Introduction. In many countries natural and man-made disasters cause damages for about 2-4% GDP of a state according to the UN statistics. Only elimination of consequences after Chernobyl disaster exceeds 2% of the total volume of GDP in Ukraine. Annually in Ukraine there are around 140-150 man-made accidents and disasters at regional and national level. Approximate structure of an emergency



situation is as following: accident emissions high-toxic substances - 4%; fires and explosions - 19.5%; transport accidents - 17.7%; accidents on life-support systems - 17.3%; accidents at radiation facilities - 8.4%; accidents at municipal systems and wastewater treatment plants - 17.3%; emergencies at other facilities - 15.8%. Experts noticed that annual national economic losses from accidents are 140-150 mln. UAH.

Table 1.

Distribution of Emergency Situations in Ukraine

	2011 y.	2012 y.	2013 y.	2014 y.	2015 y.
Total number of disasters	143	212	143	143	Data is not available, due to the lack of data on the annexed territories
– man-made	134	120	75	74	
– natural	77	74	56	59	
– social	10	18	12	10	
killed people, (person)	355	301	253	287	
– children, (person)	39	50	34	39	
injured people (person)	985	861	854	680	
– children, (person)	439	225	192	235	

Results and discussion. Emergency management should be in constant guidance from a governing body and a head of an authorized emergency response services and forces involved in the organization and execution of tasks after disaster or its consequences.

The main objectives of management are: maintaining high level of morale of personnel and constant readiness for actions; planning of actions in advance; continuous data collection and study of the situation in area of an emergency; decisions made and delivered to subordinates on time; organization and continuous interaction ensuring; organized evacuation of a population from an emergency zone; training of capabilities to conduct rescue and other emergency work associated with liquidation of an emergency situation; organization of comprehensive support capabilities; control of activities and tasks execution made by subordinates on time and assurance of necessary assistance if needed.

The basis of management is decision made by a head of emergency response, who takes full responsibility for management of subordinate forces and successful execution of tasks in emergency situations.

Management principles are continuity, strength, flexibility and stability control in emergency situations.

Efficiency of management system could be achieved through high degree of readiness of its components, sustainable performance and capability to provide centralized and immediate management of forces and means involved for emergency



response.

Organization of rapid response to emergencies is a phased implementation of organizational and managerial activities of planning emergency response, information, transfer of control and power in the highest degree of readiness, immediate management, organization of interaction and comprehensive support to ensure safety of people in an area of emergency.

Management organization carried out in accordance with the specific conditions of a situation, task and decision for application of capabilities during preparation for emergencies based on existing elements of the system of civil protection. There is one feature, which should be mentioned.. Managing organization should ensure an implementation of all claims placed in this particular situation. In other words, organizational management should provide sufficient effectiveness of the management system for those environment conditions.

To assess the contribution of safety management in achieving the ultimate goal, namely the establishment of a safe working environment, you must have methods of experimental research. Using this technique established relationship duration operations safety management of resources. For this method can not only evaluate the effectiveness of the system of safety management in the enterprise, but also to justify complex recommendations for its improvement.

In addition, the development of appropriate methods needed for the following tasks:

- first, identify the compliance management system with modern safety requirements;
- secondly, to determine the impact of the components of safety management on the efficiency of solving the assigned tasks;
- third, prior to the measures to improve safety management, estimating and predicting contribution to improve its functioning.

According to the physical meaning, the duration of the "operation" decreases with increasing number of units of a resource that is designed for its implementation. To solve the problems of planning (distribution) resources to perform complex operations to determine the total (analytical) as a function that displays this dependence, that is:

$$\tau(x). \quad (1)$$

Approximate form $\tau(x)$ is linear, that is

$$\tau(x) = -ax + b; \quad (2)$$

Refined form $\tau(x)$ is a hyperbola, that is

$$\tau(x) = \left(\frac{c}{x}\right). \quad (3)$$

$$\text{The interval } (x_{\min} \leq x \leq x_{\max}) \quad (4)$$

We verify the hypothesis of hyperbolic shape dependence $\tau(x)$.

Let the known statistical set of pairs of values

$$(\tau_j, x_j), j=1..n \quad (5)$$

Perform the regression analysis concerning a set of statistical law –

$$\tau(x) = (c/x). \quad (6)$$

The coefficient "c" define the method of "least squares".



Adds the sum of squared the difference between the values of $(\tau_j, j = 1 .. n)$ and a set of statistical values of $\tau(x_j) = c / x_j$ for each value of the argument x_j :

$$\sum_{j=1}^n (\tau_j^2 - 2\tau_j \cdot \frac{c}{x_j} + \frac{c^2}{x_j^2}) \tag{7}$$

We expand the expression (7):

$$sq = \sum_{j=1}^n (\tau_j^2 - 2\tau_j \cdot \frac{c}{x_j} + \frac{c^2}{x_j^2}) = \sum_{j=1}^n \tau_j^2 - 2c \sum_{j=1}^n \left(\frac{\tau_j}{x_j}\right) + c^2 \sum_{j=1}^n \frac{1}{x_j^2} \tag{8}$$

Define the sum of constants:

$$\sum_{j=1}^n \tau_j^2 = S1; \sum_{j=1}^n \left(\frac{\tau_j}{x_j}\right) = S2; \sum_{j=1}^n \left(\frac{1}{x_j^2}\right) = S3. \tag{9}$$

Currently

$$sq = S1 - 2c \cdot S2 + c^2 \cdot S3. \tag{10}$$

Extremum The condition of sq by "s" –

$$\frac{d(sq)}{dc} = 0 - 2 \cdot S2 + 2c \cdot S3 = 0. \tag{11}$$

Now find the unknown factor "c" of (11) –

$$c^* = \frac{S2}{S3}. \tag{12}$$

Since becoming known analytical form of the function

$$\tau(x) = \frac{c^*}{x} \tag{13}$$

Find the root mean deviation values $(\tau_j, j = 1 .. n)$ of the act (13).

Variance static set $(r_i, j = 1 .. n)$ –

$$D(\tau) = \frac{1}{n-1} \sum_{j=1}^n (\tau_j - \frac{c^*}{x_j})^2 \tag{14}$$

a sampled standard deviation –

$$\sigma(\tau) = \sqrt{D} \tag{15}$$

A measure of the probability of the hypothesis of hyperbolic dependence (3) is the value of the ratio of standard deviation to the "length" line graph $\tau(x)$ in the interval (4) –

$$\alpha = \frac{\sigma(\tau)}{L(\tau)(x)'} \tag{16}$$

$$x_{min} \leq x \leq x_{max},$$

where

$$L = \int_{x_{min}}^{x_{max}} \sqrt{1 + \left(\frac{d\tau}{dx}\right)^2} \cdot dx. \tag{17}$$

Substituting the

$$\frac{d\tau}{dx} = -\left(\frac{c^*}{x^2}\right)$$



In (17) obsessively formula –

$$L = \int_{x_{\min}}^{x_{\max}} \sqrt{1 + \left(-\frac{c^*}{x^2}\right)^2} \cdot dx. \quad (18)$$

The value of the integral calculate a numerical integration methods, such as using "trapeze" ("rectangles").

Determine the length of the "step" argument (*eps*); then the number of steps of integration –

$$m = \frac{(x_{\max} - x_{\min})}{eps} \quad (18)$$

Then (18) will have the form

$$L = \sum_{i=1}^m \left(\sqrt{1 + \left(-\frac{c^*}{x_i^2}\right)^2} \right) \cdot eps, \quad (20)$$

where

$$x_i = x_{i-1} + eps, \quad x_{i=0} = x_{\min}. \quad (21)$$

If $\alpha \leq 0.05$ (5%), we consider the hypothesis correct.

Conclusions.

Methods of experimental research are as follows:

1. Implemented «n» attempts to perform a complete transaction volume A unit of capacity and resources (1) at different amount of resources. Derived statistical set of experimental data (τ_j, x_j), $j = 1 \dots n$.
2. Implemented statistical regression analysis to test the hypothesis set of hyperbolic dependence $\tau(x)$.
3. Is calculated estimate the probability of the hypothesis as the ratio of the JMA and the "length" of the regression line $\tau(x)$.
4. If $\alpha \leq 0.05$ (5%), then the hypothesis is accepted.
5. Similarly calculated the probability of the hypothesis of "linear" dependence of $\tau(x)$. Done comparative evaluation.

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ЕТАЛОНУВАННЯ ВИМІРЮВАНЬ КОЕФІЦІЄНТА ТЕПЛОПРОВІДНОСТІ В УКРАЇНІ

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Abstract. The paper analyzes the current state of metrological support the heat conductivity measurements by reference materials, techniques and standards in Ukraine.

Key words: standard, reference material, heat conductivity.

Анотація. В роботі проаналізовано сучасний стан метрологічного забезпечення вимірювань коефіцієнта теплопровідності еталонами, методиками і стандартами в Україні.

Ключові слова: стандарт, еталон, коефіцієнт теплопровідності.

Introduction. Requirement in precision measurement instrumentation and devices for the different solid materials heat conductivity or heat resistance determination exists practically in all areas of modern science and technology, especially in building and energetics. Quality and producibility of materials basic signs and properties in area of substances, materials and products thermophysical characteristics measuring must be guaranteed by the state (or branch) systems of standardization and metrology providing. Thus methods of measuring are standardizations subject, and measurement instrumentation, that realized and intended for the mass technical and precision measuring, have to be metrology providing.

Literature review. The information analysis about the different substances and materials heat-conductivity testifies, that the value of this physical characteristic changes within the limits of eight orders, that is why it is expedient to distinguish ranges characteristic for the different substances and materials types classes, as it was done in [1] and is graphically presented on the nomogram Fig. 1.

To the numbers on Fig. 1 matches: 1, 2 – gaseous compounds and inorganics pairs, including: 1 – CO, BF₃, CS₃, HCN, H₂S, NF₃, NH₃, NO, N₂O, SF₆ etc. (0,03 < λ < 0,08); 2 – CO₂ (0,009 < λ < 0,25); 3 – water (0,56 < λ < 0,86); 4 – inorganic water solutions (0,17 < λ < 1,28); 5 – inorganic liquids (0,12 < λ < 1,16); 6 – liquid metal (8,7 < λ < 105); 7 – powders (0,02 < λ < 1,5); 8 – heat-insulation and building



materials ($0,02 < \lambda < 0,85$); 9 – powder heat-insulation is in a vacuum ($10^{-4} < \lambda < 10^{-2}$); 10 – refractory materials ($0,15 < \lambda < 35$); 11 – crystals ($0,7 < \lambda < 70$); 12 – diamond ($10 < \lambda < 8 \cdot 10^4$); 13 – minerals ($3,4 < \lambda < 360$); 14 – rocks ($1,7 < \lambda < 5,7$); 15 – pure metals ($8 < \lambda < 465$); 16 – alloys ($16 < \lambda < 233$); 17 – semiconductors ($1,2 < \lambda < 3,2$). According to this devices may be developed for research of materials with low ($\lambda < 0,01$), small ($0,01 < \lambda < 1$), middle ($1 < \lambda < 20$), high ($20 < \lambda < 500$) and extreme ($\lambda > 500$) heat conductivity value ranges, in W/(m·K).

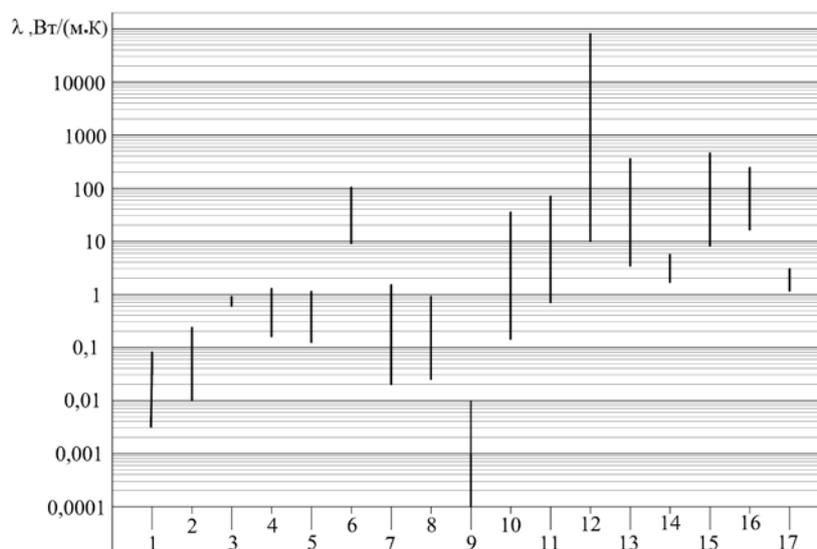


Fig.1. The different substances and materials heat conductivity ranges of values [1].

The main text. The measuring facilities metrology providing, as a rule, is based on standards and embraces the wide area of the questions related to standard and reference instrumentation, including methods for a heat conductivity unit size reproduction, storage and transmission to the operating devices and apparatus, and also the verification and calibration techniques.

Traditionally standard approach is the basic method of physical characteristic measurement traceability and validity providing. It is realized by a measurement chain that sets the measurement instrumentation precision hierarchy of 3BT from operating to standard. Complex of precision apparatus, that is created in metrology organization and is the best in metrology sense acquires status of standard. Standard apparatus are improved constantly, and every percent of their error decrease is getting with large efforts. The measurement traceability and validity providing method with the state standard and measurement chain application leads to the most reliable results [2].

Reference materials and transfer standards are the most real support means the materials and products measurement traceability properties, as they are the material carrier of corresponding value. Their basic metrology properties are a value of description that will be certified and its error. Reference materials apply, according to the operating verification techniques for heat-conducting, specific heat capacity and diffusivity of solids measuring devices and apparatus MT 115-77, for the working instrumentation verification (calibration) by the direct or indirect measuring methods



and checking by comparator. The working instrumentation and devices are admitted to application if the check results the borders of measuring relative possible error is 3...15% range. Thus reference materials and transfer standards must be verified according the procedure MT 1605-87. One of major advantages to standard materials application there is possibility of working instrumentation calibration in terms near to operating, and checks them on the exploitation object directly.

Eight reference materials are now ratified [3] and five measures that can be applied as heat conductivity transfer standards. Present information about modern state the metrology providing of heat conductivity measuring by reference materials and transfer standards is analysed and graphically presented on Fig.2 as a nomogram.

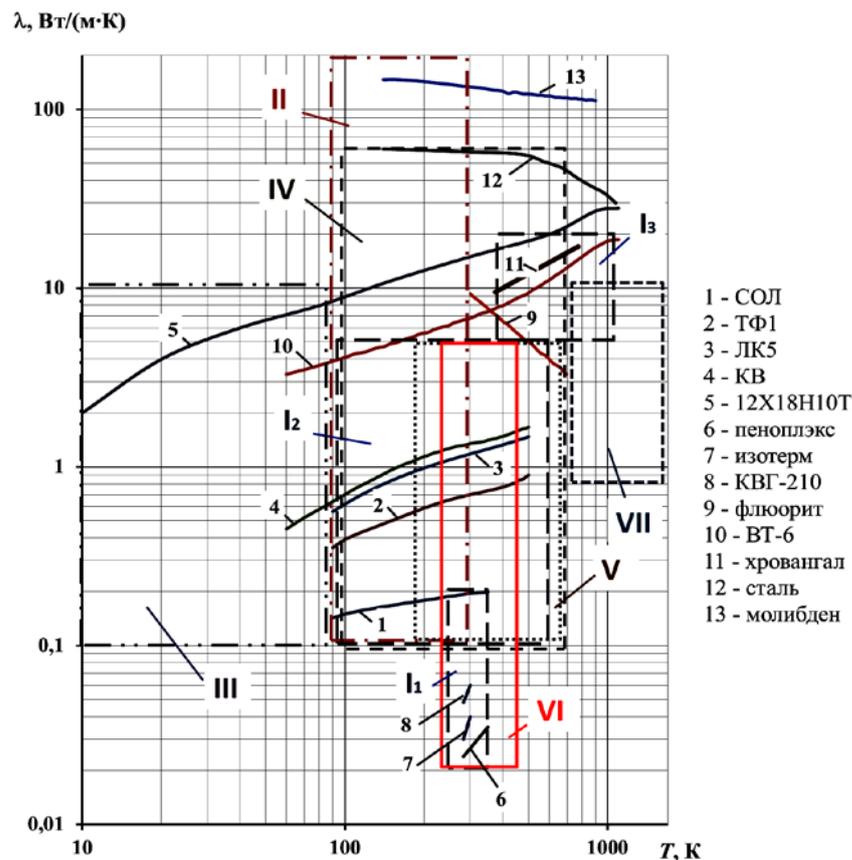


Fig. 2. The solid materials heat conductivity measuring ranges, provided with referenses, techniques, standards

On the nomogram Fig. 2 by lines 1 – 13 the dependences $\lambda = f(T)$ of reference materials (graphic 1 – 8) and control standards (graphic 9 – 13) heat conductivity are represented, and by rectangles the corresponding techniques and standards areas that operate now also on Ukraine territory are signified, namely:

I_1 – SPE, GOST 8.140-2009:	$\lambda = (0,02 - 0,2) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (250 - 350) \text{ K};$
I_2 – SPE, GOST 8.140-2009:	$\lambda = (0,1 - 5,0) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (90 - 500) \text{ K};$
I_3 – SPE, GOST 8.140-2009:	$\lambda = (5,0 - 20) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (300 - 1100) \text{ K};$
II – SPE, GOST 8.177-85:	$\lambda = (0,1 - 172,6) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (90 - 300) \text{ K};$
III – SPE, GOST 8.511-84:	$\lambda = (0,1 - 10) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (4,2 - 90) \text{ K};$
IV – Technique MT 115-77:	$\lambda = (0,1 - 60) \text{ W}/(\text{m} \cdot \text{K}),$	$T = (90 - 673) \text{ K};$



V – GOST 23630.2-79:	$\lambda = (0,1 - 5,0) \text{ W}/(\text{m}\cdot\text{K}),$	$T = (173 - 673) \text{ K};$
VI – GOST 7076-99:	$\lambda = (0,02 - 1,5) \text{ W}/(\text{m}\cdot\text{K}),$	$T = (233 - 473) \text{ K};$
VII – GOST 12170-85:	$\lambda = (0,13 - 15) \text{ W}/(\text{m}\cdot\text{K}),$	$T = (673 - 1623) \text{ K};$

Conclusions. The heat conductivity measuring large range needs the operating metrology techniques and standards existing. Measuring unity and rightness must be provided by the state standards and references system intended for a heat conductivity unit size reproduction, storage and transmission to the measurement instrumentation and devices. Now in Ukraine, disappointingly, lacks of the own heat conductivity measuring metrology providing, but the harmonization of normative base with international and European standards is carried out, that it is possible to consider the first steps in its creation.

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MODERN STANDARDIZATION METHODS OF INSULATION MATERIALS THERMOPHYSICAL PROPERTIES MEASURING IN UKRAINE

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СУЧАСНИЙ СТАН СТАНДАРТИЗАЦІЇ МЕТОДІВ ВИМІРЮВАННЯ ТЕПЛОФІЗИЧНИХ ВЛАСТИВОСТЕЙ ТЕПЛОІЗОЛЯЦІЙНИХ МАТЕРІАЛІВ В УКРАЇНІ

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Abstract. The modern standardization status in insulation building materials thermophysical researches in Ukraine is considered, the most widespread operating standards, harmonized with international (ISO and EN), are described, their accordance the real terms of researches and level of the device providing is analysed.

Key words: standardization, method, thermophysical characteristic, insulation.

Анотація. Розглянуто сучасний стан стандартизації в галузі теплофізичних досліджень теплоізоляційних матеріалів в Україні, описані найбільш поширені діючі стандарти, гармонізовані з міжнародними (ISO та EN), проаналізовано їх відповідність реальним умовам досліджень та ступеню приладового забезпечення.

Ключові слова: стандартизація, метод, теплофізичні характеристики, теплоізолятори.

Introduction. Measuring the materials and products heat conductivity coefficient and (or) heat resistance is widespread now at building industry for many reasons. Firstly, it is necessary to considerate at creation of new construction and especially heat-insulate building materials, that a heat conductivity coefficient is a passport parameter. Secondly, among numerous tasks that stand before designers and architects equally with creation the comfort terms for man stay in an apartment it is necessary to provide the energy- and resource-saving not only on the construction stages but also during building and structures further exploitation.

The construction and insulation building materials heat conductivity coefficient value must be determined not only at the new materials development but also be controlled at the products producing. Without these parameters it is impossible to solve a task of the energy saving, calculate the thermal modes of complicate configuration, optimize a technological processes etc. In addition, a heat conductivity as structure-sensitive parameter is an effective instrument in scientific researches.

Literature review. The development of different methods for insulation



building materials heat conductivity measuring actively began in the second half of XX century. At the beginning such developments were single-unit production for some thermophysical value measuring. Later the specialized organizations and companies appeared with possibilities of thermophysical devices mass production, herewith there were the knowledge and experience accumulation in the standardization and metrology providing area for thermophysical instrument-making.

Now more than twenty standards that regulates the methods, techniques and facilities for insulation materials and products thermophysical properties measuring are implemented. In the conditions of Ukraine integration into the European community the problem of national normative documents harmonization with international, that it is necessary for a collaboration and trading with the European and other countries, is getting urgent. During the last few years the number of national standards, that regulates the insulation materials thermophysical characteristics measuring methods, harmonized with international (ISO), European (EN) and Russian (GOST), were worked out in Institute of Engineering Thermophysics NAS of Ukraine [1].

The main text. As the thermophysical researches practice shows, the basic methods of insulation materials and products heat conductivity measuring that are corresponding by Ukrainian and foreign standards, are stationary – the guarded hot plate, the heat flow meter (HFM), an axial heat flux methods, and non-stationary – the hot wire and laser flash methods. In Ukraine the most widespread are following harmonized with ISO and EN standards [2]:

– the ДСТУ ISO 8301: 2007 and ДСТУ ISO 8302: 2008 standards, that regulate the insulation materials thermal resistance determination and set the method of its measuring on a flat standard by device equipped with, accordingly, a heat flow meter, or the guarded hot plate. In these standards the action principles and constructions of corresponding devices are described, and also technical requirements to the standards, terms of measuring and algorithm of data processing are given.

However it should be noted that in the harmonized documents some features does not match to initial ISO. Firstly, in ISO 8302:1991 it is indicated that at the observance of all its requirements a heat conductivity measuring error at the room temperature does not exceed $\pm 2\%$, and in a temperature range $\pm 5\%$, while according to operating in Russia and Ukraine the heat conductivity measuring instrumentation calibration technique the heat conductivity reference materials has an error $\pm 3\%$, that, naturally, leads to the error of measuring working devices not less than $\pm 6\%$.

Secondly, in ISO 8301:1991 required that operating HFM-apparatus have to be calibrated by transfer standards immediately before and after every experiment that complicates a process considerably. Researches undertaken at IET NAS of Ukraine proved that existing an optimal guard zone of HFM, the equality of thermophysical characteristics its sensible and guard zones and adhering the numerous other conditions the device equipped HFM is capable to provide high accuracy of measuring and stability of properties, due to what a calibration can be carried out once a year. These researches are implemented in developed in IET NAS of Ukraine device IT-7C [3], in that requirements of standards DSTU B V.27-105 (GOST 7079) and DSTU ISO 8301:2007 are realized. The IT-7C device is metrology attested as a



working measuring instrument of insulation and building materials heat conductivity and heat resistance with an error $\pm 3\%$;

– the DSTU ISO 8497: 2005 standard is devoted to pipes insulation applied for heat losses protecting. It regulates the cylindrical wall method for thermal resistance measuring in the stationary thermal mode. Because of the insulant product structure in flat form differs from the material structure in cylindrical form, and its properties substantially depends on heat flow direction in relation to such characteristic structures, as fibres or other prolate elements, the flat and cylindrical layers of material insulation properties characterized by different values. During the pipe insulation testing it is necessary to left an interval between a pipe and isolation for approaching the experimental terms to the operating conditions that is not realized in the flat-type devices. In this standard the requirements to the construction and main parameters of the concept test device are formulated, the experimental conditions are regulated and calculation formulas for pipe insulation are given;

– the DSTU ISO 11357-4: 2010 and DSTU EN 1159-3: 2010 standards are devoted to the plastic and ceramic insulation materials specific heat capacity measuring calorimetry methods. Modern ceramics are now the most perspective materials for chemical and metallurgical industry, electrical engineering and radio electronics, space system engineering. The non-stationary laser flash method for ceramics thermal diffusivity measuring is regulated by standard DSTU EN 821-2: 2010, and a method for ceramics specific heat capacity determination – by standard DSTU EN 1159-3: 2010, both are the indirect methods of heat conductivity determination. In the standard DSTU-P CEN/TS 1159-4: 2010 the ceramics heat conductivity determination method is rationed not only in the temperature range but also in the definite points of this range with sufficient accuracy.

Conclusions. It is possible to establish, that standardization of building heat insulators main thermophysical properties determination methods involved the wide nomenclature materials and products. Carrying out the standards harmonization with international gives the perspective European collaboration possibility for Ukraine. As for the standardized methodologies device providing, unfortunately Ukraine doesn't have an own device base and the metrology providing for this type of measuring is practically absent, that is why this problem is actual now.

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Yanovich V.P., Kupchuk I.M., Kovalchuk O.S.
**THEORETICAL STUDIES OF ENERGY PARAMETERS OF VIBRATION-
DISK CRUSHER STARCH CONTAINING SUBSTANCE**

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Янович В.П., Купчук І. М., Ковальчук О. С.
**ТЕОРЕТИЧНЕ ДОСЛІДЖЕННЯ ЕНЕРГЕТИЧНИХ ПАРАМЕТРІВ
ВІБРОДИСКОВОЇ ДРОБАРКИ КРОХМАЛОВМІСТНОЇ СИРОВИНИ**

Alcohol industry is an integral part of the state's economy and is closely related, on the one hand, numerous sectors of the economy for which alcohol is a substance, basic and auxiliary materials, on the other – with agriculture, which provides definitions of substances and production plant in return gets removed from its protein fortified food. It is the only branch of industry that is able to convert defective starch substance in benign products. Profitability and competitiveness alcohol industry is largely dependent on direct production costs, particularly for machining material - crushing it.

The article shows a schematic diagram vibration-disk mills for grinding corn starch containing substances of alcohol production, realizing the idea of a combined interaction of vibration and rotational motion of the executive body, a combination of shock and cutting the impact of work items on the material, which will handle both conditioned substance and substance with a high moisture content without significantly reducing the throughput of the equipment and to ensure the timely withdrawal of the product from the grinding zone.

It was also determined rational modes of vibration of the disk cutters by theoretical studies of energy parameters of the equipment, which resulted in a graphical power consumption depending on the motor and making the forces of the speed of the drive shaft of the machine.

Keywords: *alcohol industry, grinding, disk crusher, vibration, energy consumed, making power.*

Аннотація. Спиртова промисловість є невід'ємною частиною економіки держави та тісно пов'язана, з одного боку, з численними галузями народного господарства, для яких спирт є сировиною, основним і допоміжним матеріалами, з другого – із сільським господарством, яке забезпечує означене виробництво рослинною сировиною та отримує взамін вилучені із неї білкові вітамінізовані корми. Вона є єдиною галуззю промисловості, яка здатна перетворювати дефектну крохмалевмісну сировину у доброякісні продукти. Рентабельність та конкурентоспроможність продукції спиртової галузі значною мірою залежить від прямих виробничих витрат, зокрема на механічну обробку матеріалу – його подрібнення.

У статті приведена принципова схема вібродискової дробарки для подрібнення зернової крохмалевмісної сировини спиртового виробництва, яка реалізує ідею комбінованого взаємодії вібраційного і обертового руху



виконавчого органу, поєднання ударного і ріжучого впливу робочих елементів на матеріал, що дозволить обробляти як кондиційну сировину так і сировину з підвищеним вмістом вологості без значного зменшення пропускної здатності обладнання та забезпечити своєчасне виведення продукту із зони подрібнення.

Також було визначено раціональні режими роботи вібраційної дискової дробарки, шляхом теоретичного дослідження енергетичних параметрів даного обладнання, в результаті чого було отримано графічні залежності споживаної потужності електродвигуна та змушуючої сили від частоти обертання приводного валу машини.

Ключевые слова. спиртова промисловість, подрібнення, дискова дробарка, вібрація, споживані енерговитрати, змушуюча сила.

Introduction. A lot of different schemes of processing corn starch raw materials in alcohol are known. Thus, for ethanol and other target product for modern enterprises in Western Europe and the US used "wet" scheme, which is based in grinding hammer crushers grain that arrived after surgery soaking, and then release the starch, gluten, germ and fiber in the aquatic environment [1, 2]. For Ukraine, "dry" grinding moisture of the previous material is typical.

However, in both cases, the process flow indicated a number of problems. Thus, when grinding pre-soaked product significant energy costs take place, because with increasing humidity and temperature destructive force of compression decreases, indicating a gradual increase in the plasticity of the grain and reducing its fragility, while increasing absolute strain that corn resistant to fracture, resulting what grain grinding resistance increases also by increasing the adhesive forces is driving surface separation, leading to delays in the withdrawal of the product from the crushing zone [3, 4]. Previous dehydration for "dry" processing scheme significantly increases the specific energy costs per unit of finished product.

Therefore actual is finding ways to reduce energy costs at this process in achieving the required quality parameters of the final product.

Analysis of recent research and publications. Based on the analysis of processes [1 - 6] and structural schemes existing equipment [1, 3, 5, 7, 8] to implement the process of grinding, loose weight, we offer a better way of grinding grain substance of alcohol production, the essence of which is to develop fundamentally new scheme of the crusher, which could realize a combination of shock and cutting the impact of work items on the material, which will handle both certified substances materials and substances with a high moisture content without significant reduction of the throughput of the equipment and the timely withdrawal of the product from the zone of crushing, thus leveling excessive air circulation product layer, and consequently reduce specific energy consumption for the said treatment [9].

However, to achieve high performance process, it is necessary to do the theoretical study of power parameters developed equipment, and justify the optimal parameters for efficient operation mode.

The purpose of this research is the study of rational modes of vibration rotary crusher by theoretical studies of energy parameters of the machine.

Research Methodology. Scientific articles are based on position based on



classical theory of mechanical vibrations, electric theory, the laws of theoretical mechanics, the theory of vibration grinding. For analytical studies of energy parameters machine software Matlab, MathCad 15 is used.

Results. Fig. 1 shows the experimental-industrial model of a vibration-disk crusher [10], in which when switching on the motor 5 torque through clutch 6, at the kinematic shaft 7 of counterweights 8, the rotation of which leads to the creation of a combined power and torque unbalanced placed on it the rotor 9 with axes and discoid beat 10.

Processable material continuously goes through a boot neck 2 and crushes because of rotating and oscillating movement discoid Bill 10. With decreasing particle size material is crushed under the influence of centrifugal forces and alternating loads through the sieve surface undergoes intense classification: the particle diameter is equal to or smaller sieve openings 4 are discharged through the neck 3, the rest - re-grinding [9, 10].

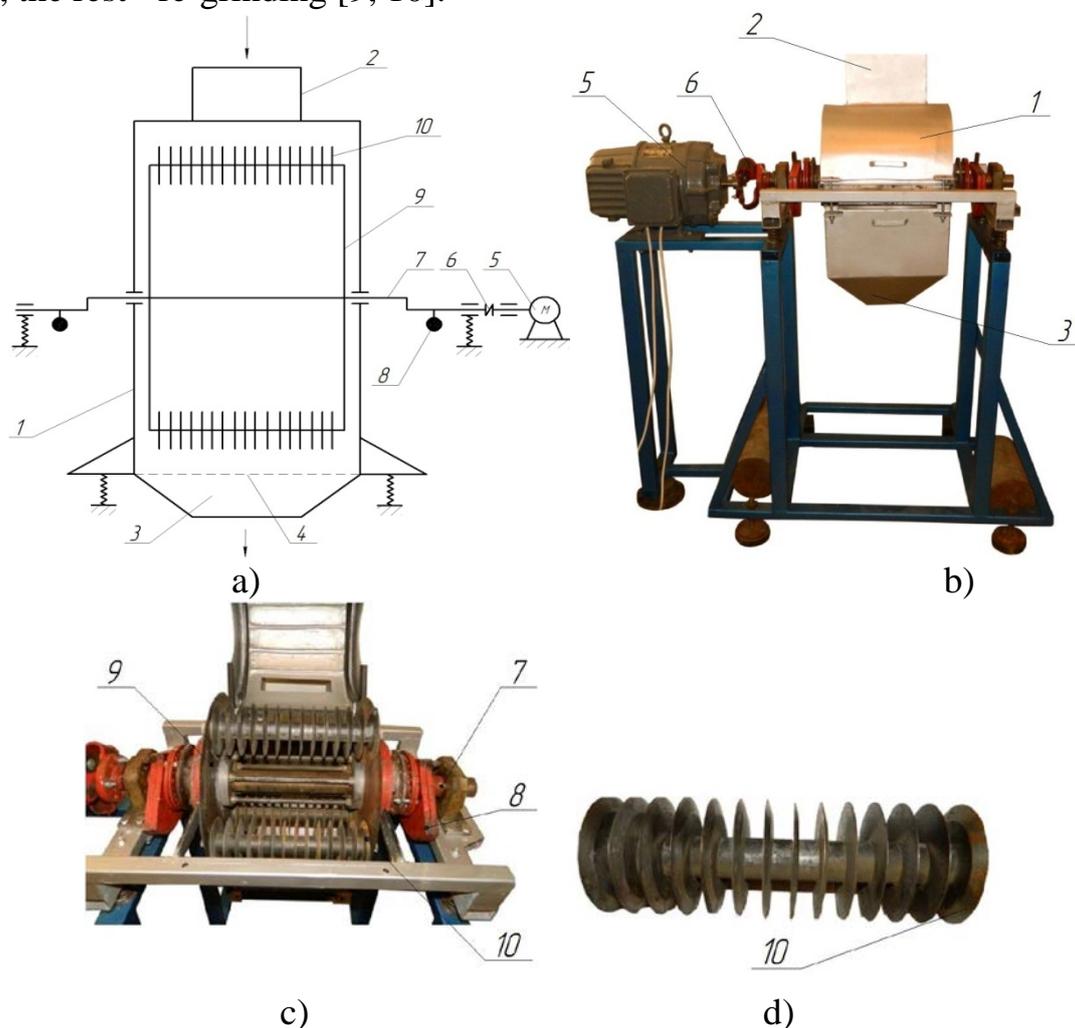


Fig. 1. Vibration-disk crusher: a) - the basic scheme; b) - general view; c) - the executive body; d) - Disc beat; 1 - the case; 2, 3 - boot loading and neck; 4 - sieve; 5 - electric motor; 6 - elastic sleeve; 7 - kinematic shaft; 8 - counterweight; 9 - rotor; 10 - discoid beat.

Power drive investigated machine can be defined as [5, 11]:

$$N_{np} = (N_{F \max} + N_{mep}) / \gamma_{np}, \quad (1)$$



Where $N_{F_{\max}}$ – the maximum power that develops by forcing power to give the executive bodies of the oscillating system required vibration parameters;

N_{mep} – the cost of power due to friction in the reference site; γ_{np} – efficiency drive.

Expression of power to force N_F forcing presented as $N_F = F_m \cdot v$ a product where $v = \sqrt{v_x^2 + v_z^2} = \sqrt{\dot{x}^2 + \dot{z}^2}$ – expression vibration; F_m – module making power.

Given that [12, 13]:

$$\dot{x} = \frac{F_m \alpha_x \omega_2}{(k_x^2 - \omega_2^2)^2 + \alpha_x^2 \omega_2^2} \cdot (\alpha_x \omega_2 \cos \omega_2 t - (k_x^2 - \omega_2^2) \sin \omega_2 t), \quad (2)$$

$$\text{and } \dot{z} = \frac{F_m \alpha_z \omega_2}{(k_z^2 - \omega_2^2)^2 + \alpha_z^2 \omega_2^2} \cdot (k_z^2 - \omega_2^2) \cos \omega_2 t + \alpha_z \omega_2 \sin \omega_2 t \quad (3)$$

the desired expression becomes:

$$N_{F_{\max}} = \sqrt{\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\partial \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right)^2 + \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right)^2} \times$$

$$\sqrt{\left(\frac{\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\partial \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right) \cdot \alpha_x \omega_2}{(k_x^2 - \omega_2^2)^2 + \alpha_x^2 \omega_2^2} \right)^2 + \left(\alpha_x \omega_2 \cos \omega_2 t - (k_x^2 - \omega_2^2) \sin \omega_2 t \right)^2} \quad (4)$$

$$\sqrt{\left(\frac{\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right) \cdot \alpha_z \omega_2}{(k_z^2 - \omega_2^2)^2 + \alpha_z^2 \omega_2^2} \right)^2 + \left((k_z^2 - \omega_2^2) \cos \omega_2 t + \alpha_z \omega_2 \sin \omega_2 t \right)^2}$$

Power to the overcoming of friction in the system can determine [5, 11]:

$$N_{mep} = 0,5 \cdot F \cdot \mu \cdot d_y \cdot \omega_2^2. \quad (5)$$

$$N_{mep} = 0,5 \cdot \mu \cdot d_y \cdot \omega_2^2 \cdot \sqrt{\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\partial \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right)^2 + \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right)^2}. \quad (6)$$

where $\mu = 0,05 \dots 0,08$ – coefficient of friction in the reference site; d_y – diameter shaft, which planted bearing: $d_y = 0,04$ mm [14].

So:



$$N = \left[\left[\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\delta \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right)^2 + \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right)^2 \right] \times \left[\frac{\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\delta \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right) \cdot \alpha_x \omega_2}{(k_x^2 - \omega_2^2)^2 + \alpha_x^2 \omega_2^2} \right]^2 + \left[\frac{\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right) \cdot \alpha_z \omega_2}{(k_z^2 - \omega_2^2)^2 + \alpha_z^2 \omega_2^2} \cdot (k_z^2 - \omega_2^2) \cos \omega_2 t + \alpha_z \omega_2 \sin \omega_2 t \right]^2 \right] \times \gamma_{mp}^{-1} \tag{7}$$

$$0,5 \cdot \mu \cdot d_y \cdot \omega_2^2 \cdot \left[\left(\left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right) + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\delta \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \right)^2 + \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right)^2 \right]$$

Load bearing components can be calculated using the assumption that the main reason for this action is the presence in the system unbalanced rotating masses [5], which is the cause of unbalanced power:

$$F_{H.sp.max} = \sqrt{F_{H.sp.x.max}^2 + F_{H.sp.z.max}^2} \tag{8}$$

Given the use of methods submitted, the unknown parameters becomes:

$$F_{H.sp.x} = F_{H.sp.x} = m_{H.sp} \ddot{x} = (m_2 - m_4) \times \left[\frac{\omega_2 \cos(\omega_2 t) \cdot (\omega_2^2 - k_x^2) - \omega_2^3 \cdot \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} \right)}{(\omega_2^2 - k_x^2)^2 + \alpha_x^2 \omega_2^2} + \frac{m_2 \cdot \omega_2 \cdot e + m_3 \cdot r \cdot \omega_2 - m_3 \cdot 2ku \cdot r_\delta \cdot \omega_3 + m_4 \cdot \omega_2 \cdot l}{\cos(\omega_2 \cdot t) m_1} \cdot \alpha_x^2 \cdot \sin(\omega_2 t)}{(\omega_2^2 - k_x^2)^2 + \alpha_x^2 \omega_2^2} \right] \tag{9}$$

$$F_{H.sp.z} = m_{H.sp} \ddot{z} = (m_2 - m_4) \times \left[\frac{\omega_2^2 \alpha_z \cdot \cos(\omega_2 t) + \omega_2^2 \cdot \left(\frac{(m_2 + m_3)\omega_2^2 e - m_4 \omega_2^2 l}{m_1} - \frac{(m_1 + m_2 + m_3 + m_4)g}{\sin(\omega_2 \cdot t) \cdot m_1} \right) \cdot \alpha_z \sin(\omega_2 t) \cdot (\omega_2^2 - k_z^2)}{(\omega_2^2 - k_z^2)^2 + \alpha_z^2 \omega_2^2} \right]$$

To solve and analysis of the equations (7, 9) energy performance vibro-disk crusher mathematical environment MathCad was applied, resulting image obtained dependence (Fig. 2). Using this program helps to determine the optimal values of energy characteristics depending on the angular velocity of the drive shaft unbalanced mass in the range of real-time conditions for the development of the system with minimal power consumption.

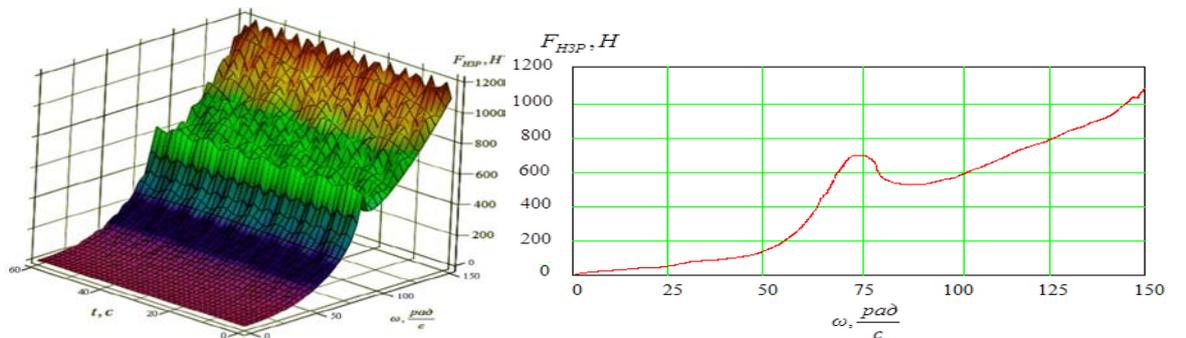
To solve this problem the database was made, which included values such as: range of angular speed of the drive shaft $\omega_2 = 0...150$ rad/s, and interval time factors $t = 0...60$ s, and adopted values of the system constants (Table. 1).



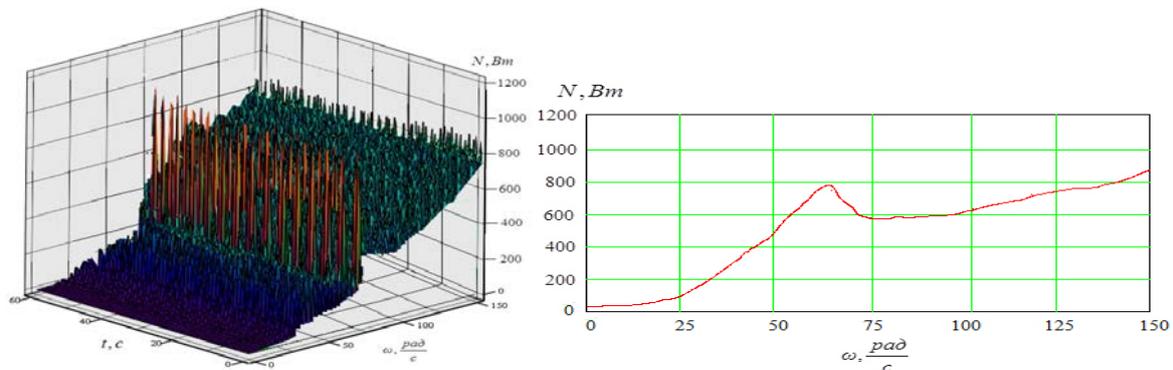
Table 1

The numerical values of fundamental constants of the system adopted for

№ s/n	Index	Vibration drive type
		Forced
1	2	3
1	Typical weight system, kg	83,2
1.1	Total moving mass, m	
1.2	$m_1 = m_{\kappa} + m_{\text{заб}} \cdot \mu + m_{o.p} + m_{n.б.}$	
1.3	$m_2 = m_{np.б.} + m_{n.д} + m_e + m_{o.д} + m_{д.o} + m_M$	
1.4	$m_3 = m_{p.д}$	
1.5	$m_4 = m_{\delta}$	5,5
2	Typical dimensions of the elements of the system	
2.1	The distance from the axis of rotation to the center of mass of the rotor e , M	0,005
2.2	Radius scratch r_{δ} , M	0,045
2.3	Radius reference disk $r_{o.д}$, M	0,14
2.4	The distance from the top scratch to the axis of rotation r , M	0,19
2.5	The distance from the axis of rotation to the center of mass counterbalances l , M	0,044
3	Tightening elastic elements C , H/M	
3.1	on the axis OX : C_x	3900
3.2	on the axis OZ : C_z	3900



a)



б)

Fig. 2. Energy dependences of the studied vibration machine:

a) – the load on the basic components of the drive shaft;

b) – the power consumption on the drive shaft.



Conclusions. Theoretical analysis of the presented equations of energy parameters developed vibration-disk crusher showed that during the work process, there is for-resonance mode when the angular speed of the drive shaft $\omega_2 = 0 \dots 50 \text{ s}^{-1}$ resonance – at $\omega_2 = 70 \dots 80 \text{ s}^{-1}$ and stable resonant mode in the range of angular speed $\omega_2 = 80 \dots 150 \text{ s}^{-1}$. Analysis of these graphical dependency developed machines with regard to previous studies amplitude-frequency characteristics allowed theoretically determine the operating parameters vibration disk crusher corresponding the value $\omega_2 = 100 \dots 115 \text{ rad/s}$ (stable over-resonance mode), with power consumption of $N = 650 \dots 750 \text{ W}$, the load on the basic components of the drive shaft $F = 600 \dots 650 \text{ N}$.

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ACCURATE INDEXATION OF VECTORS PROMOTES THE ACCURACY OF MODELING OF ASYNCHRONOUS MACHINE

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ТОЧНАЯ ИНДЕКСАЦИЯ ВЕКТОРОВ СПОСОБСТВУЕТ ТОЧНОСТИ МОДЕЛИРОВАНИЯ АСИНХРОННОЙ МАШИНЫ

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Abstract. It is useful to use mathematically more rigorous the notation of vectors of model induction machine. It is necessary to make different notation spatial axes and axes on the complex plane when analyzing vector control asynchronous machine. This makes more accurate the transformation of vectors and is help to modeling of induction machine. To account the design features of machine windings the correction coefficients in the Clarke and Park transformations are used. The design of windings affects significantly on the processes of induction machine.

Key words: notation coordinate axes of space, axes of the complex plane; transformation of vectors induction machine

Аннотация. Полезно использовать математически более строгое обозначение векторов модели асинхронной машины. Необходимо сделать различные обозначения пространственных осей и осей на комплексной плоскости при анализе векторного управления асинхронной машины. Это делает более точным преобразование векторов и помогает моделированию асинхронной машины. Для учёта конструктивных особенностей обмоток машины используются коэффициенты коррекции в преобразованиях Кларк и Парка. Конструкция обмоток асинхронной машины существенно влияет на процессы в ней.

Ключевые слова: обозначение осей координат пространства, оси комплексной плоскости; преобразование векторов асинхронной машины.

Introduction

In the studies of vector control of induction machine the idealized model (with sinusoidal distribution of magnetic induction in the air gap) usually used. This was exactly said I.P.Kopylov [1, p.39]: ["The simplest electric machine is a machine with a circular field in the air gap. ... You can not create a real machine with a circular field, so just perfect machine can exist only in our imagination. This machine has a very simple mathematical description of that simple mathematical model. "]

To analyze the vector control of induction machine the various notation of axes of coordinate in space or time in the indices is used [1–4]. The lack of unity in the notations creates unnecessary complexity in understanding the processes of asynchronous machine (AM), additional difficulties in the use of research results.

There is also a typical recording of vectors that consisting in the fact that the imaginary space axis j is denoted by the same manner as the imaginary axis of the



complex plane (in the case of displaying of sinusoidal functions time in the complex plane).

However, in education or in the calculations such a variety of symbols and permissible simplify create additional difficulties to understanding the processes and some doubts about the accuracy of the analysis and calculations.

Main provisions of the method

As basis the system applied the notations adopted in the Department of electrical machines of Moscow Energy Institute (Technical University) – (MEI) [1]. The vectors can be represented in different coordinate systems (axes) depending on the task. For example, the vector of stator voltage can be represented diversely:

$$\vec{U}_S^{(\alpha\beta)} = \vec{U}_{Ss} = \vec{\alpha}_0 U_{S\alpha} + \vec{\beta}_0 U_{S\beta} = U_S \cdot e^{\beta_0 \cdot \arctg(U_{S\beta}/U_{S\alpha})} = U_S \cdot e^{\beta_0 \cdot \varphi_{US}} = U_S \cdot [\vec{\alpha}_0 \cos(\varphi_{US}) + \vec{\beta}_0 \sin(\varphi_{US})] = U_S \cdot [1_\alpha \cos(\varphi_{US}) + \sqrt{-1}_\beta \sin(\varphi_{US})]$$

The stator unit vectors of spatial axes are here denoted: $\alpha_0 = 1_\alpha$ – the real spatial axis, $\beta_0 = \sqrt{-1}_\beta$ – the imaginary spatial axis. Axis ($\alpha\beta$) is spatial axes for bipolar machine. The axis (xyz) is spatial axes AM for multi-pole machines.

Further in the equation of stator voltage the resultant vectors of stator voltages and stator currents were denoted in the axes of stator ($\alpha\beta$), and the resultant vector of rotor current from the beginning was denoted in the axes of rotor (dq), and then was rewritten in the axes of stator ($\alpha\beta$):

$$\vec{U}_S^{(\alpha\beta)} = \vec{U}_{Ss} = R_s \vec{I}_{Ss} + \frac{d}{dt} (L_s \vec{I}_{Ss} + L_m \cdot e^{\beta_0 \theta_R} \vec{I}_{Rr}) = R_s \vec{I}_{Ss} + \frac{d}{dt} (L_s \vec{I}_{Ss} + L_m \cdot \vec{I}_{Rs}) \quad (1)$$

The resultant vectors are created by the conversion and the summation of the three phase vectors. So, the resultant current vector of stator \vec{I}_{Ss} formed of phase currents $I_{As} I_{Bs} I_{Cs}$:

$$\begin{aligned} \vec{I}_{Ss} = \vec{I}_{As} + \vec{I}_{Bs} + \vec{I}_{Cs} &= I_{As} \cdot e^{\beta_0 0^\circ} + I_{Bs} \cdot e^{+\beta_0 120^\circ} + I_{Cs} \cdot e^{+\beta_0 240^\circ} = I_{As} \cdot (\vec{\alpha}_0 \cos(0^\circ) + \vec{\beta}_0 \sin(0^\circ)) + \\ &+ I_{Bs} \cdot (\vec{\alpha}_0 \cos(120^\circ) + \vec{\beta}_0 \sin(120^\circ)) + I_{Cs} \cdot (\vec{\alpha}_0 \cos(240^\circ) + \vec{\beta}_0 \sin(240^\circ)) = \\ &= I_{As} \cdot (\vec{\alpha}_0 1 + \vec{\beta}_0 0) + I_{Bs} \cdot (\vec{\alpha}_0 (-0,5) + \vec{\beta}_0 (+\sqrt{3}/2)) + I_{Cs} \cdot (\vec{\alpha}_0 (-0,5) + \vec{\beta}_0 (-\sqrt{3}/2)). \end{aligned} \quad (2)$$

The matrix of transformation (2) forms a modification of the known transformation Clarke:

$$\vec{I}_{Ss} = \begin{vmatrix} \vec{\alpha}_0 & \vec{\beta}_0 \end{vmatrix} \cdot \begin{vmatrix} I_{S\alpha} \\ I_{S\beta} \end{vmatrix} = \frac{2}{3} \cdot \begin{vmatrix} \vec{\alpha}_0 & \vec{\beta}_0 \end{vmatrix} \cdot \begin{vmatrix} 1 & -0,5 & -0,5 \\ 0 & +\frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{vmatrix} \cdot \begin{vmatrix} I_{As} \\ I_{Bs} \\ I_{Cs} \end{vmatrix} \quad (3)$$

This transformation of the currents of stator phase windings in the resultant vector shown on Fig.1. The Fig.2 shows the rotor current vector in the systems axes of stator and rotor. The α_0 – axis is directed along center of the winding phase A stator. The β_0 – axis is orthogonal to the axis α_0 in positive direction of rotation (counterclockwise). The spatial (geometric) rotation angle of rotor is θ_r . The electric rotation angle θ_R takes into account the number of pole pairs p_Z of the stator winding: $\theta_R = p_Z * \theta_r$. The mechanical rotation of rotor denoted as the angular velocity: $\omega_r = d\theta_r / dt$. The electrical angular speed of rotor denoted so: $\omega_R = d\theta_R / dt = p_Z * \omega_r$.

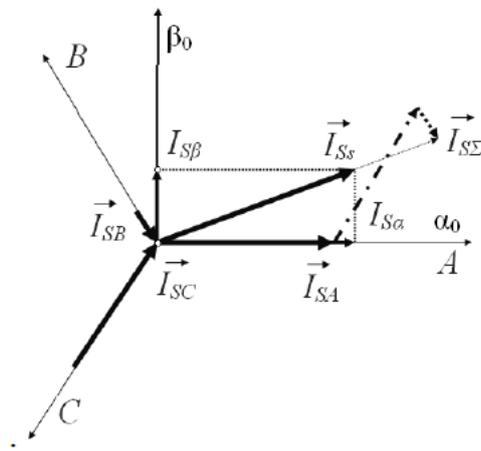


Fig.1. The vectors of stator currents.

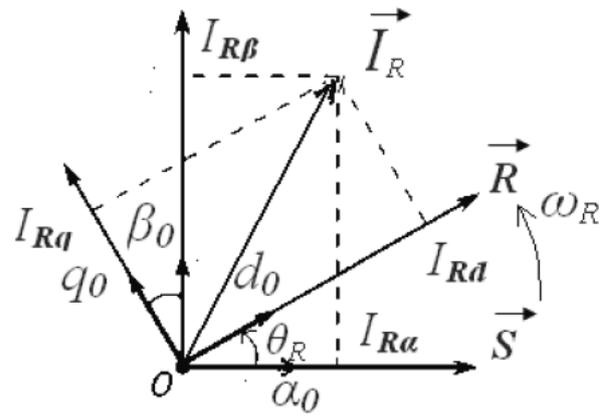


Fig.2. The vectors of rotor currents.

For the correctness analysis processes all the vectors in the equation should be written in the one and same coordinate system.

For example, in the equation of stator voltage (1) the vectors may be written in the system of axes (uv) so:

$$\begin{aligned} \bar{U}_S^{(uv)} &= \bar{U}_S^{(k)} = \bar{U}_{Sk} = \bar{U}_{Ss} e^{-\beta_0 \theta_k} = R_s \bar{I}_{Ss} e^{-\beta_0 \theta_k} + \frac{d}{dt} (L_s \bar{I}_{Ss} e^{-\beta_0 \theta_k} + L_m \cdot e^{\beta_0 \theta_R} \bar{I}_{Rr} e^{-\beta_0 \theta_k}) = \\ &= \bar{U}_{Sk} = R_s \bar{I}_{Sk} + \frac{d}{dt} (L_s \bar{I}_{Sk} + L_m \cdot \bar{I}_{Rk}) \end{aligned} \tag{4}$$

The known direct Park transformation converts the vector from stator axes into the vector in rotor axes. This is written for the projections of vector as follows:

$$\begin{cases} I_{Rd} = I_{R\alpha} \cos \theta_R + I_{R\beta} \sin \theta_R; \\ I_{Rq} = -I_{R\alpha} \sin \theta_R + I_{R\beta} \cos \theta_R. \end{cases} \tag{5}$$

The inverse Park transformation can be written in vector form:

$$\begin{aligned} \bar{I}_{Rs} &= e^{\beta_0 \theta_R} \bar{I}_{Rr} = (\vec{\alpha}_0 \cos(\theta_R) + \vec{\beta}_0 \sin(\theta_R)) \cdot (\vec{d}_0 I_{Rd} + \vec{q}_0 I_{Rq}); \\ \bar{I}_{Rs} &= \begin{vmatrix} \vec{\alpha}_0 \\ \vec{\beta}_0 \end{vmatrix}^t \cdot \begin{vmatrix} \cos(\theta_R) & -\sin(\theta_R) \\ \sin(\theta_R) & \cos(\theta_R) \end{vmatrix} \cdot \begin{vmatrix} I_{Rd} \\ I_{Rq} \end{vmatrix} = \begin{vmatrix} \vec{\alpha}_0 \\ \vec{\beta}_0 \end{vmatrix}^t \cdot \begin{vmatrix} I_{R\eta} \\ I_{R\zeta} \end{vmatrix}, \end{aligned} \tag{6}$$

Using here proposed notations for multiplication of vectors we have the well-known inverse Park transformation as an ordinary mathematical operation.

The rotation of vectors also convenient to write as numerically:

$$\begin{aligned} e^{\beta_0 \cdot (-\theta_R)} &= (\vec{\alpha}_0 \cos(-\theta_R) + \vec{\beta}_0 \sin(-\theta_R)) = \\ &= (1_s \cos(-\theta_R) + \sqrt{-1}_s \sin(-\theta_R)) = \quad ; \tag{7} \\ &= (1_s \cos \theta_R - \sqrt{-1}_s \sin \theta_R) \end{aligned}$$

$$\begin{aligned} e^{\beta_0 \cdot \theta_R} &= (\vec{\alpha}_0 \cos(\theta_R) + \vec{\beta}_0 \sin(\theta_R)) = \\ &= (1_s \cos \theta_R + \sqrt{-1}_s \sin \theta_R) \end{aligned} \tag{8}$$

Transformation of vectors can now perform common numerical mathematical operations::

$$\bar{I}_{Rs} = (\vec{\alpha}_0 I_{R\alpha} + \vec{\beta}_0 I_{R\beta}) = (1_s I_{R\alpha} + \sqrt{-1}_s I_{R\beta}) = \begin{vmatrix} \vec{\alpha}_0 & \vec{\beta}_0 \end{vmatrix} \cdot \begin{vmatrix} I_{R\alpha} & I_{R\beta} \end{vmatrix}^t =$$



$$\begin{aligned}
 &= e^{\beta_0 \theta_R} \vec{I}_{Rr} = (\vec{\alpha}_0 \cos(\theta_R) + \vec{\beta}_0 \sin(\theta_R)) \cdot (\vec{d}_0 I_{Rd} + \vec{q}_0 I_{Rq}) = \\
 &= (1_s \cos(\theta_R) + \sqrt{-1}_s \sin(\theta_R)) \cdot (1_r I_{Rd} + \sqrt{-1}_r I_{Rq}) = \\
 &= 1_s \cos(\theta_R) I_{Rd} - 1_s \sin(\theta_R) I_{Rq} + \sqrt{-1}_s \sin(\theta_R) I_{Rd} + \sqrt{-1}_s \cos(\theta_R) I_{Rq} = \\
 &= 1_s (\cos(\theta_R) I_{Rd} + \sqrt{-1}_s \sin(\theta_R) I_{Rd} - 1_s \sin(\theta_R) I_{Rq} + \sqrt{-1}_s \cos(\theta_R) I_{Rq}) = \\
 &= \begin{vmatrix} \vec{\alpha}_0 \\ \vec{\beta}_0 \end{vmatrix} \cdot \begin{vmatrix} \cos(\theta_R) & -\sin(\theta_R) \\ \sin(\theta_R) & \cos(\theta_R) \end{vmatrix} \cdot \begin{vmatrix} I_{Rd} \\ I_{Rq} \end{vmatrix} = e^{\beta_0 \theta_R} \vec{I}_{Rr} . \tag{9}
 \end{aligned}$$

This result is same as previously used formula, but is done a mathematically more correctly and therefore more convincing.

Application method

The use of symbols vectors for coordinate axes is useful in derivation of the equations with vectors of magnetic flux. The equation of stator voltages (1) now is written so:

$$\begin{aligned}
 \vec{U}_S^{(\alpha\beta)} &= R_s \vec{I}_S^{(\alpha\beta)} + \frac{d}{dt} (L_s \vec{I}_S^{(\alpha\beta)} + L_m \cdot e^{\beta_0 \theta} \vec{I}_R^{(dq)}) = \\
 &= \vec{U}_S^{(uv)} \cdot e^{\beta_0 \theta_k} = R_s \vec{I}_S^{(uv)} \cdot e^{\beta_0 \theta_k} + \frac{d}{dt} (L_s \vec{I}_S^{(uv)} \cdot e^{\beta_0 \theta_k} + L_m \cdot e^{\beta_0 \theta_k} \vec{I}_R^{(uv)}) = \\
 &= e^{\beta_0 \theta_k} \{ R_s \vec{I}_S^{(uv)} + \frac{d}{dt} (L_s \vec{I}_S^{(uv)} + L_m \vec{I}_R^{(uv)}) + \vec{\beta}_0 \cdot \omega_k \cdot (L_s \vec{I}_S^{(uv)} + L_m \vec{I}_R^{(uv)}) \} \tag{10}
 \end{aligned}$$

It is useful to recall that the time derivative used often in the methods of analysis does not change the spatial position of the vector, but the differentiation in space (by rotational angle of rotor) will change projection. Here, these relations are manifested according to mathematical operations, and do not need addition of logical reasoning.

It is possible to take into account the functional dependence between the magnetic fluxes and the stator and rotor currents [1]. We now get the equation of the stator voltage with magnetic fluxes in the axes (uv),

$$\vec{U}_{Sk} = \frac{R_s L_R}{L_s L_R - L_m^2} \vec{\Psi}_{Sk} - \frac{R_s L_m}{L_s L_R - L_m^2} \vec{\Psi}_{Rk} + \frac{d}{dt} \vec{\Psi}_{Sk} + \vec{\beta}_0 \cdot \omega_k \cdot \vec{\Psi}_{Sk}; \tag{11}$$

The equation for the stator voltage with projections vectors of magnetic fluxes is convenient for calculations:

$$\begin{aligned}
 \vec{U}_{Sk} &= \frac{R_s L_R}{L_s L_R - L_m^2} \vec{\Psi}_{Sk} - \frac{R_s L_m}{L_s L_R - L_m^2} \vec{\Psi}_{Rk} + \frac{d}{dt} \vec{\Psi}_{Sk} + \vec{\beta}_0 \cdot \omega_k \cdot \vec{\Psi}_{Sk} = \\
 &= u_0 U_{Su} + v_0 U_{Sv} = 1_k U_{Su} + \sqrt{-1}_k U_{Sv} = \\
 &= \frac{R_s}{\sigma L_s} (u_0 \Psi_{Su} + v_0 \Psi_{Sv}) - \frac{R_s k_R}{\sigma L_s} (u_0 \Psi_{Ru} + v_0 \Psi_{Rv}) + \frac{d}{dt} (u_0 \Psi_{Su} + v_0 \Psi_{Sv}) + \\
 &+ \sqrt{-1}_s \cdot \omega_k \cdot (1_k \Psi_{Su} + \sqrt{-1}_k \Psi_{Sv})
 \end{aligned} \tag{12}$$

We get the equations of stator voltage separately for projections vectors.

$$U_{Su} = \frac{R_s}{\sigma L_s} \Psi_{Su} - \frac{R_s k_R}{\sigma L_s} \Psi_{Ru} + \frac{d}{dt} \Psi_{Su} - \omega_k \cdot \Psi_{Sv} \tag{13}$$

$$U_{Sv} = \frac{R_s}{\sigma L_s} \Psi_{Sv} - \frac{R_s k_R}{\sigma L_s} \Psi_{Rv} + \frac{d}{dt} \Psi_{Sv} + \omega_k \cdot \Psi_{Su} . \tag{14}$$

There is designated: $k_S = L_m / L_S$; $k_R = L_m / L_R$; $\sigma = 1 - k_S \cdot k_R$.



Similarly, we can get the equation for the rotor voltage in axes (uv), which takes into account the rotation of rotor:

$$\vec{U}_{Rk} = \frac{R_R L_S}{L_S L_R - L_m^2} \vec{\Psi}_{Rk} - \frac{R_R L_m}{L_S L_R - L_m^2} \vec{\Psi}_{Sk} + \frac{d}{dt} \vec{\Psi}_{Rk} + \vec{\beta}_0 \cdot (\omega_k - p_Z \cdot \omega_r) \cdot \vec{\Psi}_{Rk}; \tag{15}$$

There is designated $-p_Z$ - the number of pairs of poles of the machine; ω_r - the angular velocity of rotation of rotor, $\omega_R = p_Z \cdot \omega_r$ - angular velocity of rotation of the coordinate systems (dq) of rotor or of stator ($\alpha\beta$). Then we have the equation of rotor voltage for projections vectors:

$$\begin{aligned} \vec{U}_{Rk} &= R_R(\vec{u}_0 I_{Ru} + \vec{v}_0 I_{Rv}) + \frac{d}{dt}(\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) + \vec{\beta}_0 \cdot (\omega_k - p_Z \cdot \omega_r) \cdot (\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) = \\ &= (\vec{u}_0 U_{Ru} + \vec{v}_0 U_{Rv}) = 1_s U_{Ru} + \sqrt{-1_s} U_{Rv} = R_R(\vec{u}_0 I_{Ru} + \vec{v}_0 I_{Rv}) + \frac{d}{dt}(\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) + \\ &+ \sqrt{-1_s} \cdot (\omega_k - p_Z \cdot \omega_r) \cdot (1_s \Psi_{Ru} + \sqrt{-1_s} \Psi_{Rv}) = \\ &= \frac{R_R}{\sigma L_R} (\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) - \frac{R_R k_S}{\sigma L_R} (\vec{u}_0 \Psi_{Su} + \vec{v}_0 \Psi_{Sv}) + \frac{d}{dt} (\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) + \\ &+ \vec{\beta}_0 \cdot (\omega_k - p_Z \cdot \omega_r) \cdot (\vec{u}_0 \Psi_{Ru} + \vec{v}_0 \Psi_{Rv}) \end{aligned} \tag{16}$$

The foregoing conversions done the well-known system of equations for the projections of magnetic fluxes of stator and rotor two-phase model of AM in the arbitrary system of axes (uv), convenient for calculations:

$$\begin{cases} \frac{d}{dt} \Psi_{Su} = U_{Su} - \frac{R_S}{\sigma L_S} \Psi_{Su} + \frac{R_S k_R}{\sigma L_S} \Psi_{Ru} + \omega_k \cdot \Psi_{Sv}; \\ \frac{d}{dt} \Psi_{Sv} = U_{Sv} - \frac{R_S}{\sigma L_S} \Psi_{Sv} + \frac{R_S k_R}{\sigma L_S} \Psi_{Rv} - \omega_k \cdot \Psi_{Su}; \\ \frac{d}{dt} \Psi_{Ru} = \vec{U}_{Ru} - \frac{R_R}{\sigma L_R} \Psi_{Ru} + \frac{R_R k_S}{\sigma L_R} \Psi_{Su} + (\omega_k - p_Z \cdot \omega_r) \cdot \Psi_{Rv}; \\ \frac{d}{dt} \Psi_{Rv} = U_{Rv} - \frac{R_R}{\sigma L_R} \Psi_{Rv} + \frac{R_R k_S}{\sigma L_R} \Psi_{Sv} - (\omega_k - p_Z \cdot \omega_r) \cdot \Psi_{Ru} \end{cases} \tag{17}$$

The resulting system of equations above (17) coincides with the known equations [1-3], but here it obtained by using only rigorous mathematical operations. The simulation showed that the system of equations (17) turns well correct.

Creation of the equations of the three-phase AM is based on the assumption that the distribution of magnetic flux density along the air gap is sinusoidal [1-3]. However, all AM have different of structure windings, whereby the condition of sinusoidal magnetic flux distribution in the air gap is not always satisfied [5-8]. The mutual inductances between the windings of the stator, between stator windings and rotor are dependent on the rotor position not so, as is the case in an idealized model AM with a sinusoidal distribution of magnetic induction in the air gap.

The processes in the three-phase AM studied by the conversion to the two-phase model with help of Clarke and Park transformations [1-3]. In these transformations can take into account the design of the windings by means of correction coefficients and correction functions.

The authors suggested the function of correction and correction coefficients to



elements of vectors transformation and to vector transformations formula [5–8] to obtain matching with a distribution of magnetic induction in the gap of the real machine.

The Clarke transformation now will have form –

$$\begin{cases} I_{S\alpha} = \frac{2}{3}(KAa(0) \cdot I_{As} - KAa(\pi/3) \cdot \frac{I_{SB} + I_{SC}}{2}); \\ I_{S\beta} = \frac{1}{\sqrt{3}}KAa(\pi/6) \cdot (I_{SB} - I_{SC}); \\ I_0 = \frac{1}{3}(I_{SA} + I_{SB} + I_{SC}). \end{cases}, \quad (18)$$

where $KAa(\theta)$ - correction function represents the deviation of the magnetic fluxes mutual inductance of stator windings from functional $\cos(\theta)$. Function $\cos(\theta)$ corresponds to an idealized model AM. The values of correction function $KAa(\theta)$ with $\theta=2\pi/3$ and $\theta=4\pi/3$ may be used as correction coefficients KSS to the corresponding elements of matrix inductance of stator (rotor) windings in the equations of idealized machine. The projection of vector of the flux linkage correspond to the magnetic flux transmitted through the air gap, i.e. they correspond to the magnetic flux of mutual induction between the windings of stator and rotor.

This makes it possible to apply the correction function $KAa(\theta) = KMAa(\theta) = F_{SR}(\theta)$, as an amendment to the elements of matrix of mutual inductance between the stator and rotor windings in the system of equations of idealized machine in order to obtain a matrix of mutual inductances as the real machine:

$$L_{SRm} = L_m \begin{bmatrix} \cos(\theta) \cdot F_{SR}(\theta + 0^\circ) & \cos(\theta + 120^\circ) \cdot F_{SR}(\theta + 120^\circ) & \cos(\theta - 120^\circ) \cdot F_{SR}(\theta - 120^\circ) \\ \cos(\theta - 120^\circ) \cdot F_{SR}(\theta - 120^\circ) & \cos(\theta) \cdot F_{SR}(\theta + 0^\circ) & \cos(\theta + 120^\circ) \cdot F_{SR}(\theta + 120^\circ) \\ \cos(\theta + 120^\circ) \cdot F_{SR}(\theta + 120^\circ) & \cos(\theta - 120^\circ) \cdot F_{SR}(\theta - 120^\circ) & \cos(\theta) \cdot F_{SR}(\theta + 0^\circ) \end{bmatrix}. \quad (19)$$

Simulation of processes a direct startup AM to the network with taking into account the design windings has indicated that even a slight difference from a sine wave distribution of magnetic induction significantly affects on processes in AM [6].

Modeling

Fig.4 shows a graph of speed and Fig.5 shows the dynamic mechanical characteristics of an idealized model of three-phase AM with direct start-up from the network frequency of 60 Hz under load, then reset and again take load. The initial data of model AM taken as described in [4].

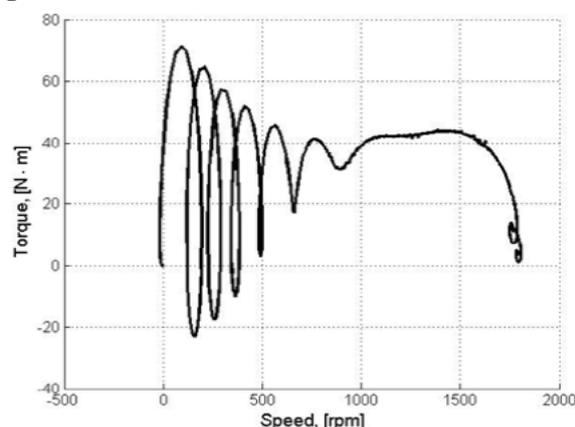
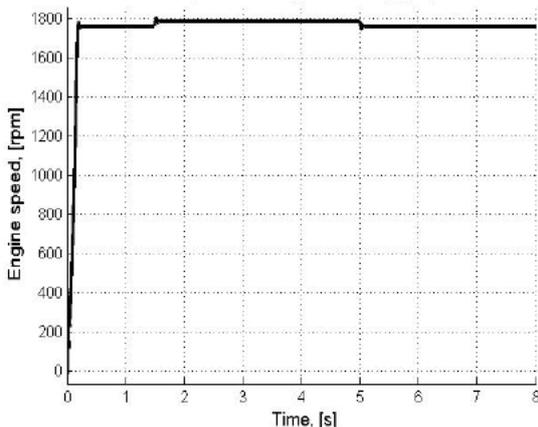


Fig.4. Speed idealized model AM. Fig.5. Torque-speed idealized model AM.



Fig.6 and. fig.7 shows graphs similar to fig.4 and fig.5 for the same three-phase machine where the correction coefficients $K_{SS} = 0.946$ and $K_{RR} = 0.946$ were introduced in the matrix of inductances of stator and rotor.

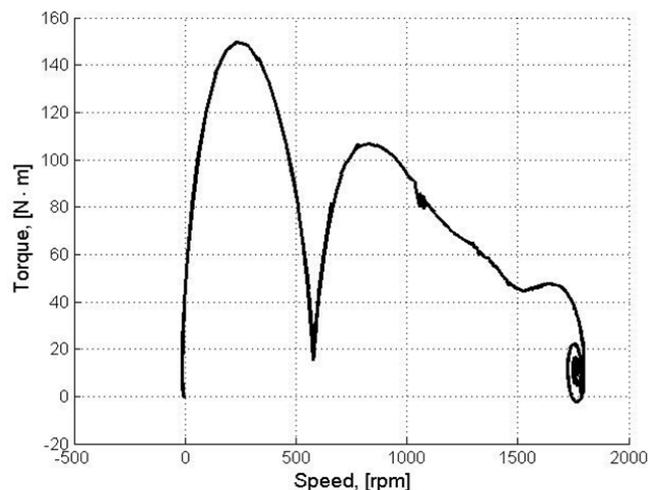
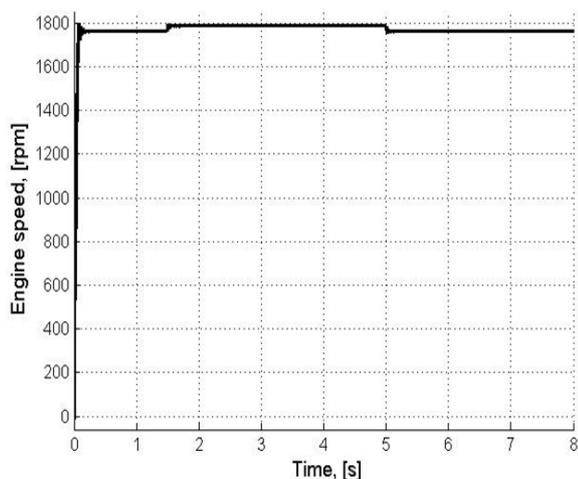


Fig.6. Speed modified model AM. Fig.7. Torque-speed modified model AM.

The graphs show that the processes in an idealized AM and in modified (real) machine may differ materially. In the chart of dynamic mechanical characteristic of modified model AM (Fig.7) disappeared loops that are characteristic of charts with any idealized model of AM (Fig.5). Availability of these loops in dynamic characteristics can not be explained by any physical processes in AM. But they are quite understandable as a result of inaccuracies idealized model AM.

. The carried out theoretical studies obviously can not replace the drive research with real asynchronous machines. However, the more accurate mathematical models can improve the more efficient production of drives of induction motor.

Applying of correction functions and correction coefficients requires no alterations to an existing drive control system. The model of asynchronous machine at modeling becomes more accurate. The graphics of process become more realistic.

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METHODICAL APPROACHES OF COMPLEX ELECTRONIC SECURITY SYSTEMS APPLYING FOR HIGHER EDUCATION INSTITUTIONS

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МЕТОДИЧЕСКИЕ ПОДХОДЫ К ПРИМЕНЕНИЮ КОМПЛЕКСНЫХ ЭЛЕКТРОННЫХ СИСТЕМ БЕЗОПАСНОСТИ В ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ

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Abstract. In this paper the technical and designed methodical approaches of applying complex electronic security systems for higher education institutions buildings and rooms were developed.

Key words: complex security system, security, higher education institution.

Аннотация. Разработаны методические подходы к техническим и проектным решениям оснащения комплексными электронными системами безопасности зданий и помещений высших учебных заведений

Ключевые слова: комплексная система безопасности, высшее учебное заведение, обеспечение безопасности.

Introduction

Higher education institution is one of the objects that needed to maintain a certain level of security, including the applying of electronic security systems. The main challenges faced by complex electronic security systems (ESS) in higher education are:

- Fire safety in accordance with fire safety standards and technical acts.
- Access control in higher educational institution campus, as well as in certain rooms, and (or) the departments of the university.
- Protection of the laboratories of the university from theft of equipment or valuable information.
- Providing the surveillance of the territory of the university, passageways and corridors of buildings.
- Providing the integration of security systems in the learning process: accounting of attendance to classes of employees and students of the university, video and audio recording of the lecture material, as well as other integration capabilities.

Developed approaches to technical and design solutions in the construction of an integrated electronic security system can solve the task of ESS equipment for higher education institutions providing, as well as provide the potential for implementing additional functions of integration and enable further expansion and development of the ESS.

Theoretical analysis

ESS of college should consist of the following sub-systems [1]: The System of



Fire Automation (SFA), Burglar Alarm System (BAS), Access Control System (ACS), CCTV.

General principles of fire automation systems are already firmly in the technical normative legal acts [2]. Also, the fire control system in the process of exploitation should not be controlled by any other system in order to prevent accidental disconnection of fire automation functions. Therefore, under the ESS, a subsystem of fire automatic works as "stand-alone" without receiving the control signals from other systems, but, in the same time passing signals to other subsystems, as well as providing information on the state of the central control unit of devices for monitoring and maintenance.

The general principles of the protection of borders means locking **security alarm systems** are also shown in the relevant technical regulations. However, it should identify the following requirements for the alarm system in the framework of the concept of building ESS in HEI:

- The alarm system should have the address structure to determine the place of occurrence of the alarm; be able to control from ESS software;
- The alarm system should have tight integration with access control implementing event scripts "alarming area for protection when leaving the last man», «lock door during an alarm accruing in the zone». As a rule, such an implementation is available when combining the access controller and the device receiving and controlling security in a single device, or the implementation of deep hardware and software integration of the access control sub-systems and burglar alarm systems [1].

Access control systems (ACS) in various educational institutions (including universities), considered by the author in [3]. Consider the basic technical solutions when installing ACS in universities.

- Application of ACS at all entrances and exits of the buildings of the university, as well as in special departments of the university (turnstiles); the inputs and outputs of laboratories (electronic locks), as well as the inputs and outputs in the classrooms ("coming-leaving" terminal device) to monitor the class attendance of students (especially in the universities, which require mandatory attendance of all occupations). This approach will identify the location of a student or employee of the university, up to the audience at any given time, exclude the possibility of the presence on campus of unauthorized persons, increase labor discipline of university staff.

- Application for registration highly protected identifiers in ACS. As such identifiers may make a secure identification card with Mifare Classic and Mifare Plus, as well as biometric identification. At the same time, it is much more convenient to operate, service and application is the use of contactless cards with protected identity, excluding the possibility of a fake ID cards.

- Integration of security systems within the ESS with automatic fire systems (emergency unlocking access points when the fire alarm occurs); alarm system (implementation scenarios of events "staging area for protection when leaving the last man", "the door lock for the burglar alarm occurs in the zone», «disarming», etc.); CCTV (ACS sync files and CCTV, which allows you to simultaneously view ACS events and archive with the corresponding cameras of CCTV



The video surveillance system is one of the most informative, but at the same time and makes the greatest demands on the hardware and software resources.

Installation of cameras should be performed at the following locations: in the vicinity of the access control access points (for the control of passages and archives synchronization); the inputs and outputs of the buildings of the institution (to monitor the situation and make-removal of material values); on the perimeter of campus (for control over the situation); in the corridors of the institution (for control over the situation); in the classroom (for control over the activities, as well as video and audio recordings of lectures and other forms of training); in interbuildings transitions (to control the movement of personnel between the buildings); in other areas (dining room, cafe, auditorium, atrium) to monitor the overall situation.

As part of the ESS, CCTV interaction with other systems is also based largely on the principles of software integration, due to the fact that the hardware and software systems of video surveillance systems often act as a platform for the integration of other security systems into a single integrated electronic security system [1].

Results

The proposed method of constructing ESS within the higher education institution will implement the possibility of monitoring the overall situation in the territory of the university at any time using the remote access to security systems.

Modular structure of modern electronic security systems, integration means openness in software and hardware, the potential to extend the functionality of complex electronic security features allows you to implementation of the system, taking into account the proposed comprehensive approach in several stages. We distinguish these stages in accordance with the priority of their creation, according to security to the current legislation:

1. Design and installation of complex fire automation systems in the building.
2. Design and installation of burglar alarm systems in the building.
3. Designing a comprehensive system of access control.
4. Designing an integrated system of video surveillance.
5. The partial or full implementation of a comprehensive system of access control.
6. The partial or full implementation of integrated surveillance systems.
7. Measures for the integration and automation of processes and reactions in the ESS.
8. Further expansion of functionality and hardware capabilities of an integrated electronic security system and modernization ESS as needed.

Summary and Conclusions

Thus, taking as a basis for this concept in the development of complex electronic security systems projects, you can improve the effectiveness of ESS, increasing the level of general security, improve the efficiency of university employees.

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**ERROR ESTIMATES FOR THE CALCULATION OF CORRELATED
COLOUR TEMPERATURE**

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**ПОГРЕШНОСТЬ МЕТОДОВ РАСЧЁТА КОРРЕЛИРОВАННОЙ
ЦВЕТОВОЙ ТЕМПЕРАТУРЫ**

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Abstract. This paper describes errors in determining correlated colour temperature (CCT) by different methods. We propose the test to evaluate the error. The main idea of the test is to use, when calculating CCT, chromaticities of the isotherm lines. We can therefore compute the absolute error as difference between CCT calculated by certain method and CCT of isotherm line. In this paper we discuss the following calculation CCT methods: Robertson, McCamy, Yoshi Ohno and Hernandez-Andres's method. Also in the paper compares the "classic" version of Robertson's method, using the 31 isotherm lines, and versions with plenty of lines. It has been shown that a decrease in the step between lines decreases error.

Key words: Chromaticity coordinates, correlated colour temperature, errors in determining CCT, isotherm lines, Planckian locus.

Аннотация. В данной статье определяется погрешность различных методов расчёта коррелированной цветовой температуры (КЦТ). Предлагается алгоритм нахождения погрешности. Главная идея алгоритма заключается в нахождении КЦТ для цветностей лежащих на изотемпературной линии. Далее мы можем рассчитать погрешность как разницу между значением КЦТ найденному по методу и КЦТ изотемпературной линии. В данной статье рассматриваются следующие методы расчёта КЦТ: Робертсона, Мак Ками, Йоши Оно и Хавьера Эрнандеса. Также в статье сравнивается классический вариант метода Робертсона, использующего 31 изотемпературную линию и версии с большим количеством линий. Показано, что при уменьшении шага между линиями уменьшается погрешность.

Ключевые слова: Координаты цветности, коррелированная цветная температура, погрешности определения КЦТ, изотемпературные линии, линия чёрного тела.

Introduction (optional).

The first methods of calculation CCT appeared in the late 1960s XX century. Over the next 50 years it was invited to a lot of CCT calculation methods [1-3]. Of course, the authors of the methods pointed error, but not always pointed evaluation way. In [2], presented an analytical method for calculating the CCT and are given absolute error of different methods of calculation CCT, but is not presented



evaluation way. Therefore, we want to propose common way to evaluate error of different methods.

But before proceeding to the description of the test, we recall that, according to [4] CCT it is temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram CIE 1960. We note that, the concept of CCT can not be used if the distance between the chromaticity of the test source and the line of the black body more than

$$\Delta C = [(u'_t - u'_p)^2 + 4/9(v'_t - v'_p)^2]^{1/2} = 5 \cdot 10^{-2},$$

where (u'_t, v'_t) and (u'_p, v'_p) – chromaticity coordinates of the test source and the Planckian radiator respectively on a diagram CIE 1974 diagram. Isotemperature line is a line, all the points which correspond to the same CCT. Therefore, if we know the temperature, which corresponds to an isotemperature line, we can calculate CCT for chromacity on this line and then find the error (absolute or relative) method at a given point. It should also be said that, according on the determination of CCT, error should not be defined in only a single point, but in a band extending along the line of the Planckian radiator (Figure 1)

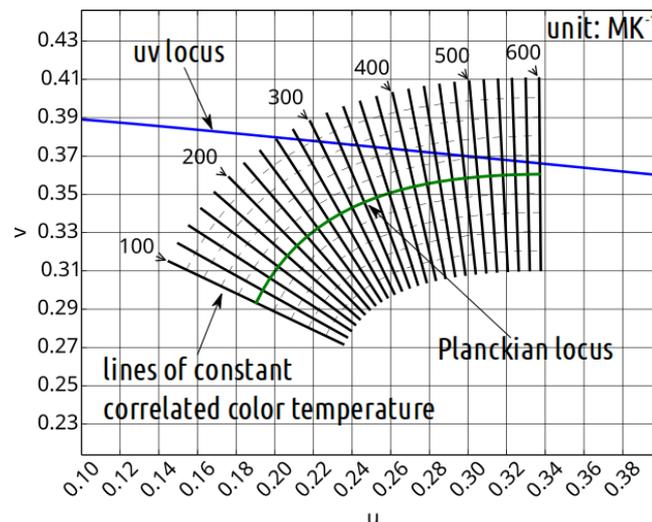


Figure.1. CIE 1960 diagram with Planckian locus and isotemperature lines

Algorithm

Algorithm for calculating the error is shown below:

- In the first stage is formed the table which stores chromaticities u, v of isotemperature lines. This uses the expression (1):

$$u_1 = u_0 \pm \frac{lv'}{\sqrt{u'^2 + v'^2}}; v_1 = v_0 \pm \frac{lu'}{\sqrt{u'^2 + v'^2}}, \quad (1)$$

where $u' = du/dt, v' = dv/dt; u_0, v_0$ – chromaticities of the Planckian radiator; l – distance between the Planckian locus and the parallel curve. Note that in order to find u' and v' we used numerical differentiation;

- In the second stage is formed the table with the results of calculation CCT for chromaticities from the first table;

- In the third stage is formed is the table with the results of calculation absolute error.

Thus, the essence of the method consists in that when calculating CCT, we use



as input data chromaticities u, v of isothermperature lines and then find the absolute error as the difference between the calculated CCT and the temperature of the isothermperature line. Figure 2 illustrates the algorithm described above.

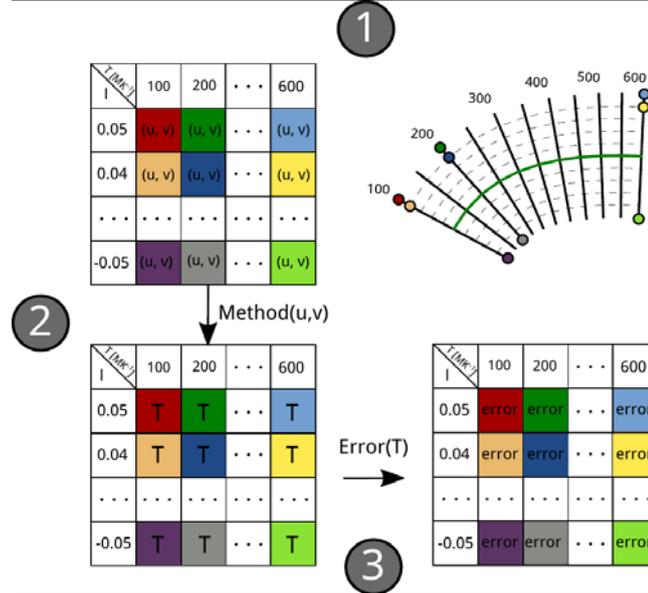


Figure.2. Algorithm for calculating the error

Error of CCT calculation methods

Robertson's method for calculating the CCT was proposed in 1968. He found a wide practical application and still has not lost relevance.

The original method is based on the table in which describes the properties of the 31 isothermperature lines (from 10 MK^{-1} to 660 MK^{-1} in increments of 10 MK^{-1}). Additionally, we calculated new tables for step 5 MK^{-1} , 2.5 MK^{-1} and 1 MK^{-1} between the isothermperature lines [10]. Error of Robertson's method for different step are shown in table 1. Analysing this table, we can be concluded, that the smaller the pitch between isothermperature lines, the smaller the error for the Robertson's method.

Table1. Errors of Robertson's method

Errors in CCT (K)			
10 MK^{-1}	5 MK^{-1}	$2,5 \text{ MK}^{-1}$	1 MK^{-1}
12,4	0,6	0,16	0,025

Figure 3 illustrates the distribution of the absolute error in the range of 1667 K - 10000 K for the table proposed by G. Wyszeczi (10 MK^{-1}) [5].

From the graph (Figure 3) shows that the error increases with increasing temperature.

McCamy's method was proposed in 1992 [6]. To calculate the CCT author offered use a third-order polynomial. The polynomial has been obtained on the assumption that all the isothermperature lines intersect at a certain point on the diagram CIE 1931.

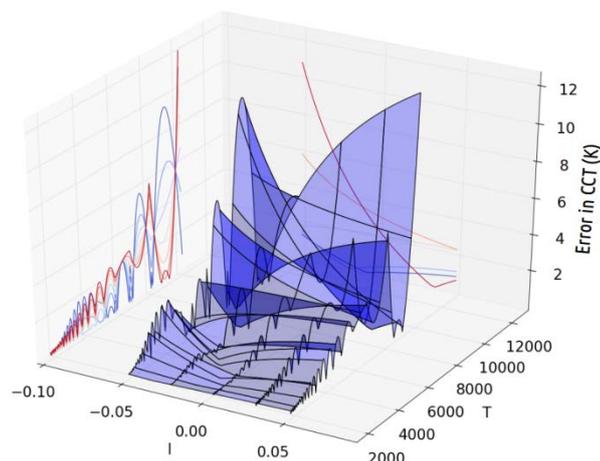


Figure.3. Errors in CCT (K) of Robertson's method (with table of G. Wyszeccki

Our test show that errors of this method (Figure 4), is considerably more than errors of the Robertson's mehod. The maximum error in the range 1700-10000 K reaches 285.4 K.

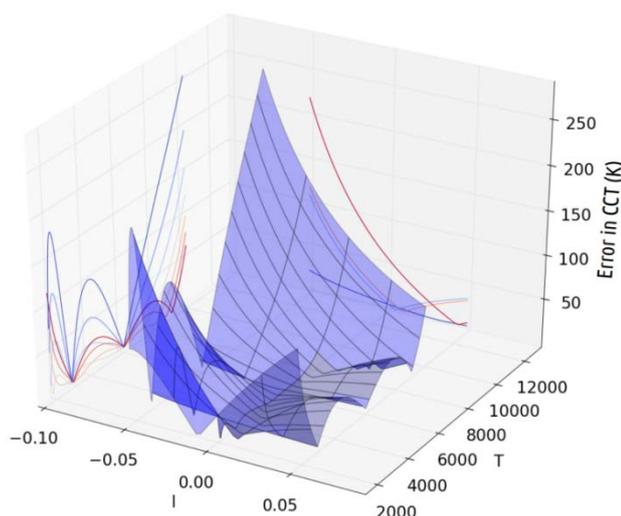


Figure.4. Errors in CCT (K) of McCamy's method in the range 1700 — 10000 K

Hernandez-Andres's method was proposed in 1999 [2]. It is also present an analytical solution. Errors of this method showed on fig. 5. This solution is also significantly inferior in accuracy of the Robertson's method. The maximum error in the range 1700-10000 K reaches 429.4 K.

In 2013 Yoshi Ohno proposed three methods for calculating CCT: method of triangles, parabolas method and combined method [1]. They are all based on the same calculation table.

Table 3 shows the absolute error of calculation CCT for methods Yoshi Ohno. Figures 6-8 are presented absolute error distribution graphs for appropriate methods of calculation CCT.

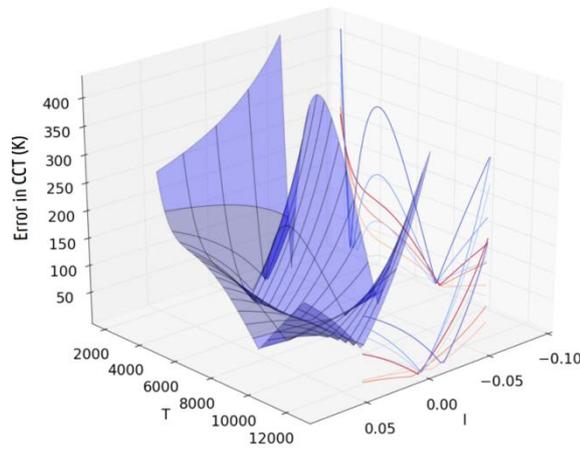


Figure.5. Errors in CCT (K) of Hernandez-Andres 's method in the range 1700 — 10000 K

Table 3 Errors of Y. Ohno's methods

method	Errors in CCT (K)
	1667 K – 10000 K
Triangular solution	19,1
Parabolic solution	8,5
Combined solution	0,9

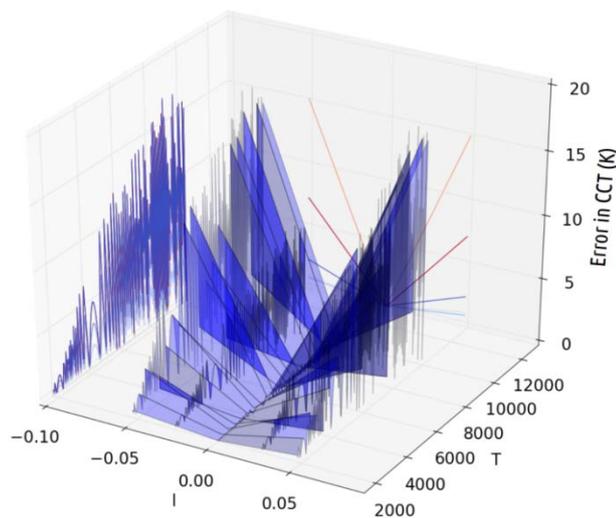


Figure.6. Errors in CCT (K) of triangular solution in the range 1700 — 10000 K

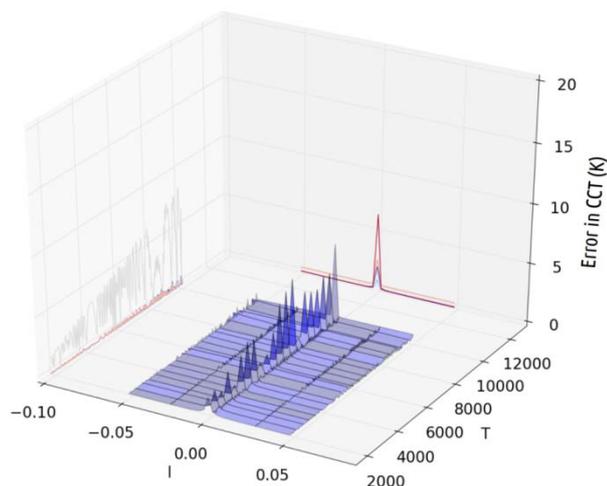


Figure.5. Errors in CCT (K) of parabolic solution in the range 1700 — 10000 K

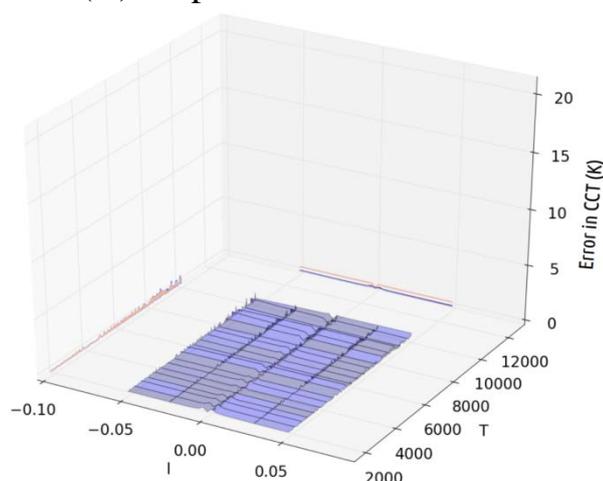


Figure.6. Errors in CCT (K) of combined solution in the range 1700 — 10000 K

Conclusioni

As a result of the work performed is established:

- The error of Robertson's method increases with increasing temperature and that the smaller the step between isotherm lines, the smaller the error;
- For triangular solution Yoshi Ohno in the range 1667 K - 10000 K an absolute error does not exceed 19.1 K, paraboloid solution in the same range is more accurate and absolute error does not exceed 8.5 K. The combined method has the highest precision. In the range 1667 K - 10000 K absolute error is 0.9;
- Errors for McCamy's method in the range 1700 K - 10000 K can grow up to 250 K;
- Errors for Hernandez-Andres 's method in the range 1700 K - 10000 K can reach to 429.4 K. As is the case with the previous method, error is strongly dependent on the location in a strip that runs along the line of the black body;
- We recommend combined method Yoshi Ohno as the most appropriate method for calculating CCT in terms of accuracy..

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SKIN-EFFECT OF FLUID IN CAPILLARIES*Bukovinian State Medical University,**Chernivtsi, Theatralna sq. 2, 58002**Yuriy Fedkovych Chernivtsi National University,**Chernivtsi, Kotsjubynskyi Str. 2, 58012*

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Abstract. In this paper we describe of the processes that occur in the electrode-less complex for measuring the conductivity of fluids. Studied the frequency dependence of the added losses d induced a tuned circuit caused by the presence of fluid resistivity ρ in the inductive solenoid capillary bound in the frequency range 2,2-8,8 MHz. Shown that $d=a_0(f)+a_1(f)\cdot\rho^{-1/2}$. Experimentally proved that the function $a_1(f)$ proportional $f^{3/2}$, and function $a_0(f)$ proportional f^2 . Different frequency dependence of the functions $a_1(f)$ and $a_0(f)$ possible to find the frequency dependence of the skin effect $h/r=A(f)\cdot\rho^{1/2}=a\cdot f^{1/2}\cdot\rho^{1/2}$, where a – constant which does not depend on the frequency and the resistivity of the fluid. The experimental dependence skin effect in fluids with different specific conductivity σ for fixed frequency oscillator circuit.

Key words: skin-effect, electrode-less method, oscillation circuit, conductivity of fluids, Q-factor, capillary.

Аннотация. В работе рассмотрены процессы, которые происходят в установке для безэлектродного измерения электропроводности жидкостей. Исследованы частотные зависимости вносимого затухания d в колебательный контур, вызваны наличием жидкости с удельным сопротивлением ρ в индуктивно связанном капиллярном соленоиде в диапазоне частот 2,2-8,8 МГц. Показано, что $d=a_0(f)+a_1(f)\cdot\rho^{-1/2}$. Экспериментально доказано, что функция $a_1(f)$ пропорциональна $f^{3/2}$, а функция $a_0(f)$ пропорциональна f^2 . Различные частотные зависимости функций $a_1(f)$ и $a_0(f)$ позволили найти частотную зависимость скин-эффекта $h/r=A(f)\cdot\rho^{1/2}=a\cdot f^{1/2}\cdot\rho^{1/2}$, где a – константа, которая не зависит от частоты и удельного сопротивления жидкости. Получены экспериментальные зависимости скин-эффекта в жидкостях с различной удельной электропроводностью σ для фиксированных частот колебательного контура.

Ключевые слова: скин-эффект, безэлектродный метод, колебательный контур, электропроводность жидкостей, добротность, капилляр.

Introduction

Electrode-less study of the fluids conductivity is important for various fields of science and production, including processes using as chemically pure fluids. The



current state of research electrical parameters of fluids provides information about the behavior and structure of various solutions [1]. Resistance of fluids was tested at the electrode-less measuring complex [2]. Experimental dependence Q -factor of oscillatory circuit with frequency f (2,2–8,8 MHz) illustrates in (Fig.1.).

The coefficient of added losses d of oscillatory circuit caused only by the presence of fluids with specific conductivity σ in capillary solenoid is connected by induction with an oscillatory circuit of the Q -meter can be written as following:

$$d = \frac{1}{Q(\sigma)} - \frac{1}{Q_0} = B(f, \sigma) \cdot \sigma, \tag{1}$$

where Q_0 and $Q(\sigma)$ is Q -factor of equivalent circuit without fluid and oscillatory circuit with fluid of a specific electric conductivity σ .

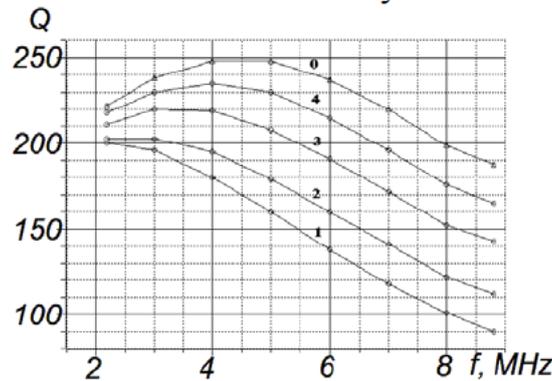


Figure. 1. Frequency dependence of quality factor $Q(f)$ oscillatory circuit (0 - in the absence of fluid, 1-4 - in the presence of fluids with different specific conductivity σ ($\sigma_1=12,5$ S/m; $\sigma_2=5,7$ S/m; $\sigma_3=1,8$ S/m; $\sigma_4=0,69$ S/m)

The coefficient d theoretically determined following way:

$$d = \frac{\omega^2 M^2}{\omega L} \cdot \frac{1}{R_s} = \frac{\omega M^2}{L} \cdot \frac{S_s}{l_s} \cdot \frac{1}{\rho} = \left(\frac{\omega M^2}{L} \cdot \frac{S_k}{l_k} \cdot \frac{l_k}{l_s} \right) \left(\sigma \frac{S_s}{S_k} \right) = B(f) \cdot \sigma \frac{S_s}{S_k}, \tag{2}$$

where $\omega = 2\pi f$, M – the natural inductance factor, l_k, S_k – length and cross-sectional area of the capillary with fluid; and S_s, l_s – length and cross-sectional area of the capillary with fluid in the reactive zone which actually runs a closed eddy currents induced by the presence of fluid in the capillary and capacity between the turns C_2 .

The ratio of $\frac{S_s}{S_k}$, if skin-effect is $\frac{h}{r_k} \leq 1$, can be computed from the following equation:

$$\frac{S_s}{S_k} = \frac{\pi r_k^2 - \pi(r_k - h)^2}{\pi r_k^2} = 1 - \left(\frac{r_k - h}{r_k} \right)^2 = 1 - \left(1 - \frac{h}{r_k} \right)^2 = 2 \frac{h}{r_k} - \left(\frac{h}{r_k} \right)^2, \tag{3}$$

where h - effective depth of penetration of the electromagnetic field in the capillary with fluid, depending on the fluids resistivity ρ . We use the relation:

$$\frac{h}{r_k} = A(f) \cdot \sqrt{\rho}, \tag{4}$$

to express coefficient d as following:

$$d = 2B(f)A(f)\sqrt{\sigma} - B(f)A^2(f) = a_0(f) + a_1(f)\sqrt{\sigma}. \tag{5}$$



We used equation (1-5) for the experimental study of Q -factor change in oscillator circuit for four fluids with fixed values of conductivity σ and eight frequencies in the range of 2,2-8,8 MHz. Frequency dependence of coefficient $d_i=(1/Q_i-1/Q_0)$ was studied and built the dependencies in logarithmic scale have the form of straight slope which indicates that coefficient d depends on the frequency f at 1.6 degrees ($\approx f^{3/2}$). Dependencies in the coordinates $(f^{3/2}, d)$ were the straight lines and experimentally confirmed the above-mentioned theoretical dependence of $1/Q$ of the frequency in the presence of skin effect. In the absence of skin effect d value proportional to the frequency f . Experimental depending of coefficient d on the conductivity of fluids for four frequencies ($f_1=8,8$ MHz; $f_2=7$ MHz; $f_3=5$ MHz; $f_4=3$ MHz) was studied. The nonlinear dependence indicated of skin effect. This is supported by a linear dependence of the coefficient d square root of conductivity for different frequencies, which is consistent with the formula (5). From the theoretical formulas (2, 5) and experimental coefficient d depends on frequency, we can conclude that the function $a_1(f)$ depends on the frequency f to the power of $3/2$. Functions after mathematical processing are as follows: $1000 \cdot a_1(f) = -0,1313 + 0,07674 \cdot f^{3/2}$, and $1000 \cdot a_0(f) = 0,08978 - 0,01185 \cdot f^2$. With dependencies $a_1(f)$ and $a_0(f)$ and considering that independent of frequency f constants (f in MHz) are not considered experimental values of the above theory, we used the formula (5) and the functions $B(f)$, $A(f)$ can be written down as follows:

$$A(f) = a \cdot f^{1/2} = 0,3088 \cdot f^{1/2}, \quad (6)$$

$$B(f) = b \cdot f = 0,1243 \cdot 10^{-3} \cdot f, \quad (7)$$

From formulas (4, 6) can be calculated dependent skin effect of specific conductivity for a range of fixed frequencies f . In Fig. 2 shows the calculation results depending on the ratio of the skin layer h to the radius of the capillary R_k conductivity fluids for four frequencies f . In Fig. 2 shows that research spending resistivity fluids in capillaries at various frequencies can obtain information about the radial distribution of the concentration of electrically active impurities in colloidal solutions, especially for the identification of a small volume of test fluid.

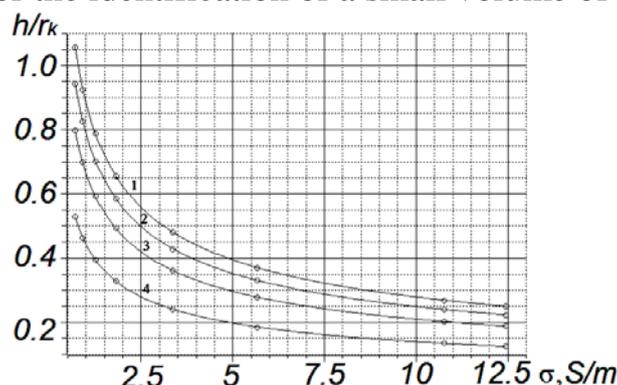


Figure. 2. Dependence of skin layer h with radius of the capillary R_k conductivity fluids for four frequencies f ($f_1 = 8,8$ MHz; $f_2 = 7$ MHz; $f_3 = 5$ MHz; $f_4 = 2,2$ MHz)

Summary and Conclusions

Were received skin-effect in fluids experimentally and described by formula (5). Comparing the experimental curves obtained with the formula (5) we can conclude that the function $h/r_k = a f^{d/2} \rho^{1/2}$ for this experimental setup is proportional to the square



root of frequency f and the square root of the resistivity ρ , where constant a not depends on the frequency f and the resistivity fluid ρ . It follows we can find for fixed radius of the capillary limit the frequency f_{lim} and resistivity ρ_{lim} , above which the skin effect is absent. At very low frequencies $f < 1$ kHz coefficient d almost too small for its consideration and ρ experimentally detect virtually impossible. Coefficient $d_i = (1/Q_i - 1/Q_0)$ proportional to the frequency $f^{3/2}$ for the considered values of resistivity fluids if the oscillatory circuit inductance is constant, and frequency variation associated with changes of capacitance exemplary capacitor.

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OPTIMIZATION OF THE TRANSMISSION CHANNEL AMPLITUDE FREQUENCY CHARACTERISTIC FOR THE OFDM TRANSMISSION SYSTEMS

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ОПТИМИЗАЦИЯ АМПЛИТУДНО-ЧАСТОТНОЙ ХАРАКТЕРИСТИКИ КАНАЛА ПЕРЕДАЧИ ДЛЯ СИСТЕМ ПЕРЕДАЧИ OFDM

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Abstract. This paper is devoted to searching transmission channel amplitude frequency characteristic optimization criterion for the OFDM transmission systems which will be simple enough for the practical application. It's proved that the found criterion corresponds to the criterion of achieved data transmission rate maximization.

Key words: OFDM transmission system, transmission technique, telecommunication technology, broadband access

Аннотация. Работа посвящена поиску критерия оптимизации амплитудно-частотной характеристики канала передачи для систем передачи OFDM, который будет достаточно простым для практического применения. Доказано, что найденный критерий соответствует критерию максимизации достижимой скорости передачи данных.

Ключевые слова: система передачи OFDM, метод передачи, телекоммуникационная технология, широкополосный доступ

Introduction.

OFDM transmission technique is widely used in last two decades in a lot of modern telecommunication technologies (ADSL, VDSL, Wi-Fi, WiMAX, LTE, BPL, G.fast) [1]. The reason for the popularity of this transmission technique is the narrow frequency band of each carrier signal used in the OFDM group signal. This narrowness of the bands allows to adjust adaptively the using of different parts of the group signal frequency band thus to effectively adapt to unstable over time characteristics of the transmission channel [2 – 7].

The problem of necessity of transmission channel amplitude frequency characteristics assessment arises often in scientific and telecommunication service providers' activities. The issue regarding to searching the criterion of transmission channel amplitude frequency characteristics estimation that would correspond to maximum performance of data transmission by OFDM transmission system is actual in many cases. Thus the purpose of the paper is to search such criterion.

The main text.

It's obviously that the main indicator of the efficiency of the data transmission over transmission channel is data transmission rate. Thus our task to achieve the



purpose of this paper is to find such criterion that would correspond to criterion of data transmission rate maximization. For solve this task let's turn to the formula for the data transmission rate in the OFDM transmission systems [8, 9]:

$$R = f_s \cdot \sum_{l=l_1}^{l_2} b(l),$$

where f_s – symbol rate;

l_1 and l_2 – numbers of first and last of used carriers;

$b(l)$ – maximum number of the payload bits transmitted during the OFDM symbol on the l -th carrier.

$b(l)$ depends on signal to noise ratio on the l -th carrier $SNR(l)$ and bit error rate p at the output of the receiver [8, 9]:

$$b(l) = \text{floor} \left\{ \log_2 \left(1 + \frac{3 SNR(l)}{h^2} \right) \right\},$$

where $\text{floor}\{x\}$ – the function which returns the largest integer less than or equal to x ;

$$h = Q^{-1} \left(\frac{p}{1,7} \right),$$

where $Q^{-1}(x)$ – function inverted to $Q(x)$,

$$Q(x) = \int_x^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{y^2}{2}} dy;$$

where p – bit error rate (for example, $h \approx 5,3$ at $p = 10^{-7}$).

Signal to noise ratio on the l -th carrier at the input of the receiver

$$SNR(l) = 10^{0,1(PSD(l) - A(l) - N(l))},$$

where $PSD(l)$ – nominal power spectral density of the transmitted signal on the l -th carrier frequency,

$A(l)$ – transmission channel insertion loss (attenuation) on the l -th carrier frequency,

$N(l)$ – power spectral density of the noise on the l -th carrier frequency at the input of the receiver.

Let's define the interrelation between achieved data transmission rate and characteristics of the transmission channel at the fixed other parameters and considering that the power spectral density of the transmitted signal and of the noise don't depend on the frequency:

$$R = f_s \cdot \sum_{l=l_1}^{l_2} \text{floor} \left\{ \log_2 \left(1 + \frac{3(10^{0,1(PSD(l) - A(l) - N(l))})}{h^2} \right) \right\} = f_s \sum_{l=l_1}^{l_2} \text{floor} \left\{ \log_2 \left(1 + \frac{3 \cdot 10^{0,1(a - A(l))}}{h^2} \right) \right\},$$

where a – constant which is equal to $PSD(l) - N(l)$.

The solved task is limited by determination of the nature of the influence of amplitude-frequency characteristic $A(l)$ on the achieved data transmission rate R . That's why it's permissible to neglect the $\text{floor}\{x\}$ function and the summand "1" under the logarithm sign:



$$\begin{aligned}
 R &\approx f_s \sum_{l=l_1}^{l_2} \log_2 \left(\frac{3 \cdot 10^{0,1(a-A(l))}}{h^2} \right) = f_s \sum_{l=l_1}^{l_2} \left(\log_2 \frac{3}{h^2} + \log_2 (10^{0,1(a-A(l))}) \right) = f_s (l_2 - l_1 + 1) \log_2 \frac{3}{h^2} + \\
 &+ f_s \sum_{l=l_1}^{l_2} \log_2 (10^{0,1(a-A(l))}) = f_s (l_2 - l_1 + 1) \log_2 \frac{3}{h^2} + f_s \sum_{l=l_1}^{l_2} 0,1(a - A(l)) \log_2 10 = \\
 &= f_s (l_2 - l_1 + 1) \log_2 \frac{3}{h^2} + 0,1 f_s \log_2 10 \cdot \sum_{l=l_1}^{l_2} a - 0,1 f_s \log_2 10 \cdot \sum_{l=l_1}^{l_2} A(l) = B - C \sum_{l=l_1}^{l_2} A(l),
 \end{aligned}$$

where B and C are constants,

$$B = f_s (l_2 - l_1 + 1) \log_2 \frac{3}{h^2} + 0,1 a f_s (l_2 - l_1 + 1) \log_2 10$$

and $C = 0,1 f_s \log_2 10$.

Thus it has been proved that

$$R \approx B - C \sum_{l=l_1}^{l_2} A(l). \quad (1)$$

It's seen from equation (1) that there is a linear relationship between the achieved data transmission rate and the sum of the transmission channel attenuations on all carrier frequencies. Thus it's obviously that data transmission rate becomes maximal when the sum of the transmission channel attenuations on all carrier frequencies of OFDM transmission system is minimal.

Summary and Conclusions.

In this paper it has been found the transmission channel amplitude frequency characteristic optimization criterion for the OFDM transmission systems which is convenient for the practical application. For this purpose it has been proposed the criterion of minimization of the sum of the transmission channel attenuations on all carrier frequencies of OFDM transmission system. It has been proved that the proposed criterion corresponds to the criterion of the maximization of the data transmission rate achieved by OFDM transmission system.

The important issue is that the interrelation between the mentioned criteria is not accurate in cases when signal to noise ratio is small in some carrier frequencies so data can't be transmitted on these carriers and therefore these carriers don't contribute to the total transmission rate achieved on given transmission channel. This issue will be considered in further publications.

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INCREASE PRECISION OF ACTIVE ENERGY DISTRIBUTION VIA MONITORING OF GAS-DIESEL GENERATOR'S ROTORS POSITIONS

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ПОВЫШЕНИЕ ТОЧНОСТИ РАСПРЕДЕЛЕНИЯ АКТИВНОЙ МОЩНОСТИ ПУТЕМ КОНТРОЛЯ ПОЛОЖЕНИЯ РОТОРОВ ГДГА

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Abstract. This article deals with problems that arising during parallel operation of diesel-generator units.

Key words: gas diesel-generator sets (DGCA), active power, control system.

Аннотация. В работе рассматриваются возникающие проблемы при параллельной работе газодизель-генераторных агрегатов.

Ключевые слова: газодизель-генераторные агрегаты (ГДГА), активная мощность, система регулирования.

There are lot of problems with parallel working generators in process of creating autonomic power plants with GDG because of their speed vibrations and non-linear load. Such non-linear load exists at power plants of Mobile Offshore Drilling Units with powerful thyristor converters. For solving such problems a new methods of measuring of generator's parameters is necessary.

For power distribution, while generators are synchronizing, while load is jumping there is very important to monitor angle positions of synchronic generator's rotors. Main phase difference between speed deviation and angle-moment on a shaft is more than phase stability margin, so GDG starting to make an self-oscillations.

Known phenomenon [1, 2], which consists that oscillations of turning angles of rotors are existing while oscillations in an antiphase are exist. Therefore the twisting mechanical moment of the diesel, as electromagnetic torque synchronous generator, represents as the form of two terms: turning angle of rotor rather synchronous speed and synchronous speed proportional speed angle deviation.

So, to solve problems with self-oscillations and increase stability of system we need to find a method of increasing stability with delay z_3 and phase angle ψ_3 .

Known [1], that electromagnetic power of generator P while parallel work is function of EMF E_{Q1} and E_{Q2} both generators, network frequency f_c , rotor angle δ_{12} and load resistance:

$$P = f(f_c, E_{Q1}, E_{Q2}, \delta_{12}, P\delta_{12}, Z_H). \quad (1)$$

For this task of power distribution we accept that load and exiting of generators not changes. Therefore got an linearized equation (1):

$$\Delta P = \frac{\partial P}{\partial f_c} \Delta f_c + \frac{\partial P}{\partial \delta_{12}} \Delta \delta_{12} + \frac{\partial P}{\partial (P\delta_{12})} \Delta (P\delta_{12}), \quad (2)$$

So, in general, according to the moments operating on a shaft (mechanical, electromagnetic and inertial) there are solutions can be:



-increase stability by increase swing masses (increase inertial moment). It can't be done because construction features;

-additional impact on electromagnetic moment of generator by exiting regulator parameters changes. This method can worse quality of electrical power;

-an improvement of automatic power distribution devices This devices focused on first engine control based on the proportions between the active components of generators currents;

-additional diesel control by derivative difference active loads of working generators, which equivalent derivative angle inconsistencies their rotors and derivative generator RPM deviation.

Let's consider as an example of stability increase parallel working GDG. Main components of stability parallel work are:

rotor oscillation damping factor :

$$\alpha = \frac{M_D}{2T_i}; \tag{3}$$

natural frequency:

$$\omega_0 = \frac{\sqrt{M_c}}{T_j};$$

frequency of free oscillations:

$$\omega_c = \sqrt{\omega_0^2 - \alpha^2},$$

Function $W(p)$ under the influence of incoming parameter can be written:

$$\Delta y = \left\{ \text{Re}[W(-\alpha + J\omega)] + \frac{\alpha}{\omega} y_m [W(-\alpha + J\omega)] \right\} \Delta x + y_m \left[W(-\alpha + J\omega) \frac{1}{\omega} \frac{d(\Delta x)}{dt} \right].$$

For mechanical moment with rotor oscillations:

$$\Delta M = M(p)\Delta\delta,$$

where $M(p)$ - transfer control function of the diesel engine speed;

$$\Delta M = M_c \Delta\delta + M_{MII} \left[\frac{d(\Delta\delta)}{dt} \right],$$

where $M_c = \text{Re}[M(-\alpha + J\omega)] + \frac{\alpha}{\omega} y_m [M(-\alpha + J\omega)];$

$$M_D = y_m [M(-\alpha + J\omega)] \frac{1}{\omega}.$$

An nonlinearity, in particular, delay, has significant effect on stability. Delay can be calculated by such formula: $W_{II3}(p) = e^{-\epsilon s}$

Than oscillating link transmission coefficient:

$$W_{II3}(-\alpha + J\omega) = e^{-\alpha\epsilon} (\cos\omega\epsilon - J \sin\omega\epsilon).$$

Coefficient of diesel self-regulation:

$$K_c = - \left(\frac{\partial M_M}{\partial \omega_s} \right) \left(\frac{\omega}{M_{MN}} \right), \tag{4}$$

It can be considered an additional torque damper:

$$M_{MII}^0 = K_c.$$

The methods of calculation of stability margin diesel generators (DG) modes with additional control by derivative difference active loads and derivative generator



RPM deviation has been created.

Main equations of system considered on basic dynamic diesel model. Main parameters are determined by optimization of tuning PID-regulator. Parameters determine the transfer function of control system RPM with delay unit:

$$W_{\Pi 3}(P) M(P) = M(P) e^{-\epsilon p}.$$

Quantitative transfer coefficient obtained from the expression (4) respectively equations (1)...(3) for a condition of limit of stability $\alpha = 0$; $p = j\omega$; $\omega = 2\pi f_c$ (f_c – native frequency of DG self-oscillations).

By obtained quantitative transfer coefficient, respectively equations (2) and (3), an equations for calculating dependency component values of damping and synchronizing moments and delay ϵ has been obtained.

After that we can obtain coefficient of attenuation of a DG rotor a , native frequency of self-oscillations ω_0 and frequency of free oscillations ω_c . Design value of frequency for considered DG is $\omega_0 = 4$ Hz. Calculation of sustainability indicators in parallel operation DG shown that frequency of free mutual oscillations not significantly different from frequency ω_0 . This because the dominating impact on oscillation frequency is exerted by the electromagnetic synchronizing moment, while intensive external influences are exist [2].

For implementation the proposed method of active power distribution between parallel working generators a structure of microprocessor system is proposed (fig 1).

There are two inductive sensors $\Delta 1, \Delta 2$ on flywheel of both DGD. An pulse signal from sensors goes on amplifiers OY1, OY2. From amplifiers signal runs to microcontroller CPU. So, microcontroller gathering a full information about position and RPM both generators and moments on shafts.

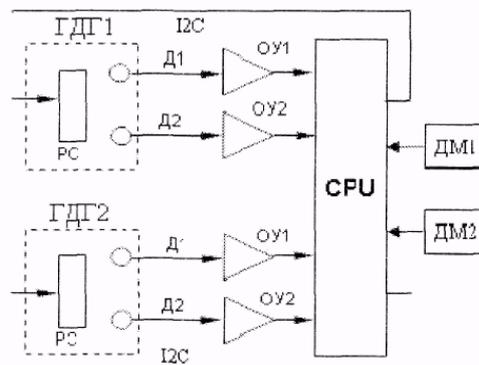


Fig 1 – Structure of microprocessor system active power distribution

If there is non-linear load, obtaining the active power component becomes problematic. If so, moment on a shaft can be measured with moment sensor on diesel shaft or across excessive pressure of turbocharger. If data has been obtained, microcontroller calculates angle inconsistencies between rotor positions of $\Gamma \Delta \Gamma 1$ and $\Gamma \Delta \Gamma 2$. Angle inconsistencies is proportional to the active power. CPU is making control signal of negative feedback. Negative feedback signal is running from CPU output on I²C bus to the speed regulator inputs. The regulator changes the fuel supply depending on the signal level with basic RPM and phase angle.

So, there is necessary to enter into control circuit RPM GDG compensating



device for reduce amplitude of GDG frequency oscillations and uneven distribution of the active power between parallel working units. Such compensating device will operate fuel delivery to the cylinders through the fuel rail.

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DEVELOPING THE SYSTEM REQUIREMENTS FOR SELECTION OF THE COMPUTER ALGEBRA SYSTEMS WITH A VIEW TO IMPROVEMENT THE EDUCATIONAL SERVICES QUALITY*Poltava National Technical Yuri Kondratyuk University**Poltava, Pershotravnevyi avenue, 24, 36011*

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РОЗРОБКА СИСТЕМИ ВИМОГ ЩОДО ВИБОРУ СИСТЕМИ КОМП'ЮТЕРНОЇ АЛГЕБРИ З МЕТОЮ ПОКРАЩЕННЯ ЯКОСТІ ОСВІТНІХ ПОСЛУГ*Полтавський національний технічний університет імені Юрія Кондратюка**Полтава, Першотравневий проспект, 24, 36011*

Abstract. The aim of article is researching the existing computer algebra systems, analysis of advantage and disadvantage; detecting disadvantages in the efficiency analysis of the selection existing special mathematical packages in preparation specialists and ways of eliminating them. The article is devoted to developing the system requirements for selection of the computer algebra systems with a view to improvement the educational services quality.

Key words: the software, the computer algebra systems, the information technologies, the web-resource.

Аннотація. Мета статті полягає у дослідженні існуючих системи комп'ютерної алгебри, аналізі їх переваг та недоліків; виявленні недоліків в питанні аналізу ефективності вибору існуючих спеціальних математичних пакетів при підготовці фахівців та шляхів їх усунення. Стаття присвячена розробці системи вимог щодо вибору системи комп'ютерної алгебри з метою покращення якості освітніх послуг.

Ключові слова: програмне забезпечення, система комп'ютерної алгебри, інформаційні технології, веб-ресурс.

Introduction. Computer algebra system (computer algebra system, CAS) is a software program for symbolic computations, that is, perform conversions and work with mathematical expressions in the analytical (symbolic) form. CAS vary in features, but usually supports the following character operations: simplifying the expressions to a smaller size or reduction to the standard view; the substitution of symbolic and numeric values in expressions; the entry of trigonometric functions using exponents, transformation of boolean expressions etc.

The main text. Today, these programs are widely used in scientific research, have a convenient interface, implements many standard and special mathematical operations using powerful graphic zasobi i have their own programming languages. Under the systems of computer mathematics understand software that provides the ability to make computational calculations on the computer doing analytical (symbolic) transformation of various mathematical and graphical objects.

V. P. Dyakonov identifies seven main classes of systems of computer mathematics: systems for numerical calculations, tabular processors, matrix systems,



systems for statistical, for special calculations, systems for analytical calculations (computer algebra), a universal system[2]. All the widely known mathematical packages: Maple, Matlab, Mathematica, provide the ability to perform both symbolic computation and the use of computational methods. Today such systems are one of the main computing tools of computer simulation in real time and used in various branches of science.

They open new possibilities for the teaching of many academic disciplines such as algebra and geometry, physics and Informatics, Economics and statistics, ecology. The use of CAS significantly increases the productivity of the scientist. The end product of the research are publications, trade, distribution and use of which currently requires skilled use of the computer. This applies to text editing, production of graphic materials, maintenance of the bibliography, placing electronic versions on the Internet, to search for articles and view them.

Today, the computer algebra system can be divided into seven major classes: system for calculations, tabular processors, matrix systems, systems for statistical calculations, special calculations, systems for analytical calculations (computer algebra), a universal system. Each system of computer mathematics has nuances in its architecture or structure. However, it can be concluded that in today's generic SCM model the following structure: is Central to the core of the system codes many pre-complaining functions and procedures that provide a sufficiently wide set of built-in functions and operators of the system. The interface gives the user the ability to go to the core with their queries and get the result on the screen. The interface is based on modern CAS tools popular Windows operating systems and provides inherent in these systems. Functions and procedures included in the core, are performed extremely quickly. So the volume of the kernel limit, but it adds a library of such commonly used procedures and functions.

Main features of software packages:

input macro language for interacting with a system that includes a specialized set of functions to solve mathematical problems;

the main character (mathematical) objects: polynomials, series, rational functions, expressions, vectors, matrices;

systems use integer, rational, real, complex numbers;

has several modes of operation, which are mutually complemented;

communication with the program development tools;

interfaces are used for communication with office tools, databases, graphic software tools [1].

Global empowerment systems and their adaptation to solve specific user tasks are achieved through the expansion packs, systems. These packages (often libraries) are written in its own programming language one way or another CAS is the creation of regular users. Kernel, libraries, packages, extensions and reference system of modern CAS accumulate knowledge in mathematics, accumulated over the millennia of its development. The growth of interest in algebraic algorithms is the result of the awareness of the Central role of algorithms in computer science. They are easy to describe in a formal and rigorous language and using them to ensure the tasks are well known and those that have been studied for centuries. While the traditional



algebra deals with constructive methods, computer algebra is interested efficiency, implementation, and hardware and software aspects of such algorithms. It turned out that when deciding about the efficiency and determination of productivity of the algebraic techniques required many other means, for example, the theory of recursive functions, mathematical logic, analysis and combinatorics. In the initial period of application of computers to symbolic algebra, it quickly became clear that the direct methods from the textbooks were often very inefficient. Instead of addressing the methods of computational approximation, computer algebra studies systematically the sources of inefficiency and leads to search for other algebraic methods to improve or even replacement of such algorithms.

Obviously that the introduction of these systems in educational process becomes the target for technical education, and requires the use of common software tools within educational institutions; build courses based on mathematics, with the use of appropriate system; the availability of computer laboratories that will effectively use a software tool.

Consequently, the system requirements on the choice of computer algebra system for improving the quality of educational services that will increase the effectiveness of educational activities are: basic theoretical training of the student of the fundamental disciplines; practical training the student to use application software; the ability to apply theoretical and practical knowledge for the formalization of practical problems and their solutions; a sufficient level of information culture of the future specialists regarding the possibilities of choice and further use of computer algebra systems for the solution of specific theoretical and practical problems.

Summary and Conclusions. The study of mathematics provides the future engineer, economist, scientist, not only a certain amount of knowledge, but also develops in him the ability to formulate, investigate and solve a variety of tasks. In other words, mathematics develops thinking of the future specialist and provides a solid conceptual Foundation for the development of many special disciplines. In addition, with its help better develop the abilities of logical thinking, concentration, accuracy and attention to detail. Computer algebra – the area of mathematics, which lies on the border of algebra and computational methods. For her, as for any region, which lies on the border of different Sciences, it is difficult to define clear boundaries.

The appropriate choice and usage of the computer algebra systems (CAS) are instrumental in the improvement the educational services quality. The wide range toolkits for the computer support the analytical, computational and graphical operations are making CAS a principal means in the professional activities for this reason their appropriate choice are given the possibility overreach and using in the educational process. It result in an increase in the students professional qualification and their competence.

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**INFORMATION MEASURING SYSTEM MONITORING TRAINING
ATHLETES ARROW COMPOUND BOW***Vinnytsia National Technical University
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**ИНФОРМАЦИОННО-ИЗМЕРИТЕЛЬНАЯ СИСТЕМА МОНИТОРИНГА
ФИЗИЧЕСКОЙ ПОДГОТОВКИ СПОРТСМЕНОВ
В СТРЕЛЬБЕ ИЗ БЛОЧНОГО ЛУКА***Винницкий национальный технический университет
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Abstract. In the article the information-measuring system for monitoring the physical training of athletes, which is designed to analyze and determine the basic characteristics of the system "compound bow – arrow" in real time. Key words: information-measuring system, frequency transducer, negative resistance, shooting compound bow.

Аннотация. В статье рассмотрена информационно-измерительная система мониторинга физической подготовки спортсменов, который предназначен для анализа и определения основных характеристик системы "блочный лук-стрелок" в реальном масштабе времени.

Ключевые слова: информационно-измерительная система, частотный преобразователь, отрицательное сопротивление, стрельба из блочного лука.

Introduction

The development of modern diagnostic equipment for biomedical and sports purposes are characterized by rapid expansion of physical methods of measurement conversion functionality, increase the technical characteristics, the widespread introduction of microelectronic technology and microprocessor technology. Today it is difficult to list all the areas of sports science, which are involved in the establishment and improvement of the skills of athletes. For several decades, the efforts of scientists aimed at improving the various sports training systems. Training athletes of medium and high qualifications vary considerably in intensity of competitive activity and the nature of the preparation for it, and in its aims, content and organization. At the same time, established many years ago general principles of training is no longer meet the requirements of today. Therefore, the search for new principles and forms of the organization of preparation of high-end shooters justified, necessary and is an important task of scientists and trainers [1].

Theoretical and experimental research

Sporting achievements archers are largely determined by their functional readiness for a specific race distance. Athletes arrow of high functional performance, demonstrate better results in various shooting distances. Improving athletic training system is a complex task that can not be solved without high-precision and high-performance of radio systems able to provide information on the degree of preparation of the athlete and the adequacy of the material settings. Upon reaching



the athlete-shooter tops sports skill and before him, and a difficult task confronts the coach. Continue to use the previous training planning schemes, only increasing the volume and intensity of the load, or to seek new forms of organization of the training process [2].

Any motor of human action (including sports) can only be performed with good physical fitness - a sufficient level of development of physical qualities. Therefore, the success of the length of the training athlete preparation process is necessary to know the level of development of the physical qualities necessary for the successful implementation of multiple high-quality shots with high psychological stress.

Physical readiness of the athlete is usually determined based on the results of a special test exercises. These results depend not only on the level of development of physical qualities, but also the art of perfection and performance shots of the athlete's ability to perform them with utmost emotional tension forces.

Of radio information system for monitoring of physical fitness and determination of muscle memory athletes archers, which is designed to improve the athlete's movements during the execution of the shot from a bow with a view to bringing them to the automatism and in the future to lead them on a subconscious level.

One of the most promising research directions in the development of radio microelectronic converters proposed in the work, is to use depending on the reactive properties and negative resistance of semiconductor devices by the influence of external physical sizes and creation on this basis of a new class of microelectronic frequency pressure transducers, angular position, acceleration, vibration induction magnetic field of optical radiation and temperature [3]. In devices of this type of conversion occurs the above external influences into a frequency signal, which allows you to create radiomeasuring microelectronic transducers for integrated technology and makes it possible to increase the speed, precision and sensitivity, to expand the range of measured values, to improve reliability, noise immunity and long-term stability of parameters.

Use as informative parameter frequency allows you to avoid the use of amplification devices, and analog-to-digital converters in the processing of information, which reduces the cost of monitoring and control systems.

Measurement and information system for monitoring and determining the physical fitness of athletes muscle memory is designed for the analysis and definition of the basic characteristics of the system "compound bow – arrow" in real time. Measurements are taken every 10 msec in parallel on all 12 channels. Fig. 1. it shows the approximate placement of sensors on block bow and release the athlete.

Fig. 2. is a block diagram of measurement and information system for monitoring the preparation of the athlete-arrow compound bow. The developed measuring system consists of two units of measurement.

The first measuring unit is located on the block onions and consists of two frequency pressure sensors (on the cover plate of onion); sensor tilt axes with frequency transducer; Sensor of angular accelerations of the axes are also with a frequency transducer; two vibration sensors on the axes with frequency transducers; temperature sensor; 3 microcontrollers and radio is transmitting information at a



frequency of 2.4 GHz. The second measuring unit, which is located on the release of an athlete consists of three pressure sensors with frequency transducers (on every finger, which are involved in pulling the bow or triggered release); sensor tilt axes with frequency transducer and the angular acceleration sensor, as along the axes with frequency transducer; 3 microcontrollers and radio is transmitting information at a frequency of 2.4 GHz [4-6].

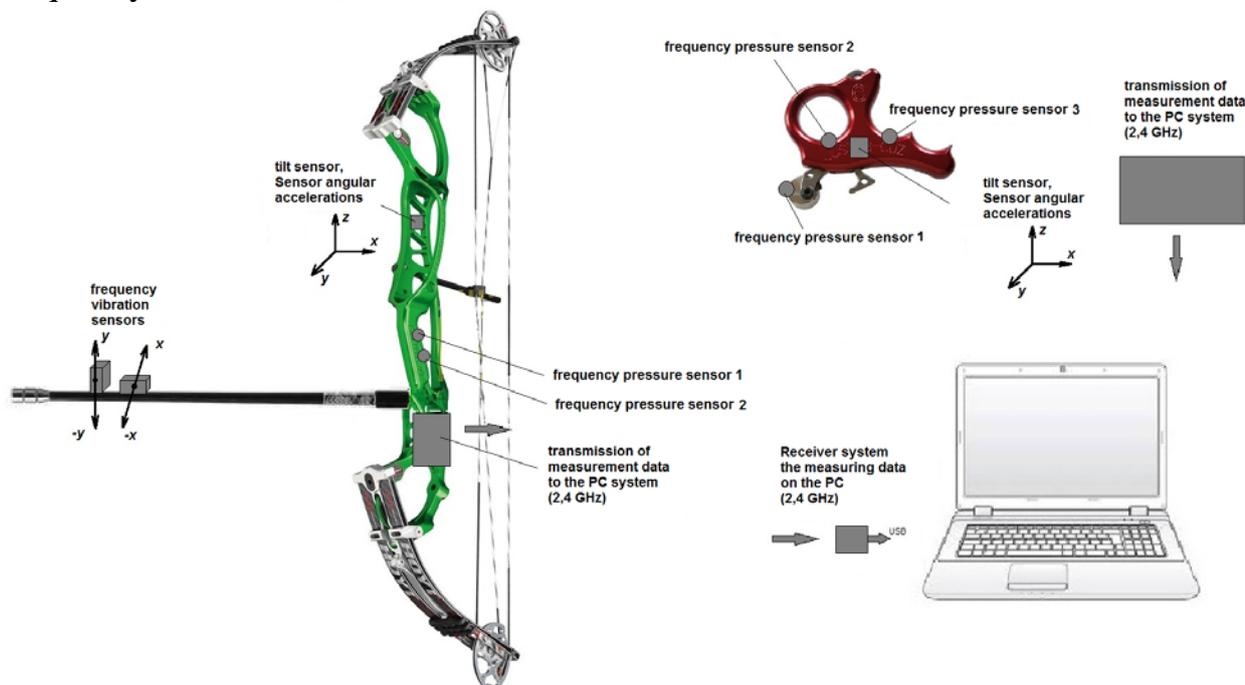


Figure.1. Placing sensors on the block bow and release sportsman

With the help of radio developed information system can determine the basic characteristics of the mechanical-biological systems "compound bow-arrows":

1. Determination of the tensile force compound bow - 15 ... 65 lb, ± 0.01 lb.
2. The possibility of determining the load distribution on the fingers - 15 ... 65 lb, ± 0.01 lb.
3. Determination of the position changing hands stretching bow hand - the three axes (x, y, z) $\pm 0,10^0$.
4. Determination of the acceleration or deceleration of thrust - 0,001g.
5. Fixes the dynamics and power of the draw.
6. Determination of pressure on the pad handles the bow and the distribution of pressure up or down on the handle - 15 ... 65 lb, ± 0.01 lb.
7. The ability to determine the care of the sight of the aiming area "10-9", "8-7" at different distances of 18 m, 30 m, 50 m, 70 m, 90 m.
8. Determination of the position change (slope) bow - on three axes (x, y, z) $\pm 0,10^0$.
9. Determine the acceleration of the bow and exit direction of the wrist when firing - in three axes (x, y, z) $\pm 0,10^0$.
10. Determination of muscle tremor.

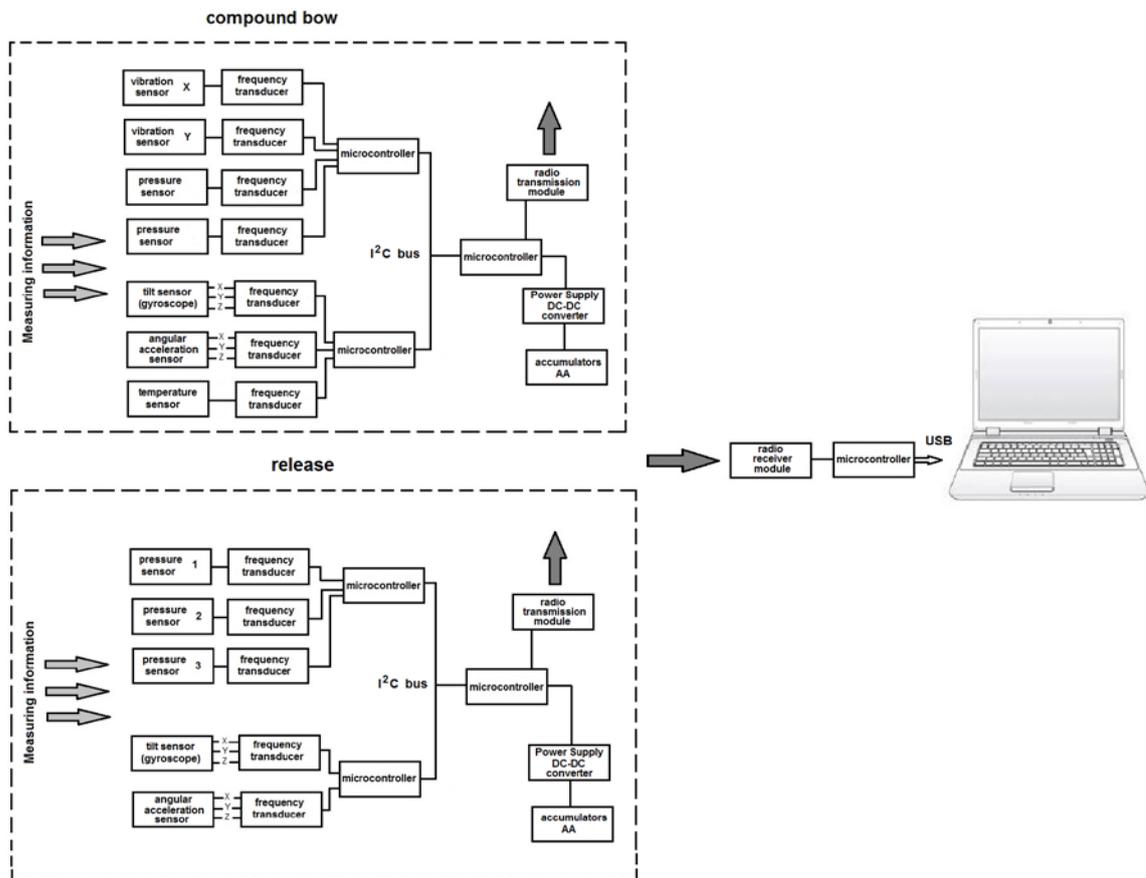


Figure. 2. Block diagram of measuring-information monitoring system arrow athlete preparation of compound bow

An original software measuring-information systems. iArch program is easy to use and requires no special training and education. Fig. 3 is a screenshot of the interface window. The program runs under various operating systems: Windows XP, Windows 7 (32 bit, 64 bit), Windows 8, Linux. The driver of the device to connect to a computer as well as software development iArch are original.

The data obtained from each sensor (every 10 msec) are displayed in digital form and in the form of graphs in visual form. The program provides a record of all sensor readings to a file with the extension .db, followed by the possibility of processing and graphic visualization for each athlete individually. Based on multivariate analysis, by processing the measured data is determined by the significance of the impact of each factor on the physical preparation of the athlete.

With the help of the developed system of radio possible improvement of athlete movements during the execution of the shot of the compound bow, bringing them to the automatism and in the future to lead them on a subconscious level, which increases the skill of an athlete and achieve maximum results.

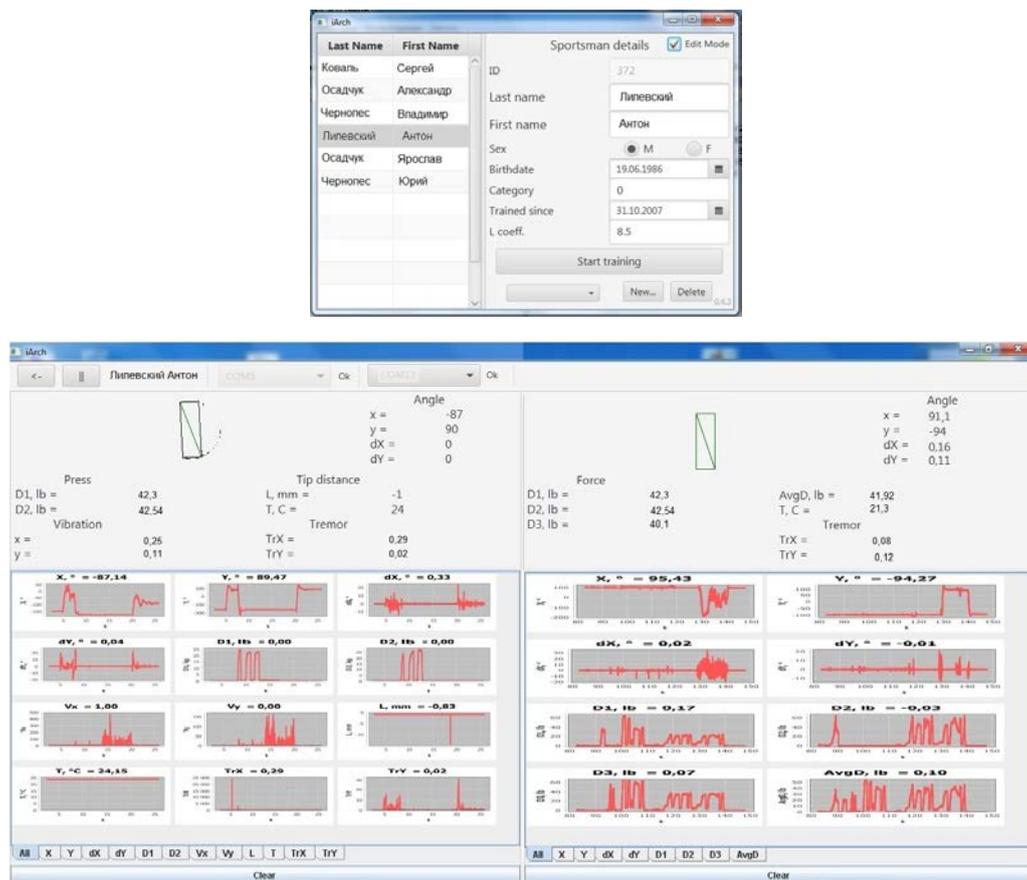


Figure. 3. iArch program interface to display, manipulate and data visualization

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спортсменів-стрілків з лука. / Осадчук О.В., Сидорук В.В., Звягін О.С.
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Myshonkov A. B., Ulyanova N. M.
INVESTIGATION OF THE PERIODS OF ARTIFICIAL SUPPLEMENTARY
LIGHTING OF LEAF LETTUCE

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Мышонков А. Б., Ульянова Н. М.
ИССЛЕДОВАНИЕ ПЕРИОДОВ ИСКУССТВЕННОЙ ДОСВЕТКИ
ЛИСТОВОГО САЛАТА

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Аннотация. В работе описываются результаты исследования эффективности различных режимов искусственной досветки листового салата с учетом естественного освещения.

Ключевые слова: искусственная досветка, автоматизированная система управления, освещенность.

Abstract. The paper describes the results of research on the effectiveness of different modes of artificial supplementary lighting leaf lettuce considering natural illumination.

Key words: artificial supplementary lighting, automated control system, lightening.

Introduction.

In most parts of the Russian Federation, the climatic environment does not allow to reap a stable harvest without the use of artificial supplementary lighting for many crops. Therefore, to increase the productivity of crop cultivation it is necessary to undertake a study of the effective ways of lighting plants and develop the automated control systems with the use of the results of this study. The development of such technical means require scientific substantiation of constructive, technological and economic parameters. This is the subject of this work, which determines its relevance.

The objective of this work was to study the comparative periods of artificial supplementary lighting of crops with the use of automatized artificial greenhouse supplementary lighting control system.

The main text.

Comparison of the effectiveness of artificial supplementary lighting modes lettuce was conducted by experimental method. As the object of study Moscow greenhouse lettuce was selected. The studies were held in the Republic of Mordovia (II light zone) in the winter-spring period.

The study used three experiment options:

1. Lettuce grown with supplementary lighting by times - supplementary lighting of lettuce is held in the morning and evening: 6-8 am and 5-8.30 pm. The total duration of artificial supplementary lighting of the second experiment option comprised 5.5 hours per day.



2. Lettuce grown with supplementary lighting by illumination - supplementary lighting may be used depending on the level of natural light on condition that the illumination is not reduced below 6 000 lux. Artificial supplementary lighting is carried out in the period from 6 am to 20.30 pm, the total length of daylight hours for this option is 14 hours and 30 minutes.

3. Lettuce grown without supplementary lighting (control sample) - the growth of lettuce takes place only in natural light.

The experimental setup consists of three isolated from each other boxes with dimensions 25x 25 x 35, painted white with the reflectance $\rho = 0,8$. Each of the boxes has not got the front wall for admission of daylight. For the first and second experimental setup options two LED lamps were mounted in the lid for artificial supplementary lighting. Artificial supplementary lighting of the plants was carried out by LED lamps ONLAYT with power 6 W, luminous flux 470 lm, color temperature 4000 K.

In the experiment there was used a ready saturated soil "BIOgrunt EcoFlora Universal". For the experiment we also used containers with capacity of 1-1,5 l. Seeds were put into the soil at a depth of 1-0,5 cm by five seeds in each container [2]. Lettuce watering was conducted on a daily basis in equal quantity for each option. The ambient temperature was maintained at 17-20 ° C at night and 20-25° C in the daytime [5].

For the experiment we developed an automated control system of artificial supplementary lighting based on microcontroller "Arduino" [1].

Turning on / off of the artificial supplementary lighting in the first option is carried out automatically with a help of a timer, which is based on real-time clock (RTC). Turn on / off of the artificial supplementary lighting in the second option is carried out automatically by the real-time clock and the light sensor (photoresistor).

Lettuce planting in the experiment was conducted on February 26, 2016. The crop for this very kind of lettuce takes place in 30-40 days, so within forty days after the coming out of the first sprouts the experiment was completed.

Duration of the artificial supplementary lighting in Option I was comprised of 206 hours and in Option II - 385 hours. Over the entire period of testing the energy consumption in Option I was comprised of 2.5 kWh and in Option II - 4,6 kWh. The study results are presented in Table 1.

Growth and photosynthesis processes are closely related to each other because their balance determines the final crop. Both of these processes are closely related to the intensity of light [3].

Insufficient intensity of natural light during the winter period resulted in a significant reduction in the rate of development of the lettuce root system. When growing lettuce without additional lighting, the root system has developed considerably weaker in comparison with the options with artificial supplementary lighting.



Table 1

Summary table of lettuce biometric characteristics depending on the option of artificial supplementary lighting

Characteristics	I (supplementary lighting)	II (supplementary lighting for illumination)	III (without lighting)
The weight of the whole plant, g	37	64	12
The mass of the root system, g	13	25	2
Mass of the aerial part, g	24	39	8
The length of the whole plant, mm	300	290	250
The length of the root system, mm	140	130	90
The aerial part length, mm	160	160	160
The width of the whole plant, mm	200	250	180
The width of the root system, mm	50	75	30
The width of the aerial part, mm	200	250	180
The average area of the leaf, cm	28,90	31,41	14,13
Specific gravity of the leaves mg / cm	31,9	33,6	29,8
The number of leaves in the first socket	12	18	9
The number of leaves in the second receptacle	14	19	10
The total number of leaves	26	37	19

Summary and Conclusions.

The experiment results showed that the increased daylight and extra lighting with LED lamps have an advantageous effect on plant growth and development. Compared experiment options, being received additional illumination with LED lamps had the more developed system of leaves, stems and the more developed root system.

According to the results of the experiments, it can be asserted that the daylight in winter and spring in the Republic of Mordovia is not enough to form a high-quality lettuce crop. Therefore it is necessary to use artificial supplementary lighting. The experiment shows that the use of automatic artificial supplementary plant lighting control system can increase the crops by 1.5-2 times as compared to the supplementary lighting by times and 4-5 times as compared to the option without artificial supplementary lighting.



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Gabdrakhmanova K. F., Nabiullin R.A.
**PETROTHERMAL ENERGY UTILIZATION OF ABANDONED OIL WELLS
WITH HIGH-PRESSURE PUMPS USE**

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**ИСПОЛЬЗОВАНИЕ ПЕТРОТЕРМАЛЬНОЙ ЭНЕРГИИ
ЗАКОНСЕРВИРОВАННЫХ НЕФТЯНЫХ СКВАЖИН С
ИСПОЛЬЗОВАНИЕМ ВЫСОКОДАВЛЕНИЯ НАСОСОВ.**

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Abstract. At the conference "Energetics and energy efficiency in the conditions of a geostrategic development and reclamation of the Arctic Region" in the report of the expert of the Federation Council of the Russian Federation on energetics Mikhail Hutorsky, it was question that the incremental value of explored reserves of organic fuel lags behind rates of its consumption. At the same time, independent experts predict decline of organic fuel production around the world. If at the end of the last decade the daily amount of crude oil production reached 81 million barrels, then by 2030 it according to projections will decrease approximately to 30 million barrels. The exploited gas fields of Russia and other countries are intensively run dry. On researches, carried out in Iceland [1], the USA [2], in China, Germany etc., it is stated that recovering of non-renewable energy resources comes from the earth depths so intensively, that according to the European independent energy agencies, our country in the 30s can already meet with a hydrocarbons export potential deficit.

There is a monotonous fall of raw materials production in the largest West Siberian province. The period of "dry" Cenomanian gas runs deeply. The previous stage of extensive natural gas developing came to the end. So gas recovery from giant fields of Nizhneye Priobye: Medvezhy, Urengoy and Yamburg constituted, respectively, more than 84%, 63% and 50%. And if not to put into operation the large-scale explored fields on the Barents and Karsky shelf, then the oil and gas capacity of the country will be depleted in as little as 20 years [3,4]. At the same time offshore fields development bears big environmental risks. Unlike other low-temperature renewable energy resources, which is based on use of petrothermal (deep) heat of Earth, the source is stable in time and doesn't depend on climatic and territorial factors. In this case it is not necessary huge territories for organization of heat elimination and thermal electric energy generation, so a petrothermal CHP (combined heat and power plant) can be constructed even in the center of a power-hungry megalopolis. An environmental advantage of such sources is absence of necessity to recover, process, transport and burn fuel. If to consider the absence of environmental damage as an economic component in cost value of energy production, then use for this purpose of deep heat is competitive in comparison with traditional methods of power generation. In current context there is a real opportunity almost across the board to use heat of interior of the Earth for the solution of power



supply problems of remote consumers irrespective of the consumption volume and a territorial arrangement. In relation to Russia taking into account its huge territory this circumstance has paramount value.

Key words: offshore fields, renewable, energy sources, petrothermal, power supply

Аннотация. На конференции «Энергетика и энергоэффективность в условиях геостратегического развития и освоения Арктического региона» в докладе эксперта Совета Федерации РФ по энергетике Михаила Хуторского, речь шла о том, что прирост разведанных запасов органического топлива отстает от темпов его потребления. В то же самое время независимые эксперты прогнозируют снижение добычи органического топлива во всем мире. Если в конце прошлого десятилетия ежедневный объем добычи нефти достигал 81 млн. баррелей, то к 2030 году он по прогнозам уменьшится примерно до 30 млн. баррелей. Интенсивно истощаются эксплуатируемые газовые месторождения России и других стран. По исследованиям, проведенным в Исландии [1], США [2], в Китае, Германии и т.д. констатируется, что извлечение невозобновляемых энергоресурсов из недр происходит настолько интенсивно, что по мнению европейских независимых энергетических агентств, наша страна уже в 30-е годы может столкнуться с дефицитом экспортного потенциала углеводородов. В крупнейшей Западно-Сибирской провинции происходит монотонное падение добычи сырья. Уходит в прошлое эпоха «сухого» сеноманского газа. Прежний этап экстенсивного развития добычи природного газа подошел к завершению. Так извлечение газа из месторождений-гигантов Нижнего Приобья: Медвежьего, Уренгойского и Ямбургского составил, соответственно, более 84%, 63% и 50%. И если не ввести в строй крупные разведанные месторождения на Баренцевом и Карском шельфе, то нефтегазовый потенциал страны будет истощен уже через 20 лет [3,4]. При этом освоение шельфовые месторождения несет большие экологические риски. В отличие от других низкотемпературных возобновляемых источников энергии источник, базирующийся на использовании петротермального (глубинного) тепла Земли, стабилен во времени и не зависит от климатических и территориальных факторов. Для организации съема тепла и производства тепловой и электрической энергии в этом случае не требуется значительных территорий, поэтому петротермальная ТЭС может быть построена даже в центре энергодефицитного мегаполиса. Экологическим преимуществом такого рода источников является отсутствие необходимости добывать, перерабатывать, транспортировать и сжигать топливо. Если учитывать отсутствие экологического ущерба в качестве экономической составляющей в себестоимости производства энергии, то использование для этой цели глубинного тепла оказывается конкурентоспособным в сравнении с традиционными способами получения энергии.

В современных условиях есть реальная возможность практически повсеместно использовать тепло недр Земли для решения проблем энергообеспечения удаленных потребителей независимо от объема потребления и территориального расположения. Применительно к России с



учетом ее огромной территории это обстоятельство имеет первостепенное значение.

Ключевые слова: шельфовые месторождения, возобновляемые, петротермальное, источники энергии, энергообеспечение

Introduction Many Russia and foreign scientists work in petrothermal energy usage; in particular works of authors are devoted: S. S. Smirnov, G. A. Cheremensky, N. A. Gnatus, Yu. A. Popov, S. L. Pevzner, V. P. Pimenov, M. D. Hutorskoy, E. I. Boguslavsky, Yu. D. Dyadkin, A. A. Chermoshentseva, A. N. Shulyupin, A. I. Filippov, P. N. Mikhaylov, O. V. Akhmetova, N. I. Stoyanov, and others.

However, by now there are no research works connected with use of the abandoned oil and gas wells, fund of which at the start of 2014 year has made 13.5 % respectively of the total number of wells, it is that number to which research as a geothermal source, this work is devoted.

The purpose and objectives of research

The work purpose is a possibility research of temperature voltage use of the oil and gas wells taken out of service for efficiency upgrading of complex power supply of industrial and municipal facilities.

In the furtherance of this goal it is necessary to solve the following problems:

- Analysis of a thermal condition of the Earth's crust in oil-producing regions of the Earth;
- Analysis of the existing mathematical models connected with the use of petrothermal energy;
- Development of a new mathematical model describing heat exchange process in the non-pumping or abandoned oil wells and in the rock mass of its surrounding;
- Program development for PC for creation of a developed mathematical model;
- Experimental verification of the developed mathematical model, in the conditions of real oil fields on the shore and the continental shelf;
- Analysis of technological process of petrothermalny energy integrated use of non-pumping oil wells by means of thermocompressors and the modes optimization of their operation with ensure the maximum cost efficiency.

2. Mathematical modeling of heat exchange process in wells

The heat conduction problem is the most common non-stationary problem of mathematical physics.

Concerning of the studied question, this task has to come down to consideration of heat exchange between the moving heat carrier in the petrothermal well and the unconstrained array of formation surrounding the borehole.

In the mathematical physics for a number of tasks, there are methods allowing to receive the analytical solution, however it is the elementary linear one-dimensional problems. The task considered by us is a multidimensional nonlinear problem. Numerical methods are the primary way of the decision for nonlinear problem which are sufficiently well developed.

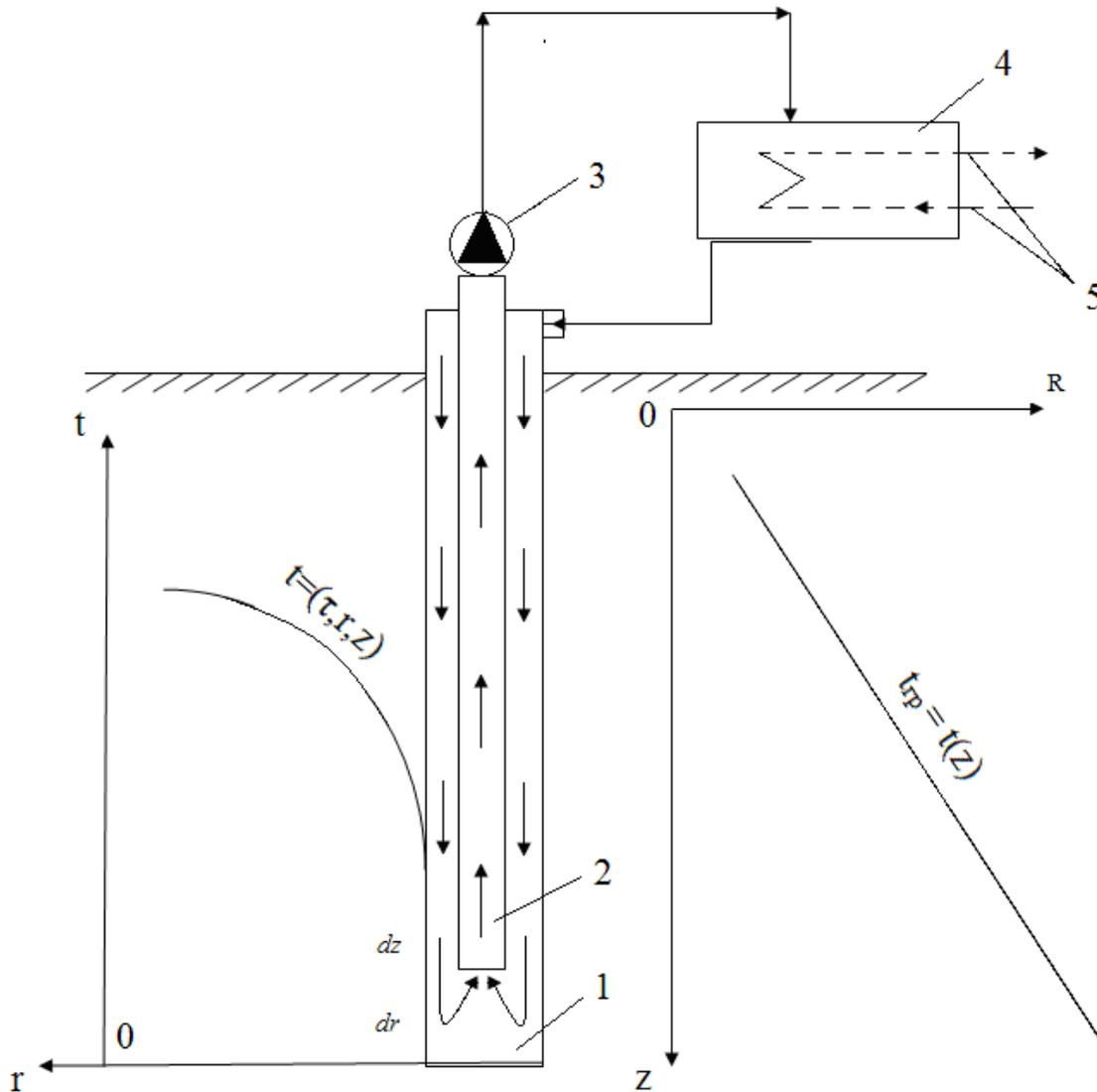
The primary way of a numerical solution of the partial differential in private derivatives is a method of finite differences which is based on digitalization.

The main problem at the numerical solution of the partial differential equations is construction or choice of a computational grid.



The uniformity of calculations in solving of such system allows to use modern computer procedures, one of which is MathCAD.

It is considered the mass of subgrade around the borehole, which represents the cylinder with a diameter – R and the forming Z, figure 1. It is expected an axiosymmetrical temperature distribution. It is considered the minor element of a cylindrical ring: R – radial direction, m; Z – vertical direction, m; R – outer radius of an external down-take pipe, m.



1-borehole, 2- tubing, 3-pump, 4- heat extractor, 5-heat to generate electricity

Figure 1– Computational scheme in the mass of subsoil

The amount changing of heat in this cylindrical ring in time: $\partial\tau$ equals:

$$dQ_T = c\rho \frac{\partial t}{\partial \tau} 2\pi \cdot r \cdot dr \cdot dz, \quad \text{W.} \quad (1)$$

The total amount of heat increment in this element is equal:

$$dQ_T = dQ_z + dQ_r = -\lambda \frac{\partial^2 t}{\partial z^2} dz \cdot 2\pi \cdot r \cdot dr - \lambda \frac{\partial^2 t}{\partial r^2} dr \cdot 2\pi \cdot r \cdot dz =$$



$$= -\lambda \left(\frac{\partial^2 t}{\partial z^2} + \frac{\partial^2 t}{\partial r^2} \right) 2\pi \cdot r \cdot dr \cdot dz, \tag{2}$$

Changes in the amount of heat (fig. 1) must be equal to the total increment, dQ_T should equal the total increment:

$$dQ_T = c\rho \frac{\partial t}{\partial \tau} 2\pi \cdot r \cdot dr \cdot dz = -\lambda \left(\frac{\partial^2 t}{\partial z^2} + \frac{\partial^2 t}{\partial r^2} \right) 2\pi \cdot r \cdot dr \cdot dz, \tag{3}$$

where: r -, z -, λ -?

The final form of the equation describing the temperature change in in the mass of subsoil [5,6]:

$$\frac{\partial t}{\partial \tau} = -a \left(\frac{\partial^2 t}{\partial z^2} + \frac{\partial^2 t}{\partial r^2} \right), \frac{^{\circ}C}{c}. \tag{4}$$

Figure 1 shows the general scheme of the borehole, and for specification of calculation we allocate the infinitely small gage section of the borehole (figure-2).

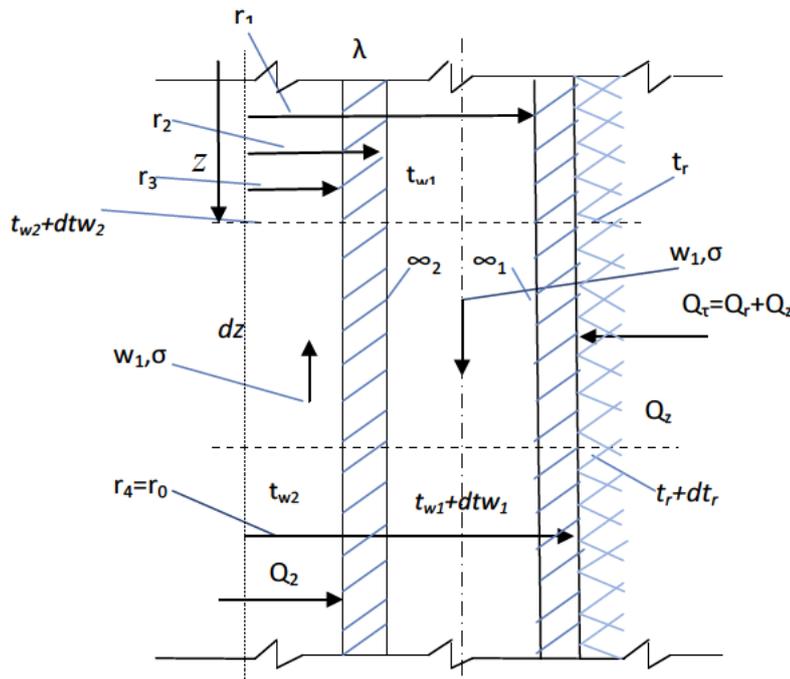


Figure 2- Scheme of the gage well section

Designations:

t_r - wall temperature of the outer of the down-flow pipe; $\alpha_1, \alpha_2, \alpha_3$ - inside surface heat-transfer coefficient of the external down-flow pipe, the outer surface of the inner rising pipe, the inner surface of the inner rising pipe respectively $\frac{\hat{A}_{\tilde{N}}}{\check{e}^2 \cdot E}$;



r_1, r_2, r_3, r_4 - the radiuses of the outer internal down-flow pipe, t_{w1}, t_{w2} - heat carrier temperature in the outer and inner down-flow pipe, m/s; 0C ; w_1, w_2 - velocity of the heat carrier in the pipe m/s; G - consumption of heat carrier, kg/s; λ - heat conduction coefficient of the inner pipe, $\frac{\dot{A}_{\check{N}}}{\check{e} \cdot 0 C}$

The values Q_1 and Q_2 are determined by the equations: W:

$$\begin{cases} Q_1 = \alpha_1 \cdot (t_r - t_{w1}) \cdot 2\pi r_1 \cdot dz + Q_2, W; \\ Q_2 = K_2 \cdot (t_{w2} - t_{w1}) \cdot dz, W. \end{cases} \tag{5}$$

The heat flow rates in the subsoil at the surface of the outer pipe of the borehole are defined by the equations:

$$\begin{cases} Q_r = \lambda \cdot 2\pi \cdot \frac{\partial t}{\partial r} \cdot r \cdot dz_{rp}, B\Gamma, \\ Q_z = \lambda \cdot \frac{\partial t}{\partial z_{rp}} \cdot r \cdot dr, B\Gamma, \end{cases}$$

By the means of algebraic manipulation, we come to form:

$$\begin{cases} Q_{r,i,j}^{cp} = \lambda \cdot 2\pi \frac{t_{i,m+1,j-1} - t_{i,m,j-1}}{\Delta r} \cdot r \cdot \Delta z_{rp}, B\Gamma, \\ Q_{z,i,j}^{cp} = \lambda \cdot \frac{t_{i+1,m,j-1} - t_{i,m,j-1}}{\Delta z_{rp}} \cdot r \cdot \Delta r, B\Gamma. \end{cases}$$

Carring out calculations on this formula (grids method) we receive the amount of energy which is deposid out by formations.

$$t(z, \tau)$$

Speed of temperature change is equal:

$$\frac{dt}{d\tau} = \frac{\partial t}{\partial \tau} + \frac{\partial t}{\partial z} \frac{dz}{d\tau} = \left| \frac{dz}{d\tau} = u \right. \text{ as } \frac{dz}{d\tau} - \text{temperature change at the expense of axial float speed}$$

$$\text{then } dz \Big| = \frac{\partial t}{\partial \tau} + \frac{\partial t}{\partial z} u$$

This speed is proportional to temperature differences in x point in timepoint τ and on the borehole wall at R1 distance of the borehole axis:

$$t(z, \tau) - T(R_1, z, \tau)$$

$$\text{So that } \frac{dt}{d\tau} = \frac{\lambda \sigma}{t_1 \rho_1} [t(x, \tau) - T(R_1, x, \tau)], t(0, \tau) = t_0 - \text{return temperature from}$$

the well.



Conductive heat transfer is given by the thermal conductivity equation

$$\frac{\partial T}{\partial \tau} = \frac{\lambda}{\rho c_2} \left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} \right) \quad (8)$$

where $T(z, r, 0) = t(z, 0) = T_n$ - onset temperature of surrounding rocks,

$$\lambda \frac{\partial T}{\partial r} + \alpha(t - T) \Big|_{r=R_1} = 0$$

- boundary condition.

Here $T(z, r, \tau)$ - rocks temperature.

Quantity of heat, which were get by heat transfer from the volume dV of the rocks, it is equal:

$$dQ = c dm \Delta t$$

where: c – specific heat of the heat transfer (liquid). But as $dm = \rho dV$,

$$\Delta t = t_{\text{bblx}} - t_0, \text{ so } dQ = c \rho dV (t_{\text{bblx}} - t_0).$$

As $dV = u \cdot S \cdot d\tau$ (S – sectional area of borehole), that $dQ = c \rho$ and $S d\tau (t_{\text{bblx}} - t_0)$, hence

$$Q = \int_{t_{\text{hav}}}^t c \rho u s [t_{\text{bblx}}(\tau) - t_0] d\tau \quad (9)$$

Conclusion:

This formula gives a chance to estimate the heat takeoff power for each type of wells. In the furtherance of this goal the temperature gradient wasn't considered at a depth.

Knowing the temperature field in the massif of rocks after the heat transfer pumping, it is possible to calculate a quantity of water which is brought to the surface of the well from the massif conductively.

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Reviewer:. Prof., d-ck those. Sciences, Mugalimov R.G. "Magnitogorsk State Technical University. GI Nosov" (MSTU. GI Nosov)

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INNOVATIVE PLUGGING SYSTEMS FOR WELL CEMENTING ON PRYKARPATTIAN FIELDS

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ІННОВАЦІЙНІ ТАМПОНАЖНІ СИСТЕМИ ДЛЯ ЦЕМЕНТУВАННЯ СВЕРДЛОВИН РОДОВИЩ ПРИКАРПАТТЯ

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Abstract. The features of well casing in conditions of Precarpathian region are considered in this paper. The research results of microstructure formation of cement rock based on plugging materials ПЦТ І-100, КРТМ and КРТМ-ПВ are given. Influence of modifying additives on the technological characteristics of plugging materials is studied. The expediency of КРТМ and КРТМ-ПВ application for well cementing in Precarpathian region is showed.

Key words: plugging systems, cementing, borehole, cement stone, modifier, corrosion-resistance

Анотація. В роботі розглянуто особливості кріплення свердловин в умовах Прикарпаття. Наведено результати дослідження формування мікроструктури цементного каменю на основі тампонажного матеріалів ПЦТ І-100, КРТМ та КРТМ-ПВ. Досліджено вплив модифікуючих домішок на технологічні характеристики тампонажних матеріалів. Показано доцільність застосування КРТМ та КРТМ-ПВ для цементування свердловин Прикарпаття.

Ключові слова: тампонажні системи, цементування, стовбур свердловини, цементний камінь, модифікатор, корозійна стійкість

Problem statement. Long-term intensive exploitation of petroleum and gas deposits of Carpathian, where during XIX - XXI centuries thousands of oil and gas boreholes have been built, the change of deposit thermodynamic characteristics intensified by deformation of mountain beds, not only complicates the production of oil and gas but increases the technogenic influence on an environment [1], first of all through breaking of timbering integrity, damaging of casing and out-of-control fluidizing.



To ensure the necessary level of reliability of the borehole casing, as an engineering structure, it is required to develop plugging material which is able to form durable corrosion-resistant cement stone, methods, by which the technological properties can be regulated, and process control of the mix structure formation; and, besides, unconventional approaches to the technology of barrier installation must be designed.

Purpose of the work: development of current trend plugging materials for cementing oil and gas wells on Carpathians region.

Methods of investigation and materials. In the research, the plugging cement ПЦТ I-100 produced by JSC „Volyncement” of the following composition: CaO – 66,4%, SiO₂ – 21,4 %, Fe₂O₃ – 3,5 %, Al₂O₃ – 5,25 %, others – 3,45 % with specific surface 295 m²/kg, produced in accordance with DSTU B.V.2.7-88-99 (ГОСТ 1581-96); complex expanding plugging mortar KPTM and KPTM-IIБ produced by Ltd. «Gelios» (Lviv) of the following composition – CaO – 57,71%, SiO₂ – 26,4 %, Fe₂O₃ – 2,35 %, Al₂O₃ – 5,89 %, others – 7,65 % with specific surface 335 m²/kg.

The structure of cement stone was studied by the method of electronic scanning microscopy, X-ray diffraction method, method of mercury pore meter. The studies of the dynamics of strength characteristics of cement stone in thermo baric conditions were implemented by non-damaging method according to API using ultrasonic cement analyzer (UCA) from the company OFI Testing Equipment Inc. (№120-50).

Results of research. Microstructure of the Portland cement stone ПЦТ I-100 at W/C=0,48 – 0,5 has been characterized by diversified morphology. Alongside with fine-grain lamellar hydrates on the surface of cement grains, the system of pores, which are connected to each other and create the capillary-porous structure, has been observed. Quite high value of W/C ratio increases the role of the cement stone crystalline component which disposes in the pore space. The hydrated products are presented by ettringite, hexagonal AF_m-phases, calcium hydroxide and fibrous hydrosilicates. Water–cement ratio exerts large influence on early hydration process of Portland cement, especially determining kinetics of calcium hydrosulphoaluminate formation. Increasing of the ettringite content at increasing values of W/C is caused by enhancing of speed of Ca²⁺ and SO₄²⁻ ions movement in the liquid. High concentration of sulphate ions was holding during certain time depending on the alkali content in the cement, that is the higher alkali content in the cement and the earlier dissolution begins, the faster decrease supersaturation of the solution by calcium ions. Liquid phase composition in the hardening system “cement – water” has been changing steadily. That results in recrystallization of hydrated compounds during all the period of cement stone operating. To improve operational characteristics of cement stone it is expedient to decrease in its microstructure the quantities and sizes of largely crystallized hydrated formations (calcium hydroxide, hydroaluminoferrite, hydrosulphoaluminoferrite), alongside with increase of metamict content of hydrated compounds.

Composites KPTM and KPTM-IIБ, despite the larger specific surface, that promote binding of excess water, and lower water-cement ratio, are characterized by better stability, and structurally rheological and filtration properties. Therefore, dehydration of the KPTM mixture has been decreased by 64,7 %, and for the mixture



with KPTM-IIB – it came to zero, that is especially important for the casing of boreholes with complicated space architecture. Bending strength of the stone increased by 44,9 % for KPTM and by 55,1 % for KPTM-IIB. At the same time the structure formation incubation period was shorter. This ensure formation of the stone with denser structure, closing of larger quantity of hydrate surface active centers in contact interactions in comparison with the reference specimen based on IIIQT I-100.

Addition Premix Cem, as crets, to the base composite cement promote and provide the possibility of directed synthesis of materials with improved properties (linear expansion of cement stone, minimum heat release, increase of structure density, durability and corrosion resistance, and also ability to self-reinforcing and self-healing of structure defects, that arise up as a result of the dynamic loading during exploitation) [2].

Character of formation of crystallization structure of composition materials modified by crets differs slightly from this of Portland cement and begins, when the size of hard phase nuclei, that arise up on the coagulative stage of solidification, exceeds the critical one, and directly depends on chemical nature of phases of the solidificating system, saturation degree of solutions hydrated new formations and surface tension coefficient on the interphase boundary. Speed of crystallizational framework formation is regulated by the diffusion coefficient of colloid particles from oversaturated solutions of hydrated new formations to the hard phase nuclei. As crystals of hydrated composition minerals are different by form and size of elementary cells, then in the process of their development the linear defects of structure are intensively created – distributions of disparity and point defects-vacancies. Crystals develop athwart to the surface of matrix in direction to the nearest aquated particles of the binder, and serve as the centers of nucleation and crystallizations, on which further hydrated products are besieging (Fig. 1). Composition materials are characterized by more even distribution of hydrates in gel mass of hydrosilicates, better ordering of coalescence contact zones and increase of amount of coalescenced fibres in the hydrosilicates blocks. The above mentioned provides formation of denser structure of the stone and closing of greater number of active hydrate surface centers in the contact interaction in comparison with a reference specimen on the base of cement of IIIQT I-100; that ensure the improvement of strength characteristics and deformation properties of the cement stone formed from the composition materials. Therefore, optimal combination of polymineral components of different genesis provides the directed synthesis of cement stone with the improved operating properties at thermobaric conditions.

The distinguishing characteristic of microstructure provided the matrices, on the basis of the modified composition cement, with increasing viscosity of destruction of cracks of the normal tearing away, higher indicators of durability and resiliency at a bending through the mechanism of breaking of development and confluence of microcracks by structural heterogenities – microreinforcing fibres, gel pores, microcapillars, by the surfaces of phases division, by grains of mineral additives and clinker, that were not used in the process of hydratation, as well as by crystals It means that phases, that appear during hydratation of composition cement, are identical with those that appear during hydration of IIIQT I-100. The difference



consists in a quantitative relationship between the low-basic and high-basic calcium hydrosilicates.

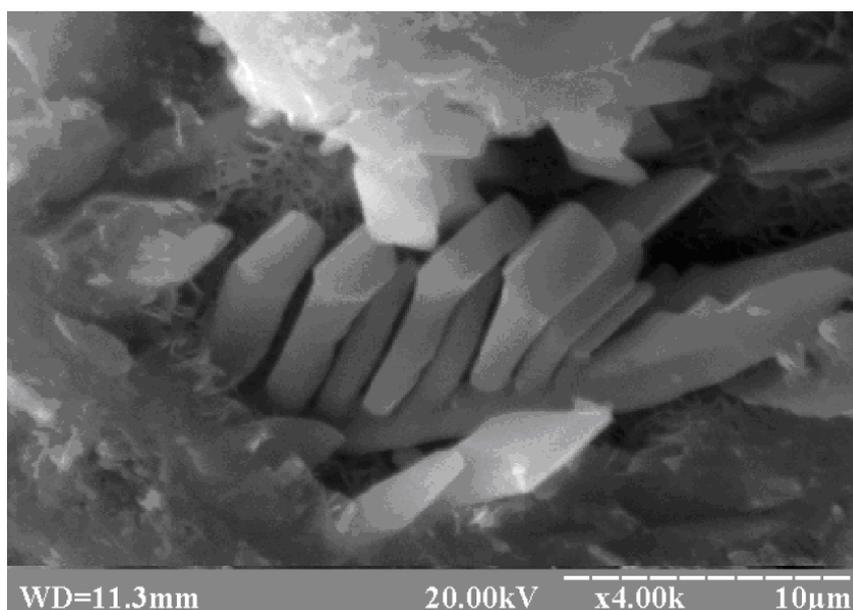


Figure 1 – Structure of cement stone KPTM-IIIB

The improvement of cement stone characteristics of KPTM and KPTM-IIIB composition mixtures is promoted by application of polyfunctional modifiers. It is known that, physico-mineralogical composition of cement, nature of additions-modifiers, solidification conditions stipulate such qualificatory descriptions of microstructure, as composition and basicity of new formations, crystal morphology, type of bonds, character of porosity, correlation of gel-like and crystalline phases, and also intensity of structure formation and destruction processes of the stone. On the basis of the research results optimal correlations of compositions binders capable to self-reinforcing, phase composition of hardened products and kinetics of expansion were determined and technological properties were studied. It is stated that increase of efficiency of cements can be achieved by introducing complex additives of polyfunctional action, that, complementing each other, allow to get additive, and occasionally synergistic effects [3].

Conclusion: The oil and gas deposits of Precarpathian region are characterized by its unique mining-and-geological properties. Undertaken studies have shown the expediency of plugging materials KPTM and KPTM-IIIB providing the necessary operational reliability of well casing on the fields of Precarpathian region. The cement stone formed on the basis of plugging materials KPTM and KPTM-IIIB has better processing properties in comparison with plugging cement *IIIIT* I-100.

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**ABOUT METAL LAYER DEPOSITION ON CATHODE AT
ELECTROLYSIS OF IONIC MELTS**

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Иванов В.И., Нестеренко Т.Н., Лукошников И.Е.
**ОСАЖДЕНИЕ СЛОЯ МЕТАЛЛА НА КАТОДЕ ПРИ ЭЛЕКТРОЛИЗЕ
ИОННЫХ РАСПЛАВОВ**

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Abstract. The mathematical model forming of metal layer, deposited on a cathode at the electrolysis of molten salts is worked out. The estimation of influence of thermal stream parameters on the growth layer dynamics of electrodeposited metal at electrolysis is executed.

Keywords: electrolysis, molten salts, deposition on a cathode, metal layer, modeling

Аннотация. Разработана математическая модель формирования слоя металла, осаждаемого на катоде, при электролизе расплавов солей. Выполнена оценка влияния параметров теплового потока при электролизе на динамику роста слоя осаждаемого металла

Ключевые слова: электролиз, расплав солей, осаждение на катоде, слой металла. моделирование

Introduction

The electrolysis of ionic melts with deposition of crystalline metal on a cathode is widely used at the production of refractory metals: titanium, vanadium, zirconium and other.

Analysis of researchs

The mechanism of cathode metal deposition at electrolysis is well studied. In work [1] the aspects of influence electric and mass streams at electrocrystallization metals from molten salts on transfer of discharge ions to the cathode and subsequent reduction of deposited metal on its surface are expounded. In work [2] the features of forming of hydrodynamic, thermal and concentration boundary layers along moving line length of cathode are described and the estimation of thermal stream influence on electrodeposition metal from ionic melt is executed.

Problem statement

The attempt of quantitative estimation of influence of thermal stream parameters at electrolysis on the dynamics of metal layer forming, deposited on cathode is made.

Main part of researches

The most complete approaching to the real process at the modeling of metal deposition process with the moving border it is possible at formulation problem to a phase transfer [3].

The mathematical model was developed at next assumptions: a calculation area



for a cathode and deposited metal has axial and thermal symmetry; hardening metal layer, deposited on a cathode, is carried out at the temperature of phase transfer; coefficient of heat exchange on the cathode surface is accepted by constant; thermophysical parameters of deposited metal and molten electrolyte do not depend from temperature.

Then change of the temperature field of metal layer, deposited on a cathode described by one-dimensional nonlinear equation of heat conductivity in cylindrical coordinates for area with the moving border ($R < r < R + \xi$):

$$\rho_i \cdot \tilde{n}_i \frac{\partial \dot{O}_i}{\partial \tau} = \frac{\lambda_i}{r} \left[\frac{\partial}{\partial r} \left(r \frac{\partial T_i}{\partial \tau} \right) \right], \quad \tau > 0 \tag{1}$$

at initial and border conditions

$$\xi(r, \tau) \Big|_{\tau=0} = 0 ; \tag{2}$$

$$T_m(0, \tau) \Big|_{r=R} = T_c ; \tag{3}$$

$$T_m(\xi, \tau) \Big|_{r=R+\xi(\tau)} = T_{cr} ; \tag{4}$$

$$\lambda_m \frac{\partial T_m}{\partial r} \Big|_{r=(R+\xi)-0} = \lambda_\ell \frac{\partial T_\ell}{\partial r} \Big|_{r=(R+\xi)+0} + \rho \cdot L \frac{d\xi}{d\tau} , \tag{5}$$

where ρ_m, c_m – density and heat capacity of deposited metal respectively; λ_m, λ_ℓ – coefficient of heat conductivity of deposited metal and molten electrolyte respectively; T_c, T_{cr} – a temperature of cathode and phase transfer respectively; T_m, T_ℓ – a temperature of deposited metal and molten electrolyte respectively; r, τ – radial and temporary coordinates respectively; R – a cathode radius; ξ – a coordinate of deposited metal front; L – a specific heat of phase transfer.

Multiplying both parts of equation (1) on dr and integrating it on the coordinate r within the scope from R to $R + \xi$ taking into account conditions (3)-(5), the examined task over is reduced to expression of kind

$$\begin{aligned} \rho_m \cdot \tilde{n}_m \frac{d}{d\tau} \int_R^{R+\xi} T_m(r, \tau) dr &= \frac{\lambda_m}{r} \cdot T_m(r, \tau) \Big|_R^{R+\xi} + \lambda_m \int_R^{R+\xi} \frac{T_m(\xi, \tau)}{r^2} dr + \lambda_\ell \cdot \frac{\partial T_\ell}{\partial r} \Big|_{r=R+\xi} + \\ &+ \lambda_m \int_R^{R+\xi} \frac{T_m(\xi, \tau)}{r^2} dr + \lambda_\ell \cdot \frac{\partial T_\ell}{\partial r} \Big|_{r=R+\xi} + \rho_m \cdot L \frac{d\xi}{d\tau} - \lambda_m \cdot \frac{\partial T_m(r, \tau)}{\partial r} \Big|_{r=R} \end{aligned} \tag{6}$$

If to suppose that the change of temperature on electrochemical cell radius and layer thickness of deposited metal followed to the linear law that after the substitution of correlations (7) and (8) in expression (5) and simple transformations we get the linear equation in complete differentials in relation to the change of layer thickness of deposited metal E at the electrolysis Fo

$$\frac{E dE}{[D_2 \cdot \ln(1 - D_1 \cdot E) + C_2 \cdot \theta_2 \cdot E]} = \frac{2d Fo}{(\theta_1 - 2C_1) \cdot D_2} . \tag{7}$$

Non-dimensionless variables and criteria similarities, included in equation (7), are determined by correlations: $E = \xi/H$ – relative layer thickness of deposited metal (H – a dip depth of cathode in molten electrolyte); $D_1 = H/R$ – a relative dip depth of cathode in melt; $D_2 = \delta/H$ – a relative thickness of dynamic boundary layer of melt (δ – a thickness of dynamic boundary layer of melt); θ_1 – a relative temperature of



cathode; $\theta_1 = (T_c - T_{cr}) / (T_{cr} - T_c)$; θ_2 – a relative temperature of melt; $\theta_2 = (T_\ell - T_{cr}) / (T_{cr} - T_c)$; C_1 – a relative heat of phase transfer and discharge of ions on a cathode; $C_1 = \rho_m \cdot L / c_m \cdot (T_{cr} - T_c)$; C_2 – a relative coefficient of heat conductivity of the system «molten electrolyte – deposited metal»; Fo – a Fourier criterion.

Logarithmic function in equation (8) it is possible to develop in a convergence power series and limited by its two first terms. Subsequent integration of correlation (8) results in nonlinear algebraic equation

$$E^2 + \frac{4(C_2 \cdot \theta_2 - D_1 \cdot D_2) \cdot E}{D_1^2 \cdot D_2} + \frac{8(C_2 \cdot \theta_2 - D_1 \cdot D_2)^2 \cdot Fo}{D_1^2 \cdot D_2 \cdot (\theta_1 - 2C_1)} = 0. \quad (8)$$

Size of density of thermal stream from molten electrolyte to the surface of cathode it is possible to calculate on a formula

$$q = \lambda_\ell \cdot \left. \frac{\partial T}{\partial r} \right|_{r=R+\xi}. \quad (9)$$

On the other part the size of the same stream can be defined as

$$q = \alpha \cdot (T_\ell - T_{cr}). \quad (10)$$

Right parts of equations (9) and (10) are compared and also take into account, that $\alpha \cdot \delta / \lambda_\ell = Nu$. Then after the substitution of values T_m and T_ℓ in the got equation, subsequent integration of its left part on dr , and also simple transformations, it is possible to write down $D_2 = 1/Nu$.

We put this correlations in equation (8) at $Z = (C_2 \cdot \theta_2 \cdot Nu - D_1) / D_1^2$ and taking into account that $E > 0$ and $Fo > 0$, have a final decision of initial task

$$E = 2Z \cdot \left[\left(1 - \frac{2Nu \cdot D_1^2 \cdot Fo}{\theta_1 - 2C_1} \right)^{0.5} - 1 \right]. \quad (11)$$

Computational experiment executed at the next values of relative parameters: $D_1 = 2.0-10.0$; $C_1 = 1.0$; $C_2 = 1.0-1.2$; $\theta_1 = 1.0-2.0$; $\theta_2 = 0.7-1.0$; $Nu = 3.0-12.0$, – testifies to practical independence of value $E(Fo)$ from the parameter C_2 , to inappreciable influence on its parameter C_2 and increase with the growth of parameter Nu . It is related with convective character of molten electrolyte motion in an electrochemical cell, which is carried out because of difference of densities for its elementary volumes. Influences of parameter D_1 on $E(Fo)$ have subsidiary character.

It is easily to notice that the decision of equation (11) loses physical sense at nonfulfilment of condition $1 - 2C_1 < 0$, i.e. the processes of ions transfer from molten electrolyte to the cathode surface and subsequent discharging on its take place when $2C_1 > \theta_1$. Consequently, the size of parameter C_1 determines the conditions of behaviors the directed electrodeposition of base metal crystals on the cathode surface.

The results of decision for thermal task of electrolysis of molten salts allowed to fix decisive influence of parameters C_1 and Nu on the layer thickness growth of the electrodeposited metal $E(Fo)$. Thus if by the size of parameter C_1 it is determined the presence of the discharge ions directed motion, it the size of parameter Nu defines the heat exchange intensity by convection on the border of division «melt–deposited metal», the degree increase which is arrived by active interfusion of molten



electrolyte.

Conclusions

Offered approach to the study of electrodeposition for refractory metals from ionic melt of salts allows to execute the influence estimation of thermal stream parameters at electrolysis to the growth dynamics of base metal deposit on a cathode and can be used for researches in electrometallurgy.

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USING OF EXPERIMENTAL AND STATISTICAL METHODS IN FOOD TECHNOLOGY RESEARCH PROCESSES

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ПРИМЕНЕНИЕ ЭКСПЕРИМЕНТАЛЬНО-СТАТИСТИЧЕСКИХ МЕТОДОВ ИССЛЕДОВАНИЙ ПРОЦЕССОВ ПИЩЕВЫХ ТЕХНОЛОГИЙ

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Abstract. On the basis of these studies there was confirmed that construction of the optimal model systems in addition to the use of formal mathematical and computational methods involves the use of various heuristic arguments, based on experience and deep understanding of content by engineers. This approach made it possible to develop a standard algorithm and produce the successive stages of mathematical modeling and experimental design and compromise multi-objective optimization of processing foods. The example of the optimal high pressure processing parameters of scrambled eggs with cheese its effectiveness.

Key words: experimental and statistical approach, optimization, food technology, high blood pressure, scrambled eggs with cheese.

Аннотация. На основании проведенных исследований подтверждено, что создание оптимальных модельных систем кроме использования формальных математических и вычислительных методов предусматривает применение различных эвристических соображений, основанных на опыте и глубоком понимании содержания предмета инженерами-технологами. Такой подход дал возможность разработать типовой алгоритм и представить последовательные этапы математического моделирования и планирования эксперимента и компромиссной многокритериальной оптимизации процесса обработки полуфабрикатов. На примере нахождения оптимальных параметров обработки высоким давлением омлета с сыром продемонстрировано его эффективность.

Ключевые слова: экспериментально-статистический подход, оптимизация, пищевые технологии, высокое давление, омлета с сыром.

Introduction.

The intensive development of applied biotechnology, information technologies, systems analysis and mathematical methods created the objective conditions for a new level of understanding of the physical nature of the analytical and numerical description of processes in the processing of raw materials of animal and vegetable



origin. This allows the scientific validation for the possibility of obtaining new products with a given composition using alternative technologies, and the ability to process control at all stages of food production.

For the formal description of complex systems further development and improvement methodology a multivariate statistical models of linear parameters and, in general, nonlinear factors are necessary. Solving of real applications requires the development of sequential methods of experiment planning in arbitrary form, custom field factorial space, a formalized structure of multivariate statistical models, unknown to researcher, robust estimations of model coefficients in the original multicollinearity factors [1].

Mathematical apparatus used must meet the basic statistical properties of complex systems and processes [1]. Here are the main ones.

1. Results of the experiment are the result of cumulative exposure groups of managed, unmanaged and uncontrolled factors. Physical properties of the studied system and process can not be completely defined and contain uncertainty.

2. The experimental results are approximate numerical values without specifying any of their theoretical properties and forms (structures) of connection between the conditions of the experiment and its results.

3. The inductive method of knowledge is realized in the experiment – the result separate from its generalization to all hypothetical similar results.

4. It is assumed that the complex conditions of the experiment are typical for examined group of complex systems and processes, and therefore the result can be extended to other members of the class of systems studied.

Multivariate statistical modeling and optimization of multi-objective compromise are the most common applied research methods. All experts believe that regression analysis is one of the main methods of mathematical statistics. It is widely used in scientific and applied research in various spheres of human activity. However, solving applied problems "regression Analysis and interpretation of the results require deep knowledge and ability to properly assess the information received" [1].

Statistical methodology of regression analysis should provide stability, certainty is obtained by multivariate statistical models. You must use sustainable plans of multifactorial experiments, the choice of "true" structure models, stable models evaluating the coefficients in the original multicollinearity factors [1].

Experts in the field of statistical methods draw attention to the complexity of the problems of statistical methodology. Methodology for modeling of complex systems and processes inevitably involves heuristic recommendations and decisions that are difficult to formalize. These solutions are used in data analysis, experimental design theory, applied statistics and technological processes [1].

The aim of this work – to demonstrate typical algorithm of this study to explore the effect of high pressure on processing parameters scrambled eggs with cheese. The author expresses his sincere gratitude to the Director of the Institute of Food Production DonNUET Mykhailo Tugan-Baranovsky Doctor of Technical Sciences, Professor. V.A. Sukmanov for experimental data on the properties of food masses under high pressure, which are executed under his supervision, for participation in the



discussion of planning and conducting experiments and developing methodology the problem of optimization of technological processes.

It was necessary for the experiment to evaluate the effectiveness of integrated action of several factors on the quality of the developed food, namely, cheese omelet. Dependent variables: y_1 - water activity (a_w); y_2 - a comprehensive quality (K). Factors affecting these parameters: x_1 - pressure (P, MPa); x_2 - temperature ($t, ^\circ C$); x_3 - dovhotryvalist processing (τ, c); x_4 - weight of water per 100 g melange (g); x_5 - weight of milk powder per 100 g melange (g); x_6 - ksantovana gum (% of the total weight of the mixture); x_7 - weight cheese 100 g melange (g).

The experimental results indicate linear dependence of water activity on most factors, then this finding based on seven factors set we used fractional replica of marginal limiting factors for the number eight experiments.

Table 1

Plan an experiment to find the coefficients of the linear model

x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y_1
1	1	1	1	1	1	1	1	0,705
1	1	-1	-1	-1	-1	1	1	0,82
1	-1	-1	1	1	-1	-1	1	0,775
1	-1	1	-1	-1	1	-1	1	0,82
1	-1	-1	-1	1	1	1	-1	0,795
1	-1	1	1	-1	-1	1	-1	0,775
1	1	1	-1	1	-1	-1	-1	0,81
1	1	-1	1	-1	1	-1	-1	0,745

It is estimated coefficients eight following a busy plan (Table 2):

Table 2

The coefficients of the linear model

x_7	x_6	x_5	x_4	x_3	x_2	x_1	x_0
-0,00063	-0,00688	-0,0144	-0,00937	-0,03063	-0,00313	-0,01063	0,780625

To release the linear effects of the first order interactions used the method of "pass." In its application added a new cue, all the signs which are opposite the original remark. Got rates further and final linear model (Table. 3).

Table 3

The coefficients of additional and final linear model

	x_7	x_6	x_5	x_4	x_3	x_2	x_1	x_0
Additi onal LM	0,01125	-0,005	0,01	0,00125	-0,02625	0,005	-0,015	0,77625
Final LM	0,005312	-0,00594	-0,0022	-0,00406	-0,02844	0,000937	-0,01281	0,778438

After the addition, the model leaving only statistically significant factors:



$$y_1 = 0,778 - 0,013x_1 - 0,028x_3 \quad (1)$$

To determine the complex quality depending on the pressure, temperature and time we used a central composite uniform, rotatable plan for three factors, the construction of which is related to conduct experiments in twenty double repeatability. Repeating provides increased accuracy assessments and promotes the release of weak signals over background noise. In addition, we used randomization - random order of realization of experiments designed to combat systematic error.

The first phase was conducted rotatable central compositional planning (TSKRP). The treatment results were typical method [2].

Parallel experiments in the center of the plan to determine that the regression equation of the first order received by PFE results may not provide a satisfactory mathematical description of model systems and planning must go to the second order to take into account evaluation factors and quadratic effects build adequate mathematical model.

Statistical analysis of experimental data contained calculating estimates of regression coefficients, checking their significance, evaluation of reproducibility of experiments and establishing the adequacy of the resulting regression equation. This used statistical criteria Cochran, Fisher and Student (for confidence level 95%).

The regression equation which adequately describes the dependence of response on factors which are managed, is:

$$y_2 = 0,965 - 0,022x_1 + 0,026x_2 + 0,008x_3 - 0,013x_1x_2 - 0,012x_1x_3 - 0,014x_2x_3 - 0,031x_1^2 - 0,006x_2^2 - 0,015x_3^2 \quad (2)$$

The coefficient of determination $R^2 = 0,939508$. The model is adequate for the Fisher criterion: $F_p = 4,67 < F_m = 5,05$ for significance level 0.05, 5 degrees of freedom.

In this case, one can see that a priori reasoning largely confirmed because not only were significant linear effects of factors, but the pair interaction and quadratic effects. Of the three linear effects of two distinguished: the effect factor - and the pressure factor - the duration of the experiment. Apparently quantify the factors influencing them stronger temperature of the experiment. Temperature variation in selected intervals not make a significant impact on this figure as a linear coefficient less. But the impact of this factor manifested equally with other factors in paired interactions. The content of the interaction effect is that the influence of one factor depends on what level is another factor.

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Graphical analysis of two-dimensional graphs and regression lines of a fixed



value of one of the three factors shows that the maximum values of complex quality found in the experiment. This allows you to find the extremes of the classical methods of analysis. To find the optimal parameters x_1, x_2, x_3 first "compromise" optimization problem formulated in this way. Need to find the meaning of control factors that ensure the maximum $y_2 = f(x_1, x_2, x_3)$ at a given value $y_1 = \varphi_1(x_1, x_2, x_3)$. The values of the independent variables thus be kept in the experiment, which borders determined by the value factors "star" points. Analytical it can be written as an expression $\varphi_2(x_1, x_2, x_3) = x_1^2 + x_2^2 + x_3^2 = R^2$ of that factor space is a sphere of radius centered at the center of the experiment. Thus, we "compromise" optimization problem: maximize function

$$y_2 = 0,965 - 0,022x_1 + 0,026x_2 + 0,008x_3 - 0,013x_1x_2 - 0,012x_1x_3 - 0,014x_2x_3 - 0,031x_1^2 - 0,006x_2^2 - 0,015x_3^2 \tag{3}$$

under conditions $\begin{cases} y_1 = 0,778 - 0,013x_1 - 0,028x_3, \\ x_1^2 + x_2^2 + x_3^2 = R^2. \end{cases}$

For solving this problem applied Lagrange multiplier Lagrange. For this build target function $F_1(x_1, x_2, x_3, \lambda_1, \lambda_2)$, which is the sum equation and optimization of products φ_1, φ_2 on the relevant factors λ_1, λ_2 :

$$F = 0,965 - 0,022x_1 + 0,026x_2 + 0,008x_3 - 0,013x_1x_2 - 0,012x_1x_3 - 0,014x_2x_3 - 0,031x_1^2 - 0,006x_2^2 - 0,015x_3^2 + \lambda_1(0,778 - 0,013x_1 - 0,028x_3 - y_1) + \lambda_2(x_1^2 + x_2^2 + x_3^2 - R^2) \tag{4}$$

In accordance with the method of computing algorithm built Lagrange system of equations containing partial derivatives of the objective function for all independent variable and uncertain Lagrange multipliers:

To solve the resulting system of equations using integrated suite of MAPLE 13. The value calculated by changing the radius of the sphere in the range of 1.628 to 0, and the lowest setting possible. Characteristic of the results of calculations are presented in Table 4.

$$\begin{cases} \frac{\partial F}{\partial x_1} = -0,022 - 0,013x_2 - 0,012x_3 - 0,062x_1 - 0,013\lambda_1 + 2\lambda_2x_1; \\ \frac{\partial F}{\partial x_2} = 0,026 - 0,013x_1 - 0,014x_3 - 0,012x_2 + 2\lambda_2x_2; \\ \frac{\partial F}{\partial x_3} = 0,008 - 0,012x_1 - 0,014x_2 - 0,030x_3 - 0,028\lambda_1 + 2\lambda_2x_3; \\ \frac{\partial F}{\partial \lambda_1} = 0,778 - 0,013x_1 - 0,028x_3 - y_1; \\ \frac{\partial F}{\partial \lambda_2} = x_1^2 + x_2^2 + x_3^2 - R^2; \end{cases}$$

The best followed recognize data recorded in the second row of the table 9, when the value of complex quality becomes maximum, equal to 0.98. The optimal solution of encoded values and natural factors are presented in Table 5.



Table 4

The results of calculations for the optimal values of factors

R	The coded values of factors			function review	
	x_1	x_2	x_3	y_2	y_1
0,4	-0,229	0,285	-0,162	0,974	0,786
0,64	-0,1	0,6	-0,2	0,98	0,786
0,9	0,577	-0,449	-0,525	0,924	0,786
1,68	1,361	-0,443	-0,879	0,864	0,786

Table 5

The optimal solution

The coded values of factors			Dietary factors mentioned			Function review	
x_1	x_2	x_3	P, MPa	t, C°	τ , c	y_2	y_1
-0,1	0,6	-0,2	695	122	425	0,98	0,786

Graphic interpretation optimal solution below (Figure.1-3).

As the expert determination organoleptic qualities omelette that is integrated Quality can not be held simultaneously for all seven control factors (it is necessary to simultaneously carry out, for example, in the double frequency of 326 experiments TSKRP), we have decided to sequential replacement of the third factor (linear rate three times lower than the corresponding coefficients of the first and second factors) to other factors.

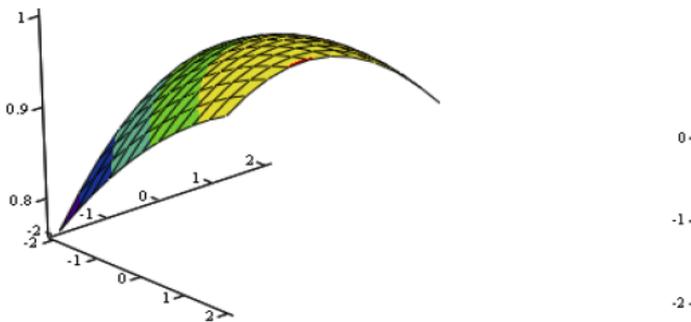


Figure.1. Surface Review and line-level regression at $x_1 = -0,1$.

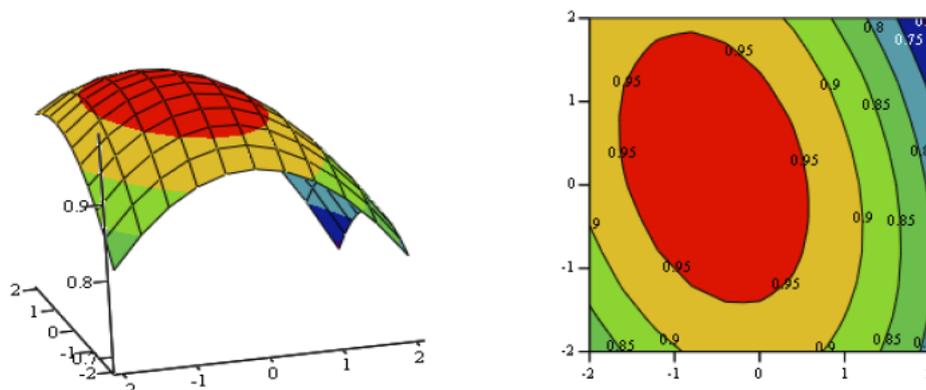


Figure.2. Surface Review and line-level regression at $x_2 = 0,6$.

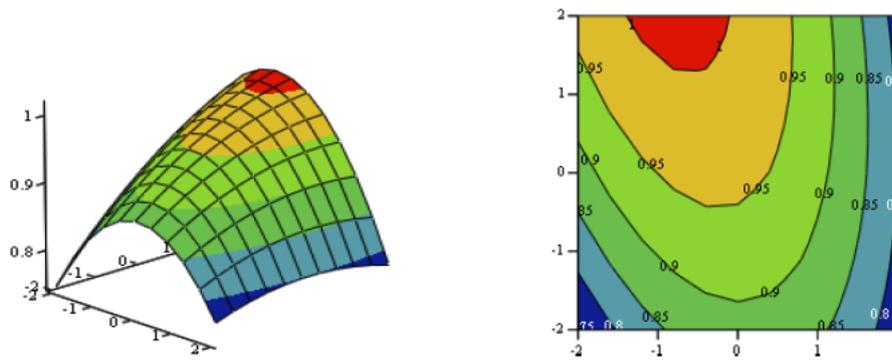


Figure.3. Surface Review and line-level regression at $x_3 = -0,2$.

For all models we verified the significance of the regression coefficients. Since orthogonal plan, they determined the same variance. Next to the regression coefficients calculated confidence interval with a certain confidence probability. In this expression - criterion (Student test) has the same number of degrees of freedom, and the variance of reproducibility. Significant factor if its absolute value than the confidence interval.

Excluded non-significant regression coefficients and again inspected the adequacy of the model with significant coefficients.

If instead x_3 the plan will include the experiment x_4 , the regression equation which adequately describes the dependence y_2 of the response factors now will look like:

$$y_2 = 0,953 - 0,007x_1 + 0,008x_2 + 0,011x_4 + 0,0025x_1x_2 - 0,001x_1^2 - 0,010x_2^2 - 0,005x_4^2 \quad (5)$$

The coefficient of determination $R^2 = 0,949504$. The model is adequate for the Fisher criterion: $F_p = 0,08 < F_m = 5,05$ for significance level 0.05, 5 degrees of freedom.

The optimal solution of encoded values and natural factors are presented in Table 6 and graphical interpretation optimal solution is shown in Figure 4-6.

Table 6

The optimal solution

The coded values of factors			Dietary factors mentioned			Function review	
x_1	x_2	x_4	P, MPa	t, C°	x_4 , g	y_2	y_1
-0,11	0,63	0,52	694,5	122,6	14,04	0,96	0,77

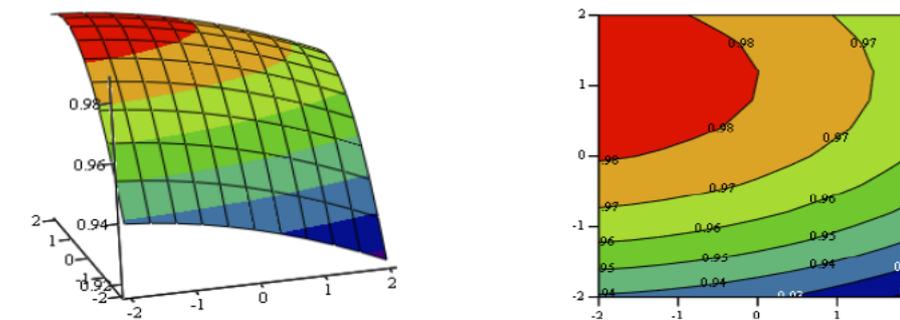


Figure.4. Surface Review and line-level regression at $x_2 = 0,63$

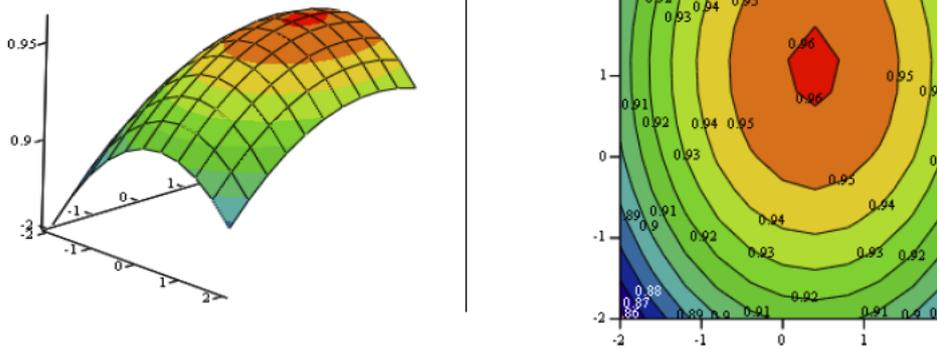


Figure.5. Surface Review and line-level regression at $x_1 = -0,11$

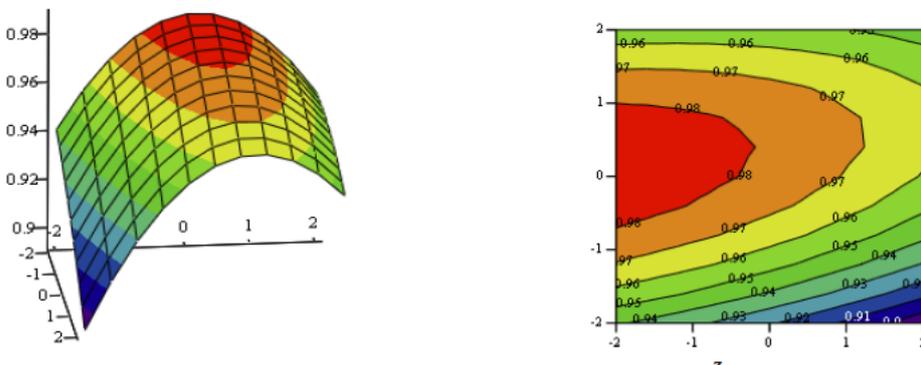


Figure.6. Surface Review and line-level regression at $x_4 = 0,52$.

In the same way investigations are carried out when replacing in terms of experiment variable X_3 sequence variable X_5 , X_6 and X_7 .

Statistical analysis of the complete model interpretation in terms of the object of study. His do so. We provide experimental verification found the optimal parameters and assessment of the accuracy and the reliability parameters optimization. Under these optimal values of ten factors was conducted parallel experiments for all seven factors results and statistical analysis are shown in Table 7.

Table 7

Results optimization

parameter optimization	The value		Dispersion S^2	Criterion t_p	Error δ	Confidence interval
	y_i^p	y_i^e				
y_1	0,786	0,748	0,0045	1,79	0,048	0,738-0,834
y_2	0,98	0,941	0,005	1,74	0,051	0,929-1,0

Here t_p - the estimated value of Student's t test, δ - the forecast error parameter optimization.

The results of calculations for the optimization of given parameters, presented in the form of confidence intervals indicate that their experimental values do not exceed the respective ranges and hence proving the reliability of the results.

The results have practical use and they have been accepted as the basis for selecting rational parameters of cooking omelette with these additives, processed high



pressure.

Summary and Conclusions.

Experimental values for optimization parameters do not extend beyond the suitable confidence intervals obtained by calculation method, indicating the accuracy and reliability of the results.

Thus, we can conclude that in addition to the formal mathematical and computational methods, various heuristic arguments, based on experience and deep understanding of content engineers, play an important role on creating of the optimal model systems.

Thus, we developed a structural parametric model for prediction of a quality of the finished product at optimum settings of the parameters and characteristics of biological materials process high pressure processing foods.

The algorithm of mathematical modeling and multi-objective optimization compromise the processing of foods is elaborated.

The proposed research methodology can be applied to find the optimal parameters of other processes food technology. Further improvement of methodology using fuzzy sets theory, the concept underdetermined models and interval analysis are planned.

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**QUALITY ASSESSMENT OF DRINKING MILK DIFFERENT
MANUFACTURERS IN THE TRADING NETWORK OF THE CITY OF
CHERNIHIV**

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**ОЦЕНКА КАЧЕСТВА ПИТЬЕВОГО МОЛОКА РАЗНЫХ
ПРОИЗВОДИТЕЛЕЙ В ТОРГОВОЙ СЕТИ Г. ЧЕРНИГОВА**

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Abstract. The article described the main indicators of the quality of drinking milk, color, taste, smell, consistence, density, mass fraction of fat, acidity and indicators of honesty of producers - the presence of ammonia, soda. The results of the evaluation of the quality of drinking milk of domestic producers organoleptic and physicochemical parameters.

Key words: milk, quality, protein, fat, lactose, manufacturers, natural product, adulteration, density, acidity, labeling, evaluation Commodity, authenticity.

Аннотация. В работе охарактеризованы основные показатели качества молока питьевого: цвет, вкус, запах, консистенция, плотность, кислотность, а также показатели честности производителей – наличие аммиака и соды. Приведены результаты оценки качества молока отечественных производителей по органолептическим и физико-химическим показателям.

Ключевые слова: молоко, качество, белки, жиры, лактоза, натуральный продукт, фальсификация, плотность, кислотность, маркировка, товароведная оценка, подлинность.

Introduction.

Milk is a product of the normal cow's secretion. From physicochemical side milk is a complex polydisperse system where dispersed medium is water and dispersed phase is substances that are in a molecular, colloidal and emulsion state. Lactose and mineral salts create molecular and ionic solutions. Proteins are in soluble (albumin and globulin) and colloidal (casein) state while milk fat is in the form of an emulsion. Milk contains more than 200 different mineral and organic substances. Cow's milk is also a source of phosphorus and calcium. This fact actually determines its role in the diet of children as at the early age an active growth of the skeleton and teeth takes place. This valuable product contains manganese, iron, cobalt, which together with vitamin B₁₂ take an important role in hematopoiesis. Carbohydrate component of milk is presented in the form of lactose - milk sugar, the approximate number of which is 5%. Biological and nutritive value of milk is in the optimum balancing of components, its easy digestibility by human body. All milk nutrients (proteins, fats, carbohydrates, minerals, trace elements, vitamins, enzymes) are in such a ratio that meets human needs. The range of milk production technology is divided into pasteurized melted, ultra pasteurized and sterilized.



The main text.

The aim of our work was to evaluate a compliance of the quality of the samples of drinking milk produced by leading manufacturers with the current regulatory requirements and to the declared marking.

To estimate the quality of milk in Chernihiv drinking cow's milk samples in different types of packaging and producers were selected. Milk is packaged in bottles made of polymeric materials, in soft packs of multilayer polymer films and bags made of composite materials. The questionnaire of consumers showed that most of them (70%) prefer pasteurized milk, followed by (20%) – ultra pasteurized, then sterilized (7%) and the last place - Baked (3%).

Therefore, the object of our study was pasteurized milk produced by PJSC "Kulikovskoe moloko" Kulikovka village, Chernihiv region. - TM "Kulikovka"; SE "Milkilend-Ukraine", JSC "Chernihiv molokozavod", Chernigov - TM "Dobryana"; JSC "Galicia", Lviv - TM "Vesela ferma"; JSC "Kombinat Pridneprovsky" Dnipropetrovsk – TM " Zlagoda"; PJSC "Yuriiia", Cherkasy - TM "Voloshkove pole"; JSC "Kremenchuzky miskmolokozavod", Kremenchug - TM "Prostokvashino"; LLC "Belotserkovsky molochny kombinat", Bila Tserkva, Kyiv region. - TM "Bila liniia"; Ltd. "C-TRANS", Dnepropetrovsk - TM "Zavzhdy vygidna tsina" and ultra pasteurized - TM "Vesela buronka", "Selianske" LLC "Lustdorf" Illintsi, Vinnytsia region.

The characteristics of the samples were studied according to the labeling. It was found out that most of the products contains only whole and skim milk, and only sample of the milk TM "Zavzhdy vygidna tsina" has a substitute for milk fat.

Organoleptic evaluation of the quality of the milk samples was performed according to the following criteria: appearance and texture, taste and smell, color.

For all samples organoleptic characteristics fully meet the requirements of ISO 2661:2010, except for TM "Zavzhdy vygidna tsina" - the consistency has lumps of fat.

One of the most important physical parameters of milk that can certify its purity or forgery is density. Therefore, we have determined the density of the samples. The density of milk ranges from 1026 to 1032 kg / m³. If the milk is diluted with water, density decreases. In accordance with the requirements of ISO 2661:2010 the density of the samples should be at least 1027 kg / m³. These requirements are met by all samples except milk "Dobryana" and "Zavzhdy vygidna tsina" (Table 1).

Ammonia and soda are like indicators of the honest manufacturers. Both ammonia and baking soda are added to milk in order to slow down the process of its corruption. The presence of these substances in the milk is not allowed. Ammonia was not detected in all samples of milk. But soda was found in the milk of the «Kulikovka», "Dobryana", "Vesela ferma", "Zlagoda", "Zavzhdy vygidna tsina." Price of milk depends on the mass fraction of fat in it. Milk fat is expensive, but due to light absorption (97%) and high content of bioactive substances it is one of the most valuable edible fats.



Table 1

Physical and chemical properties of milk quality

TM	Density, kg/m ³	Fat, %	Dry residue, %	Titrated acidity, °T	Presence of soda	Presence of ammonia
1 Kulikovka	1030	3,15	11,9	16,9	Found	Not found
2 Dobryana	1026	2,7	10,3	20,0	Found	Not found
3 Vesela buronka	1029	3,2	11,7	19,5	Not found	Not found
4 Vesela ferma	1030	2,5	10,1	19,0	Found	Not found
5 Zlagoda	1031	3,2	12,2	19,2	Found	Not found
6 Selanske	1028	2,6	10,7	17,9	Not found	Not found
7 Voloshkove pole	1027	2,6	10,4	16,7	Not found	Not found
8 Prostokvashino	1028	3,2	11,4	17,2	Not found	Not found
9 Bila liniia	1027	2,6	10,4	18,0	Not found	Not found
10 Zavzhdy vygidna tsina	1026	3,2	10,9	19,1	Found	Not found

Adulteration of milk made by reducing the fat content in it is one of the most common. While examining the fat content in selected samples of milk, it was found that, in general, it meets information specified on the package. No correspondence was found only in two samples: milk "Kulikovka" contained 3.15% fat instead of declared 3.2%, and in a sample of milk "Bila liniia" - fat content exceeding 0.1%. The highest content of dry milk residue was determined in milk TM "Zlagoda" - 12.2%, and the lowest - in milk TM "Vesela ferma" - 10.1%. Most of the milk samples contains less dry milk residue than established limits. Low content of solids, especially in combination with a low fat content, clearly demonstrates the adulteration.

Summary and Conclusions .

The results of the evaluation of the quality of 10 brands' milk samples show that only three products, in particular "Vesela buronka", "Prostokvashino", "Selianske", have excellent quality, "Voloshkove pole" and "Bila liniia" have satisfactory quality. Unsatisfactory results were received by samples of milk "Dobryana", "Vesela ferma", "Zlagoda", "Zavzhdy vygidna tsina" due to the presence of soda. Milk "Kulikovka" did not pass the test because of the presence of sodium and reduced fat.



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**E.N.Ochkolyas¹, T.K.Lebskaya²,
CHANGES ORGANOLEPTIC PARAMETERS OF BUTTER WITH
SEAWEED DURING THE STORAGE**

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**ИЗМЕНЕНИЕ ОРГАНОЛЕПТИЧЕСКИХ ПОКАЗАТЕЛЕЙ
СЛИВОЧНОГО МАСЛА С МОРСКИМИ ВОДОРОСЛЯМИ В ПРОЦЕССЕ
ХРАНЕНИЯ**

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Annotation. The aim is to investigate the influence of algae on changes the organoleptic characteristics quality of the butter in storage.

Keywords: butter, laminaria, fucus, spirulina, cystoseira, storage, quality indicators, organoleptic characteristics.

Аннотация. Цель работы состоит в том, чтобы исследовать влияние водорослей на изменения качества органолептических показателей в процессе хранения.

Ключевые слова: масло сливочное, ламинария, фукус, спирулина, цистозира, хранение, показатели качества, органолептические характеристики.

Introduction. Butter is a product containing a large amount of fat, which is subjected to hydrolytic and oxidative damage in the process of storage. Addition of natural antioxidants in butter contributes to maintaining high consumer performance of the product by blocking the accumulation of free radicals and free fatty acids. Numerous studies have shown, that the addition of herbal supplements improves the organoleptic characteristics of the product, has a positive effect on the formation of its structure and consistency, gives the product a high ductility index, thermal stability and spreadability, and slows oxidation processes during storage [1-6]. As the additives one had used herbal supplements of functional destination – polysaccharides with pectin and inulin, cryo-powder made of beetroot, blackcurrant buds, artichoke, carrot, with the addition of flax seeds etc. [2]. In the laboratories of the All-Russia Dairy Research Institute a wide range of oily paste with honey, cocoa, chicory, fruit and berry, vegetable and mushroom supplements, herbs and spices, and even with sea- or meat products had been developed [3].

In France, scientists had developed many delicacies based on butter and those contained vinegar mixed with a dry white wine, onions, sorrel, carbohydrates



(sucrose and lactose), sodium glutamate, spices, dextrin, cereals flour, edible salts [7].

There are some scientific developments concerning complex addition of extracts of sage, cinnamon, rosemary, cloves, oregano, cumin and thyme. The aim of these types of butter development was the improvement of stable quality characteristics of the final product during storage due to the addition of natural antioxidants. Researchers have found that plant extracts and their supplements have improved organoleptic characteristics of the products, greatly enhanced their consumer characteristics and contributed to the formation of stronger structural links in monolith, inhibited the growth of microorganisms and slowed oxidation and hydrolysis processes during the storage. At the same time, using the above mentioned ingredients in the butter production cannot solve urgent problems, such as elimination and prevention of iodine deficiency, entry into the diet such antioxidants like selenium, pigments, bioflavonoids and polysaccharides, which together improves organoleptic indicators of butter [8] and obviously will help to increase their storage life.

Currently, there is increased attention to algae, which contain a complex of organic and mineral substances essential for our body. Chemical composition of algae is characterized by containing high-molecular polysaccharides such as alginic acid (25%), mannitol (up to 21%), fructose (4%), vitamin B₁, B₂, B₁₂, a, C, D, E, pigments, bioflavonoids, iodine, selenium, etc. Therefore, algae considerably exceed usual terrestrial plants. Thus, the use of algae as supplements (additives) can solve the problem of the storage life prolongation and increase the biological value of the product.

The main objectives of this study is to determine the effect of algae supplements on the organoleptic characteristics and lipid indicators of quality during the storage under different temperature conditions.

Materials and Methods of the study. Butter with algae was produced using the method of high fat cream whipping. Adding those prepared additives was provided before the thermomechanical processing of fat cream. They used algae powder made of laminaria, fucus, spirulina, cystoseira. Control sample of butter with fat content of 62.5% was produced from the same raw material by the conventional technology.

The samples were stored under two temperature conditions: $3\pm 2^{\circ}\text{C}$ (above) and $7\pm 2^{\circ}\text{C}$ (below). They observed the changes in the organoleptic characteristics according to the method [8]. Before the first evaluating, the consistency of butter samples with algae was adjusted to the desired temperature. The consistency was measured at a temperature of $18\pm 1^{\circ}\text{C}$ by cutting. The main characteristics to judge were the stable or changeable butter structure, the presence or absence of moisture on the cut. The color of the test samples of butter with algae was determined by eye inspection. The smell and the taste was determined using organoleptic method: 5 g of the product was chewed for 30 seconds without swallowing, distributed across the mouth and has been got a taste captured in the initial moment of the sample placed on the tongue and after chewing.

Results of the study. One of the main causes of butter quality decrease is the oxidative damage at its fat phase, which predetermine changes in product's flavor. Results on the change of organoleptic evaluation of butter samples with algae



compared to the control (during the storage at a temperature of $+3\pm 2^\circ\text{C}$) are shown in Fig. 1.

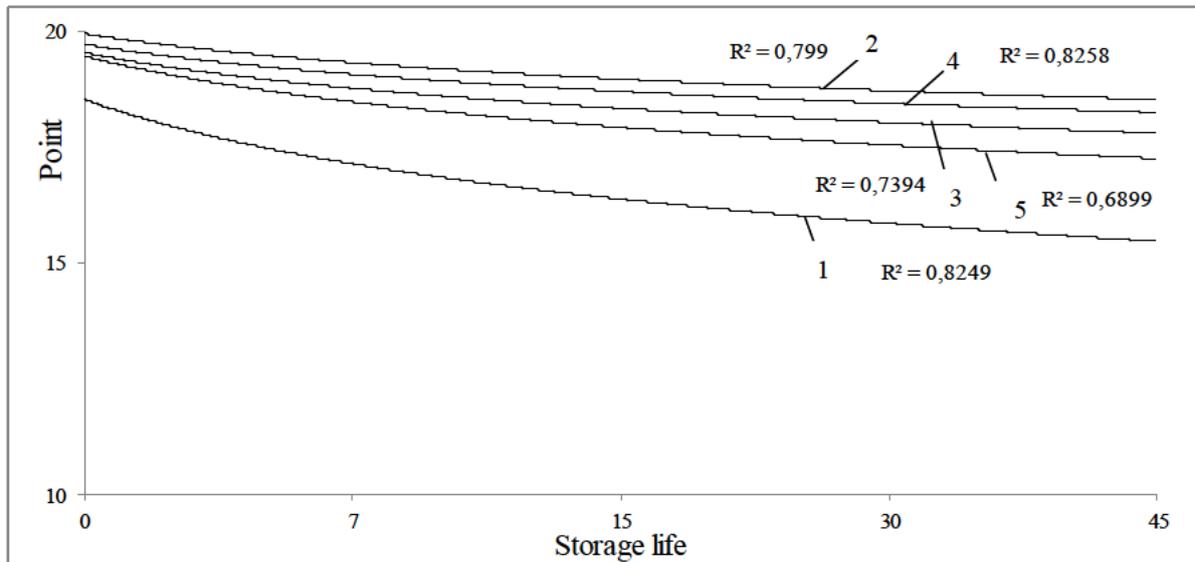


Fig.1. Dynamics of changes of organoleptic characteristics of butter at a storage temperature $+3 \pm 2^\circ\text{C}$;
 butter: 1 – control; 2 - with laminaria; 3 - with fucus; 4 - with spirulina; 5 - with cystoseira

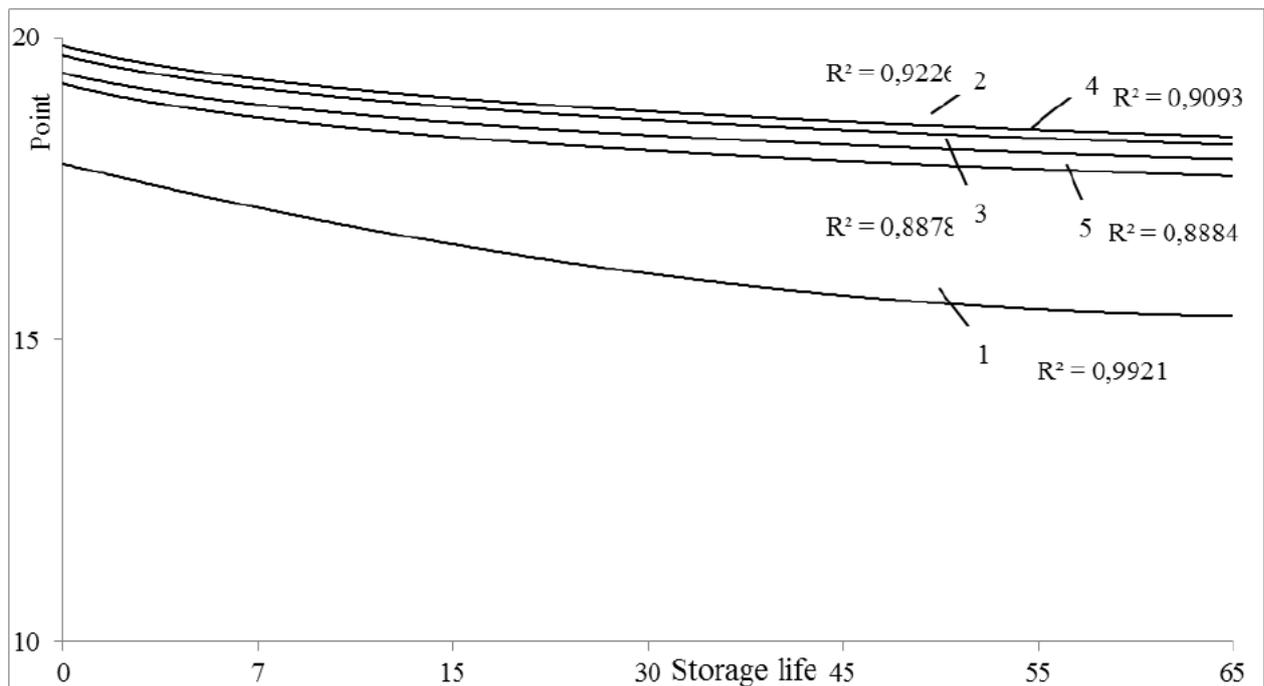


Fig. 2. Dynamics of changes of organoleptic characteristics of butter at a storage temperature $-7\pm 2^\circ\text{C}$;
 butter: 1 - control; 2 - with laminaria;
 3 - with fucus; 4 - with spirulina; 5 - with cystoseira

All samples had acceptable organoleptic characteristics and had plastic moderately dense texture, pure and pleasant taste, and aroma of additives used.



The deterioration of the organoleptic characteristics during the storage was observed in all butter samples, however in the control sample these changes took place at a higher rate as compared with the samples with algae. Thus, on the 45th day of storage the reduction of the organoleptic characteristics in the control sample was of 4 points, while in the samples with algae – 2 points.

Freezing and cold storage slows the deterioration of product quality, which is also resemble with our data. Storage at a temperature of $-7\pm 2^{\circ}\text{C}$ is characterized by the processes of slowing the deterioration of organoleptic characteristics (Fig. 2).

The deterioration of organoleptic characteristics in the control sample is observed on the 55th day of the storage by 4 points, in the samples with algae – 2 points. The main defect of the butter at this stage is its weakly expressed oxidized and fatty taste.

The deterioration of organoleptic characteristics is caused by the processes of oxidation and hydrolysis of the product's fat phase.

Conclusions. Addition of algae to butter slows the deterioration of the organoleptic characteristics, as well as the processes of oxidation and hydrolysis of fat during storage both at low and high temperature conditions. The effect observed may be caused by the presence of selenium element in algae, pigments, bioflavonoids, as well as the formation of polysaccharide-lipid complexes on the surface of nanograins, which protect the fat phase from oxidation and hydrolysis processes.

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**SENSORY ANALYSIS OF BUTTER WITH SEAWEED ACCORDING TO
 THE FLAVOUR PROFILE METHOD**

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**СЕНСОРНИЙ АНАЛІЗ ВЕРШКОВОГО МАСЛА ІЗ МОРСЬКИМИ
 ВОДОРОСТЯМИ МЕТОДОМ ПРОФІЛЮ ФЛЕЙВОРУ**

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Abstract. The results of sensory analysis of butter with seaweed according to the flavor profile method are presented. Also it was proved its expediency of to identify the organoleptic properties of butter.

Keywords: butter with seaweed, organoleptic evaluation, sensory analysis, flavor profile method, descriptors, profilograph.

Анотація. Наведено результати сенсорного аналізу вершкового масла із морськими водоростями методом профілю флейвору. Показано доцільність його використання для виявлення дескрипторів органолептичних властивостей вершкового масла.

Ключові слова: вершкове масло із морськими водоростями, органолептичне оцінювання, сенсорна характеристика, метод профілю флейвору, дескриптори, профілографа.

Problem statement. The problem of health and increasing people lifetime is one of the most important and urgent in biology and medicine. Recently in Ukraine there has been an increase in cardiovascular, gastrointestinal, endocrine and cancer diseases, which evoke a severe violation of immunity. The main cause of these types of pathologies is unfavorable ecological situation, as well as significant changes in the structure and quality of nutrition.

Modern nutrition system is not able to fully meet the needs of the essential macro and micronutrients, and vitamins. Therefore, it is believed that an unbalanced nutrition system may be a cause of the low population lifetime. Raising levels of radiation and chemical threats still more complicate this situation [1, 2].

Today in Ukraine a trend of expanding the segment of the market with health products is prevailing. Health products which contain functional ingredients can be seen, from an economic point of view, as powerful means of improvement of the competitiveness of enterprises through the production of such products; as well as, – from the social and cultural points of view – as assistance and development towards a healthy nutrition lifestyle.



Among these products one can include a butter with seaweed (laminaria, fucus, spirulina and cystoseira). Due to a combination of good organoleptic properties and good content of bioactive compounds, it is a promising trend in the dairy industry. In the National University of Life and Environmental Sciences of Ukraine they had developed formula of butter with laminaria, fucus, spirulina and cystoseira [3, 4], which contain some kinds of bioorganic compounds of Iodine selenium and other minerals, vitamins A, B, C.

Today existing state standards [5] of butter with fillers do not involve complex assessment of physical and chemical and organoleptic quality characteristics. Normative documents regulate only common quality and safety characteristics, such as the appearance and texture, color, taste and smell, fat content, moisture content, the content of toxic elements and etc. They do not take into account the chemical composition of algae and their previous treatment.

Flavour profile method is one of the methods used to describe the sensory characteristics and is considered to be a fundamental to many other descriptive methods. Today the term flavor means the combined effect of the flavoring properties, the aromatic perception and touch sensations in the mouth [6]. Flavour profile method is an attempt to characterize flavour, taking into account all descriptors that form the overall impression of the product according to five basic criteria: character of descriptors, their intensity, sequence of these descriptors display after taste and its completeness (phenomenon which is shown the overall impression of the product components compatibility) [7, 8].

The aim of the study is to determine the flavor profile of the developed samples of butter with seaweed and establishing of their compliance to hypothetical standard.

Materials and methods of the study. Objects of research were those developed samples of butter with laminaria butter, butter with fucus, butter with spirulina, butter with cystoseira, and "buterbrodne" butter was as a control sample.

Sensory analysis of butter had been held according to the international standards ISO. To create profiles the method described in GOST ISO 6564:2005 "Sensory evaluation. Methodology. Methods of flavor spectrum creation" [9].

The results of the study. A sample of butter with laminaria was characterized by harmonious taste and aroma with salty taste that resembles the taste of caviar.

Sample of butter with fucus was less harmonious with salty taste that resembled a taste of pistachio.

Butter with Spirulina had high taste properties similar to the taste of herring.

According to the descriptor, the sweet taste was characteristic for the butter with cystoseira. After this, sample taste resembled a chocolate butter.

For a visual perception of results the profilograph of flavor of developed samples of butter with seaweeds presented (Fig. 1 - 4).

Comparing the calculated overall assessment in scores, the closest to the standard are the samples of butter with laminaria and fucus (assessment of 30.0). The deviation in 1.7 and 3.0 scores from the standard is in samples with cystoseira and spirulina, which means that they need to improve these butter formula to close them to the standard.

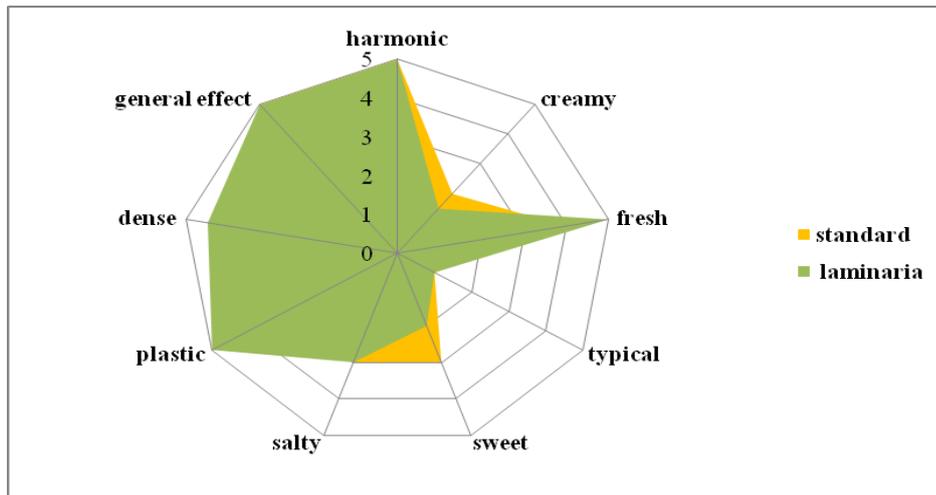


Fig.1. Profilograph of flavor of butter with laminaria

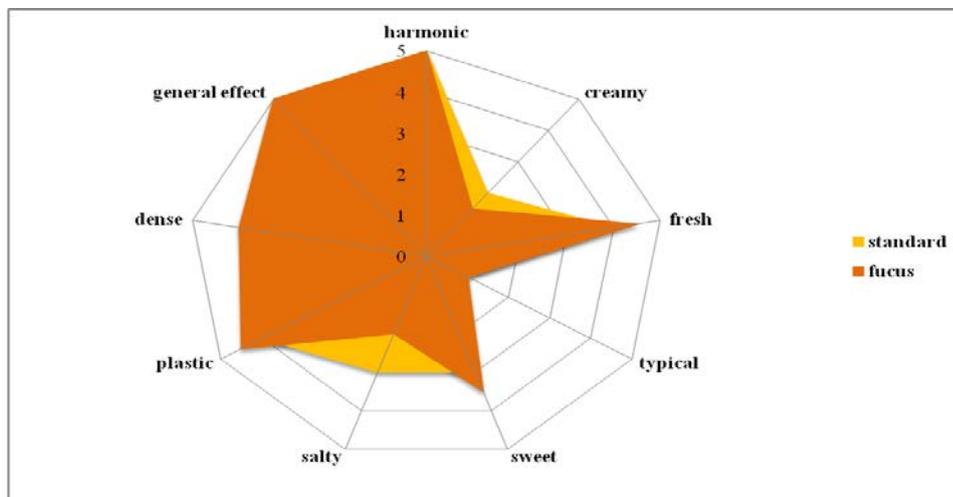


Fig.2. Profilograph of flavor of butter from focus

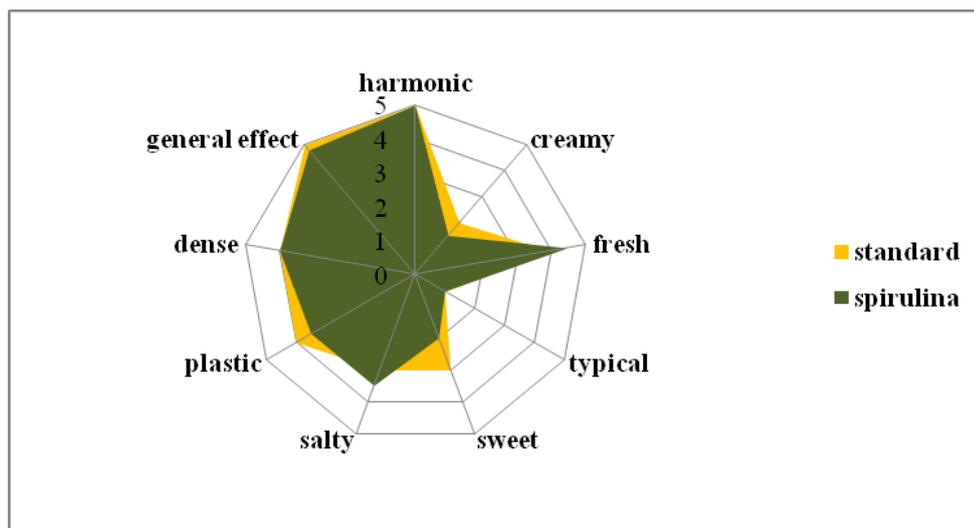


Fig.3. Profilograph of flavor of butter with spirulina

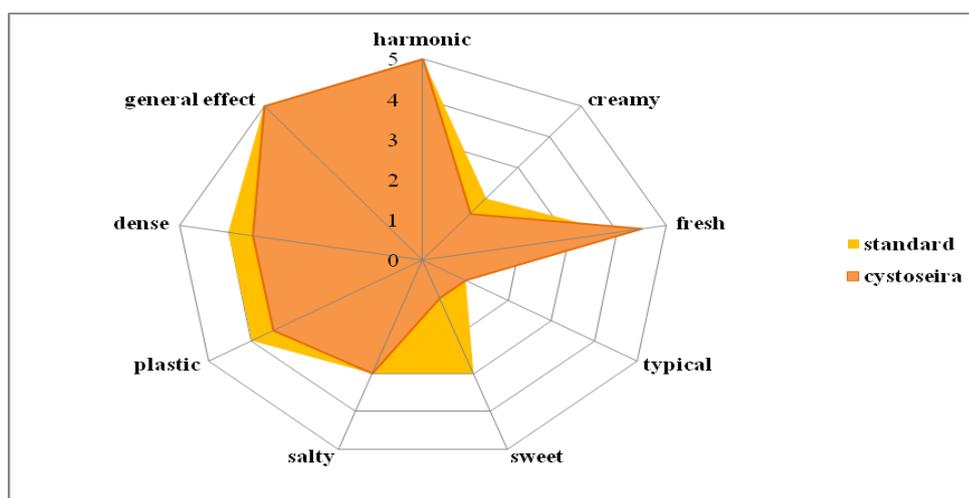


Fig.4. Profilograph of flavor of butter with cystoseira

Conclusions. Aromatic and flavor complex of butter with seaweed demonstrates the originality and uniqueness of the product. Organoleptic profile developed confirms the relevance of using seaweed in butter production technology. During our study of butter with seaweed there were indicated some key descriptors of aroma and taste. All the samples are close to the standard according to the organoleptic characteristics, and thus the needs of the target categories of consumers are met.

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STATE OF MARKET FOR DAIRY PRODUCTS IN UKRAINE

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СТАН РИНКУ МОЛОЧНОЇ ПРОДУКЦІЇ В УКРАЇНІ

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Abstract. *A system analysis of milk production was conducted, and the issues of production and consumption of milk and dairy products were highlighted.*

Keywords: market, milk, dairy products, butter, assortment of butter with fillings.

Анотація. *Проведено системний аналіз виробництва молока, висвітлені питання виробництва і споживання молока та молочної продукції.*

Ключові слова: *ринок, молоко, молочні продукти, вершкове масло, асортимент вершкового масла із наповнювачами.*

In recent years there is a trend of increasing interest in high-grade types of natural raw materials and food products, as they are the main factors of human health. The main value of milk and dairy products is that they contain fats, proteins, minerals, hormones and many enzymes and vitamins. Each component of milk has beneficial properties that are determined by a high biological value.

Milk fat is extremely essential for normal human body growth and development: its components and vitamins protect the body from infectious diseases, make the skin supple and inaccessible to penetration of microbes, have positive affect on eyesight. Butter is also necessary to eat for patients after surgeries on the stomach and intestine.

Today a special relevance has the research of the market of raw milk, the structure of dairy products production in Ukraine and highlighting some promising directions in technology of production of butter with fillers to provide the nation with a healthy food.

The aim of research was to determine the state and prospects of development of the butter market in Ukraine.

Materials and methods of the study. The materials for the research were literary data, statistics data from State Statistics Service of Ukraine. They used research methods: analytical analysis of literature on this subject, and monitoring the range of butter.

The amount of milk in a world market for now is about 600 million tons. Here



cow's milk is over 80%, the rest is buffalo, goat and sheep milk. According to the Ukrainian Union of Dairy Enterprises, the world average production of milk per year is 714 million tons. Ukraine is among the ten most important world producers of milk and dairy products: EU – 148 million tons, India – 112,1 million tons, USA – 87 million tons, China – 36,7 million tons, Russia – 31,8 million tons, Brazil – 29,5 million tons, New Zealand – 15,48 million tons, Ukraine – 11 million tons, Australia – 9,02 million tons, Belarus – 6,6 million tons and Kazakhstan – 5,38 million tons [1].

According to the data of publishing house “Agravery”, the production of milk in Ukraine in 2015 was 42%, which is by 28% less compared to the previous years. Experts say, that is it caused by the reduction of stock in a private sector and so goes the growth of milk production by the agricultural enterprises [2, 3]. Milk production in Ukraine in 2010-2015 years is presented in Figure 1.

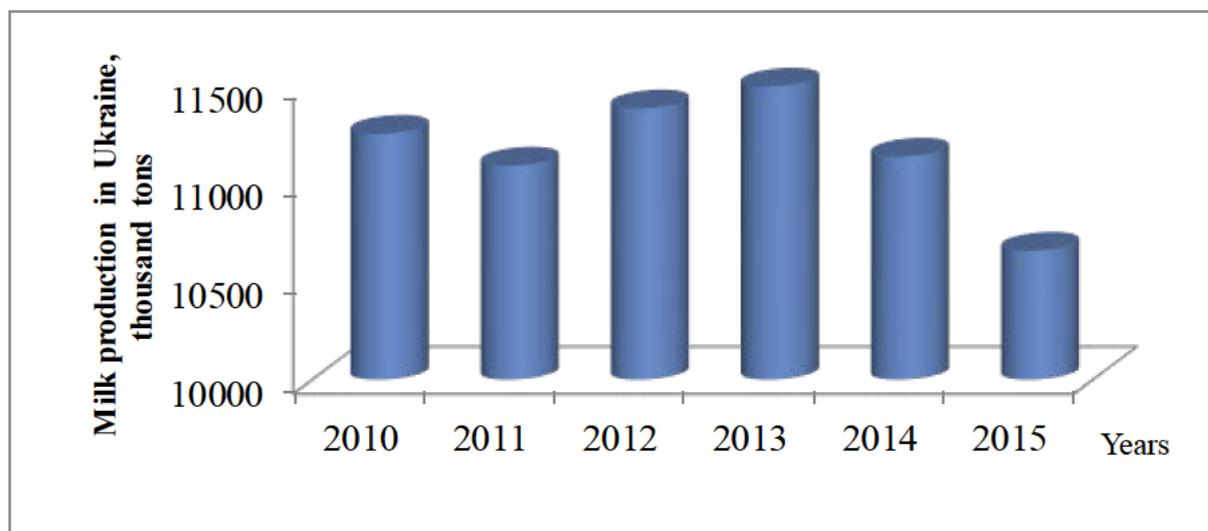


Fig.1. Dynamics of milk production in the last five years

Reduced milk production, rising prices on milk products, reduced purchasing power have led to a significant reduction in the consumption of dairy products. The average annual consumption of milk and dairy products per person in Ukraine in terms of milk in 2010 was 206,4 kg, in 2014 – 222,5, in 2015 – 218,6 kg; it means that the level increased by 1.06% compared to the data of 2010 year, and fell by 1.75% compared to the year 2015.

More than 300 companies are engaged in milk processing in Ukraine, but almost 80% of the market is controlled by 50 plants, most of which are the parts of the large holdings. The main producers of butter in Ukraine are presented in Figure 2.

Analyzing the data of Figure 2, we can conclude that in Ukraine there is a big number of companies-producers of butter. Almost all regions have their own plant specializing in butter production. State of butter production in Ukraine is shown in Figure 3.

Since 2012, the dairy industry in the country gradually restores the pre-crisis production volumes - from 79,5 thousand tons in 2010 to 114,5 thousand tons in 2014. The volume of butter production in Ukraine in 2015 was 101 thousand tons, which is by 11.4% less than the year before.

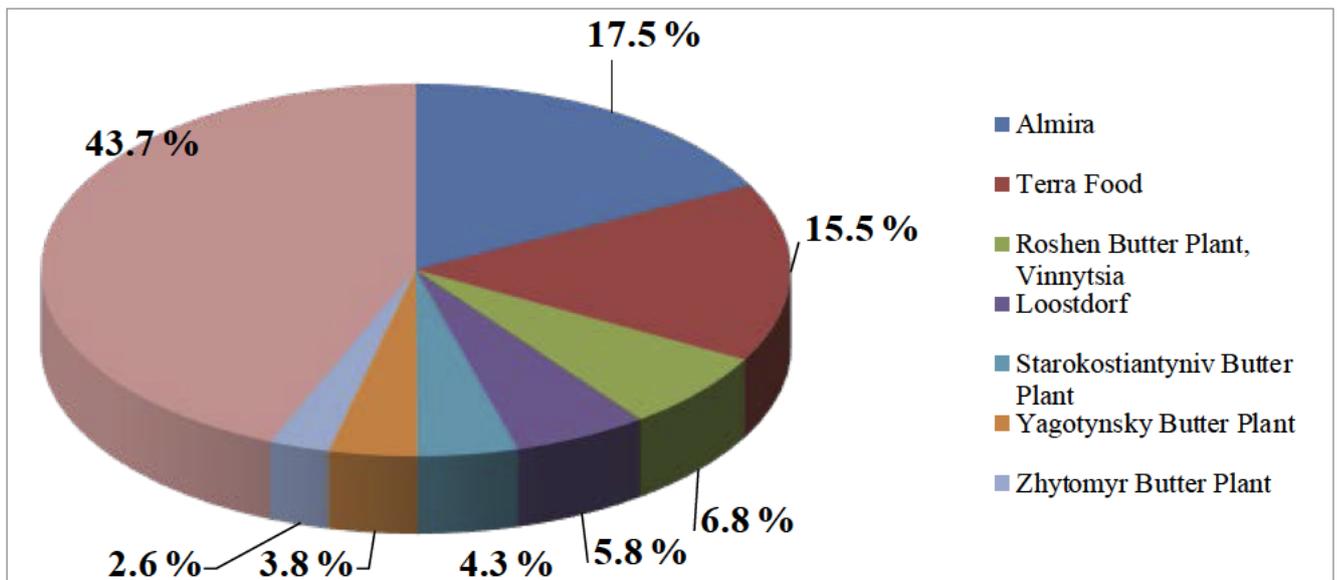


Fig. 2. Market share of major manufacturers in the butter market in Ukraine [4]

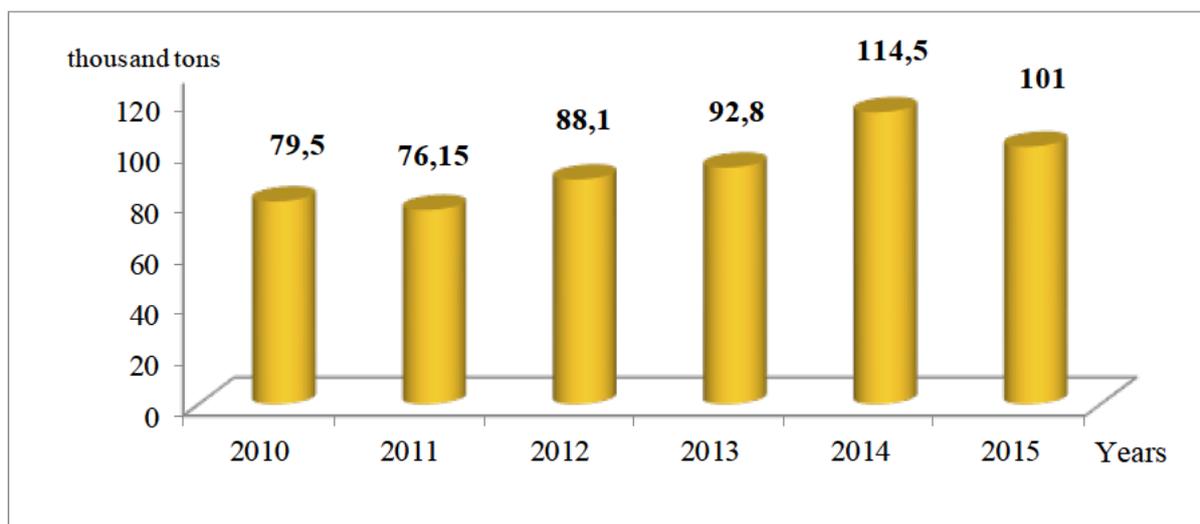


Fig. 3. Butter production in Ukraine [5, 6]

Analyzing the range of butter with fillers in Ukraine, we can say that here the only representative is a chocolate butter.

Conclusions. The analysis provided shows that during 2010 - 2015 years a milk production decreased by 1.75% compared to 2010 year. This shows that the gap between incomes and prices for milk and dairy products affect its demand.

Analyzing the range of butter with fillers in Ukraine, we can say that here the only representative is a chocolate butter. Therefore, a special attention should be paid to the development of new types of butter with seaweed.

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Annotation. This article provides an assessment of the possibility of using dietary supplements of kelp as an ingredient for health food.

Key words: laminaria, amino acids, mineral composition, iodine.

Анотація. У даній статті розглянута можливість використання біологічно активної добавки морської водорості ламінарії в якості інгредієнта для здорової їжі.

Ключові слова: ламінарія, амінокислотний склад, мінеральні речовини, йод.

Introduction. Edible marine algae, also called sea vegetables, are plants that grow in the sea. East Asian population (Japan, Korea, China) have regularly utilised the sea vegetables since ancient times. The result of such a diet is very high iodine consumption and extremely low incidence of breast cancer [1]. In Ukraine, as a contrast, there is a considerable lack of interest for their consumption, and consequently the cultivation of autochthonous algae is negligible [2].

Laminaria are the most utilised brown algae in macrobiotic diet, where these algae are consumed daily, although in small quantities [6]. Their chemical composition indicates that laminaria are valuable ingredients to any diet [7], but they are also of particular nutritional importance to vegans and vegetarians, because together with legumes and grains they represent the supplementary source of proteins [1].

When compared to land plants marine algae have 10-20 times higher content of vitamins and represent an excellent source of vitamins A, D, E, B-complex and B₁₂ [1,3].

Marine algae are an excellent source of minerals due to their capacity to absorb inorganic substances from the sea by polisaccharidic structure of their surface. Mineral composition and mineral contents are the functions of environmental, geographical and physiological factors [2, 4]. Mineral content is higher than that in edible land plants and animal products [4], and that is why the sea vegetables are effective in relatively small supplementary amounts and can supply our food with many missing elements [7].

The carbohydrates in marine algae, containing soluble fibres of alginates and



insoluble cellulose, are indigestible by man and therefore considered dietary fibres. They differ chemically and physicochemically from those in land plants. Due to their polysaccharidic structure they bind metal ions, and can remove heavy metals from our bodies [5].

Lipid content in sea vegetables is very low, ranging from 1–5 % of dry matter [8]. Nevertheless algal lipids have a higher proportion of unsaturated fatty acids than land plants [2]. Furthermore, marine algae possess antibiotic and anticarcinogenic activity [7]. They contain lignans that are readily converted by intestinal microflora to non-steroidal estrogenic molecules, which explains their therapeutic and preventive effect against estrogen-driven neoplasms [1]. The aim of this work was to evaluate laminarija as natural and useful food supplements in our western staple diet.

Material and methods. Mass fraction of amino acids - the method of ion exchange chromatography on an automatic analyzer amino Biotronik LC 2000 (Germany), the proportion of tryptophan - colorimetric method after alkaline hydrolysis samples [9].

The study of mineral seaweed kelp conducted using a portable analyzer energodispersive roentgen ElvaX-med, it provides an opportunity to analyze the mineral composition of drinking water, juice, alcoholic beverages, food additives, etc [10,11].

Results and discussion. Results of the study laminarija amino acid composition shown in table 1.

Table 1

The essential amino acid ratios compared with FAO/WHO, g/100g of protein

Amino acid	Laminaria	FAO/WHO reference protein
Valine	3,21	5,00
Isoleucine	2,55	4,00
Leucine	4,68	7,00
Methionine+ Cystine	1,69	3,50
Threonine	3,88	4,00
Phenylalanine+ Tyrosine	2,85	6,00
Lysine	2,86	5,50
Total	21,72	36,0

Analyzed algae contain all the essential amino acids. The table shows that the content of individual AKC and the amount of essential amino acids in the protein seaweed lower compared to the ideal protein, indicating that not their high biological value.

The basic component in sea vegetables is iodine, an essential trace element and an integral part of two hormones released by the thyroid gland. Results of the study the mineral composition of laminaria are presented in table 2.



Table 2

The mineral composition of laminaria in mg / 100 g of product

Minerals	Laminaria	Recommended daily dose [11]
K	1340, 3 ± 35,4	120,0
Ca	448,2 ± 15,6	100,0
Mg	124,1 ± 11,5	40,0
P	143,1 ± 8,6	120,0
Fe	8,75 ± 0,52	1,50
I	56,68 ± 2,23	0,15
Se	5,41 ± 1,4	0,07

The analysis of data showed that sea kelp is rich in potassium and are able to meet 53.6% of the daily requirement of this element. Especially valuable is the iodine content, it exceeds the daily requirement of this trace mineral needed for normal functioning of the human thyroid gland.

Conclusions. Sea kelp is a great source of most minerals, analyzed algae can often compensate for low levels of minerals in food plants. Furthermore, considering that the sea vegetables eaten regularly are the best natural source of iodine, and that they represent an easy and nontoxic way to meet the daily requirement of iodine in the diet, the analyses algae consumed as food.

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МОРСЬКІ ВОДОРСТІ В ПРОДУКТАХ ХАРЧУВАННЯ

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Annotation. The work substantiates the effectiveness of the use of marine algae in food.

Key words: red seaweeds, brown seaweeds, green seaweeds.

Анотація. Дана робота присвячена обґрунтуванню ефективності використання морських водоростей в продуктах харчування.

Ключові слова: бурі, зелені, червоні водорості.

Marine microalgae, or the term seaweeds, are plant-like organisms that generally live attached to rock or other hard substrata in coastal areas. The classification into divisions is based on various properties such as pigmentation, chemical nature of photosynthetic storage product, the organization of photosynthetic membranes, and other morphological features.

Traditionally, they belong to four different groups, different colors based on empirically: *blue-green algae* (phylum: Cyanophyta, up to 1500 species), *red algae* (phylum: Rhodophyta, about 6000 species), *brown algae* (phylum: Ochrophyta, classes: Phaeophyceae, about 1750 species), and *green algae* (phylum: Chlorophyta, classes: Bryopsidophyceae, Chlorophyceae, Dasycladophyceae, Prasinophyceae, and Ulvophyceae, about 1200 species).

Most people don't realize how important marine macroalgae are, both ecologically and commercially. In fact, seaweeds are crucial primary producer in oceanic aquatic food webs. They are rich both in minerals and essential trace elements, and raw materials for the pharmaceutical and cosmetics industry [1]. Seaweed is a very versatile product widely used for food in direct human consumption. Its classified taxonomically as algae and they represent a food group that is not normally ingested in unprocessed form to any great extent in Western societies. Humankind is no strangers to the use of algae as a food source.

A seaweed may belong to one of several groups of multicellular algae: the red algae, brown algae and green algae. As these three groups are not thought to have a common multicellular ancestor, the seaweeds are a polyphyletic group. In addition, some tuft-forming blue green algae (Cyanobacteria) are sometimes considered as seaweeds — "seaweed" is a colloquial term and lacks a formal definition. Two specific environmental requirements dominate seaweed ecology. These are the presence of seawater (or at least brackish water) and the presence of light sufficient to drive photosynthesis. Another common requirement is a firm attachment point. As a result, seaweeds most commonly inhabit the littoral zone and within that zone more frequently on rocky shores than on sand or shingle [2].



Seaweeds occupy a wide range of ecological niches. The highest elevation is only wetted by the tops of sea spray, the lowest is several meters deep. In some areas, littoral seaweeds can extend several miles out to sea. The limiting factor in such cases is sunlight availability. The deepest living seaweeds are some species of red algae. Others have adapted to live in tidal rock pools. In this habitat seaweeds must withstand rapidly changing temperature and salinity and even occasional drying [3].

Red seaweeds. Red seaweeds have had a more diverse evolution than the green and the brown. Many species cannot stand desiccation and dominate the inter-tidal rock pools. Others tolerate desiccation, such as the purple laver which can often be seen stretched out like a dry black film over mussel beds on rocky beaches. Red seaweeds such as *Polysiphonia lanosa* are epiphytes, these are plants that grow on other plants for physical support. In this case the epiphyte benefits from the host's buoyancy lifting it closer to the sunlight. The red colour of the seaweeds is due to the larger amount of red phycoblin pigments overriding the green pigment chlorophyll. The main biomass of red algae worldwide is provided.

The red algae *Gelidium*, *Gracilaria*, *Pterocladis* and other many red algae are used in the manufacture of the important agar, used widely as a growth medium for microorganism and other biotechnological and food applications. Another important red seaweed alga is *Eucheuma* used in the production of Carrageen an important product used in cosmetics, food processing and industrial uses, as well as a food source [3].

Brown seaweeds. *Laminaria* sp. «kombu», *Undaria* sp. «wakame» is edible and an important resource Asia countries especially China and Japan. They are consumed raw, boiled or dried material with sweetened green beans, jelly, crushed ice, and coconut milk in Southern Vietnam [5]. *Laminaria* was in plentiful supply in Japan, mainly from the northern island of Hokkaido, where several naturally growing species were available.

Green seaweeds. The green colors of the seaweed are due to the green pigment chlorophyll required for the photosynthesis of light. Using only chlorophyll means that green seaweeds require good levels of light and therefore will not thrive in shadowed areas or too any depth. It does give them an advantage, the ability to live higher up shore without competition from the red or brown seaweeds. These algae are eaten by humans as edible raw, dried, or cooked.

Seaweeds are a rich source of chemical having anti-oxidant and antimicrobial properties. Presence of fibers and minerals helps in improving the mineral content reduces the salt content. The adding of seaweeds or their extracts to food products will help in reducing the utilization of chemical preservatives [4].

Edible seaweeds contain various bioactive compounds with potential health benefits and their use as functional ingredients opens up new prospects for food processing, meat product formulations included. Seaweeds basically contain high proportions of polysaccharides along with various other potentially beneficial compounds such as good-quality protein and essential fatty acids, particularly long-chain ω -3 polyunsaturated fatty acids. Alginates are the most abundant ionic polysaccharides present in brown seaweeds.

Some seaweed polysaccharides are used by food industry as texture modifiers



because of their high viscosity and gelling properties. In Asia seaweeds have been used for centuries in salads, soups and as low calorie dietetic foods. The dietary fibre which constitutes 25-75 % of the dry weight of marine algae and represents their major component, is primarily soluble fibre. Thus, we can conclude that algae is a promising trend in food technology.

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THE PROSPECTS OF CHIA SEEDS USAGE IN BUTTER PRODUCTION TECHNOLOGY

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ПЕРСПЕКТИВИ ВИКОРИСТАННЯ НАСІННЯ ЧІА В ТЕХНОЛОГІЇ ВИРОБНИЦТВА ВЕРШКОВОГО МАСЛА

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Annotation. The objective of this study was to evaluate chia seed from her chemical components and prove their claim for functional properties.

Key words: functional food, omega-3, chia.

Анотація. Мета даної роботи полягала в дослідженні харчової та біологічної цінності насіння чіа, для використання в технології вершкового масла.

Ключові слова: функціональні продукти, омега-3, насіння чіа.

Introduction. The search for novel foods is a relevant practice worldwide. *Salvia hispanica* L., also known as chia, is an herbaceous plant cultivated semi-annually, and it belongs to the family Labiatae, division Spermatophyta and kingdom Plantae [1]. Chia is native to the region that stretches from North Mexico to Guatemala. Chia seed contains a significant amount of lipids (approximately 40% of the total weight), with almost 60% of the lipids comprising Omega-3 fatty acids. Dietary fiber constitutes more than 30% of the total weight of the seed, and approximately 19% of the seed contains proteins of high biological value. Unsaturated Omega-3 fatty acids are nutritionally important for good health and are beneficial for individuals suffering from heart disease, diabetes and immune response disorders [2].

Functional foods have received heavy attention in recent years as components of healthy lifestyle changes. The term “functional” is used to refer to a food that is regularly consumed to provide physiological benefits or to reduce the risk of chronic disease in addition to its basic nutritional functions. Many new foods contain bioactive functional compounds including fiber, prebiotics, probiotics, oligosaccharides, phytochemicals, antioxidants, and other substances that confer functional properties or beneficial effects on human health [3].

Functional foods offer health benefits in addition to the nutritional value inherent in their chemical compositions, and they may have potential roles in reducing the risk of chronic diseases. Important functional foods that need to be consumed on a daily basis are fruits, vegetables, legumes and grains; these materials generally provide the body a high intake of vitamins, minerals, phytochemicals (antioxidants and anticarcinogenic molecules) and fibers, which are essential for the proper functioning of the organism and for the maintenance of health [4].

Natural antioxidants protect the human body against free radicals, inhibit many



chronic diseases, and prevent lipid oxidation in food. Phenol compounds are important components of many edible plants, including soybean, canola, flaxseed and olive, which are used as food or food ingredient sources. Synthetic antioxidants are widely used for its performance, however, they present different toxicological problems. The legislation on food safety has gradually become more rigorous, requiring the use of toxicity tests for synthetic antioxidants. Additionally, consumers tend to use natural products as antioxidants, as these appear safe and do not require testing.

Chia seeds are a promising source of antioxidants due to the presence of polyphenols, chlorogenic and caffeic acids, myricetin, quercetin and kaempferol, which protect consumers against adverse conditions such as cardiovascular diseases and certain cancers [5].

Thus, the objective of this work was to evaluate chia seed for its chemical components.

Chemical composition of chia seeds. Analysis of the literature shows that Chia seeds are characterized by a high content of dietary fiber 22.6 g / 100 g, the lipid content 33.3 g / 100 g. The levels of protein and ash were and were 23.7 g/100 g and 4.6 g/100 g, respectively.

With all these features, chia seeds can be used as emulsifiers and stabilizers due to their high fiber content, and as an ingredient for products gluten-free, and with low carbohydrate content. In addition, there is the possibility of extracting oil for production of capsules of ω -3, and protein concentrates obtained due to their protein content. So, chia seeds can be used for enrichment of products, such as in butter technology.

Like chia seeds, flaxseeds are a renewable source rich in ω -3 and other functional components [6], and their use in formulations increases the ω -3 fatty acid content of popular foods. The high caloric value presented by chia seeds is associated with its high levels of lipids.

From a nutritional standpoint, lipids have a high energy value and are important precursors of fat-soluble vitamins (A, D, E and K) and essential fatty acids (linoleic, linolenic and arachidonic acids).

Looking at lipid content of seeds of chia have presence of palmitic acid (7%), stearic acid (3.23%) linolenic acid (60.68%) and polyunsaturated fats (PUFA) (81.15%), a lower value for linoleic acid (20.47%) and a higher value for oleic acid (7.48%). The incorporation of ingredients with high PUFA content into the diet provides numerous health benefits. The chia seed can be considered a functional food because it is a source of ω -3 fatty acids, with at least 0.1 g of ω -3 in 100 g of product, and has high levels of total dietary fiber, up to 3 g in 100 g of product and protein.

Conclusions In conclusion, chia seeds showed high levels of lipids, proteins and fibers compared with other seeds. It is suggested that fiber, one of the components of chia, due to its high water retention capacity, are important for the production of other products such as emulsifiers. In addition, chia seeds presented high content of phenolic compounds with antioxidant activity effectively suggesting that chia can bring health benefits when used in food products. The diversity along with the amount of nutrient composition in chia seed can help to have a healthy diet and



increase the value of the butter.

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THE PROSPECTS OF GOJI BERRIES USAGE IN FOOD PRODUCTS

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ВИКОРИСТАННЯ ЯГІД ГОДЖІ В ПРОДУКТАХ ХАРЧУВАННЯ

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Annotation. The objective of this work consisted in the studied the biological value of goji berries for use in food technology.

Key words: goji berry, elements, human nutrition.

Анотація. Мета даної роботи полягала в дослідженні біологічної цінності ягід годжі, для використання в технології продуктів харчування.

Ключові слова: ягоди годжі, харчування людини, мікроелементи.

Introduction. Goji berry, is the fruit of the shrub with the same name (Family Solanaceae) from north-west China. This ellipsoidal reddish fruit 1-2 cm long has been long known not only due to its nutritive features but also due to its numerous benefits for human health. Its nutritive and pharmacological features are caused by a large number of active biological compounds that make it. Literature supplies numerous information regarding the composition and nutritive and therapeutically importance of this medicine-fruit [1].

Goji berries contain 19 amino acids the building blocks of protein - including eight that are essential for life, 21 trace minerals - including germanium, an anticancer trace mineral rarely found in foods, more protein than whole wheat (13 percent), a complete spectrum of antioxidant carotenoids, including beta-carotene (a better source than even carrots).

Goji berries are the richest source of carotenoids of all known foods. In addition, this fruit is rich in vitamin C (at higher levels than even those found in oranges), B-complex vitamins - necessary for converting food into energy, vitamin E - very rarely found in fruits, only in grains and seeds, beta sitosterol - an anti-inflammatory agent, as well as a large number of essential fatty acids - which are required for the body's production of hormones and for the smooth functioning of the brain and nervous system [2].

The benefits on human health, the therapeutically features of the goji berries are associated to a large number of immune-modular, antihypertensive, hepatic, anti-ageing, anti-fatigue, anti-oxidant. All these features recommend the introduction of the goji berries in nutrition either fresh, dried, or in preparations as healthy foods such as teas, syrups, jam, etc.

The remarkable nutritive features of the goji berries are also due to the important content in minerals, some of which are essential for the normal functioning of the human body: Ca, Mg, K, P, Fe, Zn, Cu, Cr, I, Se, etc. We need to mention the fact that accidentally – because of anthropic causes (soil and climate conditions, the existence of some pollutants, some improper processing, etc.) these fruit can also



contain some toxic elements (Hg, Pb, As, Cd, etc.) that have a negative impact on the human body [3].

This is why we believe we need to use this fruit as a nutrition supplement for essential minerals. In this paper, the authors determine the distribution of some essential microelements in goji berries samples imported from China.

Material and Methods. The study of mineral seaweed kelp conducted using a portable analyzer energodispersive roentgen ElvaX-med, it provides an opportunity to analyze the mineral composition of drinking water, juice, alcoholic beverages, food additives, etc.

Roentgen analysis method based on measuring the intensity of x-ray radiation of atoms of a chemical element in the excitement of X-rays using a miniature x-ray tube. The resulting spectrum consists of a set of analytical lines. Registration of analytical intensities is performed using a multichannel spectrometer with energy semiconductor detector (Si-p-i-n diode) with thermoelectronic cooling. Specialized software allows building the most likely model range, identify its analytical lines in the presence of a large number (15-30) elements of the sample, determine the mass concentration of the element, the exact weight of the object and, accordingly, the concentration of elements in the sample [4, 5].

Results and discussion. Studies have shown the elements we analysed, Zn is the best represented with values between 90 and 125 mg/kg, followed by Fe in smaller concentrations of 43-81 mg/kg. Mn and Zn are in almost equal concentrations (between 3.70 and 6.05, and 5.9 and 10.0 mg/kg, respectively), but lower than Fe and much lower than Zn. We need to mention that Zn and Cu above certain concentrations established by regulations have negative effects on the human body. In our case, the samples we analysed do not contain excessive amounts of Zn and Cu. Cr was identified in very small concentrations of 0.21-0.50 mg/kg.

We did not identify any detectable amounts of toxic elements such as Pb and Cd. Experimental data show that goji berries can be considered one of the richest fruits in essential elements such as Fe, Zn, Mn, Cu, and Cr.

When using systematically this fruit as a mineral supplement we need to take into account not to go above certain daily doses. Improper excessive consumption can overload the body with certain minerals or nutrients that could have unwanted side effects. This is why it is imperative to have a good control of the concentration of minerals not only to know the quantum of essential or toxic elements but also to avoid excess or cumulative effects caused by other constituents of such fruit.

Results from the determination of some mineral microelements in goji berries point out important amounts of essential elements and very small, negligible amounts of toxic elements. As such, goji berries analysed are of interest as supplementary supply of some essential elements with a substantial contribution to the daily mineral.

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**ВЛАСТИВОСТІ ВЕРШКОВОГО МАСЛА З НАПОВНЮВАЧАМИ
МОРСЬКИХ ВОДОРОСТЕЙ**Національний університет біоресурсів та природокористування України,
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Annotation. In the article the expediency of creation of new types of butter using algae. It was established that the addition of laminaria, fucus, spirulina and cystoseira butter recipes to improve its nutritional value thanks to improved macro and trace element composition, namely enrichment of the final product form iodine and selenium.

Key words: butter, functional ingredients, laminaria, fucus, cystoseira, spirulina, iod, selen.

Анотація. Обґрунтовано доцільність створення нових видів масла вершкового із використанням наповнювачів з морських водоростей. Встановлено, що додавання ламінарії, фукусу, спіруліни та цистозіри до рецептури масла вершкового сприяє підвищенню його харчової цінності завдяки покращення макро- і мікроелементного складу, а саме збагаченню кінцевої форми продукту йодом та селеном.

Ключові слова: вершкове масло, функціональні інгредієнти, ламінарія, фукус, цистозіра, спіруліна, йод, селен.

Introduction. Alteration of nutritional systems in Ukraine has led to low consumption of dietary ingredients (complete protein, complex carbohydrates, vitamins and minerals), which causes a reduction of human body resistance to adverse environmental factors in the overall [1-3].

Today the problem of iodine deficit is one of the major factors of deterioration of physical and mental health throughout the world. In Ukraine, the problem of iodine deficiency diseases years has escalated dramatically in recent. This is due to the elimination of the previous system of prevention of iodine deficiency diseases, as well as with a noticeable reduction in nutrition of a share of products relatively rich in iodine and other microelements [4]. Modern technology of iodine enriching of food products involves the use of thermal processing of food, resulting in disrupt of up to 50% of iodine included in the product [3]. Therefore, the enriching of traditional food with iodine material without thermal processing is a topical issue today.

Butter is one of the most popular and essential food products. This is a product



with a high concentration of milk fat, including natural fats, which have the highest nutritional and biological value.

It should be noted, that currently in the production of butter they widely use food ingredients targeted at the use of the additives of natural origin, and having specific functional properties, a wide range of colors and flavors, a higher content of biologically active substances, micro- and microelements. However, expansion of the range of these types of products does not lose its relevance.

One of the prospective directions in the production of functional products is the use of seaweed. In this area, a particular attention is paid to biologically active additives of laminaria, fucus, spirulina and cystoseira seaweed.

Materials and methods of the study. Organoleptic assessment of control samples and experimental butter had been held for twenty-grade scale according to DSTU 4399: 2005 [5].

The study of mineral seaweed had been conducted using a portable analyzer energodispersive roentgen ElvaX-med, it provides an opportunity to analyze the mineral composition of drinking water, juice, alcoholic beverages, food additives, etc [6].

Results and discussion. As a result of the taste assessment of a control sample of butter, it got the lowest score - 17.5. The quality of the butter with the seaweed was always higher compared to the control sample: butter with laminaria and fucus got almost the maximum score, and with spirulina and cystoseira – 18.5 and 18.0 respectively.

Through the use of fillers in butter the most significant indicators (such as "taste" and "consistency") had improved. Adding seaweed in amounts of 3 up to 4% per 100 g of product allows to keep its creamy taste in all butter samples.

The highest score obtained a butter with laminaria by its organoleptic properties, which were characterized by a plastic, solid in appearance, and uniform weight consistency; taste and smell was pure, creamy, salty with a pleasant taste of seaweed, had a light olive color. Butter with fucus had light brown color with a slight odor of cream and little flavor fucus, and a salty taste with a slight flavor of additives introduced.

Butter with spirulina was different from previous samples with a pistachio color, high taste properties, similar to the taste of herring.

Butter with cystoseira was characterized with plastic, dense texture, and a slightly dark cream color. The taste of this sample was similar to the chocolate butter.

Thus, the organoleptic characteristics of butter with seaweed fillers dominated the control sample characteristics. To evaluate the effectiveness of adding to a butter of seaweed (such as minerals), we had conducted a comparative analysis of the mineral composition of new products according to 10% of human daily needs (Table 1).

Analysis of these data proves, that through the use of fillers a butter is enriched with all the macroelements, but their level is below of 10%.

Microelement composition of butter with fillers is characterized by the presence of iodine and selenium in amounts that exceed 10% of the dietary reference intake rates of these ingredients. Thus, the content of iodine and selenium in the investigated



samples of butter assumes they are products with functional ingredients, allowing them to recommend for the use of both prevention and deficiency of iodine and selenium in the diet.

Table 1

Assessment of compliance of seaweed mineral fillers in butter according to the dietary reference intake

Element	Butter with					10% of the dietary reference intake rates, mg [7]
	control	Laminaria	Fucus	Spirulina	Cystoseira	
<i>Macroelements</i>						
Calcium	10.16±0.21	11.91±0.37	16.56±0.60	13.18±0.54	49.98±1.16	120.0
Potassium	15.53±0.34	39.14±0.93	22.59±0.92	28.29±0.45	37.98±1.32	100.0
Magnesium	0.52±0.03	1.89±0.08	1.76±0.06	1.86±0.09	1.56±0.05	40.0
Phosphorus	25.3±0.20	27.7±0.21	26.4±0.24	27.2±0.21	26.1±0.20	120.0
<i>Microelements</i>						
Iron	0.026±0.26	0.22±0.013	0.018±0.004	slight presence	0.014±0.004	1.50
Iodine	–	56.68 ± 2.23	65.45 ± 2.39	48.03 ± 1.81	25.59 ± 1.45	0.15
Selenium	–	5.41 ± 1.4	3.41 ± 1.2	7.2 ± 1.3	3.2 ± 1.5	0.07

Conclusions. Consumer properties of butter with seaweed are characterized by higher organoleptic characteristics thanks to improved taste and texture, and can be recommended for elimination of iodine deficiency and increase of antioxidant properties of the human body.

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**USE OF LAMINARIA AND FUCUS BIOLOGICALLY ACTIVE
ADDITIVES AS INGREDIENTS FOR HEALTHY NUTRITION**

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**ИСПОЛЬЗОВАНИЕ БИОЛОГИЧЕСКИ АКТИВНОЙ ДОБАВКИ ИЗ
ЛАМИНАРИИ И ФУКУСА В КАЧЕСТВЕ ИНГРЕДИЕНТОВ ДЛЯ
ПИТАНИЯ ОЗДОРОВИТЕЛЬНОГО НАЗНАЧЕНИЯ**

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Abstract. *The article deals with the assessment of the possibility of biologically active food additives from seaweed (BAA) using – laminaria and fucus, as ingredients for healthy nutrition.*

Keywords. *Laminaria, fucus, chemical, amino acid and mineral composition.*

Аннотация. *В статье дана оценка возможности использования биологически активных пищевых добавок (БАД) морских водорослей – ламинарии и фукуса, в качестве ингредиентов для питания оздоровительного назначения.*

Ключевые слова. *Ламинария, фукус, химический, аминокислотный и минеральный состав.*

Recently the trend of a healthy lifestyle and adherence to the principles of balanced nutrition becomes relevant. When identifying the imbalance in nutrition structure of the population regarding the main components, the necessity to find a solution to its correction is becoming urgent [1, 2].

Butter is one of the most popular and essential food products. This is a product with a high concentration of milk fat, including natural fats, which have the highest nutritional and biological value.

It should be noted, that today in the production of butter they widely use food ingredients targeted at the use of the additives of natural origin, and having specific functional properties, a wide range of colors and flavors, a higher content of biologically active substances, micro- and microelements. However, expansion of the range of these types of products does not lose its relevance.

One of the prospective directions in the production of healthy products is the use of brown algae in the form of seaweed dietary supplements – laminaria and fucus. Considerable amount of works is devoted to the properties of brown algae and the possibility of their use for food fortification [1]. However, fishing season, especially drying process have a significant effect on the properties of algae.



The object of research is a biological value of BAA from laminaria and fucus seaweed produced by "B-MIN" Ltd, the Russian Federation.

Research subject is amino acid and mineral composition of the algae.

Amino acid composition of proteins was studied by ion exchange chromatography method on an automated analyzer Biotronik LC 2000 (Germany), the amount of tryptophan – by a colorimetric method after the alkaline hydrolysis of the samples; mineral structure – according to the State Standard DSTU ISO 11885:2005 by atomic-emission spectrometry method with inductively linked plasma.

Results of the study. Comparative characteristics of macro and micronutrients in BAA from Laminaria and Fucus are presented in Table 1.

Table1

Characteristics of compliance of a content of macro- and microelements in laminaria and fucus

№ 3/II	Element	Laminaria	Fucus	10% of the dietary reference intake rates, mg [3]
1.	<i>Macroelements</i>			
1.1	Calcium	1340, 3 ± 35,4	686,5 ± 25,3	120,0
1.2	Potassium	448,2 ± 15,6	295,9 ± 12,7	100,0
1.3	Magnesium	124,1 ± 11,5	44,5 ± 0,8	40,0
1.4	Phosphorus	143,1 ± 8,6	134,1 ± 7,8	120,0
2.	<i>Microelements</i>			
2.1	Iron	8,75 ± 0,52	3,56 ± 0,33	1,50
2.2	Iodine	56,68 ± 2,23	65,45 ± 2,39	0,15
2.3	Selenium	5,41 ± 1,4	3,41 ± 1,2	0,07

Data analysis has shown that the algae are rich in potassium and can meet from 2.9 up to 53.6% of the daily needs of this element. Especially valuable is the high iodine content, in all samples it exceeds the daily rate. This mineral is needed for normal functioning of human thyroid.

To characterize the nutritional and biological value it is important to determine the amino acid composition of algae. The assessment of the compliance of the amino acid composition of Laminaria and Fucus proteins to the perfect protein is presented in Table 2.

The data in Table 2 show that additives from laminaria and fucus have the whole spectrum of essential acids, but their number is inferior to the perfect protein according to the FAO/WHO scale. Qualitatively amino acid composition of algae is identical, but the differences are manifested in the quantitative content. Among the essential amino acids only the amount of threonine in BAA from laminaria is close to their value in a perfect protein, and in additives from fucus it exceeds its content. The fact is that the amino acid threonine supports the normal digestive system functioning, and is actively involved in the processes of digestion and assimilation of nutrients.

Thus, the use of biologically active food additives from algae – laminaria and



fucus –in butter production enriches this product with microelements, essential and nonessential amino acids and allowsto expand the range of healthy food products.

Table2

The assessment of the compliance of the amino acid composition of laminaria and fucus proteins to the perfect proteinin FAO/WHO scale

Amino acid term	Perfect protein FOA/WHO, g per 100 g of protein	Laminaria, *g/100 g of proteinбел ка	Fucus* g/100 g of protein	Laminaria score, %	Fucus score, %
<i>Essential amino acids, including</i>					
Threonine	4,0	3,88	4,89	87,0	122,2
Valine	5,0	3,21	4,22	64,2	84,4
Methionine + Cystine	3,5	1,69	1,0	48,2	28,5
Isoleucine	4,0	2,55	3,21	63,7	80,2
Leucine	7,0	4,68	5,82	66,8	83,1
Phenylalanine + tyrosine	6,0	2,85	1,49	47,5	16,6
Lysine	5,5	2,86	3,76	52,0	68,3
Tryptophan	1,0	Slight presence	Slight presence	-	-
Total	36,0	21,72	24,39	-	-
<i>Nonessential amino acids, including</i>					
Aspartic acid		6,84	8,95		
Serin		3,52	4,14		
Glutamic acid		7,83	12,73		
Proline		2,93	3,46		
Glycine		3,97	1,49		
alanine		6,47	5,02		
Arginine		2,89	3,07		
Total		56,17	63,25		

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Kalinovskaya I.N., Katovich O.M., Chukasova-Ilyushkina E.V.
**THE TECHNOLOGY OF MULTILAYER MATERIALS WITH FLAME
RETARDANT FINISHING OF COTTON WASTE PRODUCTION**

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**ТЕХНОЛОГИЯ МНОГОСЛОЙНЫХ МАТЕРИАЛОВ С
ОГНЕЗАЩИТНОЙ ОТДЕЛКОЙ ИЗ ОТХОДОВ
ХЛОПЧАТОБУМАЖНОГО ПРОИЗВОДСТВА**

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Abstract. The paper deals with the technology of multi-layer materials with flame-retardant finishing of cotton waste production. A yarn producing technology of waste cotton production system for carded open-end spinning. The mathematical dependences for determining the properties of textile materials as a result of fire-retardant finish. The parameters of the tissue adhesive and a basis for the preparation of the laminate.

Key words: laminate, fireproof finish, carded spinning system, waste cotton production.

Аннотация. В работе рассматривается технология многослойных материалов с огнезащитной отделкой из отходов хлопчатобумажного производства. Разработана технология получения пряжи из отходов хлопчатобумажного производства по кардной системе прядения пневмомеханическим способом. Получены математические зависимости позволяющие определить свойства текстильных материалов в результате огнезащитной отделки. Определены параметры склеивания ткани и основы при получении многослойного материала.

Ключевые слова: многослойный материал, огнезащитная отделка, кардная система прядения, отходы хлопчатобумажного производства.

Not reduced interest in the world to modern multi-layer materials having excellent properties as compared with traditional textile. And if you add that in this case solves the problem of the correct use of the waste production of cotton and cotton fiber low grades, the production of this type of material and becomes cost-effective.

For the processing of cotton spinning waste production system used carded cotton spinning production line pile - card sliver, which produces tape for power spinning machines, which use spinning spindleless ways. a production line system allows to produce yarn in 2 - 4 transition.

In terms of «Gronitex» (Republic of Belarus) developed a technology for producing large yarn linear density of production waste carded spinning system. In the production of yarn waste carding machine from Rieter C60 were used – 50 % and combing noil with Rieter machines – 50 % [1].

The yarn of cotton spinning waste production received open-end spinning. To



increase the tensile load of yarn and its alignment on the structure of the single yarn was twisted in two additions on the twisting machine double torsion Geminis company Savio.

The resulting spun yarn linear density of $50 \text{ tex} \times 2$ investigated the physico-mechanical properties and performance of the device *nerovnoty* using Uster Tester 5.

In terms of «Baranovich Cotton Production Association» (Republic of Belarus) obtained spun yarn processed into fabric. Basic physical and mechanical characteristics of severe tissue Article 943: width - 239.1 cm, the surface density - 118.8 g/m^2 , the breaking load of the fabric strip $50 \times 200 \text{ mm}$ - 196 N (base) and 310 H (ducks).

Analysis of the tissue quality indicators leads to the conclusion that on the physical and mechanical characteristics it meets the requirements of STB 969-2010.

The resulting fabric can be used as a decoration of furniture, window decorations, openings (shutters, roman blinds and Japanese, roll-curtains), in the manufacture of textile wall coverings and other laminates. Such materials are requirements to ensure fire safety: flammability, combustibility, the ability of flame propagation along the surface; smoke-forming ability; the toxicity of combustion products. Therefore it was necessary to furnish special fire-retardant fabric obtained.

In these studies to impart fire-retardant properties of the resulting fabric is selected «Clariant» (Switzerland) Pekoflam DPN.

Fire retardant properties of textile materials are imparted with the final finishing in a continuous manner on tenter-drying machine. Application sizing composition is carried out by padding followed by drying and heat-setting [2].

The sizing composition has the following composition: Pekoflam DPN 200-500 g/l; phosphoric acid 20 g/l; crosslinking agent Cassurit HML 60 g/l; Nuva HPU 50 g/l (to give water, dirt repellent).

As a result, preliminary studies found that to achieve the desired flame retardant effect it is necessary to determine the optimal drug concentration Pekoflam DPN and the fusing temperature, which depends on the type of fiber, the surface density of the material, its structure. An analysis of the influence of various factors on the properties of the material with a special finish Pekoflam DPN, during the experiment as input parameters adopted: the concentration of the flame retardant solution for dressing, g/l, X_1 ; fixing temperature, °C, X_2 .

As optimization criteria adopted by the flammability performance of textile materials: Y_1 - oxygen index, %; Y_2 - smoke generation coefficient, m^2/kg ; Y_3 - flammability (char the length), mm.

These samples were tested in accordance with GOST 12.1.044-89 paragraph 4.14 (oxygen index), GOST 12.1.44-89 paragraph 4.18 (coefficient of smoke), the SNB 11.03.2 -. 21 § 6.6 (flammability fabric) under laboratory conditions. EE «VSTU» and the research center of the Vitebsk regional Ministry for Emergency Situations management.

As a result, processing and analysis of experimental determined mathematical models of investigated parameters, which are as follows:

- oxygen index: $Y_1 = 35,67 + 4,68X_1 + 2,12X_2 - 1,65X_1^2$;
- smoke coefficient: $Y_2 = 294,03 - 14,15X_1 + 14,2X_{11} + 1,075X_{12}$;



– flammability: $Y_3 = 37 + 0,33X_1 - 4,667X_2 + 0,667X_{22}$.

The following qualitative indicators adopted for optimization that will be attributed to the group of developed materials flammability: oxygen index of 40 %; moderate smoke-forming ability (smoke index) - no more than 306 m²/kg, burning height - no more than 34 mm.

After imparting flame retardant properties of the fabric of production and waste cotton cotton low grades it was used to produce multi-layer textile material consisting of cloth and fabric bases [3].

For compounds with a cloth woven fabric substrate (as a base can be: paper, fleece, nonwoven textile material) is applied to the base layer adhesive materials are then gluing unit (a pair of rollers creating a pressure).

The host applied external pressure (P_B , Pa) defined by the formula

$$P_g = q \cdot l_{ck} \cdot \sqrt{R \times ((H_1 + H_2) - H_3)}, \quad (1)$$

where q – specific bonding pressure, Pa/cm²; l_{ck} – length of the glued area, m; R – radius of the rollers, cm; H_1 – the thickness of the textile web, cm; H_2 – the thickness of the base web with adhesive applied thereto, cm; H_3 – the thickness of the wall covering in the nip rollers, cm.

As a result of studies to determine the optimum pressure bonding site found that the specific pressure (q) must be 630 - 945 Pa/cm².

The results of the study obtained a sample of the laminate, which is the top layer of fabric waste cotton production and cotton fiber low grades, which has flame-retardant properties, the bottom layer - fleece.

The material obtained has the following properties: color fastness to light - 5 points, abrasion resistance - not less than 1.0 thousand cycles - layer bond strength of at least 25 cN, stiffness - 0.20 - 0.25 H, thickness -. 1.5 - 1.8 mm, the surface density - 300 - 360 g/m².

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Polischuk L.V., Kalashnyk O.V., Kyrychenko O.V., Moroz S.E.
**EVALUATION OF QUALITY OF TABLE LINEN BY GRAPHICAL
METHOD**

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Поліщук Л.В., Калашник О.В., Кириченко О.В., Мороз С.Е.
**ОЦІНЮВАННЯ ЯКОСТІ СТОЛОВОЇ БЛИЗНИ ГРАФІЧНИМ
МЕТОДОМ**

Abstract. We consider the possibility of evaluation of table linen, namely cotton napkins, using graphical methods. Indicators of napkin quality are defined using standard methods. The following values of indicators such as number of stitches per 10 cm, breaking load, capillarity, shrinkage, and the size of the product do not meet the requirements of regulatory documents and manufacturers' information.

Key words: table linen, napkins, evaluation, quality, breaking load, capillarity, changes in linear dimensions after wet treatments.

Introduction.

The market of fabric in Ukraine is overfilled with various goods of domestic and foreign production. However, their quality level does not always meet regulatory requirements, consumer expectations, etc.

Napkins are a critical element of table and interior decoration. It has been found that napkins for table setting perform both aesthetic function, and practical one - protecting clothes from accidental drops and crumbs of food. Nowadays table-napkins are made from a variety of fabrics; while choosing them it is important to pay special attention to quality indicators. Choosing the right material for manufacturing napkins will allow to simplify care, keep them perfectly clean and extend their service life.

The main text.

Object of study is an embroidered napkin *Arya* with product number 1500116 assorted of 50 × 70 cm size, in pack, produced by TURKUAZ TEKSTIL company (Turkey). Quality requirements and test methods for cotton waffle piece goods are set by State Standard 11027-80 [1]. Standard methods have been used for defining regulatory indicators.

In accordance with State Standard 3811-72 [2], the length and width of piece goods were measured in three points using a simple ruler and were calculated as the arithmetic average of the results of three measurements.

To determine breaking load during uniaxial stretching, the PT-250M-2 machine was used; its design and mode of operation are based on deformation of fabric strips and load measurement, extensibility during fabric break, which it acquires while stretching. The mode settings for tensile-testing machine PT-250M-2 and sample preparation have been set by State Standard 3813-72. [3]

Capillarity of wafer piece goods has been defined in accordance with State Standard 3816-81 [4]. Capillarity was determined by the height a 1% solution of potassium dichromate rose in the unit sample of 300 × 50 mm after 30 minutes. The



arithmetical average of the results of three measurements calculated with the accuracy of less than 1 mm was taken as the final test result.

The index of change in linear dimensions after wet treatments was determined by the method of State Standard 30157.0-95 [5] and State Standard 30157.1-95 [6].

The research of quality indicators of *Arya* napkins has yielded the results (Table 1) which will be the basis for evaluation of napkin quality.

Table 1

Research results of quality indicators of *Arya* napkin

№	Indicator	Value	
		regulatory and according to the manufacturer's information	measured
1	Product size, cm:		
	- length	70,0	68,5
	- width	50,0	48,1
2	Number of stitches per 10 cm, not less, units.	25	23
3	Breaking load, N (kgf) (average value):		
	- warpwise	559 (57)	285 (30)
	- fillingwise	294 (30)	305 (30)
4	Capillarity, not less, mm for 30 minutes.	100	21
5	Change in linear dimensions after wet treatments,%		
	- warpwise	8,5	14,0
	- fillingwise	5,0	2,0

As you can see, the results of the study show that quality indicators of cotton napkins do not meet the requirements of regulatory documents (number of stitches per 10 cm, breaking load, capillarity, shrinkage) and labeling characteristics indicated on the packaging – the size of the product.

To visually appreciate the research results and improve efficiency of evaluation of the quality level of cotton napkins, we constructed the diagram (Fig. 1) to compare the actual values of indicators with regulatory ones and the manufacturer's information.

The difference between qualitative characteristics was determined by comparing area of the polygons formed by triangles between axes of the chart. Area of polygon was calculated by formula 1:

$$S_b = \sum_{i=1}^n S_i, \quad (1)$$

where S_i – area of the i -th triangle, units, which is calculated by formula 2:



$$S = \frac{1}{2} \cdot a \cdot b \cdot \sin \alpha, \quad (2)$$

where α – angle between sides a and b .

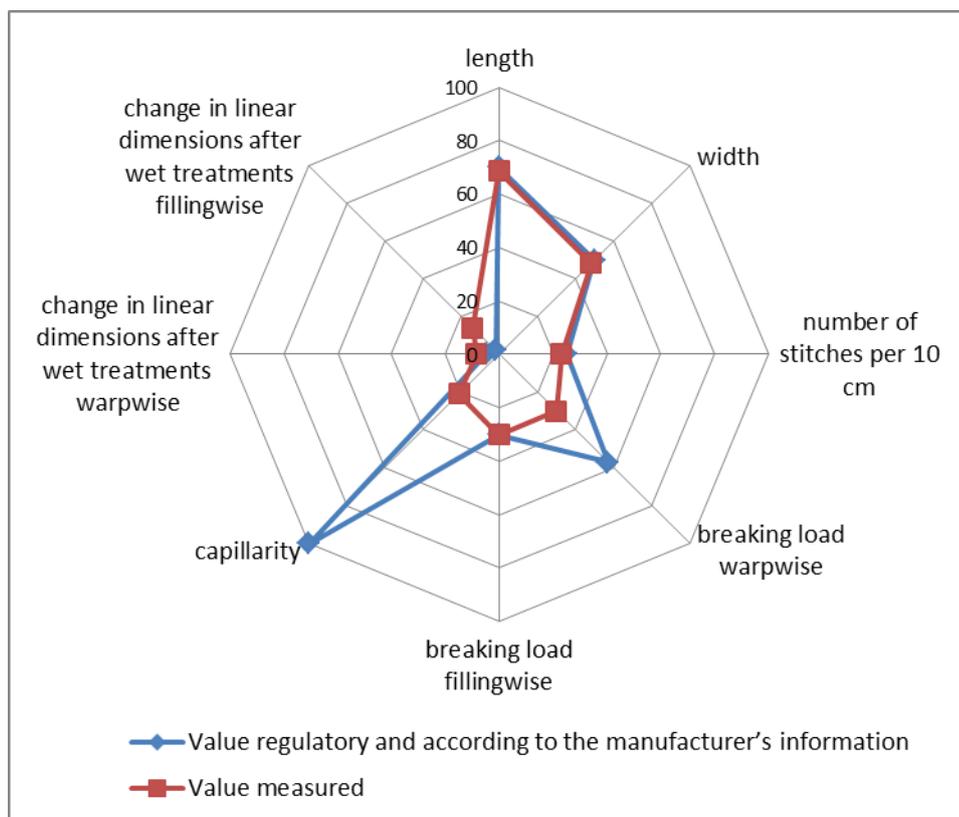


Figure.1. Comparison of qualitative characteristics of the object of study with standard values

The computer program was used to calculate areas of formed triangles; as a result of calculations, we received areas of the polygons which were compared with each other.

Area of the polygon that identifies the level of napkin quality by normative values and the manufacturer's information is 4078.238360, units; the actual value of the sample of *Arya* napkins is 2785,169867, units. Thus, the graphical method has made it possible to conclude that the quality level of *Arya* napkins produced by TURKUAZ TEKSTIL company (Turkey) is much lower than the level specified by regulatory documents.

Summary and Conclusions.

The quality level of table linen has to meet the needs of a wide range of consumers. Identification and comparison of values of napkin quality indicators allow to choose the products with high strength, capillarity, minimal shrinkage, of required size, etc.

The use of the graphical method clearly demonstrates the results of comparison of normative and actual values of the indicators under study. Calculation of areas of polygons makes it possible to assign a numerical value to the quality level of the object that has been investigated.

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DETERMINING THE OPTIMUM THICKNESS OF THE FOUNDATION PLATE OF THE SILO CONCRETE MIXING UNIT, TAKING INTO ACCOUNT SOIL CONDITIONS DRY PORT "ALTYN KOL"

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Бекбосынов Д.Б., Турашев А.С.

ОПРЕДЕЛЕНИЕ ОПТИМАЛЬНОЙ ТОЛЩИНЫ ФУНДАМЕНТНОЙ ПЛИТЫ СИЛОСА БЕТНОСМЕСИТЕЛЬНОГО УЗЛА В УСЛОВИЯХ СУХОГО ПОРТА «АЛТЫН КОЛЬ»

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Abstract. In this paper we describe the use of the stress-strain state of the base of the foundation and to determine the optimal thickness of the foundation plate with the use of mathematical models.

Key words: The foundation, silo, bunker, anisotropic base

Аннотация. В работе рассматривается напряженно-деформированное состояние основание фундамента и определение оптимальной толщины фундаментной плиты с использованием математической модели.

Ключевые слова: Фундамент, силос, бункер, анизотропное основание.

Kazakhstan in the world by area is the ninth largest and has the longest continuous land border.

The land border in the north and west of the border with Russia, on the east by China, on the south by Kyrgyzstan, Uzbekistan and Turkmenistan. The total length of the land borders is 13 200 km.

Due to its favorable geographical location of Kazakhstan, as in the days of the "Great Silk Road", continues to service several international transport corridors from North to South and from West to East, thereby linking the promising regions for the development of trade relations.

Today, Kazakhstan is implementing several large-scale projects. One of the most important is the "New Silk Road" and the new economic policy "Nurly Zhol - Path to the Future", which is to revive the country's historic role as the main binder continent level and turn it into the largest business and transit bridge between Europe and Asia.

As part of a large-scale project in the west of Kazakhstan has "Seaport Aktau", and in the east dry port «KTZE-Khorgos Gateway».

KTZE-Khorgos Gateway Dry Port introduced in 2015, it is strategically located on the Kazakh-Chinese border on Kazakhstan territory, in the Panfilov district of Almaty region.

To improve the effectiveness of management of infrastructure facilities, as well as increasing the capacity of the dry port pleasing range of economic and social measures. Thanks to these measures only in the first half of this year from China - Europe - China through Kazakhstan proceeded 429 container trains, which is 2.4



times more than in the same period of 2015.

On the territory of FEZ "Khorgos-Eastern Gate", in addition to creating a dry port, built an infrastructure that will ensure the work of the FEZ. Build housing for social workers, developed a draft master plan for the construction of a new city with a population of 100 thousand inhabitants - Nurkent city.

In addition to the dry port it is planned to construct such objects as objects of agricultural and food industry, light industry for the production of leather and fur raw materials of primary processing, heavy industry for the production of metal products, as well as facilities for the assembly of machines and equipment.

Panfilov district of the Soviet era has always been famous for its agricultural sector, and the coming industrial cities - Almaty are in a distance of 350 km, 336 km of Taldykorgan.

Like other regions of Kazakhstan, the climate of the region is sharply continental and geological structure of a variety of soil.

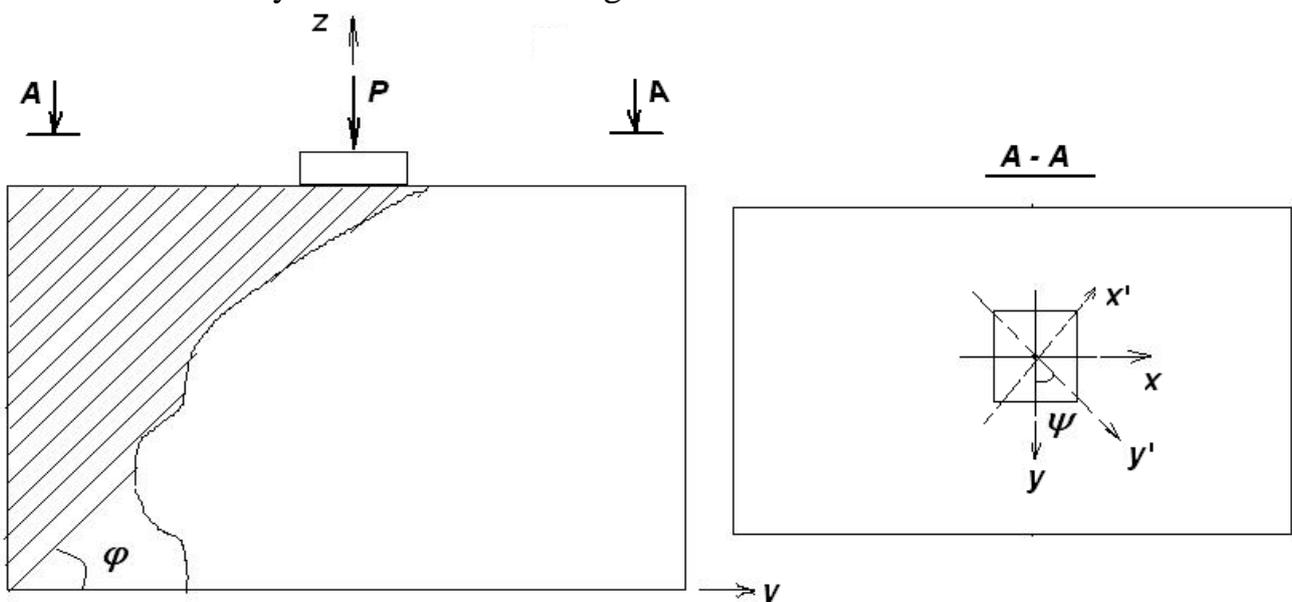
In addition, the construction site is located in an 8-point seismic zone, the soils are not only isotropic properties, but the properties of the anisotropy.

In this regard, the design of buildings and structures in the region, it is necessary to take into account the complex special collaboration system "Base - base plate".

Under the joint venture 3.02-128-2012 RK / 1 / foundations separate silos and silo buildings should be designed as a monolithic reinforced concrete beamless slabs. On the rocky soil and coarse soil is allowed to take the foundations of free-standing, band or ring, monolithic or prefabricated.

Pile foundations are usually provided when the calculated deformation of the natural base exceeds limits or does not provide its stability, while in other cases the feasibility study.

This article discusses the problem of anisotropic elastic static system "foundation slab-foundation", when in vertical plate are constant static load. Design scheme of such a system are shown in Figure 1.



Picture 1

The equations of generalized Hooke's law / 2 / for an anisotropic plate and the



anisotropic base can be represented as:

$$\begin{aligned}
 \sigma_x &= e_{11}\epsilon_x + e_{13}\epsilon_z + e_{14}\gamma_{yz} + e_{15}\gamma_{xz} + e_{16}\gamma_{xy}, \\
 \sigma_x &= e_{31}\epsilon_x + e_{33}\epsilon_z + e_{34}\gamma_{yz} + e_{35}\gamma_{xz} + e_{36}\gamma_{xy}, \\
 \tau_{yz} &= e_{41}\epsilon_x + e_{43}\epsilon_z + e_{44}\gamma_{yz} + e_{45}\gamma_{xz} + e_{46}\gamma_{xy}, \\
 \tau_{xz} &= e_{51}\epsilon_x + e_{53}\epsilon_z + e_{54}\gamma_{yz} + e_{55}\gamma_{xz} + e_{56}\gamma_{xy}, \\
 \tau_{xy} &= e_{61}\epsilon_x + e_{63}\epsilon_z + e_{64}\gamma_{yz} + e_{65}\gamma_{xz} + e_{66}\gamma_{xy},
 \end{aligned}
 \tag{1}$$

where given the elastic moduli e_{kl} ($k, l = 1, 3, 4, 5, 6$), through modules d_{ij} defined by (3 and 4).

$$e_{kl} = d_{kl} \tag{2}$$

$$d_{11} = a_{11} \cos^4 \psi + (2a_{12} + a_{66}) \sin^2 \psi \cos^2 \psi + a_{22} \sin^4 \psi,$$

$$d_{12} = a_{12} + (a_{11} + a_{22} - 2a_{12} - a_{66}) \sin^2 \psi \cos^2 \psi,$$

$$d_{13} = a_{13} \cos^2 \psi + a_{23} \sin^2 \psi,$$

..... (3)

.....

.....

$$d_{66} = a_{66} + (a_{11} + a_{22} - 2a_{12} - a_{66}) \sin^2 2\psi$$

Equations of state of anisotropic material foundation slab are also written in the form (1), only the expressions for modules d_{ij} (4) instead E_k, ν_k, G_2, φ and ψ we should use the appropriate elastic constants and angles φ and ψ anisotropic material plate $E_k^n, \nu_k^n, G_2^n, \varphi^n, \psi^n$. From equation (1) is easy to obtain the corresponding equations of plane-strain and elastic isotropic. To do this, you must take the values of the angles $\psi^n = \psi = 0$, and for an elastic isotropic, then $E_k = E, \nu_k = \nu, G_2 = G, E_k^n = E^n, \nu_k^n = \nu^n, G_2^n = G^n$.

The boundary and contact conditions take a solved problem in the following order: On top smooth boundary l Plate act normal AC voltages:

$$\sigma_z^n = P(x), \tau_{yz}^n = \tau_{xz}^n = \tau_{xy}^n = 0; \tag{4}$$

the lower boundary of a smooth plate firmly and continuously engaged with the base:

$$\sigma_z^n = \sigma_z, \tau_{yz}^n = \tau_{yz}, \tau_{xz}^n = \tau_{xz},$$

$$u^n = u, w^n = w, v^n = v \text{ при } -a \leq x \leq a; \tag{5}$$

The lateral boundaries of the "AE" and "the DF" (7), as well as the lower boundary of "the EF" (8) are not deformed by the action of the applied normal stress:

$$u = w = v = 0 \text{ при } x = \pm \infty Na, -H \leq z \leq H; \tag{6}$$

$$u = w = v = 0 \text{ при } x = \pm \infty Na, z = -H. \tag{7}$$

Thus, the task of studying the static stress and strain state of anisotropic elastic



spatial system "foundation slab-foundation" is reduced to a special quasi-spatial elastic problem generalized plane deformation - the problem of two variables / 2, 3 /.

The set contact edge of half the problem of determining the stress and anisotropic half-space displacement and the deformable plate, which are in equilibrium under the action of normal stresses at the upper boundary of the latter, with the boundary conditions (6-7), a strict analytical methods to solve very difficult.

Therefore, to analyze the stress state of the layered anisotropic medium involve numerical method for Applied Analysis - Finite Element Method (FEM) / 4 /.

As is known, the system of resolving algebraic equations FEM relative displacements of all the nodes is given by

$$[R]\{U\} = \{F\}, \quad (8)$$

Where $\{U\}$ - the matrix of unknown movements of all system components;

$\{F\}$ Matrix of the given forces in the nodes.

Solving basic algebraic equations $3N$ order (5) (where N - number of nodes), taking into account boundary conditions and using methods of linear algebra, we find movements $\{U\}$, all N nodes, then strain through them respectively $\{\varepsilon\}$ and a voltage $\{\sigma\}$ calculated at each element.

Numerous calculations have shown that the angle of incidence of the isotropy plane substantially affect the nature of the distribution of displacement.

The analysis also shows that with an increase in the deflection angle to the longitudinal axis of the plate from the line stretch isotropic plane ψ , the total character of the distribution points of the boundary move it does not change, although the degree of asymmetry relative to the vertical axis z decreases.

Where $\varphi = \psi = \pi / 2$ Based in the anisotropic displacement will be the same as in the half-plane isotropic. With the growth of the deflection angle ψ at a constant angle of incidence of the isotropy of the vertical movement w decreases.

With the increase in rigidity of the elastic plate the vertical movement is reduced and the contact section of the system is also observed asymmetry in the inclined plane of isotropy $\varphi \neq 0$ and this picture is in motion w values saved ψ and for $\varphi \neq \pi / 2$.

Conclusions: In the calculation of foundations on anisotropic substrates is necessary to take into account not only the properties of the soil, but the corners of occurrence of layered anisotropic soil φ and the location of the foundation plate about the z -axis, and take into account the angle ψ .

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BIOETHANOL AS A TRANSPORTATION FUEL

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БИОЭТАНОЛ КАК ТОПЛИВО ДЛЯ ТРАНСПОРТА

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Abstract. In this paper we describe the use of cellulose as a feedstock for bioethanol production.

Key words: bioethanol, cellulose, greenhouse gas emissions, bioethanol yield.

Аннотация. В работе рассматривается перспектива использования в производстве биоэтанола сырья, содержащего целлюлозу.

Ключевые слова: биоэтанол, целлюлоза, выброс парниковых газов, выход биоэтанола.

Introduction — History of Bioethanol as a Transportation Fuel

Ethanol and ethanol blends have a long history as alternative transportation fuels. As far back as 1826, Samuel Morey used an ethanol turpentine mixture as the fuel in his experiments with internal combustion engines. In 1860, Nicholas Otto began experimenting with ethanol-powered internal combustion engines. In the United States, bioethanol and ethanol turpentine blends were popular as fuels long before the development of petroleum crude oil-based gasoline as a fuel. Oil was found in 1859 in Pennsylvania, and later, the discovery of a ready supply of oil in Texas and other parts of the United States coupled with unfavorable taxation on ethanol-based fuels made gasoline and kerosene more popular fuels. Early US automobile engines were developed to run on pure ethanol or ethanol blends. In 1896, Henry Ford designed his first automobile, the “Quadricycle” to run on pure ethanol [1]. The famous Ford Model T, generally regarded as the earliest affordable automobile, was first manufactured in 1908 and was capable of running on gasoline, ethanol, or a gasoline-ethanol mixture [1].

Gasoline-ethanol mixtures have been used in Germany and France as early as 1894 by the then developing industry of internal combustion engines [2]. Brazil has utilized sugarcane-derived bioethanol as a fuel since 1925. By that time, the production of bio-ethanol was 70 times bigger than the production and consumption of gasoline [3]. In the United States bioethanol was widely used as a main transportation fuel until the early 1900s. However, with the discovery of new oil wells, ethanol became less competitive with gasoline as it became more expensive to produce than petroleum-based fuel, especially after World War II.

In the 1970s, the energy crisis was a turning point in the renewed interest in ethanol. During this period major industrialized countries of the world, particularly the United States, Canada, Western Europe, and Japan, were heavily affected; they faced substantial gasoline shortages and perceived and real elevated prices. The cri-



sis led to stagnant economic growth in many countries as oil prices climbed. Another factor that contributed to the renewed interest in ethanol was the discovery that methyl tertiary butyl ether (MTBE), which was added to gasoline to increase its octane rating and to help prevent engine knocking, was contaminating ground water [4]. During this time ethanol was identified as a less toxic favorable substituent for MTBE as an octane number enhancer, and as a result of this discovery, a slow but steady growth in the usage of ethanol was seen after the 1970s. Later, this movement was further supported due to mandates in the Clean Air Act Amendments of 1992 to reduce carbon monoxide emission by the addition of oxygenates. As a consequence of this amendment, use of ethanol as an oxygenated additive became widespread in the United States, and MTBE in gasoline was banned in almost 20 states by 2006. MTBE suppliers were concerned about potential litigation due to a 2005 court decision denying legal protection for its use. Then, MTBE's fall from grace opened a new market for ethanol as a primary substitute as an octane number enhancer [1].

However, the steep growth in ethanol consumption in the United States after 2005 as a transportation fuel was driven by a string of federal legislation aimed at reducing oil consumption and boosting energy security. The Energy Policy Act of 2005 required the use of 7.5 billion US gallons of renewable fuel by 2012, and the Energy Independence and Security Act of 2007 raised the standard to 36 billion US gallons of annual renewable fuel use by 2022 [5]. Of this requirement, 16 billion US gallons had to be advanced biofuels, defined as renewable fuels that reduce greenhouse gas emissions by at least 50% [5].

Alcohol Fuels

Alcohol fuels are oxygenated fuels containing one or more oxygen atoms per molecule. Monohydric acyclic saturated alcohols make a homologous series with general formula $C_nH_{2n+1}OH$. The lower members like methanol, ethanol are completely miscible with water, and as you go down the series, miscibility decreases as the larger alkyl group can make the molecule more hydrophobic. The boiling point and volatility of the alcohols increases as molecular weights increase in the series. Practically any of the small organic molecules in the alcohol family can be used as a fuel. However, alcohols that have been considered as motor fuels are methanol (CH_3OH), ethanol (C_2H_5OH), propanol (C_3H_7OH), and butanol (C_4H_9OH). Propanol has two isomers, n-propanol, and iso-propanol, whereas butanol has four isomers, n-butanol, sec-butanol, iso-butanol and tertbutanol. Nevertheless, ethanol is the most popular alcohol fuel due to lower toxicity and easy accessibility via fermentation methods.

Biobutanol is another renewable alcohol fuel under development, and can be prepared by fermentation as well as catalytic routes. Unfortunately, the rise in alcohol concentration causes butanol to be toxic to the fermentation microorganisms, killing them off after a period of time. This makes the butanol fermentation process expensive. Therefore, new modifications are constantly being researched, including the modification of enzymes and genes involved in biobutanol formation via fermentation. However, with the current state of technology, methanol and bioethanol fuels are technically and economically more suitable for internal combustion engines [6].



Fuel Characteristics of Ethanol

As discussed in the earlier section, ethanol was first introduced on a larger scale in the 1970s as a blend in fuel to serve as a replacement for methyl tertiary butyl ether (MTBE). Ethanol has a octane number of 108.6, comparable to 110 of MTBE [7]. Mixing about 10% of ethanol to gasoline can boost the octane number of the fuel [8]. The octane number is a measure of the gasoline quality for prevention of early ignition, which leads to cylinder knocking. Fuels with higher octane numbers are preferred in spark-ignition internal combustion engines (ICEs). An oxygenate fuel such as bioethanol provides a reasonable antiknock value [8]. In addition to a higher octane number, ethanol has broader flammability limits, higher flame speeds and higher heats of vaporization. These properties allow for a higher compression ratio and shorter burn time, which lead to theoretical efficiency advantages over gasoline in an internal combustion engine. A comparison of important physical properties and fuel characteristics of ethanol, methanol and gasoline is shown in Table 1.

Table .1
Physical properties and some fuel characteristics of ethanol, methanol, and gasoline [9].

Property	Methanol CH ₃ OH	Ethanol C ₂ H ₅ OH	Gasoline C ₄ – C ₁₂
Molecular weight (g/mol)	32	46	~ 114
Specific gravity	0.789 (298 K)	0.788 (298 K)	0.739 (288.5 K)
Vapor density rel. to air	1.10	1.59	3.0–4.0
Liquid density (g cm ⁻³ at 298 K)	0.79	0.79	0.74
Boiling point (K)	338	351	300–518
Melting point (K)	175	129	–
Heat of evaporation (Btu/lb)	472	410	135
Heating value (kBTU gal ⁻¹)			
Lower	58	74	111
Upper	65	85	122
Tank Design/pressure (psig)	15	15	15
Viscosity (cp)	0.54	1.20	0.56
Flash Point (K)	284	287	228
Flammability/			



Explosion limit (%) Lower (LFL)	6.7	3.3	1.3
(%) Upper (UFL)	36	19	7.6
Auto ignition temperature (K)	733	636	523–733
Solubility in water	100% Miscible	100% Miscible	Negligible (~ 0.01%)
Azeotrope with water	None	95% Ethanol	Immiscible
Peak flame temperature (K)	2143	2193	2303
Minimum ignition energy in air (mJ)	0.14	0.23	–
Research Octane num- ber (RON)	108.7	108.6	91–93

First Generation Ethanol Production

The United States is the largest ethanol producer in the world, producing 56.04 billion liters, and Brazil is the second largest producer with 26.85 billion liters in 2015. These two countries together contributed to 85% of the world's fuel ethanol in 2015 (97.21 billion liters).

Almost all of the first generation ethanol produced in the United States is corn ethanol, and sugarcane is the main feedstock for its production in Brazil. Sugarcane gives a much higher ethanol yield compared to the corn used for ethanol production in the United States; a comparison of the yields is shown in Table 2.

Table 2.

A comparison of feedstocks; sugarcane and corn used for first generation ethanol production in Brazil and in the United States [1].

Feedstock	Annual yield (US gal/acre)	Notes
Sugarcane	727–870	Used as feedstock for most bioethanol produced in Brazil. Newer processing plants burn residues not used for ethanol to generate electricity. Grows only in tropical and subtropical climates.
Corn	330–424	Used as feedstock for most bioethanol produced in the USA. Only kernels are processed using first generation technology.

Advantages of Cellulosic Ethanol

Cellulosic ethanol is the biofuel produced from many forms of lignocellulosic biomass such as grasses, wood, agricultural wastes, or inedible parts of plants. The



use of lignocellulosic biomass for the production of biofuels, and particularly the cellulosic ethanol, has a number of advantages, as shown below.

1. Cellulosic biomass is the most abundant form of organic carbon on earth. Unlike corn and sugarcane now used to make most ethanol, cellulose is not used for food; therefore cellulosic ethanol will not have adverse effects on food supply and prices. As there is a very wide range of plant materials that can be used for cellulosic ethanol production, it can be grown in all parts of the world. Cellulosic ethanol can be made of many agricultural wastes like corn stover, wheat straw, rice straw, grasses, farm residues, industrial wastes, sawdust, forest thinnings, waste paper, and municipal wastes. Fast-growing woody crops such as poplar and willow are also attractive options for cellulosic ethanol production.

2. Cellulosic ethanol achieves a significant reduction in greenhouse gases compared to other forms of ethanol. On a life-cycle basis, all biofuels produce lower GHG emissions compared to gasoline. Corn-based bioethanol offers rather limited benefits, as it reduces GHG emissions by only 18% compared to gasoline. In contrast, cellulosic bioethanol results in almost 90% lower emissions [9]. On a life-cycle basis, not all bio-fuels are equal in terms of environmental benefits. The net energy balance of biomass to bioethanol conversion is the key parameter that explains the interest in using bioethanol fuel instead of fossil gasoline. From a life-cycle assessment (LCA) viewpoint, the ratio of the energy content of bioethanol to the net non-renewable primary energy consumed in the whole production process must be taken into consideration. As the approach is LCA oriented, the energy input must be estimated in terms of primary energy [11]. Studies have shown that corn-based bioethanol yields 20–30% more energy, typically fossil fuel energy, than is consumed in making it. On the other hand, sugarcane and cellulosic bioethanol yield renewable energy nine times worth the fossil energy used to produce them [9]. The reductions in carbon dioxide emissions mean that bioethanol is better for the environment. Using renewable resources-based bioethanol or bioethanol-gasoline blends as transportation fuels can significantly reduce gasoline use and exhaust greenhouse gas emission [6].

3. Land-use change (LUC) is another parameter used in evaluating the biomass-based renewable fuels. Dunn and coworkers from Argonne National Laboratory, USA, have recently published their results on a land-use change and greenhouse gas emissions from corn and cellulosic ethanol [12]. Land-use change occurs when land is converted to biofuel feedstock production from other uses or states, including forests, non-biofuel feedstock agricultural lands, and grasslands. This type of land-use change is at times called direct LUC. The resulting change in crop production levels like, for example, an increase in corn production, may cause a decrease in soybean production and in turn affect corn exports in one country, shifting the land uses in other parts of the world through economic linkages. This latter type of LUC is called indirect LUC and can be estimated through the use of economic models. A change in land use causes a change in carbon stocks above ground and below ground. As a result, a given LUC scenario may emit or sequester carbon. When a LUC scenario results in a net release of carbon to the atmosphere, it is debatable if biofuels result in GHG reductions at all [13, 14]. Of particular concern is the conversion of forests [15, 16], an inherently carbon-rich land cover that in



some cases may be a carbon sink. Their conversion to biofuel feedstock production land could incur a significant carbon penalty [17]. The estimation of LUC and the resulting GHG emissions is accomplished through the marriage of LUC data with aboveground carbon and soil organic carbon (SOC) data for each of the land types affected. The amounts and types of land converted as a result of increased biofuel production can be estimated with an agricultural-economic model, for example, a computable general equilibrium (CGE) model; several recent reports [18] provide an overview of CGE models their application to estimating LUC associated with biofuel production.

The researchers from Argonne National Laboratory investigated the effect of several key carbon content modeling parameters for the United States land-use change and greenhouse gas (LUC GHG) emissions. They used the international carbon emission factors from the Woods Hole Research Center, and the LUC GHG emissions were calculated from these LUCs and carbon content data with Argonne National Laboratory's Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) model. Some of the key results of their study are summarized in Table 3, showing the range of land-use change and greenhouse gas (LUC GHG) emissions (g CO₂e/MJ) for ethanol produced from switchgrass, miscanthus, corn stover and corn.

Table 3

Range of land-use change green house gas (LUC GHG) emissions (g CO₂e/MJ) for ethanol produced from switchgrass, miscanthus, corn stover, and corn [12].

	Switchgrass	Miscanthus	Corn Stover	Corn
Minimum US LUC GHG emissions	-3.9	-12	-0.24	1.2
Maximum US LUC GHG emissions	13	-3.8	-0.19	7.4
International LUC GHG emissions	6.7	1.7	-0.97	3.5
LUC GHG emissions range	2.7 to 19	-2.1	-1.21	4.7 to 11
Lifecycle GHG emissions range	10 to 26	-8.5 to -0.20	0.97 to 1.0	62 to 68

Argonne National Laboratory's study indicates that cellulosic ethanol production from miscanthus has the lowest LUC GHG emissions, whereas the highest is from corn ethanol [12]. In an earlier study, Scown et al. also reported comparable GHG sequestration (between -3 and -16 gCO₂e/MJ) for ethanol production using miscanthus grass, but their study was limited to active cropland [19].

This study clearly demonstrated the advantage of cellulosic ethanol varieties



over corn ethanol, as switch-grass, miscanthus, and corn stover produced lower LUC GHG emissions parameters in comparison to corn.

4. Processing lignocellulosic biomass for cellulosic ethanol through the saccharification-fermentation route leaves lignin as a byproduct, because only sugars can be converted to ethanol in this method. But, lignin can serve as an energy-rich boiler fuel for distillation of ethanol, or can be used as a raw material for lignin-based feedstock for the chemical industry. According to NREL analysis, there is enough lignin produced in these plants to provide all the energy needs of an ethanol production facility, and any excess lignin can be burned in thermal power plants to produce electricity [20]. Lignin-based, value-added chemicals, like vanillin, are interesting polymer precursors or monomers. Furthermore, lignin can be used as a filler or copolymer as well. The use of byproducts from the cellulosic ethanol plants for chemicals, renewable resources-based polymer production and power generation is known as the integrated bio-refinery concept, which will be an integral part of the sustainable energy landscape of the future. This possibility of generating value-added products and electricity from byproducts is another advantage in cellulosic ethanol.

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Abstract. Results of calorimetric research of hard and liquid biofuels samples heating value with application of bomb calorimeter combustion are presented.

Key words: biofuel, combustion value, bomb calorimetry, gross and net calorific value.

Анотація. Представлено результати калориметричних досліджень теплотворної здатності зразків твердого і рідкого біопалива із застосуванням бомбового калориметра згоряння.

Ключові слова: біопаливо, теплота згоряння, бомбова калориметрія, вища та нижча теплотворна здатність.

Introduction. Basic characteristic of any fuel is its heating or combustion value that characterizes the capacity of fuel for calorification at combustion. The heating value of traditional agile fuels mine-out from oil is well enough studied, unlike this characteristic for the numerous type of hard, liquid and gaseous types of biofuels, such as a bioethanol and biodiesel, and also their mixtures with traditional fuels.

Basic data and methods. The bomb calorimetry is one of the substances thermo-chemical research basic methods [1]. At the Institute of Engineering Thermophysics of National Academy of Sciences of Ukraine a number of bomb calorimeters for research the fuel samples combustion value are worked out and attested [2]. On Fig. 1 a measuring complex KTC-4 is presented which includes: the heat flow bomb aneroid isoperibol calorimeter (1), a computer block (2), two universal calorimetry bombs ВКУ- 2 (3), support and key for bombs (4) and press for sample making (5).

The calorimeter KTC- 4 basic technical data:

- the combustion value measuring range 10...40 kJ;
- basic relative error $\pm 0,2$ %;
- the measuring preparation time – up to 1,5 hours ;
- measuring time – 0,5 hours.

The calorimeters principle of operation is in a heat flow measuring, that appears at the fuel incineration, and its integration for heat determination that was evolved at the test sample combustion.

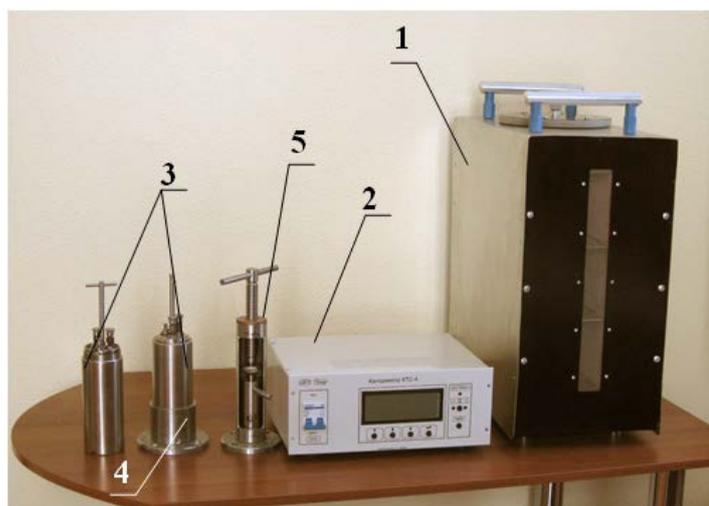


Fig. 1. The heat flow bomb calorimeter KTC- 4

The fuel test sample, prepared in accordance with the operating standards requirements, is burned at high pressure of oxygen in the calorimetric bomb filled by oxygen at 2,5...3,0 MPa pressure and accommodated in the calorimeters thermal block. The thermal block surface temperature is stabilized by the mounted electric heater with electronic regulator. A heat that is evolved at fuel test sample combustion is determined by the heat flow integration that is measured by the thermo-electric heat flow transducer. The information data measuring and processing is executed by a microprocessor device, and a result is a heat value (in Joules), that was evolved at the fuel test, that is represented on the electronic block digital display. A measuring result by a serial interface is passed to computer for further processing: bringing the adjustments, calculation the gross and net calorific value, printing a protocol. For the exception the temperature and air convection influences in a premise the calorimeter thermal block is placed in a climatic chamber. The line regulator is usually used because of supply voltage unstable.

The bomb calorimeter KTC-4 has a number of unique advantages compared to analogues: it provides an information data automatic measuring and processing, does not need the distilled water and premises with the special temperature-humidity conditions as distinct from traditional aquatic calorimeters.

The combustion value of numerous hard and liquid biofuels test samples was experimentally determined at a calorimeter KTC-4. Research objects had components that easily evaporating and flaming up at a contact with oxygen, and samples were burned in packing from a polyethylene. The diesel fuel basis substances are boiling and overflowing from crucible at combustion, and a burn result may be not fully. For the boiling prevention of such samples a cotton filler (cotton wool) was added. The combustion heat of polyethylene and filler (cotton wool) was preliminary determined by the same calorimeter and it was taken into calculation at experiments results data processing.

The fuel test sample mass M_{FUEL} , a polyethylene packing mass M_{PAC} , a lighting copper wire M_{WI} and filler M_{FIL} masses also are measured at preparation for test. During a calorimetry experiment carrying out in the device KTC-4 the heat value Q_{FUEL} that evolved at test sample combustion is determined (in Joules), and after the



test the mass of lighting copper wire rest M_{W2} is measured. If there are not burned bits and pieces of test sample in a bomb, experiment is considered as invalid.

The specific combustion heat of fuel in a bomb is calculated by a formula:

$$q_{BOMB} = (Q_{FUEL} - q_W \cdot (M_{W1} - M_{W2}) - q_{PAC} \cdot M_{PAC} - q_{FIL} \cdot M_{FIL}) / M_{FUEL}, \quad (1)$$

where q_{BOMB} – the specific combustion heat of fuel in a calorimeter bomb;

Q_{FUEL} – measured fuel test combustion heat;

$Q_W = 2510$ J/g – a lighting copper wire specific combustion heat;

$q_{PAC} = 46382$ J/g – a polyethylene packing specific combustion heat;

$q_{FIL} = 16700$ J/g – a cotton filler specific combustion heat;

The combustion heat measuring of every substance was carrying out two times.

In accordance to a standard [3], if the combustion heat measuring results in a bomb differ no more than 130 J/g, an average value that is considered the result of the combustion heat measuring in a bomb is calculated. If results differ more than 130 J/g, the third test have been carried out and the result is considered an average value between two the nearest.

The gross calorific value of fuel q_G is calculated by a formula:

$$q_G = q_{BOMB} - (94 \cdot S + q_3 \cdot \bar{V} / M_{FUEL}), \quad (2)$$

where S – a mass part of sulphur in a fuel, %;

$q_3 = 6$ J/cm³ – a formation heat of 1 cm³ 0,1 mole/dm³ aquafortis solution;

$\bar{V} = 5$ cm³ – a middle volume of 0,1 mole/dm³ alkaline solution that is expended for washout titration at the calorimeter calibration;

The net calorific value of fuel q_N is calculated by a formula:

$$q_N = q_G - 24,42 \cdot (8,94 \cdot H + W), \quad (3)$$

where 24,42 – a vaporization heat at 25°C calculating on 1% water appeared, kJ/kg;

8,94 – a hydrogen to water mass part conversion factor ;

H – a mass part of hydrogen in a fuel;

W – a mass part of water in a fuel.

The net calorific value calculation result is rounded off to the nearest value, multiple 10 kJ/kg. The admixtures and water contents are determined by normative documents [4, 5].

Results. The calorimetry researches results some types of hard and liquid biofuels samples are tabulated in a table 1.

Table 1

The biofuels samples researches results

Test sample	Humidity $W, \%$	Test calorific value, MJ/kg	
		gross q_G^T	net q_N^T
Wood briquettes	3,5	18,5	17,0
Graft briquettes	24,8	15,4	13,7
Biomixture of a 50% silo and 50% chicken dung	9,1	16,8	15,5
Beet bagasse granules	8,2	16,2	14,8
Sunflower husk granules	11,3	18,1	16,6
Milled peat	26,6	11,4	9,8



	0	15,5	14,5
Bioethanol	0,3	29,0	26,1
Biodiesel	0	40,9	37,3

Conclusions. Calorimetry analysis of different types of biofuels, including the bioethanol and biodiesel, and also granular wastes of food and processing industry, carried out by the bomb calorimeter KTC-4, confirms the high calorific value indexes of such fuels that testifies to expediency and economy of its making and mass use instead of traditional types of fuel.

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BIOLOGICAL SUBSTANCES PROPERTIES CALORIMETRYC COMPLEX ANALYSIS

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КОМПЛЕКСНИЙ КАЛОРИМЕТРИЧНИЙ АНАЛІЗ ВЛАСТИВОСТЕЙ БІОЛОГІЧНИХ РЕЧОВИН

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Abstract. A calorimetric methods and device for synchronous thermal analysis are considered for complex research of biological substances thermophysical characteristics.

Key words: drying, differential scanning calorimetry, synchronous thermal analysis, evaporation heat, heat capacity.

Анотація. Розглянуто калориметричні методи та прилад синхронного теплового аналізу для комплексного дослідження теплофізичних характеристик біологічних речовин.

Ключові слова: сушіння, диференціальна сканувальна калориметрія, синхронний тепловий аналіз, теплота випаровування, теплоємність.

Introduction. The pharmaceutical and biotechnological industries rapid development needs the new types of raw material using and corresponding analysis their thermophysical properties for productive processes optimization. The finishing stage of biotechnological, food, chemical and pharmaceutical production are drying process mainly. Desired product high quality and stability depends on the drying apparatus quality, the process technical automation and mechanization level, air cleanness ets.

Literature review. For the drying processes parameters calculation any raw material or substance in industrial scales it is necessary to know basic thermophysical characteristics of these materials: specific evaporation heat, specific heat capacity, heat conductivity coefficient, critical destruction temperature and other, that must be taken into account at the choice of drying method and equipment [1]. For this purpose the calorimetry methods of researches – differential scanning calorimetry (DSC) and microcalorimetry are applied that requires the corresponding device base existing.

In the second half of XX century for biological raw material drying processes researching the synchronous thermal analysis method (STA) is well-proven by leading scientists [2]. This method includes:

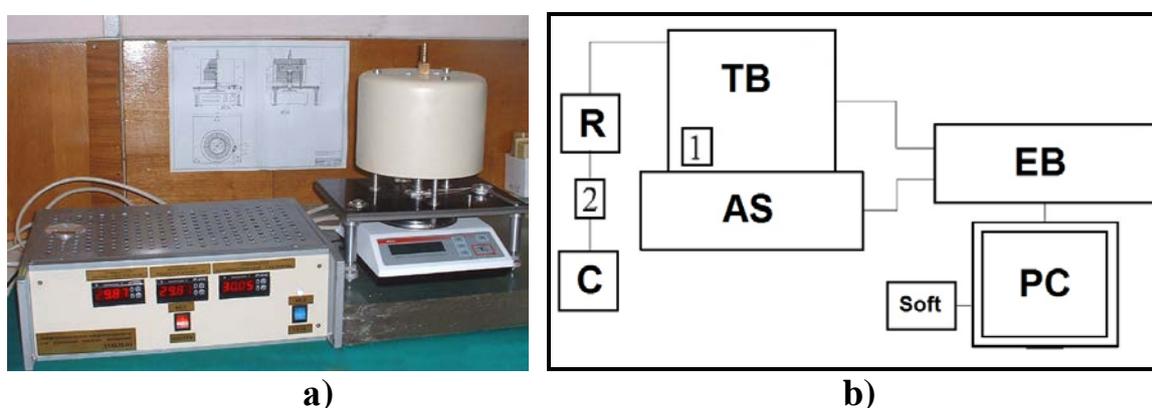
- differential microcalorimetry (DMC) – the test sample phase transfer energy



value measuring,

- thermogravimetry (TG) – the sample mass losses change in time registration.

Basic data and methods. At the Institute of Engineering Thermophysics of National Academy of Sciences of Ukraine a STA device DMCI-01 is developed and patented [3]. It combines calorimetric and thermogravimetric analyses and allows with sufficient reliability to define the specific evaporation heat of both, free and related to material moisture in the moist dispersible material thin layer drying process in laboratory or productive terms. The STA device DMCI-01 original view is shown on Fig. 1, a), structural scheme – on Fig. 1, b). This device is a functionally incorporated measuring complex from a thermal block (TB), an analytical scale (AS), a compressor (C) and receiver (R), an electronic block (EB) and personal computer (PC) with corresponding software (Soft) (Fig. 1, b).



**Fig. 1. STA device DMCI-01 original view (a) and structural scheme (b):
1 – a humidity sensor, 2 – air flow-sensor**

The STA device DMCI-01 operating principle based on the continuous and simultaneous measuring an experience substance test sample mass losses and heat value that is spent in time unit on moisture evaporation in the isothermal drying process of moist dispersible material or liquid in thin layer. The DMCI-01 device basic difference from the known analogues is possibility to carry out measuring at an optimal temperature condition, supporting the product surface temperature approximately equal to the ambient that is getting by the independent calorimetry platform temperature control.

STA device DMCI-01 basic technical data:

- specific evaporation heat measuring range 500...2500 J/g;
- basic relative error $\pm 0,5\%$;
- temperature range 18...105 °C;
- test sample mass 1...5 g.

DMCI-01 device thermal block is developing by a differential scheme version (fig. 2), that means an experience substance test sample 6 and the standard 7, which is the thermally inert substance, evaporation effects comparison. Upper 1 and lower 2 blocks supports the stationary set temperature by built-in electroheaters and control system and provides isothermal mode $T = const$ into a working chamber 8. The calorimetric platform 3 by basic electroheater carried into a temperature



$T_{CP} = T + \Delta T$, where a heat flow is being supported by the temperature difference $\Delta T = 4...10$ K through the an experience substance test 6 and standard 7.

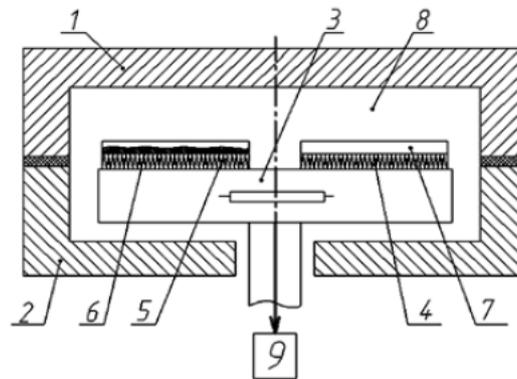


Fig. 2. STA device DMCI-01 thermal block schematic diagram

The air temperature around the material is supported constantly and all its heating activity equals a zero and totally heat value that expended to experience substance test sample and standard, that is measured by the differentially united sensors 4 and 5, is spent only on evaporation. At the same time the substance mass change in the drying process is fixed by analytical scale 9.

A calculation formula for the specific evaporation heat r determination is:

$$r = \Delta Q_{1-2} / (\Delta m / \Delta \tau), \quad (1)$$

where $\Delta Q_{1-2} = k \cdot \Delta E$ – a heat flow difference values, W, between cells there are an experience substance test sample (1) and standard (2) placed;

$\Delta m / \Delta \tau$ – an experience substance test mass time-history, kg/s

k i ΔE – an experimentally found conversion coefficient and differential signal of sensors 4 and 5 set under a cell with an experience substance test sample 6 and a standard 7.

The rating temperature is determined as a function $T = f(E_T)$, where $f(E_T)$ is a polynomial, that approximates temperature dependence of transformation function the used temperature measuring device with signal E_T .

On fig. 3 the graphically presented results the sample of apple research on drying at a certain temperature.

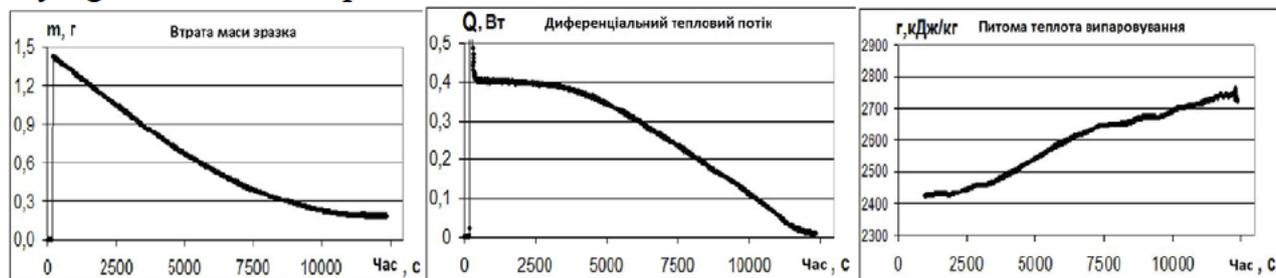


Fig. 3. The sample of apple research results on the device DMCI-01

Conclusions. The biological substances thermophysical properties calorimetric research and analysis methods review confirms perspective the STA method for getting the representative experimental data. The simultaneous STA (DSC/DTA) and TG analyses realization possibility at developed in IET NAS of Ukraine DMCI-01



device considerably facilitates and accelerates research the test samples different by a anatomic morphological structure and chemical composition, thermolabile materials and substances.

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**RESEARCH OF MATERIALS FOR THE FOOD INDUSTRIAL EQUIPMENT
EFFECTIVE HEAT INSULATION***National University of Life and Environmental Sciences of Ukraine**Kyiv, Heroyiv Oborony 13, 03041*

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**ИССЛЕДОВАНИЕ МАТЕРИАЛОВ ДЛЯ ЭФФЕКТИВНОЙ
ТЕПЛОИЗОЛЯЦИИ ОБОРУДОВАНИЯ В ПИЩЕВОЙ
ПРОМЫШЛЕННОСТИ***Национальный университет биоресурсов и природопользования Украины**Киев, Героев Обороны 13, 03041*

Abstract. In this article the results of the research thermophysical characteristics of modern insulating materials for the equipment isolation applied in food industry are represented.

Key words: insulation, heat conductivity, food industry.

Аннотация. В работе представлены результаты исследования теплофизических характеристик современных теплоизоляционных материалов для изоляции оборудования в пищевой промышленности.

Ключевые слова: теплоизоляция, коэффициент теплопроводности, пищевая промышленность.

Introducing. To the heat-insulation materials applied in food industry produce hard sanitary-hygienic requirements. They must contain the only closed pores, be ecofriendly, proof to corrosions, fungus and to the damage by rodents. To recommended for the food industrial equipment isolation materials belong the foam rubber, foam polyethylene, mineral cotton wool, rarer use shells from foamed polyurethane and expanded polystyrene.

Basic data and methods. The insulation materials efficiency basic parameters are their thermophysical properties: heat resistance and effective heat conductivity factor. For its determination at the Institute of Engineering Thermophysics NAS of Ukraine the IT-7C device was developed, metrology attested and practically implemented [1] (Fig.1). The symmetrical scheme of heat-metrical method is realized in it in accordance with the requirements of standards DSTU B.27-105 (GOST 7079) [2] and DSTU ISO 8301 [3] with the use of two identical primary heat flow transducers made according the DSTU 3756 [4].

Essence of the method regulated in [2, 3] is to create the stationary heat flow through a flat sample, directed perpendicularly to its facial (working) surfaces. The heat conductivity factor is determined on results measuring the sample thickness, its working surfaces temperature values difference and superficial heat flow density value getting regularly and unidirectionally through a sample.

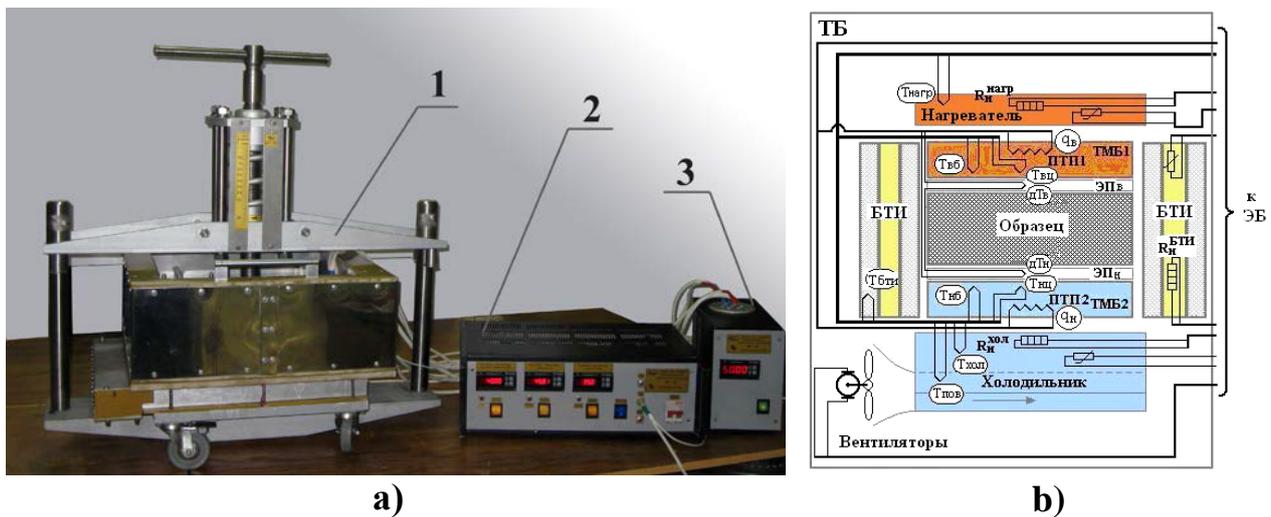


Рис. 1. The IT-7C device (a) and the thermal block functional scheme (b)

The IT-7C device (Fig.1, a) consists of three main blocks:

1 – a thermal block, in that the test sample material is placing and required temperature and thermal modes are providing (Fig.1, b);

2 – an electronic block containing facilities for the thermal modes adjusting, primary measuring data reception, pre-processing and transmission it to a computer for post processing by the corresponding software.

3 – a thermostating unit for thermocouples cold junction.

In accordance with the requirements of national and international standards the IT-7C device allows the thermophysical parameters measuring on building materials and heat insulation test samples square or round form from 100 to 300 mm overall dimensions and up to 120 mm thick with maximum productivity and rated accuracy.

The IT-7C device basic technical data:

- the heat conductivity coefficient value measuring range 0,02...3,0 W/(m·K);
- basic relative error $\pm 3\%$.
- the working temperature values range minus 235...450 K.
- the sample size 300×300×(10...120) mm.

At research preparation the test samples are given the proper shape, suitable for placing in a measuring cell: solid samples are polished for giving the working surfaces the plane-parallel form, for soft and fibred samples the additional accessory – distances or limitary frame are made. Before placing in the thermal block measuring cell samples are measured and weighed for the calculation of their density.

For reliable result at least three test samples of one material have to be measured in the dry state at the mean values of temperature $+10^{\circ}\text{C}$ and $+25^{\circ}\text{C}$ or in all working temperature range depending on the aim of experiment. The heat conductivity calculation formula is :

$$\lambda = h \cdot (\Delta T / \bar{q} - R_K)^{-1}, \quad (1)$$

were h – thickness of the test samples, m;

$\Delta T = T_H - T_C$ – difference of temperature values hot T_H and cold T_C sample working surfaces, K;

$\bar{q} = 0,5 \cdot (q_H + q_C)$ – superficial heat flow density mean value through hot q_H and



cold q_C sample working surfaces, W/m^2 ;

R_K – the summary contact heat resistance correction of measuring cell determined during device calibrating, $m^2 \cdot K/W$.

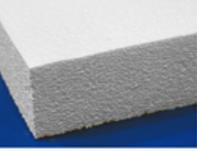
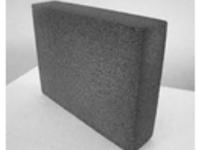
The heat conductivity value $\bar{\lambda}_T$ at the temperature T is determined as a mean value for N -samples heat conductivity $\lambda_{T,i}$ measured taking into account the measuring error δ by a formula:

$$\bar{\lambda}_T = \frac{1}{N} \sum_{i=1}^N \lambda_{T,i} + \delta. \quad (2)$$

Results. In a table 1 the researches results at IT-7C device of the modern heat insulation materials recommended for using in food industry are presented.

Table 1

The modern insulators heat conductivity determination experimental results

Name of material		Density, kg/m^3	Heat conductivity, $W/(m \cdot K)$	
			Certificate data	Experimental data
Foam polyurethane		40 ... 45	0,028	0,024...0,026
Mineral cotton wool		10 ... 13	0,031 ... 0,046	0,035...0,04
Eurobatex (Foam rubber)		85	0,033...0,044	0,036...0,038
Expanded polystyrene		10 ... 38	0,038...0,048	0,043...0,046
Foam glass		110...150	0,045...0,052	0,045...0,06

Conclusions. The experimental researches data (table. 1) of modern insulators heat conductivity coefficients is well correlate with certificate or passport data of these materials.

The researches results confirm the foam polyurethane high insulation properties, that, along with functional and hygienical, does it a leader for food industry equipment effective heat insulation, especially for the difficult form constructions.

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Mykhailovska E.V., Nalyvayko A.I.
THE RESEARCH OF THE COMPOSITION OF TABULAR WATERS OF
THE PRYCARPATHIANS

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ИССЛЕДОВАНИЕ СОСТАВА ПЛАСТОВЫХ ВОД ПРИКАРПАТЬЯ
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Аннотация. Исследовано содержание йода в пластовых водах нефтегазовых месторождений Прикарпатья. Предложено экспоненциальную зависимость содержания йода от минерализации пластовых вод месторождений Внешней и Внутренней зоны Прикарпатского прогиба.

По результатам исследований выявлено увеличение содержания йода от увеличения минерализации вод на этих месторождениях. Значительное содержание йода в пластовых водах месторождений Прикарпатского прогиба (больше 50 мг/л) свидетельствует о необходимости утилизации пластовых вод этих месторождений за счет усовершенствования систем сбора и подготовки. То есть на этих месторождениях возможно применение установок извлечения из воды йода, который может быть использован в других отраслях промышленности.

Ключевые слова. Пластовая вода, месторождение, утилизация, минерализация, йод.

Annotation. Iodine content in tabular waters of oil and gas fields of the was analyzed. The exponential dependence of iodine content on the salinity of tabular waters in fields of Outer and Inner Zone of Prycarpathians bending was proposed.

According to the research, the exponential dependences were found between the content of iodine and the salinity of tabular waters of this fields. The considerable content of iodine in tabular waters of the fields of Prycarpathian bending (more than 50 mg/l) testifies about the necessity of the utilization of tabular waters of these fields by improving collection and preparation systems.

The use of installations to extract iodine from water on this fields is one of the methods of improving such systems that can be used in other branches of industry.

Keywords. Tabular water, the field, utilization, salinity, iodine.

Tabular waters utilization is an actual problem for all industrial objects water of oil and gas industry. It's caused because tabular waters are aggressive in many cases, they cause an intensive corrosion of oil-field equipment and constructions.

The corrosion may result in tabular water leaks while gathering them and preparing, which may cause soil pollution as well as potable water sources pollution. Tabular water oil and gas fields are complex solutions that may contain a certain quantity of salts and microelements (iodine, bromine, boron, rubidium, barium,



molybdenum and others). Tabular waters composition depends on the nature of the oil stratum, physical and chemical properties of oil and gas. A sufficient quantity of iodine for industrial utilization prevails at oil and gas fields of Western Ukraine. Iodine content tabular waters is directly connected with processes of accumulation in sludges.

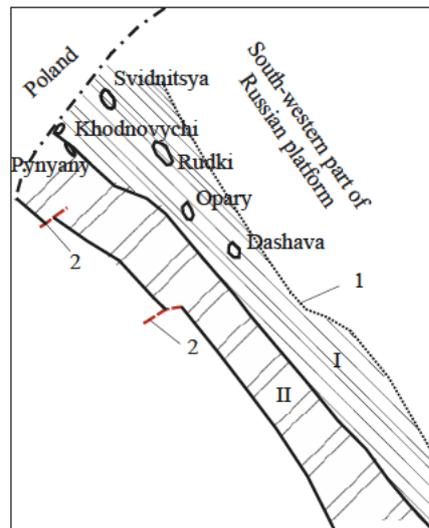
N.A Kuznetsova has made some experiments with the model of the stratum in conditions similar to tabular ones (temperature is under 150 °C, pressures is under 25 MPa), which have shown that temperatures to 150 °C are sufficient for almost complete (93%) transition of absorbed iodine from rocks into water. Thus, admitting the leading role of thermolysis in iodine release from rocks, temperatures under 100 - 150 °C should be considered optimal and sufficient [1]. The works by Kalabugin L.A, Ksenzenko V.I [1] Belonozhko P.N [2] Bakiyev S.A [3] Kryuchenko N.O [4] and others are consecrated to research of iodine content in such waters. According to the Vinogradov A.P [5], iodine accumulation in underground water of deposits and its considerable content in them is connected with the history of oil and gas formation and it cannot be disagreed to. A chemical composition of tabular waters depends, to considerable extent, on the value of their salinity. The extent of their salinity varies from a some hundred grams per 1 m³ in fresh water and up to 80 kg/m³ in concentrated pickles. According to the chemical composition, waters are more complex than according to the level of their salinity. That is why the purpose of the work is to analyze the results of iodine content in the example of the Prycarpathians and reveal dependences of iodine content of salinity to analyze the possibility of industrial utilization of such waters.

In the geological and structural attitude the Carpathians belong to one geological region the affined structure, the composition of rocks, the conditions of their formation and the character of useful minerals. This is a young mountain area [6]. Almost all known oil and gas fields of this region are connected with the Prycarpathian bending, in the limits of which two zone, Outer and Inner are distinguished (Drawing. 1). The Outer zone of the bending is the area of development mainly of gas fields. It is the area where a powerful sand-loamy complex of Miocene ages deposits accumulates (mainly sandy-stones). The Inner zone of the bending is the area of development mainly of oil fields. It is the area where chalk deposits accumulate. Underground waters with high iodine content can be related to different geological structures, but more often they are formed in marginal bendings and intermountainous cavities with high indexes of thermal streams.

Multicomponency of water from drill-holes at different depths from different deposits of carbo-hydrates testifies about their genetic connection with strata where they are situated. These waters have different salinity. Studying Prycarpathians and Carpathian region started with the description and the discovery of water sources for evaporation of table salt. It is known that density of tabular water depends on the depends on the quantity of dissolved salts and in it and ranges between 1010 - 1020 kg/m³. According to the research, A.V Kudelsky [7] defined that the lower temperature limit of iodine ejection from the organo-mineral complex of sediment rocks and its accumulation in undergroundwater is 35 – 50°. However, intensity the



processes of destruction of iodine-containing organic substances are at temperatures more than 125 – 150 °C



Drawing 1. The map of the fields of Prycarpathian oil and gas region: 1– the boundary of Russian platform, 2 – rupes; I – Outer Prycarpathian bending zone; II – Inner zone

The research of water tests of iodine content were made from drill-holes of gas fields of Outer (field Rudki, Opary, Swidnica, Hodnovichi, Dashava, Kalush) and Inner (fields Pynyany) zone of Prycarpathian bending [8]. The research resulted in selecting the samples from the drill-holes of fields that belong to the objects of Outer Prycarpathian bending zone (field Rudki, Opary, Swidnica, Hodnovichi, Dashava). Tabular water in Opary field was taken from productive intervals from 420 to 637 m of horizons Dashava of lower Sarmatian Formation.

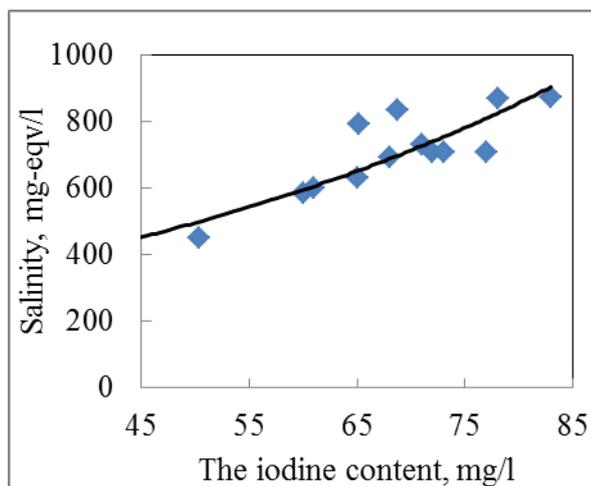
It was discovered that the density of tabular water in such a case was about 1,2 g/cm³, the salinity was about 1,000 mg-eqv / l, and iodine content from 60,8 to 67,71 mg / l. After the analysis of tabular water samples from the interval of 784 - 800 m of Swidnica field, a high iodine content, 107,49 mg / l. Also a considerable iodine content to 115 mg/l was discovered in Dashava field at quite high index of salinity – 2114 mg-eqv/l. In Rudki field an iodine content is a bit less – about 56 mg/l, with the decrease of salinity to 720 mg-eqv/l.

In Hodnovichi field the iodine content in tabular waters is from 68,07 to 83,57 mg/l, the salinity is from 1411 to 1624 mg-eqv/l. With all these things, there is an increase of the iodine content in tabular water with the increase of salinity. A corresponding graph is drawn for a detailed analysis of the dependence of iodine content in tabular water on the salinity (drawing 2).

According to the results of the research the exponential dependence was revealed between the iodine content and the salinity of tabular water of the fields of Outer Zone of Prycarpathian bending as:

$$M_1 = 412,26e^{0,051I_1}, \quad (1)$$

where M_1 – the salinity of tabular water of the fields that are being exploited in Outer Zone Prycarpathian bending, mg-eqv/l;



Drawing 2. The graph of dependence of the iodine content on salinity of water of Outer Prycarpathian bending zone.

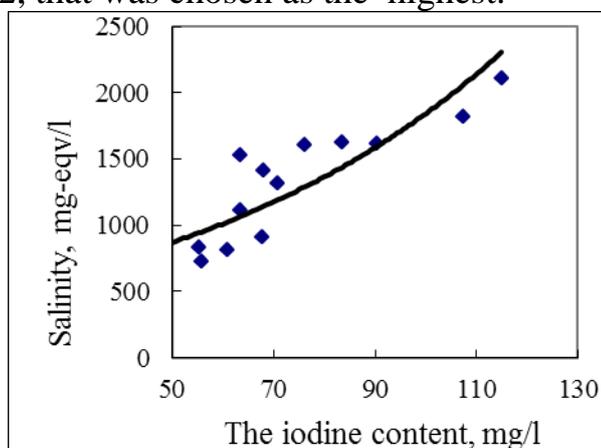
I_1 – the iodine content in tabular water of the fields that are being exploited in Outer Zone Prycarpathian bending, mg-eqv/l.

The highest coefficient of accuracy $R^2 = 0,6774$ was chosen for the most accurate approximation.

The samples from the field Kalush, that belongs to outer zone of the Prycarpathian bending, were selected for the most complete analysis. The samples were taken from the depth about 710 m. The research of water analysis with high iodine content (from 53,75 to 56,42 mg/l) showed that the iodine content in the samples of tabular waters of this field increases with the increase of the salinity value. The salinity of waters in the field of Kalush was from 2589 to 3765 mg-eqv/l. The correlated dependence was found according to the drawn graphs of the change of the iodine content in water on its salinity of the field of Kalush (drawing 3)

$$M_2 = 25,369e^{0,0862I_2}, \quad (2)$$

where M_2 – the salinity of tabular water of the fields of Kalush, mg-eqv/l; I_2 – the content of iodine in tabular water of the fields of Kalush, mg/l. The dependence was made by paying attention to the extent of accuracy of the approximation $R^2=0,8372$, that was chosen as the highest.



Drawing 3. The graph of dependence of the iodine content on salinity of water of the field of Kalush of Outer Prycarpathian bending zone.

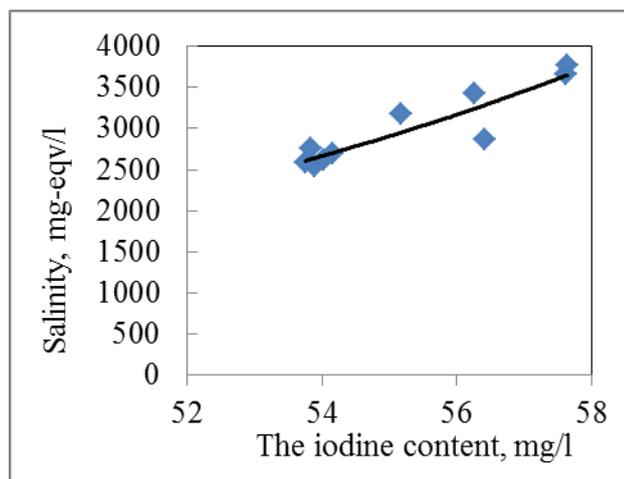


The samples from the field of Pynyany that belongs to the Inner zone Prycarpathian bending, were selected for more complete analysis of the dependence of iodine content on the salinity. The research of the analyzes of water with the anomalous content of iodine (from 50,4 to 82,95 mg / l) showed that the samples were taken from the depth from 1731 to 2040 m from the sandy-loamy horizons Dashava of lower Sarmatian Formation .

The correlated dependence was found according to the drawn graphs of the change of the iodine content in water on its salinity of the field of Pynyany (drawing 4).

$$M_3 = 199,27^{0,018I_3}, \quad (3)$$

where M_3 – the salinity of tabular water of the fields of Pynyany, mg-eqv/l; I_3 – the content of iodine in tabular water of the fields of Pynyany, mg/l. The dependence was made by paying attention to the extent of accuracy of the approximation $R^2=0,7332$, that was chosen as the highest. It was found that the density of tabular water by this was to $1,02 \text{ g/cm}^3$, was up to the salinity was to 880 mg/l and the content of iodine was to 82,95 mg/l.



Drawing 4. The graph of dependence of the iodine content on salinity of water of the field of Pynyany of Inner Prycarpathian bending zone.

An average index of iodine concentration since 1954 was chosen during the research in the drill-holes of each field. It is determined that the content of iodine increases with the increase of salinity, that was also proved by the research of S.A Bakiev [3]. According to S.A. Bakiev, the salinity increases in the direction of the immersion of the water-containing complexes, that is to bendings and below along the cut. The content of iodine increases in fields of Uzbekistan also in this direction. According to the research, the exponential dependences were found between the content of iodine and the salinity of tabular waters of the fields of Inner and Outer zone of Prycarpathian bending and the increase of iodine content from the increase of the salinity of waters in these fields was found. The considerable content of iodine in tabular waters of the fields of Prycarpathian bending (more than 50 mg/l) testifies about the necessity of the utilization of tabular waters of these fields by improving collection and preparation systems.



The use of installations to extract iodine from water is one of the methods of improving such systems that can be used in other branches of industry. The content of iodine was researched in tabular waters of oil and gas fields of the Prycarpathians. The exponential dependence of iodine content on the salinity of tabular waters in Outer and Inner zone of Prycarpathians bending was proposed.

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TECHNOLOGY CLOSED CYCLE FOR PROCESSING WASTE TO PRODUCE ENERGY*National university of life and environmental sciences of Ukraine**Heroyiv Oborony st., 15, Kyiv, Ukraine*

Abstract: By using fresh manure as organic fertilizer it is poorly absorbed by plants. Recycling by composting it takes a lot of time and effort. The best way to obtain valuable organic fertilizer from manure - its methane fermentation. This produces gas energy - biogas, which can be converted into heat and electricity. To increase the yield of biogas as a substratum, you can use other waste: the crude glycerol, the precipitate vegetable oil, waste vegetable oil, what creates technology closed loop processing of livestock, crop and food waste, biodiesel production waste to produce valuable organic fertilizer and electric and thermal energy from biogas .

Keywords: biogas, waste, crude glycerin, the precipitate vegetable oil, energy

Introduction. Livestock is the second most important branch of agriculture in Ukraine. The level of development of the market depends on high-calorie content of foods – meat, dairy products and the like. First place in the structure of animal meat and milk cattle breeding takes direction, but in suburban areas dominated by dairy and meat direction. Dairy cattle breeding is developed only in certain areas, focused on large dairy plants and the city. The leaders in the production of meat are the Carpathians, followed marshy woodlands, forest and steppe. The highest concentration of cattle in the Right Bank Forest-Steppe and west marshy woodlands.

Typically, cattle manure is used to enhance the fertility of the soil as an organic fertilizer. However, in the first year of application of fresh cattle manure plants utilize phosphorus 30-40%, 60-70% potassium, and only about 18% of the nitrogen contained in the manure. Full assimilation of manure nutrients by plants takes place within three years. Upon decomposition of manure together with mineralization of nitrogen, phosphorus and sulfur is not less than 70% of the organic carbon material is converted to carbon dioxide. On the one hand, this improves the power plant through photosynthesis, but significant amount of carbon dioxide is not consumed by the plants, falls into the upper atmosphere, increasing the greenhouse effect [1].

Therefore, before you make fresh manure into the soil it is necessary to prepare. Composting is formed humus, the nutrients are absorbed better. However, the composting process takes quite a long period of time, thus not solved the problem of emission of carbon dioxide. Another method of preparing the manure to a more complete absorption of plant nutrients is its methane fermentation. This produces valuable organic fertilizer – bioslam and a significant portion of the carbon, that would otherwise participate in causing the greenhouse gas carbon dioxide is converted into the energetically valuable – methane gas in admixture with carbon dioxide forming biogas.

Purpose of the study. Development of technology for closed loop recycling with the production of organic fertilizers and electricity and heat from biogas.



Results. Discussion and Analysis. The production unit (PU) of the National University of Life and Environmental Sciences (NULaES) of Ukraine "Agronomic Experimental Station" is planned to put into operation in the XXI century with a barn on 304 head of cattle in the first stage and 500 head of cattle in the long term. Waste from the farm can be processed by methane fermentation to obtain valuable organic fertilizer and biogas energy – gas. Biogas production in PU NULaES of Ukraine "Agronomic Experimental Station" can be closely linked not only to the livestock industry, but also with the crop, namely vegetable oil and biodiesel, which will significantly intensify its output.

After collecting the seeds of oilseeds *pererabatyvayutsya* first in vegetable oil [2], and after Biodiesel in [3]. Straw part (about 20%) will be processed into pellets which can be used for heating premises biodiesel plant. The rest of the straw plowed after grinding to restore soil fertility, or used as litter on cattle farms.

Produced biodiesel used as fuel for tractors and agricultural machinery, used for field work, cake arrives on the farm as feed for cattle and crude glycerol, which is not currently used and is collected in a storage tank, to be supplied to the biogas plant as substrate [4]. As a substrate can also be used after the precipitate vegetable oil vegetable oil production [5] and the waste oil from the dining room.

Educated planned biogas combusted in a cogeneration installation. The generated electricity at the same time will be fed into the grid on the "green tariff", and produced thermal energy – to maintain the heat balance of the digester, and partly for hot water supply – farm buildings and other objects that are a short distance from the biogas plant.

Formed after the methane fermentation of manure is used as organic fertilizer for crop yields in the next year, including oilseeds.

The scheme closed loop recycling of agricultural waste and vegetable raw materials with the production of biogas and organic fertilizer complex for PU NULaES of Ukraine "Agronomic Experimental Station" is shown in Fig. 1.

Need PU NULaES of Ukraine "Agronomic Research Station" in the diesel fuel is 120 t/year. When using biodiesel as a 5% additive to diesel fuel a year to produce 6 tons of biodiesel. Biodiesel production from rapeseed oil leaves about 20% crude glycerine, i.e. 1,2 m. When using a 100% biodiesel as a fuel in its production is crude glycerol 24 m.

To produce 120 tons of biodiesel B100 uses about the same amount of oil, 0,2%, or 0,5 tons, which is by the precipitate vegetable oil. In the production of 6 tons of biodiesel B5 the precipitate vegetable oil yield is 0,02 tons.

Out Waste fat food production is approximately 50 kg/shift, or 18 tons/year.

So, in an economy in the production of biodiesel B100 annually turns out 32,5 tons of waste for use as a substrate in the production of biodiesel B5 – 19,22 m.

Daily digester volume of 10 m³ load 6,79 tons of cattle manure and co-substrate of 0,21 m. At the annual operation of a biogas plant during the 340 days requirement management in co-substrate was 160 tonnes. At the same time, the production of bio-waste and waste edible fats will last for 155 days of work in the production of biodiesel B100 and 92 days of work in the production of biodiesel B5. The rest of the



co-substrate will be purchased from third parties.

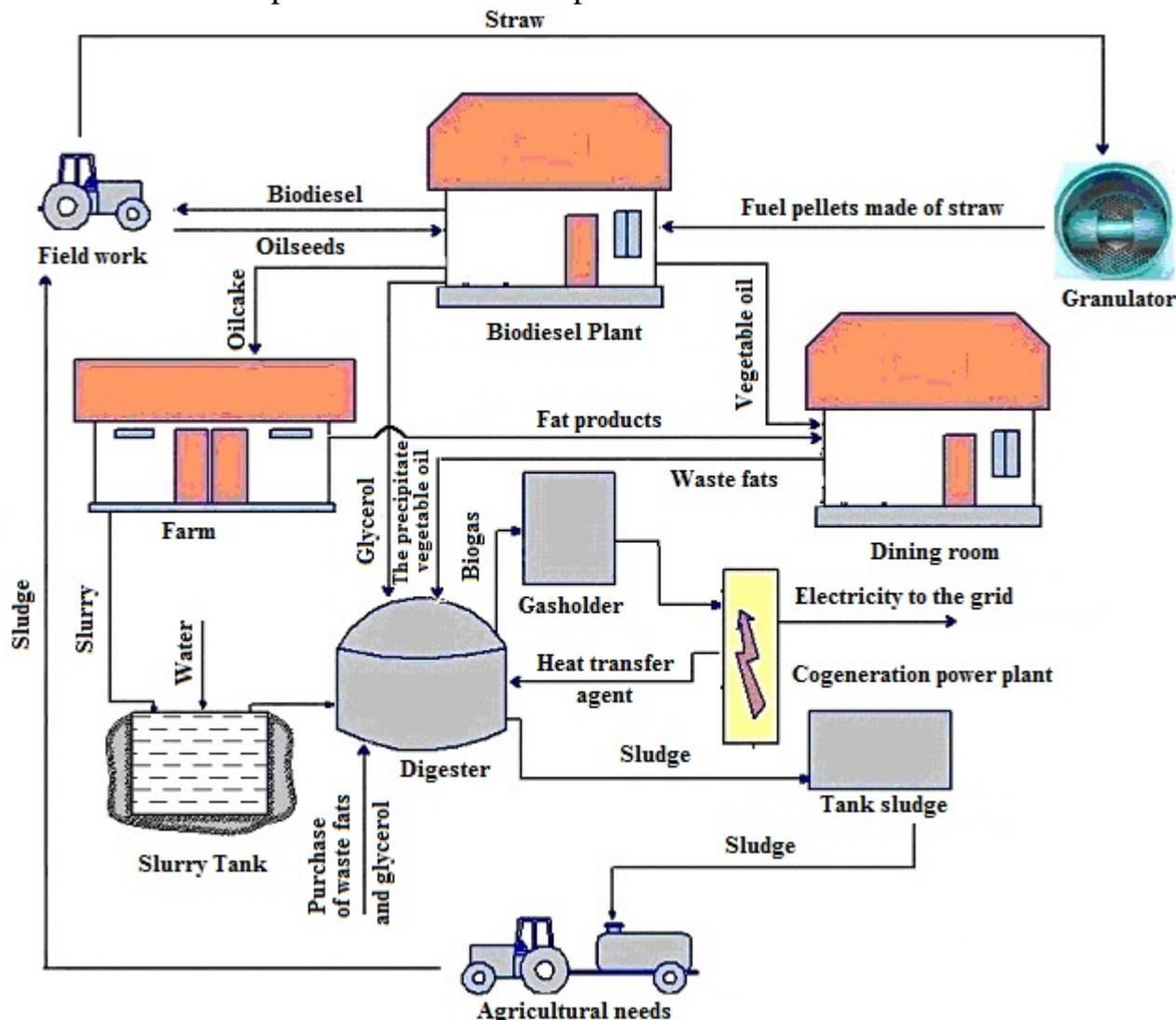


Fig. 1 Driving technology closed loop recycling of agricultural waste and vegetable raw materials with production of biogas and organic fertilizer for PU NULaES of Ukraine "Agronomic Experimental Station"

Summary and Conclusions

With the introduction of the technology of the closed recycling loop in PU NULaES of Ukraine "Agronomic Experimental Station" is scheduled to receive a valuable organic fertilizer and electric and thermal energy from biogas at full processing of livestock, crop and food waste, biodiesel production waste.

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UDK 662.763.3

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RESEARCH PARAMETERS AND MODES FOAM FLUSHING BIODIESEL*National university of life and environmental sciences of Ukraine**Heroyiv Oborony st., 15, Kyiv, Ukraine*

Abstract: In the production of biodiesel as potassium hydroxide catalyst is used, which causes corrosion of engine parts. Therefore biodiesel is freed from the catalyst by neutralization with a weak aqueous solution of citric acid to form a salt (potassium citrate) forming the small plates, the deposition of which takes a considerable time. One way to release platelets from biodiesel potassium citrate is its rinsing foam, which through ball biodiesel mixed with water by bubbling air bubbles. A laboratory study of biodiesel foam washing method. It is established that in order to achieve biodiesel standard alkalinity according to DIN 51606 at 5 mg/kg is sufficient for 2-3 hours air sparging

Keywords: biodiesel, bubbling, compressor, alkalinity

Introduction. In the production of biodiesel according to the conventional technology is used an alkaline catalyst (usually potassium hydroxide), which causes corrosion of the aluminum engine parts [1]. Therefore biodiesel is removed from the catalyst by neutralization with a weak aqueous solution of citric acid [2] to form a salt (potassium citrate) formed in the small plate, which deposition takes considerable time [3].

Literature review. To clean the biodiesel from the catalyst residues have developed different ways, the main of which is the so-called "wet" and "dry" cleaning biodiesel. In recent years began to appear information about the development of enzymatic biodiesel purification method.

When dry cleaning is used adsorbent which separates impurities from the biodiesel. Some systems use ion exchange resins, in other – magnesium silicate mineral, one type of which is sold under the brand name Magnesol, company Dallas Group Inc Amerisa Inc, or other inorganic adsorbents such as bleaching earth [4].

A common method of removing water-soluble impurities is the "wet" cleaning of biodiesel, which is also called water washing. In this process, water is used, which serves as a solvent, flushes impurities, leaving pure biodiesel. Water washing is divided into bubble (foam), aerosol and bulk.

When using an aerosol spray washing system placed over a layer of biodiesel, with the possibility of water flow after the flow through the fuel. Aerosol flushing less fuel mixes than bubble and gradually removes soap. Softer stirring is less likely to form an emulsion. However, this process uses a larger amount of water and requires a more complex equipment [5]. According to the theoretical foundations of spray washing biodiesel, which are given in [6], the deposition plates aqueous solution of potassium citrate in the purification of biodiesel from the catalyst can be from 0,5 to 40 days. Therefore, to speed up the process it is recommended to spray thicker biodiesel in water droplets that attach to their pollutant particles and transport them to the bottom of the reactor. Since the diameter of the water droplets 1 mm



further increase their dispersion does not significantly affect the deposition rate. Therefore, it is desirable to wash the biodiesel therein by spraying water droplets with a diameter of 0,5-1 mm. Speed of deposition of such droplets is less than 2 minutes. When reducing the dispersion of droplets of deposition rate increases substantially. Experimental study of aerosol washing biodiesel is presented in [7]. It was determined that the resulting alkalinity of biodiesel is reduced by about a factor of 2, and the tendency to reduce it for a longer washing time. When atomizing washing the resulting alkalinity of biodiesel only close to the standard value of 5 mg/kg, whereas in the medium and the coarse the fifth hour reaches the value of 3,5-4 mg/kg under the same initial values, which corresponds to the theoretical calculations.

When washing mixed equal volume of water and biodiesel, after which they are mixed, the mixture settles, the water is drained and the process repeated many times [4]. As a result of experimental studies surround washing biodiesel for four hours noted unsatisfactory exempt biodiesel from catalyst residues [8].

Froth is to mix washing water 1/3 and 2/3 of biodiesel and air bubbling through the water layer. Air bubbles provide indirect stirring both liquids – they occupy a small amount of water and transferred through its biodiesel selecting catalyst salts formed by the neutralization of biodiesel weak aqueous acids and other impurities. When the bubble is broken at the surface, the water descends and selects more catalyst salts and impurities.

However, in the literature there are no data on the optimum parameters and modes of foam washing biodiesel.

Purpose of the study. Explore foam washing biodiesel and install optimal settings and options for the maintenance of the set of indicators of its quality.

Input data and methods. In a 300 ml flask flowed biodiesel after neutralization 1/3 and 2/3 water. The neck of the flask, a nozzle with two entrances. After one of the inputs to the flask with a titanium tube nozzle blown air from microcompressor which Barbot through the layer of biodiesel and water layers (Fig. 1). The air flow rate was 20 and 60 l/hr. The flask with the help of a tripod was placed in an incubator ТЖ-TC-01/16. The studies were conducted at 20, 40 and 60°C.



Fig. 1. Investigation of froth washing biodiesel



The time of the experiment takes 4 hours. Selection of biodiesel samples to determine the alkalinity was carried out every hour. Also, every hour there is a replacement of contaminated water to clean.

Results. Discussion and Analysis. Dynamics of changes in the alkalinity of biodiesel is shown in Fig. 2 (with an air flow of 20 l/hr) and Fig. 3 (at an air flow rate of 60 l/hr).

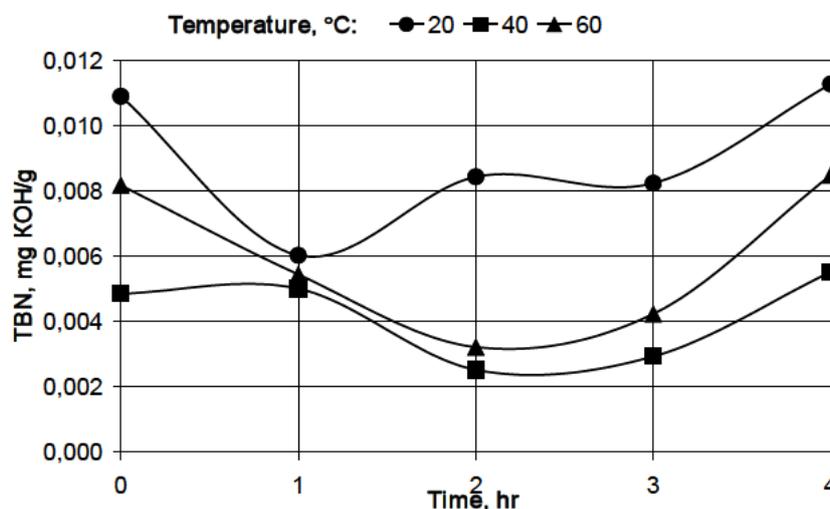


Fig. 2. Changes in alkalinity foam washing biodiesel in time at an air flow rate of 20 l/hr

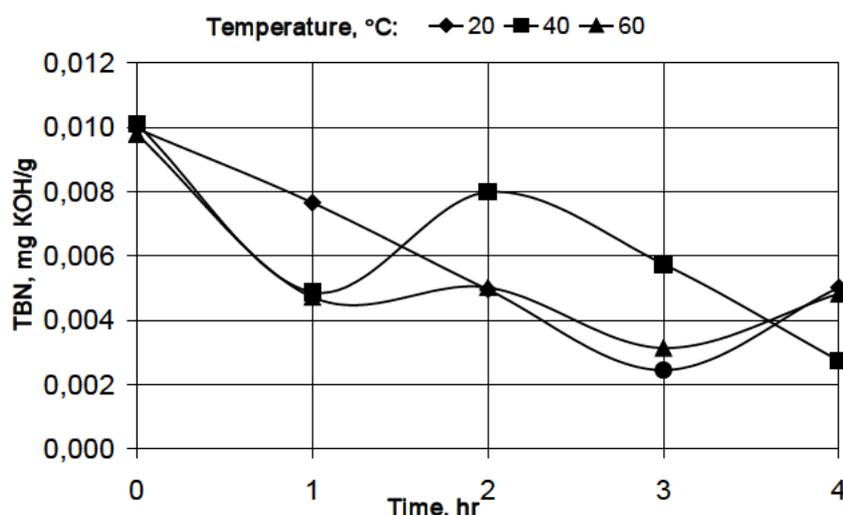


Fig. 3. Changes in alkalinity foam washing biodiesel in time at an air flow rate of 60 l/hr

As can be seen from Fig. 2, air flow rate 20 l/hr and a temperature of biodiesel 40°C alkalinity is reduced by half for two hours sparging, at a temperature 60°C – almost tripled. With further gassing tendency to increase alkalinity. When 20°C temperature for one hour bubbling observed decrease the alkalinity by 2.5 times, but it was not reduced to standardized values. When bubbling further alkalinity is also increased. However, it should be noted that the initial alkalinity of biodiesel at 20°C was almost 1,5 times higher than the initial temperature alkalinity and 40°C – 2-fold compared to the initial temperature 60°C alkalinity.

Therefore, when washing the foam with biodiesel airflow of 20 l/hr biodiesel



alkalinity within 1-2 hours of bubbling is reduced by 2-3 times. Further bubbling impractical because alkalinity is not reduced, and grows.

When the air flow rate of 60 l/hr (Fig. 3) after 3-4 hours of sparging alkalinity biodiesel reduced 4,5 times, but there is some further growth.

Summary and Conclusions

When froth washing to achieve biodiesel standard alkalinity according to DIN 51606 at 5 mg/kg is sufficient for 2-3 hours of air bubbling.

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**RESEARCH OF NOISES IN G.FAST SYSTEM OF BROADBAND ACCESS
WHEN WORKING OVER “ТПП” TYPE MULTI-PAIR CABLE**

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**ИССЛЕДОВАНИЕ ПОМЕХ В СИСТЕМЕ ШИРОКОПОЛОСНОГО
ДОСТУПА G.FAST ПРИ РАБОТЕ ПО МНОГОПАРНЫМ КАБЕЛЯМ
ТИПА ТПП**

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Abstract. In this paper we have given the results of crosstalk and interference noises research in the transmission system for G.fast technology on domestic telephone cable ТПП type. The estimation of the ratio of power spectral density level of the crosstalk without and with «vectoring» crosstalk compensation system and interference noise when variations the guard time interval length and the subscriber line length.

Key words: transmission system, «vectoring», crosstalk, interference, guard time interval.

Аннотация. В работе приведены результаты исследования мощности переходных и интерференционных помех в системе передачи по технологии G.fast по отечественным телефонным кабелям типа ТПП. Дана оценка соотношения уровня спектральной плотности мощности переходных помех без применения и с применением системы компенсации переходных помех «vectoring» и интерференционных помех при вариации длительности защитного интервала и длины абонентской линии.

Ключевые слова: система передачи, система «vectoring», переходные помехи, интерференция, защитный интервал.

Introduction.

G.fast digital subscriber lines (SL) technology of broadband access (BA) networks is designed to preservation of existing telephone cables inside buildings at construction FTTx BA networks, while ensuring that high transmission rates, comparable to completely optical FTTH BA networks.

Technology G.fast – is further development of the VDSL2 technology, optimized for short distances, which provides 10...30 subscribers connection over copper multi-pair telephone cable at bitrates up to 1 Gbit/s [1]. Such an increase transmission rate over copper multi-pair telephone cables achieved by extending the [2]. In this case there are certain tasks that need resolving.

First, the telephone cable own attenuation is increasing at the high frequencies, respectively, SNR is decreasing, may lead to restrictions of the SL length, for which the G.fast transmission system (TS) application is appropriate, and therefore at a certain increasing of the G.fast TS line length lose its advantages in the rate before the VDSL2 TS.



Second, a crosstalk attenuation between multi-pair telephone cable pairs that has a frequency dependent character will lead to significant the transitional noise (crosstalk) at high frequencies in the parallel operation of these SP. Moreover, Far End CrossTalk (FEXT) attenuation is also dependent on the SL length, and therefore the FEXT level (which dominated in asymmetric xDSL TS, which using information transmission parallel method with use a plurality of orthogonal harmonic carrier-signals (OHS) [3]), will increase with decreasing the line length. So, a significant decreasing of the transmission rate in G.fast TS parallel working over multi-pair telephone cable for each of them is observed.

Third, broad band of frequencies determines significant signal linear distortion and the presence of the interference noise, and a significant channel number will intensify this problem (in xDSL SP with DMT-modulation should take into account intersymbol and interchannel interference [3]). So, interference noise may also lead to the decreasing in the transmission rate of the G.fast TS when the large line length.

From the foregoing it can be concluded that the effective G.fast technology implementation at domestic broadband access network one of the questions that need answers, is to determine the different noise types ratio of power and contribution of each to the resulting SNR.

Methods of research and experiment, especially.

Crosstalk and interferential noise, and thermal noise and other additive noise types from various external sources can affect on the achievable transmission rate of OHS TS which works on multi-pair telephone cables.

Research was carried out by the analytical simulation of G.fast TS over the telephone cable TIII-0,4 type with the following initial data:

- G.fast TS spectrum mask corresponds to Rec. ITU-T G.9701 [2];
- frequencies plan up to 106 MHz;
- channels (l) – 43...2047 to ensure electromagnetic compatibility with ADSL2 + TS is used;
- samples number of the orthogonality interval (N)– 4096;
- samples number of the guard time interval (L) varies 128...640
- sending envelope kind of the signal linear – traditional («Π»-shaped);
- transmission medium – TIIIππ type telephone cables with the number of pairs from 10 till 30, and 0.4 mm wire diameter whose parameters have been obtained from [4];
- crosstalk investigated at 100 percent cable load;
- line length (l_{line}) varies– 50...250 m;
- additive noise is defined as an AWGN (additive white Gaussian noise) with a uniform level of power spectral density (PSD) within the minus 140...120 dBp/Hz.

Calculation of interference noises performed in accordance with the method described in [5] and [6], the crosstalk are calculated in accordance to the method described in [7].

Results and discussion.

As shown in [4] and [7], the main cause of limiting the transmission rate when working on multi-pair telephone cables, is crosstalk (it's FEXT for OHS TS), and effective method of these noise combating is the application of crosstalk



compensation system regulated Rec. ITU-T G.993.5 [8], which was called «vectoring».

Fig. 1 shows the results of calculation of crosstalk PSD distribution to the sub-channels at the G.fast TS receiver input with 100 percent load ТППЭП-10x2x0,4 and ТППЭП-30x2x0,4 cables by G.fast systems without «vectoring» (in the figure referred to as FEXT) and using «vectoring» (in the figure referred to as Vectoring) with a cable length of 50 and 250 meters. For comparison, in the figure also shows the AWGN PSD at a level of thermal noise is equal minus 140 dBp/Hz.

Analyzing the results, we can conclude that the power level of crosstalk $G_{fext}(i)$ are significantly higher than the AWGN and can reach minus 115...100 dBp/Hz, depending on the line length. Application «vectoring» system can significantly reduce the crosstalk power: for short line crosstalk $G_{vect}(i)$ comparable to an AWGN (do not exceed the level of minus 120 dBp/Hz), and for long – considerably less (do not exceed the level of minus 145 dBp/Hz).

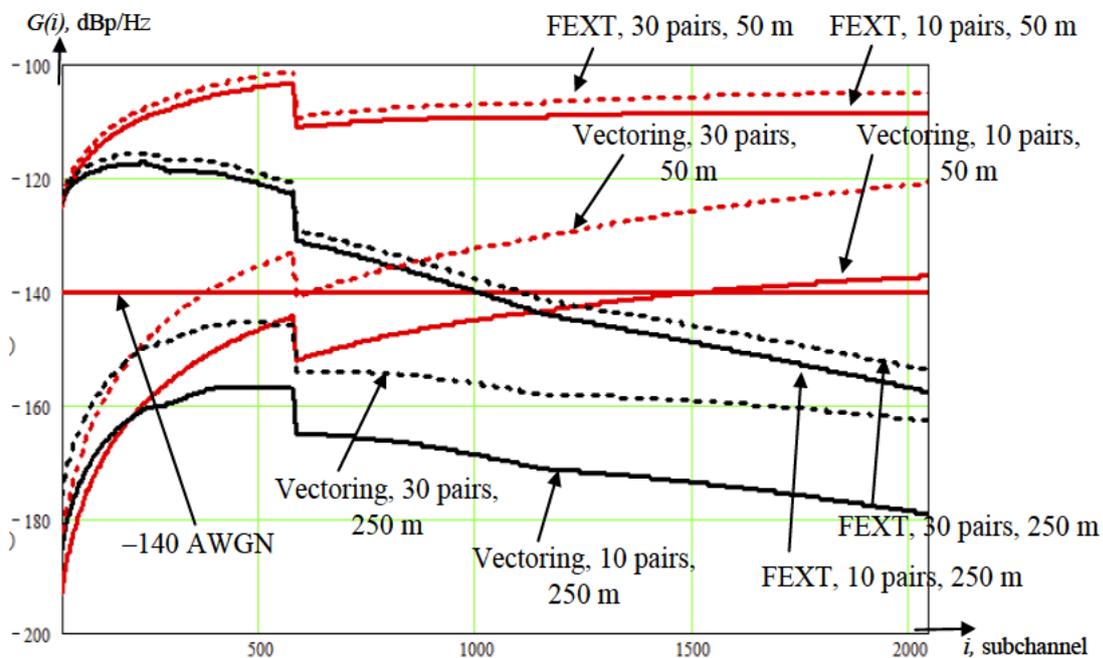


Fig. 1. Crosstalk PSD at the G.fast TS receiver input at 100 percent loading of ТППЭП-0,4 cable without «vectoring» and using «vectoring»

In accordance to the method described in [5], the interference noise estimated as the percentage ratio of the effective values interference to signal $h(i)$ at the optimum moment of the beginning of integration (the signal processing at the receiver). Conversion of the $h(i)$ in the interference noises PSD level $G_{int}(i)$ is performed by the formula:

$$G_{int}(i) = 20\lg(h(i)) + G_{s rec}(i) - 40, \tag{1}$$

where the 40 – square of the percent converted into dB; $G_{s rec}(i)$ – signal PSD level at the receiver input, which is determined:

$$G_{s rec}(i) = G_{s tr}(i) - A_{line}(i), \tag{2}$$



where $G_s tr(i)$ – signal PSD level at the transmitter output; $A_{line}(i)$ – the line attenuation.

Fig. 2 shows the distribution of the signal PSD at the transmitter output $G_s tr(i)$ and the receiver input $G_s rec(i)$ when G.fast TS is working over TPPEP-0,4 cable with line length from 50 to 250 meters.

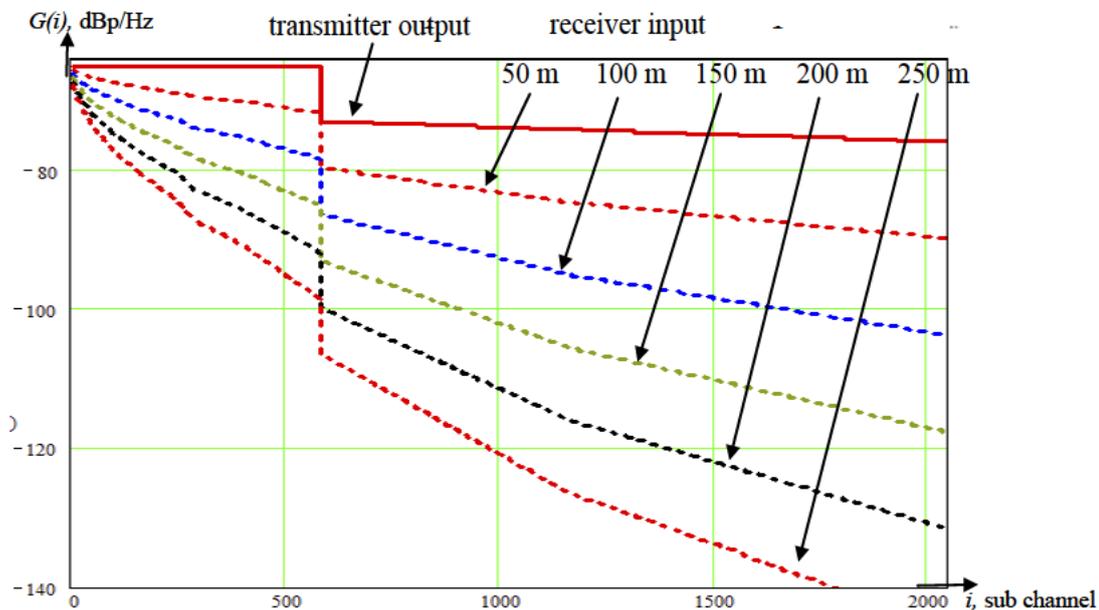


Fig. 2. Signal PSD at the transmitter output and the receiver input G.fast TS when working over cable TPPEP 0.4

Multi-frequency structure of the OHS TS group signal determines the specific opportunities for these TS adaptation to the changing characteristics of the transmission channel. One such possibility is the guard time interval duration variation as a function of linear distortions in the transmission channel. In this paper is investigated interference power at variation of the guard interval time duration from 128 to 640 samples and the line length from 50 to 250 meters.

The results of the interference PSD level calculation when the line length variation shown in Fig. 3 *a* and *b*, respectively, for the guard time interval duration is 256 and 320 samples, and Fig. 4 *a* and *b* when the guard time interval duration variation, respectively, for the line length is 150 and 250 m.

According to Fig. 3 and 4 we can conclude that the interference power distribution for sub-channels increases unevenly with increasing line length, and at the upper subchannels even decreasing interference power is observed, that associated with a large line attenuation in this frequency range. Increasing duration the guard time interval predictably resulted in a decrease interference noise power: thus increasing the duration on each 128 samples reduces the noise PSD level approximately 6...9 dB. For the considered variations of the guard time interval duration interference level does not exceed the AWGN level minus 140 dBp/Hz on most subchannels.

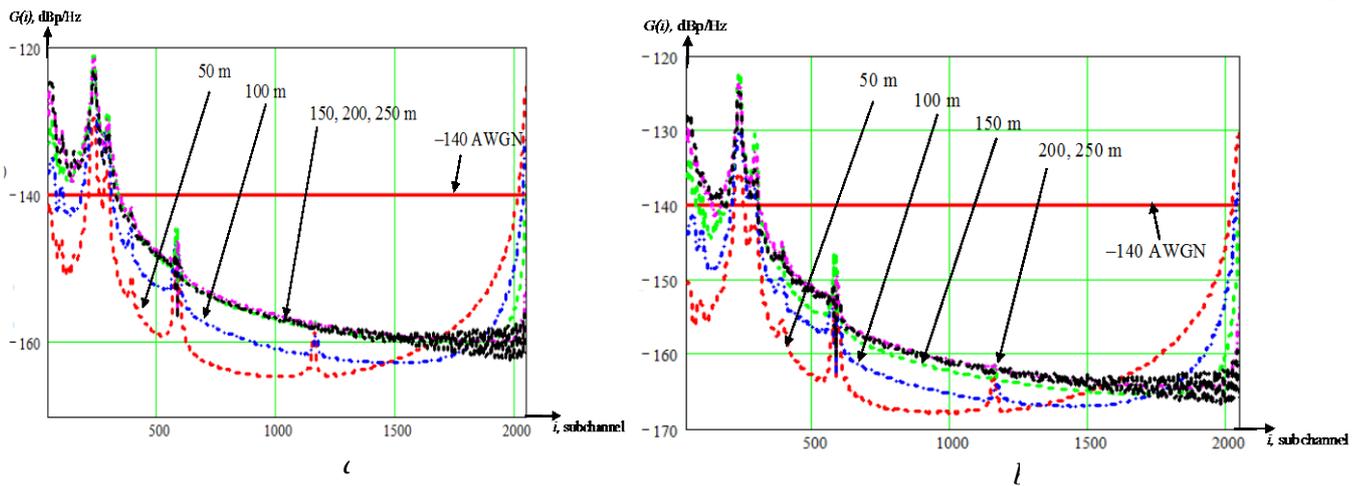


Fig. 3. Interference PSD at the receiver input G.fast TS when the line length variation (ТППЭп-0,4 mm, $L = 256$ (a) и 320 (b))

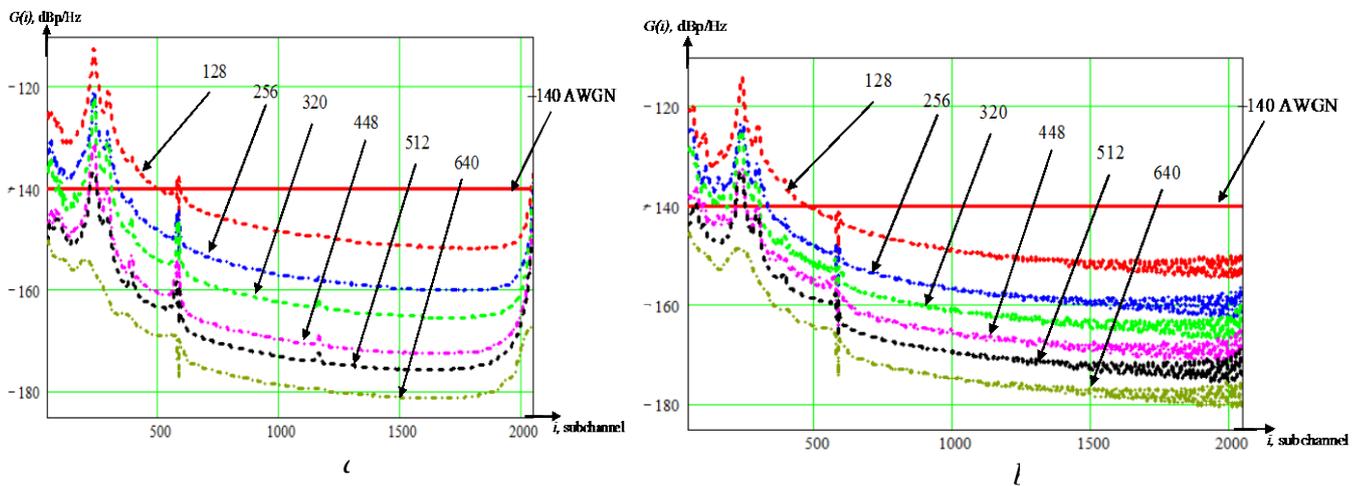


Fig. 4. Interference PSD at the receiver input G.fast TS when the guard time interval duration variation (ТППЭп-0,4 mm, $l_{line} = 150$ (a) and 250 m (b))

The achievable transmission rate in any telecommunications system is determined by the signal to noise ratio (SNR), which is also called Immunity (A_{im} – the difference between the signal and noise level, measured in decibels). Therefore, to evaluate the impact of noises on the information transmission in G.fast TS consider immunity A_{im} .

Fig. 5 a and b shows immunity A_{im} distribution at G.fast TS subchannels, with a 50 and 250 meters cable length, respectively, from the different noise types: crosstalk without «vectoring» and with them, interference when guard time interval duration is 128 and 320 samples and minus 140 dBp/Hz AWGN.

And Fig. 6 shows immunity A_{im} of the total noises for variants: FEXT without «vectoring» + interference + AWGN, «vectoring» + interference + AWGN and AWGN only.

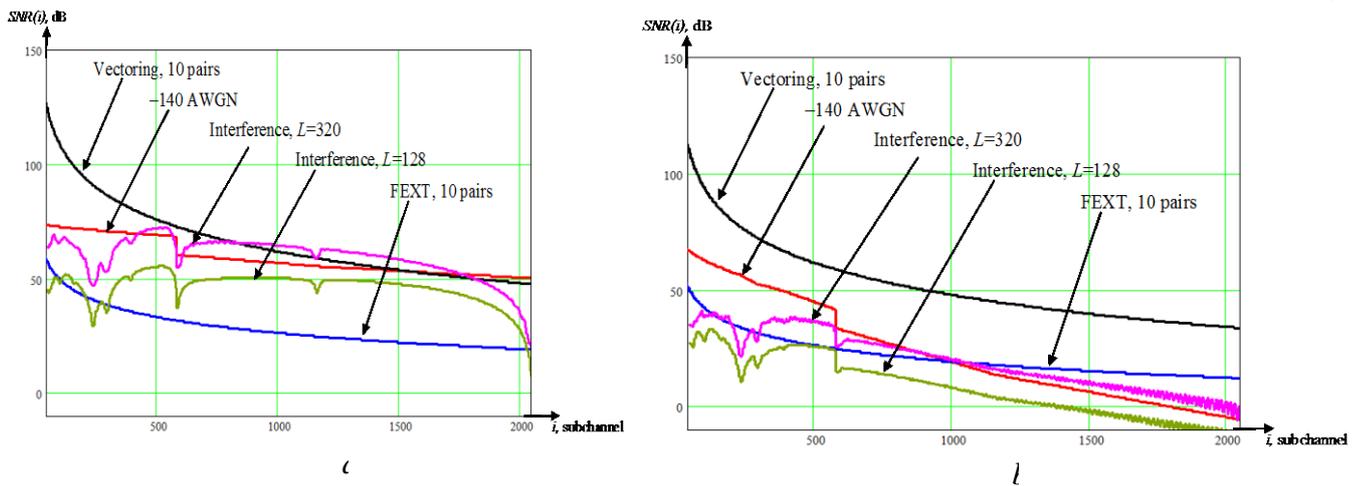


Fig. 5. Comparison of immunity from various noise kinds at the receiver input G.fast TS (ТМПэп-0,4 mm, $l_{line} = 50$ (a) and 250 m (b))

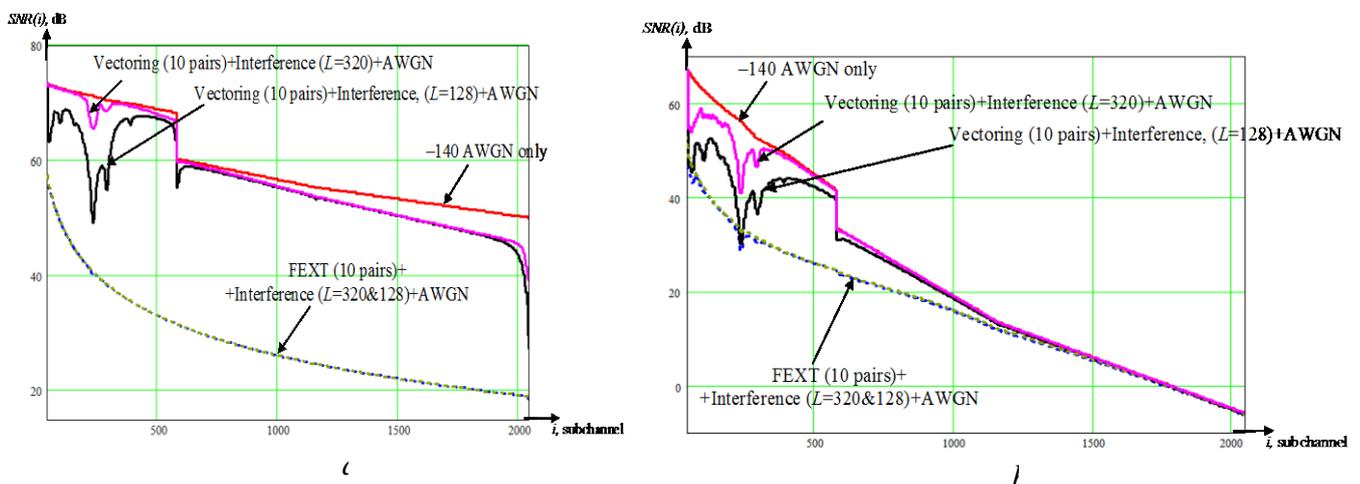


Fig. 6. Comparison of immunity from total noises at the receiver input G.fast TS (ТМПэп-0,4 mm, $l_{line} = 50$ (a) and 250 m (b))

Analyzing the results, we can conclude that the crosstalk is the dominant noise kind, which reduces immunity in comparison with the AWGN variant at 15...30 dB, so the G.fast TS using is impractical without crosstalk compensation system. Crosstalk and interference are commensurate with AWGN for variants with «vectoring», therefore further calculations of the G.fast TS transmission rate must take into account not only the AWGN and the application of crosstalk compensation system «vectoring», but also interference

Conclusion.

In this paper was investigated the ratio of PSD level crosstalk without using and with using compensation crosstalk system «vectoring», interference at the guard time interval variation duration in the G.fast TS when working over cable ТМП-0,4 at the subscriber line length from 50 to 250 m.

Obtained the following results:

- G.fast using in domestic subscriber lines without «vectoring» system does not have perspectives because of the high power level of crosstalk that exceeds the



AWGN level on 20...40 dB;

- crosstalk is reduced by using «vectoring» to the thermal noise: depending on the line length the noise level is less than minus 145...minus 120 dBp/Hz;

- interference power level varies within minus 180...minus 115 dBp/Hz, depending on the guard time interval duration and the line length. Respectively a guard time interval duration selection is possible to provide an acceptable level of interference;

- when calculating the transmission rate should take into account AWGN, the «vectoring» system using and interference.

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THE STRENGTH PROPERTIES OF WELDING, GLUE AND GLUEWELDING JOINTS UNDER DIFFERENT TYPES OF LOADING

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ПРОЧНОСТНЫЕ СВОЙСТВА СВАРНЫХ, КЛЕЕВЫХ И КЛЕЕСВАРНЫХ СОЕДИНЕНИЯ ПРИ РАЗЛИЧНЫХ ТИПАХ НАГРУЖЕНИЯ

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МІЦНІСНІСТНІ ВЛАСТИВОСТІ ЗВАРЮВАЛЬНИХ, КЛЕЄВИХ І КЛЕЄЗВАРНИХ З'ЄДНАНЬ ПРИ РІЗНИХ ТИПАХ НАВАНТАЖЕННЯ

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Аннотация. Проведены сравнительные испытания на прочность трех типов соединения частей деталей, которые можно применять при устранении трещин в базовых чугунных деталях. Исследования проводились при статическом и циклическом типах нагрузки всех видов соединений отдельно и последовательно (на симметричных и асимметричных циклов нагружения). Определены крепкие сие свойства трех типов соединения и приведены их характеристики при различных типах нагрузки. Определены режимы сварки и состав клееных композиций. Построены кривые Вейлера, что позволило выбрать тип оптимального соединения для устранения трещин и пробоин в чугунных корпусных деталях сельскохозяйственных машин.

Abstract. Comparative test of strength three types of connection parts details that may be used in addressing cracks in the basic iron details. The studies were conducted under static and cyclic loading all kinds of types of joints separately and consecutively (for symmetric and asymmetric loading cycles). Strong dream properties defined three types of joints and their properties are given for different types of loads. Determined welding and bonded warehouse compositions. Built curves Veylera, select the type allowing seamless connectivity to eliminate cracks and holes in the iron body parts of agricultural machines.

Keywords: electric welding point, cast iron, composition, welding point, loading, cyclic durability, cycle.

Анотація. Проведено порівняльні випробування на міцність трьох типів з'єднання частин деталей, які можливо застосовувати при усуненні тріщин в базових чавунних деталях. Дослідження проводилися при статичному та циклічному типах навантаження всіх видів з'єднань окремо і послідовно (на симетричних і асиметричних циклів навантаження). Визначено міцні сні властивості трьох типів з'єднань та приведені їх властивості при різних



типах навантаження. Визначено режими зварювання та склад клеєних композицій. Побудовано криві Вейлера, що дозволило вибрати тип оптимального з'єднання для усунення тріщин і пробоїн в чавунних корпусних деталях сільськогосподарських машин.

Ключові слова: електроконтактне зварювання, точка, чавунні, композиція, зварювання точки, навантаження, циклічна міцність, цикл.

Introduction. During the operation in the basic iron parts are different in type, direction and magnitude of the load. We know from the literature that almost 85% of the basic parts of agricultural machines are made of gray cast iron, ET-15, ET-18, ET-21 and ET-24. Design feature basic parts agricultural machinery carry significant weight in the presence of various sizes thickness jumpers complex configuration, with abrupt changes in the radius of curvature, surface fitting coupled parts, oil feed holes and threaded holes and coordinated. Cracks in the walls of the body parts causing a change in their geometric dimensions, changes in alignment between the landing openings and others. Because of the diversity of the nature of the loads occurring tensions that destroy and details. This conjugate with some heterogeneity of metal structure, microscopic, intercrystalline cracks, pores, and others. [1, 3, 4, 6]. Today remains a problem eliminating cracks and holes in the iron body parts.

Analysis of recent research. According HOSNYTY [1, 2], 15-22% buildings transmissions and 8-11% of tractors distributing boxes are cracked. The origin of these defects related to the features of material and design details, nature, size and direction of internal and external load [3]. The main source of internal tensions, which are linked with metallurgical processes is thermal shrinkage brake cooling down at different speeds elements details. The nature and magnitude of this inhibition is due to the fact that at 600 - 650 ° C iron passes from elastic to plastic state. At high temperature thick of complex configuration details usually tangentially compressed and thin - arm stretched. A characteristic feature cast iron body parts are also extremely molecules under deformation forces with different nature, size and direction of action. The combination of internal pressure from the effects of stress and residual stress leads to violation of the integrity of the material and the appearance of cracks, holes and calving.

The problem of creating effective technologies that can restore workability cast iron parts, paid in his writings scholars such as E. Paton, Lobanov LM, Belyayev I.P, Vavilov VP, Lyalyakin V.P., A. Dorofeev L., Klyuev VV Molodyk NV Telnov [1, 2, 4] and others. Determining the impact on the durability of these components is of great practical importance. That is why it is important to determine the properties of solid sleep mitsnisnisni compounds used to eliminate cracks and holes to ensure high machine reliability [2].

The aim - to establish an objective picture of the impact of cyclic loading on strength properties of joints, weld, glue and glue factory, which is used for removal of cracks and holes in the iron base parts of agricultural machines.

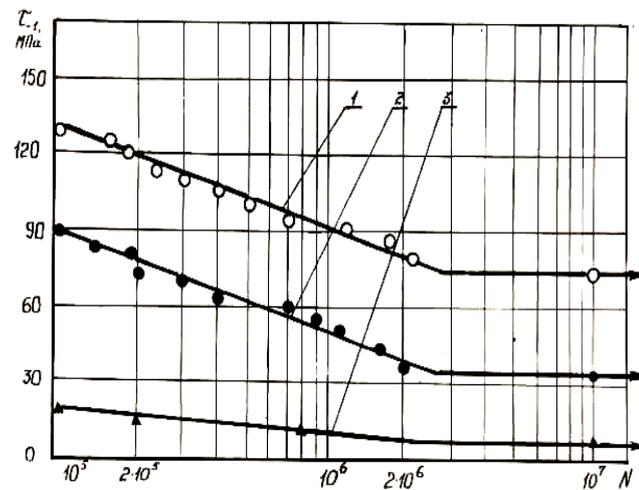
The methodology of the research. For comparative objective results, testing of welded, glued and kleyezvarnyh connections [1, 2] conducted in accordance with the standards for special purpose models, which consisted of two elements: iron plate (SCH- 18) with dimensions 100h the 60 and 10 mm steel straps (steel 20) with



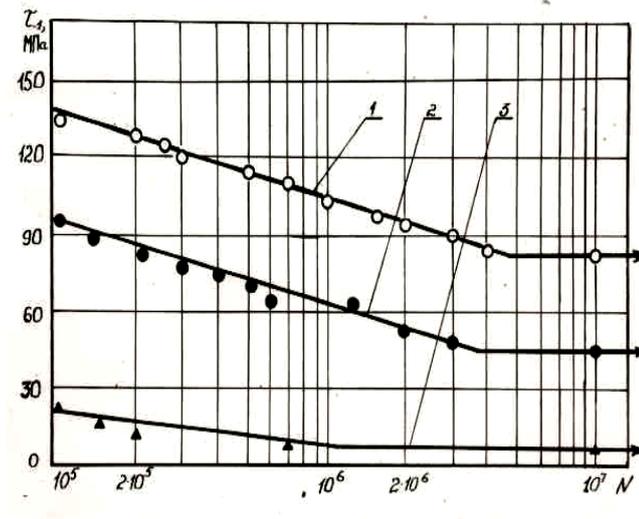
dimensions of 0.8 mm 100h 60s. In the absence of reliable data on the nature of the load, which details stand during the operation, conducted experiments with axial tension - compression symmetric and asymmetric cycles. This allowed neobhidnoyumiroyu with precision modeling of connections in conditions close working [4]. Highly effective in detecting defects in body parts is to use non-destructive holographic methods [1, 3]

The results of research strength properties of compounds that were tested.

As a result of experimental studies have found that in each of the cases, the mechanism of stress distribution has a different character (Fig. 1). Comparison of experimental data shows that the limit of endurance glue welding connection higher than welding (spot welding) at 1.91 and 2.05 times, respectively, for each load cycle. Lowest strength under cyclic loading has glue connection.



a)



b)

Fig. 1. Strength properties comparison types joints when loading cycles used:

a) symmetrical, asymmetrical; 1-glue welding, welded, glued.

A high endurance limit kleyezvarnoho connection because the adhesive perceives a significant part loading and unloading, welding points. Glue layer serving as a damper between the steel and iron ribbon detail. This positive effect on



increasing the longevity of cyclic compounds. Thus, the process of redistributing the load across the plane of the steel lining and reduces stress concentration in the area of welding points.

With asymmetrical load cycle endurance limit of the studied compounds in 1.16 ... 1.22 times higher than the symmetric. This is due to the different nature of early destruction with different coefficients of asymmetry. In symmetric - destroyed the first adhesive seam (reduced adhesion), and only then, is the destruction of nearby points of welding.

Based on experimental data by factors of safety for each connection type safety factor defined for dangerous intersections details. Conditions strength is determined by the equation:

$$n = \frac{\tau_{-1}}{K_{\sigma_d} * \tau_a + \varphi_{\sigma} * \tau_m} \quad (1)$$

where τ_{-1} - the ultimate endurance compound mPa;

K_{σ_d} - reduction ratio limit of endurance;

τ_a - peak voltage cycle mPa;

φ_{σ} - coefficient of influence of constant normal stress;

τ_m - mean stress cycle mPa.

The results of the calculations showed in Table 1.

Table 1. Safety factor of the joins

Name of parameters	Name of the weld (welding of point-valued)	Glue welding	Glue
Endurance limit, mPa	36,0	74,0	6,0
Safety factor	1,44	2,87	0,24

Sufficient safety margin has only glue welding.

Conclusions. Thus, experimental studies have shown:

- glueweldsng connection has the highest strength under cyclic loading;
- the limit of endurance of the compound with asymmetric loading cycle is less important than the symmetrical;
- a sufficient margin under cyclic loading has only gluewelding.

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Abstract. In the article the method of heat quantity measuring accuracy increasing by the differential heat-flux calorimeter due to reduction of uncontrolled heat exchange and heat losses from the butt ends of the calorimeter massive temperature-stabilized block is examined.

Key words: combustion heat, differential calorimeter, heat flux, adiabatic heat insulation.

Introduction. One of major characteristic of fuel is its combustion heat. Traditionally for determination of combustion heat of fuel and chemical matters use enthalpy aquatic bomb calorimeters, but the last years for such measuring the heat-flux calorimeters acquire distribution, or conductive calorimeters [1, 2] which have ponderable advantages by comparison to traditional aquatic one, in particular, do not require conditioning and exact weighing of water, easily automatized and does not need the special apartments for exploitation.

The literature review. In a conductive calorimeter [1] cell with a reactionary vessel – by a calorimetric bomb – it is surrounded a sensible calorimetric shell, mounted in the massive temperature-stabilized block. A shell is united from instrumentation calculable by the system which measures and processes the signals of primary heat flux and temperature sensors. On the massive block surface an electric heater is placed, which serves as the executive element of the temperature control system and after the signal of temperature sensor regulates heater`s electric power to support the permanent value of block temperature. The calorimetric block external surface is conventionally forced-air cooling by a ventilator.

At measuring the sample of the probed material is placed in a calorimetric bomb, fill it oxygen and set in a cell, and after temperature stabilizing in a calorimeter carry out the arson of sample. A heat which arises up as a result of combustion of sample passes through a calorimetric sensible shell, an electric signal, which is registered, measured and integrated instrumentation calculable by the system, is as a result generated. Integral value of signal from a moment the arson of sample to the moment of the repeated temperature stabilizing in a calorimeter proportional the amount of heat which was released in a reactionary vessel.

The modern heat flux calorimeters responses requirements in relation to exactness of measuring, diminishing of preparation duration and carrying out a test, but they have failings – uncontrolled changes of temperature and rate of air movement which blows a calorimetric block, and other external indignations are drawn by the vibrations of calorimetric shell signal which can result in worsening of devices metrology characteristics.



Input data and methods. The well-known method of struggle against influence of external indignations in conductive calorimeters is the differential connecting of sensors. However, differential heat flux calorimeters are rather large, in their temperature-stabilized blocks during measuring there can be heterogeneity of temperature which can increase the measuring error. The butt-end surfaces of massive block and calorimetric cells from every side are covered the layers of heat-insulation material, but it is not ideal thermal defence, as a result external indignations, such as uncontrolled changes of external air temperature or direct falling of sunbeams, influence on the thermal field in a massive block, and a heat which is released in a calorimetric cell as a result of the sample reaction can partly pass outside.

Diminishing of temperature heterogeneity and heat losses from the butt ends of the calorimetric temperature-stabilized block is possible to attain placing primary heat flux sensors and electric heaters on every butt end of massive block, which together with a regulator will form active adiabatic heat-insulation for retreating of uncontrolled heat exchange [2]. At Fig. 1 the differential calorimeter general view scheme is represented.

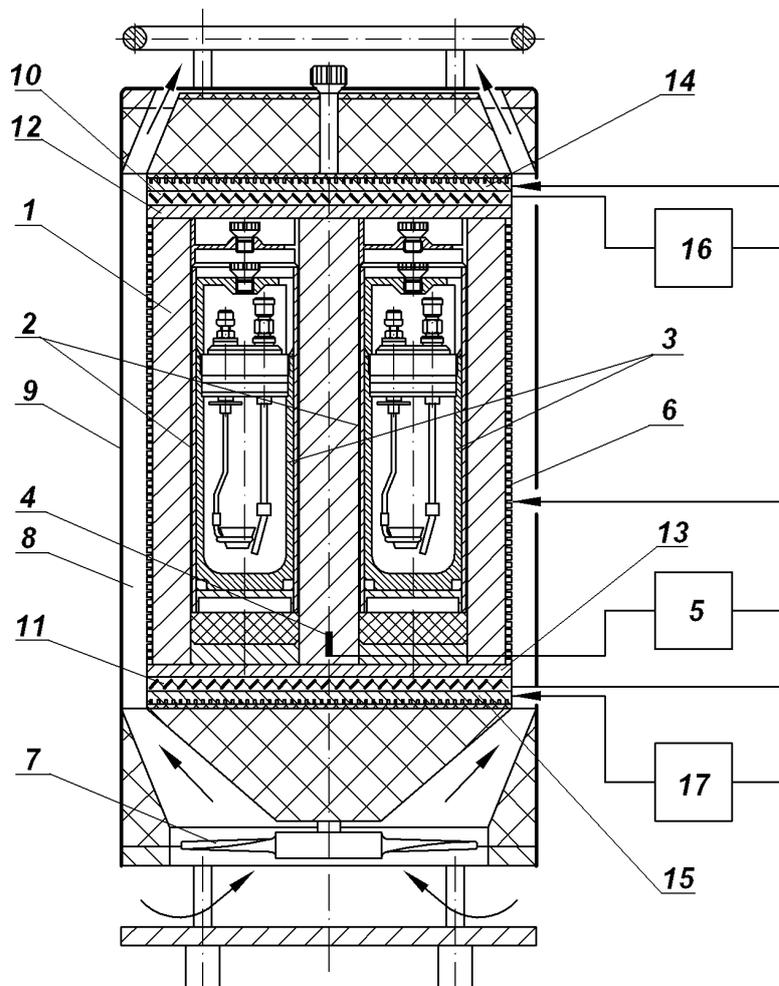


Fig. 1. A differential calorimeter structure

In the massive temperature-stabilized block 1 (Fig. 1) two calorimetric cells are placed with sensible shells 2 and reactionary vessels 3, and also temperature sensor 4, which is connected to the entrance of thermo regulator 5, the output of which is



connected to the electric heater 6, located on a massive block side. Side of block 1 has the system of the guided air cooling, which contains a ventilator 7 and circular coaxial channel 8 for cool air, formed by the side of block 1 and a case 9. On the overhead butt end of massive block heat flux sensor 10 is located, and on other butt end there is an analogical sensor 11. One of sides each of these sensors is in a thermal contact with a massive block through temperature levelling plates 12 and 13, and on other side the compensative electric heaters 14 and 15 of butt ends are placed. Output overhead sensor 10 connected to the entrance of regulator 16, the output of which is connected to the overhead butt end electric heater 14, and output bottom sensor 11 connected to the entrance of regulator 17, the output of which is connected to the lower butt end electric heater 15.

Results and discussion. As a thermostating temperature of massive block 1 it is set higher than surrounding air temperature, through the butt ends of block a heat stream, directed from him, will begin to flow and at this time sensors 10 and 11 will generate signals which are given on the entrances of regulators 16 and 17, that trick into electric power on the butt ends heaters 14 and 15, and as a result heat flow through the butt ends of massive block will be compensated. If a heat flow through the butt ends of the temperature-stabilized block is increased, for example, as a result of heat emission from the sample reaction in reactionary vessels 3, sensors 10 and 11 generate a signal, proportional a heat flow through the proper butt end. Signals of sensors 10 and 11 given on the entrances of regulators 16 and 17, which promote the value of electric power which is given on the butt ends heaters 14 and 15, what a present heat flow is compensated to. In the case of heat emission diminishing in cells the heat flow change through butt ends automatically results in diminishing of electric power value which is given on the butt ends heaters. Thus, on every butt end of massive block the system of automatic maintenance of a zero heat flow is formed – an active adiabatic heat-insulation, which provides the increasing of measurements accuracy of heat which is released or taken in at physical, chemical or biological processes, by means of diminishing of uncontrolled heat exchange through the butt ends of the temperature-stabilized block.

Conclusions. The differential heat flux calorimeter heat measurements accuracy increasing by means of diminishing of uncontrolled heat exchange and heat losses from the butt ends of the massive calorimetric temperature-stabilized block is possible to achieve by organization of active adiabatic heat-insulation at every butt end, placing on them the system of automatic maintenance of a zero heat flow, made from heat flux sensor, electric heater and managing regulator.

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Burova Z.A.¹, Grischenko T.G.², Dekusha L.V.²**THE PRIMARY MONITORING DEVICES OF POWER OBJECTS
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Abstract. In the article the models of primary heat flux and temperature sensors and measurement devices based on them to high-quality monitor the thermal state of industrial power systems are described.

Key words: heat flow, temperature, sensor, monitoring, power object.

Introduction. Through monitoring of the power objects thermal state, in particular, boilers, boiler equipment, hot-water systems and others for the heat losses determination of it is necessary simultaneously to measure basic thermophysical parameters – temperature and heat flux – in many points of object during enough great while. It is conditioned that a power equipment, as a rule, changes office hours depending on loading which in same queue changes not only during a season, but also for a day long. It is conditioned that a power equipment, as a rule, changes its operating regime depending on capacity which in same queue changes not only during a season, but also for a day long. In addition, efficiency and operation life of generating equipment to a great extent depend on the state of heat insulation.

The literature review. Monitoring of power objects heat engineering parameters and characters must have the proper device providing. For determination of temperature there are sufficiently many various devices, which will realize both contact and noncontact measuring methods. For measuring of heat flow density, heat resistance and thermophysical properties in Ukraine the specialized measuring devices [1, 2] are serially developed on the basis of primary heat flux transducers (sensors) (farther – HFS) [3] and temperature (farther – TS) [4]. Application of HFS and measuring devices basis on their allows to determine heat losses through the power equipment structure envelope (farther – SE) by the direct measuring.

Input data and methods. At the choice of measuring devices for the concrete SE inspection it is necessary to take into account many factors: SE type, its characteristics, the internal contrasting heat-conducting including presence (for example, establishment details), the surface roughness degree, the heat exchange with an environment condition etc. At implementation of generating devices monitoring in default of additional radiance sources and for possibilities of providing identical degrees of HFS and SE surfaces blackness usually use two HFS models: in hard (Fig. 1, a, c) and in flexible (Fig. 1, b, d) design, in which the primary HFS and TS sensors are structurally combined [2]. Primary sensors are being applied with a direct current voltage standard measuring instrument or in the complete set of sensors unstandardized specialized digital heat flux and temperature measuring devices ITP-22, ITP-23, ITP-23M, ITP-24 models [2] (Fig. 1, e, f).

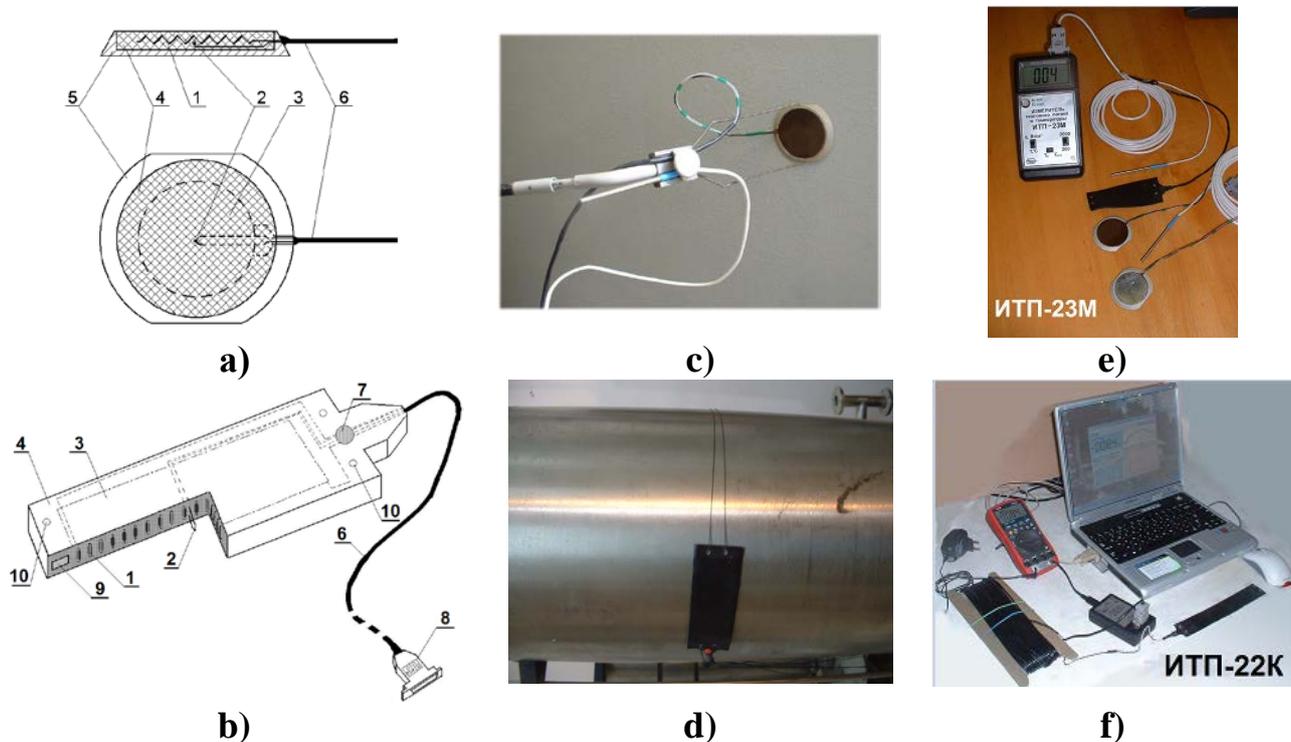


Fig. 1. Structural schemes of HFS in hard (a, c) and flexible (b, d) design and measuring devices on their basis (e, f):

1 – bimetallic thermoelements battery; 2 – temperature transducer;
 3 – heat sensible area; 4 – protective area; 5 – frame; 6 – sensors load leads;
 7 – surface mark for a heat flux direction-finding; 8 – connector cable with the HFS number; 9 – mounting plate; 10 – mounting hole.

In both models of sensors (Fig. 1) as a mounted TS for the controlled object surface temperature determination a chromel-alumel thermocouple is applied with TXA (K) type static transformation characteristic [4], its hot junction is located in the HFS centre. The TS generate thermal EMF, which is proportional the temperature difference between a hot and reference junction, a signal from bridge circuit, proportional the temperature of reference junction, is added to. A total signal is equal to the controlled object surface temperature value.

Every hard designed HFS frame is fastened on a sliding telescopic support stick for comfort control of hot surfaces and highly located objects. It is also TS_A mounted on a support stick for measuring temperature of air near-by the controlled object surface. Sensor ST_A is a chromel-alumel thermocouple, which reference junction is placed in thin-walled metallic tube.

Results and discussion. The HFS mounting on the control objects surfaces are demonstrated on Fig. 1: c – hard HFS on the flat walling-up surface of boiler; d – flexible HFS on the cylinder pipeline surface. As required of heat flux density measuring simultaneously by few HFS located in the different points of the controlled surface it is expedient to provide some distance between nearby HFS, so influences the temperature (or heat) field on each other are eliminated.

Identical by structural design hard HFS may have differences in the emissivity of their heat sensitive surfaces, that predefined by the tasks of researches. For



example, through monitoring objects which are edged outwardly a metal (by an aluminum, by stainless steel etc.), HFS which has sensitive surface coverage emissivity $0,20 \pm 0,02$ are used. In other cases HFS with emissivity $0,92 \pm 0,02$ are used for measuring. If emissivity of heat exchange experimental surface differs from the HFS emissivity more than $\pm 0,05$, on its heat sensitive surface glue on thin tape with the proper value of emissivity for providing measuring probability.

In default of such smoothing the actual value of heat flux density is determined by a calculation after a method, which takes into account the measured values of heat exchange convective and radiation components, and also controlled object surface temperature the and middle environmental surfaces temperature. In the case when constructions surfaces, which surround the sample object, such as soil, buildings and structures, have an identical temperature and emissivity approximately near to 1,0 (from 0,75 to 1,0), a close calculation can be executed by an equation:

$$q_0 \approx q_M - \sigma \cdot (\varepsilon_{HFS} - \varepsilon_{OS}) \cdot \left((t_{OS} + 273)^4 - (t_{ES} + 273)^4 \right) \quad (1)$$

where q_0 and q_M – an actual and measured value of heat flux density on the object surface, W/m^2 ; t_{OS} and t_{ES} – a temperature of controlled object surface and the middle environmental surfaces temperature, $^{\circ}C$; ε_{HFS} and ε_{OS} – an emissivity of HFS free surface and of the controlled object surface (values for different materials are systematized in normative literature).

Conclusions. Application of primary heat flux and temperature sensors and domestic production measuring devices on their basis allows to carry out the high-quality monitoring of power objects thermal state and to determine thermal losses through their structure envelope by the direct measuring.

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Abstract. In the article the combined method of the no-touch and contact examining of heat engineering factors is presented for effective determination heat losses of industrial power objects by multichannel measuring systems.

Key words: heat flow, temperature, sensor, monitoring, power object.

Introduction. An industrial power equipment has large sizes usually, and thermal processes are distinguished by considerable duration in time, that is why for the quality monitoring their heat engineering parameters and characteristic realization expedient is the multichannel measuring systems application with possibility of connecting complete sets primary sensors and devices in a necessary amount for object thermophysical parameters determination and experience data array accumulation for further treatment.

Input data and methods. For the complex monitoring of generating objects heat engineering parameters and characteristic with multichannel measuring complex application special procedure is worked out [1], in that advantages of no-touch and contact measuring methods are united and the direct measuring and calculation methods of heat exchange determination coefficient is combined. This technique [1] consists in execution next experimental and calculable operations:

- 1) to partition preliminary the controlled object surface structure envelope (SE) on probably homogeneous and equal area measuring zones;
- 2) to non-contact scan the measuring zones surfaces by electronic control and measuring device (pyrometer) and to build the surface temperature values fields;
- 3) to educe in the got temperature field characteristic zones there is most of identical temperature values in that. In case of availability these measuring zones to the operator it is necessary to place on a surface each of them for two temperature and heat flux sensors, that have contrasting external surfaces emissivity, and to write down their signals. For cases with difficult accessing surfaces it is necessary:
 - a) to do repeated surface partition with the selection of not only characteristic but also anomalous zones with maximal or minimum temperature value;
 - b) to execute in the specified zones the non-contact measuring of temperature T_{SE} (by pyrometer) and falling heat radiation flux q_{FALL} (for example, by a radiometer), and also an air temperatures T_A in a boundary layer by any temperature measuring device, screened from the extraneous sources of heat radiation action;
- 4) to choose an equation for the calculation of convective heat exchange coefficient α between the controlled surface SE and environment on the basis of a



kind, sizes and spatial location surface SE, terms of heat exchange with an environment and presence of an air force motion near the surface SE;

5) to calculate the surface total heat flux density q_{Σ} actual value of by an equation:

$$q_{\Sigma} = \alpha \cdot (T_A - T_{SE}) + A_{SE} \cdot q_{FALL} - \sigma \cdot \epsilon_{SE} \cdot T_{SE}^4 \tag{1}$$

where A_{SE} i ϵ_{SE} – absorptive ability and integral hemispherical emissivity of surface SE accordingly; σ – Stefan-Boltzmann constant.

6) to calculate the arithmetical mean value of total heat flux \bar{q}_{Σ} at all surface SE by an equation:

$$\bar{q}_{\Sigma} = \left(\sum_{n=1}^N q_{\Sigma_n} \cdot S_n \right) / \sum_{n=1}^N S_n \tag{2}$$

where S_n – an area of each (n) measuring zone, N – a number of zones;

7) to specify a \bar{q}_{Σ} value taking into account substantial differences in anomalous measuring zones and to compare them to the normative heat losses values for this type of power object.

Results and discussion. Experimental approbation of this technique was carried out for making a comparison between results of no-touch and contact measuring methods at complex research of heating water gas boiler TBГ- 8 [2] heat losses. Thus for the non- contact temperature measuring the pyrometer "Fluke-574" was applied, for contact – thermocouples built-in heat flux sensors [3], what also measure the resulting heat flux density value. Separately the air temperature values near a boiler were registered. Determination of falling heat radiation density value was executed contactless by absolute cavity radiometer ПАИ-12Д [3].

The boiler surfaces partition on zones and the results of thermophysical parameters measuring in each of them is shown on Fig. 1. An overhead number is the heat flux density value, measured by touch-control heat flux sensors, lower is the surface temperature, measured by a thermocouple and pyrometer, the values of that coincide within the limits of measuring error.

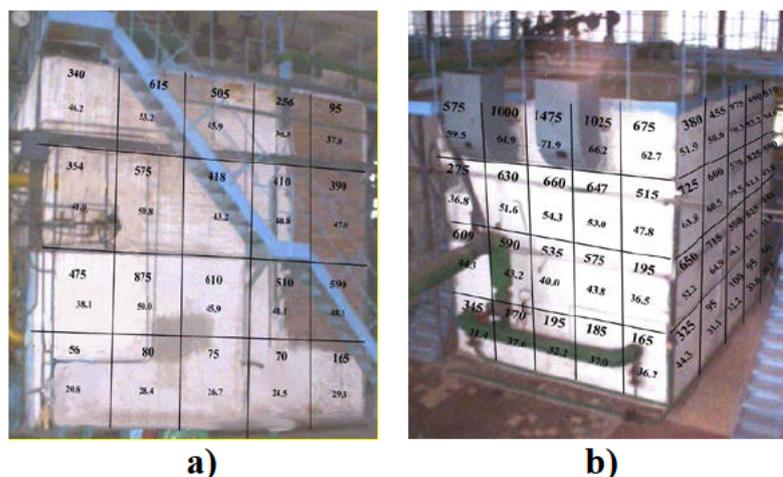


Fig. 1. Distribution of heat flux and temperature on boiler TBГ-8 right lateral (a) and left lateral and back (b) surfaces

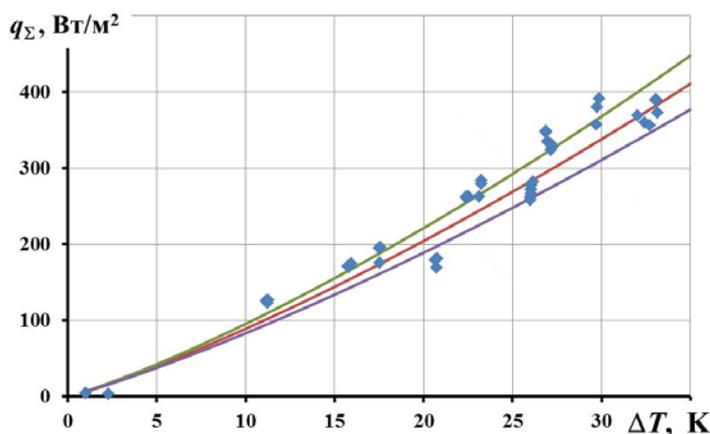


Fig. 2. Results of inspection of boiler TBГ- 8 right lateral surface

For the reliable researches results analysis the boiler right side was select, which was not influenced by other heat power equipment. On Fig. 2 results of inspection the boiler TBГ- 8 select surface thermal condition as experimental points are shown and calculation graphic of heat flux density dependences from the difference of temperature values between surface SE and environment, got on the basis of equalization (1) and calculation the convection heat exchange coefficient α mean value with the use of the known criterion equalizations and semiempiric dependences, got at free convection researches for the different size, geometry and space location surfaces [1].

The graphics (Fig. 2) analysis testifies that divergence of no-touch and contact measuring results does not exceed 6%, they answer each other within the error limits of measuring and heat exchange coefficient calculations.

Conclusions. The combined inspection technique of power objects thermal condition, based on the non-touched temperature measuring and using the specialized devices for falling heat flux density and heat exchange coefficient measuring, allows to get the correct heat flux values through the investigated objects SE. The results of inspection allow to estimate the power object thermal condition objectively, for example, boilers or other heat power equipment walling-up and heat isolation, with pointing of critical zones, in that damages of constructive elements there are possible, that result in unjustified heat losses.

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CHANGES IN THE CHEMICAL COMPOSITION OF POTATO TUBERS DURING PROLONGED STORAGE

Abstract. The investigations of changing in the chemical composition of potato tubers of different varieties during prolonged storage were presented. The best for storage were potatoes tubers of Vodohray variety was establishment. They have high biochemical indexes during long term of storage.

Key words: potatoes tubers, chemical composition, long term of storage, quality.

Introduction.

Potatoes are the most universal of crops, and its tubers are widespread food. Depend on the content of nutrients, it has one of the first places among main food crops [1-5].

The goal components of the chemical composition of potato tubers are dry matter, starch, crude protein, essential amino acids, sugars, vitamins, nitrates and glycoalkaloids [6-8].

Potatoes are widely used for livestock feed and as raw material for industry [9]. As the number of nutrients that can be received per unit area of field, potatoes have one of the first places. The nutrients per hectare it gives 2-4 times greater than rye or barley, and second only before sugar beet and maiz. The tubers contain an average of 75-80% water and 25% dry matter [10, 11]. Starch contained in tubers from 14 till 25%, and in some varieties - up to 30% [12], crude protein is an average up to 2%. The values of the potatoes were determined by high taste and good for the human body chemical composition. Of particular importance is a protein of potato, which has more value than protein other crops [13]. However, during storage losses of potato tubers can be up to 20-30% [14, 15]. Therefore, the actual problem is the selection of potato varieties that have high storage capacity during storage and has high nutritional and biological value.

Aim of study was to define varieties suitable for potato storage, which have high nutritional and biological value.

Initial data and methods.

The study was conducted during the 2014-2015 years in the scientific and educational laboratory of technology of storing, processing and standardization of crop products after name prof. B.V. Lesik of NULES Ukraine. For research use varieties Zov and Vodohray. Tube potatoes were grown at the Institute of Potatoes NAAS of Ukraine. Control was quality of potato tubers research varieties immediately after harvesting. Both experimental potato varieties in quantities are 10 kg were stored during 8 months at a temperature of 2-4 ° C and relative humidity of air is 80%. After each month of storage in the potatoes tubers determined biochemical parameters: dry matter, titrated acidity, starch, content of mono sugars, vitamin C). The scheme of researches is shown on the fig.

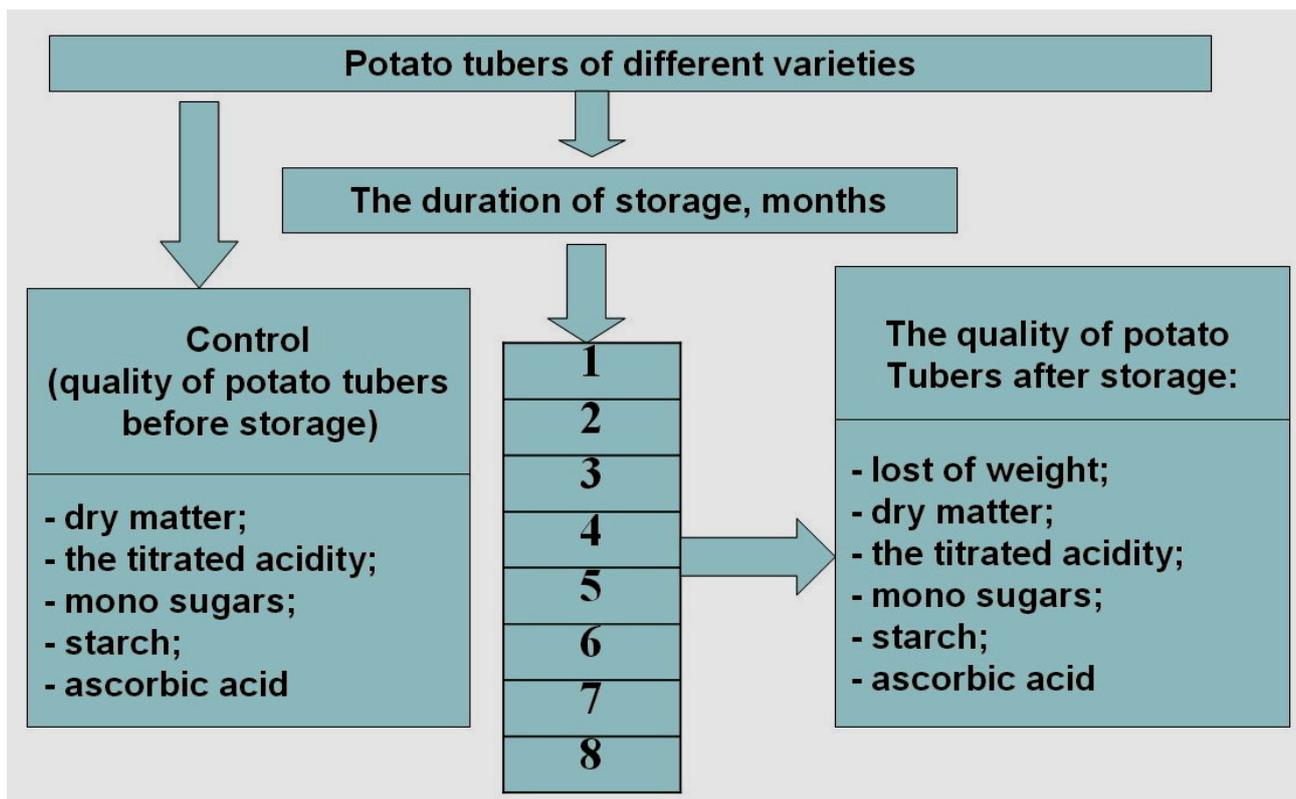


Fig. The scheme of researches.

Results. Discussion and Analysis.

The most important factors that affect on the storage capacity of potato tubers is the quality of potatoes before storage, technology of handling and diseases.

Potato tubers before storage are carefully sorted out injured and culling seems obvious signs of disease, because the first impact factor of lost during storage was excluded.

Storage conditions chosen such as most researchers recommend (temperature is 2-4 ° C, humidity – 80%), which also excluded the impact of this factor on quality and weight lost of tubers during storage. Therefore, the major losses suffered by the tuber infestation and respiratory illnesses during their long storage. These results are presented in Table 1.

Table 1
Losses of potato tubers of research varieties during storage (average for 2014-2015 years)

Variety of potatoes	Month of storage								Total losses, %
	October	November	December	January	February	March	April	May	
Zov	100	100	100	100	100	95	89	80	20
Vodohray	100	100	100	100	100	99	99	98	2

By analyzing the results, we see that for the finish of storage (period is 8 months) losses in the amount was 20% in the Zov potato tubers and tuber varieties



Vodohray had only weight lost – 2%. This confirms the findings of other researchers who claim that one of the most significant factors are keeping quality potato varietal characteristics, and they must be considered when selecting varieties for long-term storage.

Biochemical parameters varieties of potato research throughout the storage period are presented in Tables 2-5.

Table 2
Dynamics of titrated acidity in the potato tubers of different varieties in the process of long term of storage

Varieties of potatoes	Quality potato tubers before storage	September	October	November	December	January	February	March	April	May
Zov	0,27	0,27	0,27	0,23	0,23	0,2	0,2	0,18	0,17	0,17
Vodohray	0,34	0,3	0,28	0,27	0,24	0,24	0,2	0,2	0,17	0,17

Table 3
Dynamics of starch in the potato tubers of different varieties in the process of long term of storage

Varieties of potatoes	Quality potato tubers before storage	September	October	November	December	January	February	March	April	May
Zov	15	15	15	15	15	14,8	14,7	14,3	14,1	14,1
Vodohray	12,2	12,2	12,0	12,0	12,0	11,7	11,3	10,9	10,7	10,5

Table 4
Dynamics of mono sugars in the potato tubers of different varieties in the process of long term of storage

Varieties of potatoes	Quality potato tubers before storage	September	October	November	December	January	February	March	April	May
Zov	0,86	0,86	0,86	0,88	0,9	0,9	0,92	0,97	1,1	1,18
Vodohray	0,86	0,58	0,64	0,7	0,74	0,75	0,8	0,8	0,84	0,89

Quantity of mono sugars in potato tubers varieties Vodohray and Zov during storage increases due to the passage of the hydrolysis process polysaccharides complex (starch) under the action of amylase enzymes.

Vitamin C is partially decomposed, especially in the spring, the amplification



process of germination and respiration of potato tubers.

Table 5

Dynamics of vitamin C in the potato tubers of different varieties in the process of long term of storage

Varieties of potatoes	Quality potato tubers before storage	September	October	November	December	January	February	March	April	May
Zov	16,7	16,5	16,3	16,0	15,2	14,1	13,4	11,9	10,2	9,24
Vodohray	11,0	11,0	10,9	10,7	10,7	10,6	10,4	9,8	9,4	8,36

Conclusions

The questions about the impact of the varietal characteristics, duration and storage conditions on the quality of potato tubers were researched.

The results show that under optimal storage conditions (temperature, humidity of air) by the amount of weight lost of potato tubers are the main influence their varietal characteristics and quality before storage.

The best for storage is a variety of potato tubers Vodohray, which is almost affected by disease and as a result had losses during storage in an amount is 2% opposite 20% in Zov variety. Moreover, this variety of potato tubers had a high solids content – 21.0% and starch – 14.1%.

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QUALITY OF PASTA DEPENDING ON DRYING REGIMES AND INITIAL MOISTURE CONTENT OF GRAIN*National University of Life and Environmental Sciences of Ukraine, Kiyv*

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КАЧЕСТВО МАКАРОННЫХ ИЗДЕЛИЙ В ЗАВИСИМОСТИ ОТ РЕЖИМОВ СУШКИ И НАЧАЛЬНОЙ ВЛАЖНОСТИ ЗЕРНА*Национальный университет биоресурсов и природопользования Украины, г. Киев*

Abstract. The effects of different regime pasta drying properties of wheat varieties Kharkiv 23 Woodland 90 and Early 93. Established that the heating temperature grain drying technology affects performance, increases the coefficient of cooking, increase dry matter losses during cooking, deteriorating color pasta.

Key words: Pasta, wheat, grains, technological performance, regime drying.

Приведены результаты исследований влияния различных режимов сушки на свойства макаронных изделий из зерна пшеницы сортов Харьковская 23, Полесская 90 и Ранняя 93. Установлено, что температура нагрева зерна при сушке влияет на технологические показатели, увеличивается коэффициент развариваемости, увеличиваются потери сухих веществ при варке, ухудшается цвет.

Ключевые слова: Макароны изделия, зерно пшеницы, мука грубого помола, технологические показатели, режим сушки.

The main raw material for the production of pasta grains are grains of hard and soft wheat and wheat flour bakery.

The protein content in wheat grain is essential to the quality of pasta. It affects the amount of cooking pasta properties, saving form, the loss of dry matter. Low protein content negatively affects the ability of flour to form a dough and keep giving it form and behavior of the dough during extrusion and drying. Evaluate the quality can also for gluten content, which must be at least 25% for manufacturing good quality pasta [1,2,3,4,5].

The aim of research was to study the regimes drying wheat and the impact of technological change on the performance of pasta.

Material and methods of research. Investigation performed at the department of storage technology, processing and product standardization after prof. BV Lesik NULES of Ukraine. For studies on the regimes of drying grain, selected grains collected direct combine harvesting, with humidity of 17-18%; 20-21%. Drying was carried out in a dryer modeled mine. The subject of research was selected grain and flour of wheat zoned: Woodland 90 (mild winter); Early 93 (soft spring); Kharkiv 23 (durum spring) [6].

Results. We defined three grain pasta properties studied wheat. Evaluated quality pasta at nine balls system by the method of the State Commission on sort testing.



Organoleptic estimation of in scores was defined as the average of estimates colored grains, dried and cooked pasta. Defined as the loss of solids during cooking pasta and tenderize factor.

For all regimes drying the best performance had pasta made from durum wheat grain varieties Kharkiv 23 organoleptic evaluation which was 6,8-7,5 points, dry matter losses during cooking - 5,90-6,48% rate tenderize - 3,29-3,41. Pasta and grain varieties of winter wheat Woodland 90 were average, and the lowest pasta properties were characterized by pasta with grain varieties Early 93 (organoleptic evaluation 4,5-5,4 points, loss of dry matter 6,78-7,44% coefficient tenderize was 3,57-3,73) (table).

Depending on the heating temperature grain drying changes color pasta. Brown pigment content slightly increases when the temperature of heating grain, leading to deterioration of organoleptic evaluation.

Thus, in the mode of drying grain moisture content 17-18% carrier temperature 120 ° C with an exposure of 60 minutes organoleptic evaluation of pasta compared to the control decreased by 0.5 points from grain Kharkov grade 23, 0.5 points - Woodland 90; 0.6 points - Early 93, humidity 20-21% - 0.5; 0.5; 0.8; Points varieties respectively.

Tenderize pasta ratio increased in all three grades investigated with increasing heating temperature and the initial grain moisture.

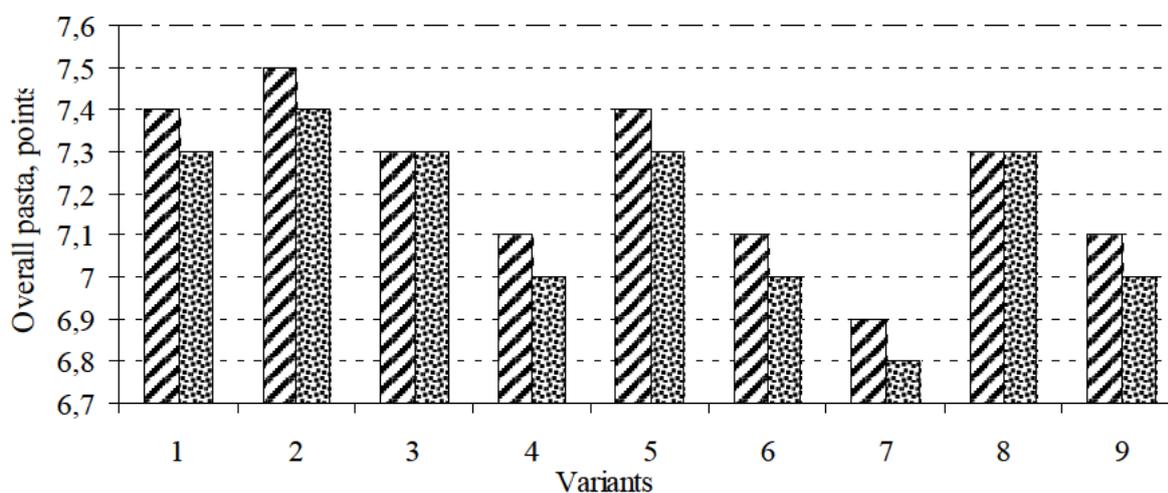
The loss of solids during cooking pasta increased with increasing temperature and carrier term exposure drying grain. The highest loss of dry matter had pasta, manufacture of grain dried at 120 ° C carrier exposure and 60 minutes. For varieties with 17-18% grain moisture they were: Kharkov 23 - 6,38% Woodland 90 - 6.77% 93 Early - 7,35%. With increasing initial moisture content of grain dry matter loss increased.

Effect regimes drying grain pasta properties

Variants	Regimes drying		The initial humidity 17-18%			The initial humidity 20-21%		
	temperature carrier, °C	exposure, minute	loss during cooking, %	weight ratio tenderize	overall pasta, points	loss during cooking, %	weight ratio tenderize	overall pasta, points
	Early 93							
1	Air-solar (control)		6,78	3,57	5,4	6,80	3,64	5,3
2	80	30	6,85	3,59	5,2	6,90	3,60	5,2
3	100	30	6,89	3,62	5,0	7,06	3,63	5,1
4	120	30	7,11	3,67	4,9	7,14	3,69	4,9
5	80	60	7,05	3,58	5,0	7,11	3,59	5,0
6	100	60	7,15	3,63	5,1	7,18	3,65	4,9
7	120	60	7,35	3,69	4,8	7,44	3,73	4,5
8	I-80	30	6,92	3,62	5,2	7,12	3,64	5,2
	II-100	30						
9	I-80	30	7,23	3,68	4,9	7,34	3,70	5,0
	II-120	30						
	<i>LSD</i> ₀₅		0,19	0,02	0,21	0,23	0,04	0,25

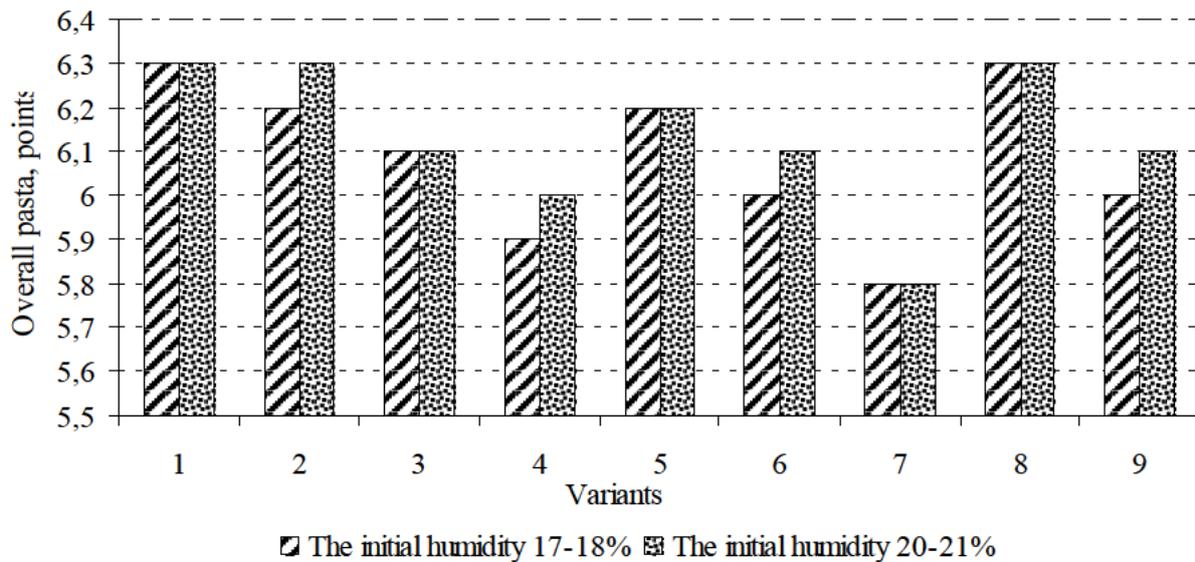


Sort Woodland 90								
1	Air-solar (control)		6,26	3,42	6,3	6,37	3,53	6,3
2	80	30	6,24	3,49	6,2	6,48	3,56	6,3
3	100	30	6,32	3,53	6,1	6,44	3,59	6,1
4	120	30	6,58	3,60	5,9	6,65	3,62	6,0
5	80	60	6,37	3,57	6,2	6,45	3,58	6,2
6	100	60	6,43	3,62	6,0	6,56	3,64	6,1
7	120	60	6,76	3,66	5,8	6,85	3,67	5,8
8	I-80	30	6,34	3,58	6,3	6,49	3,59	6,3
	II-100	30						
9	I-80	30	6,68	3,64	6,0	6,73	3,67	6,1
	II-120	30						
	<i>LSD</i> ₀₅		0,13	0,02	0,18	0,15	0,03	0,19
Sort Kharkiv 23								
1	Air-solar (control)		5,94	3,29	7,4	6,01	3,31	7,3
2	80	30	5,90	3,30	7,5	5,97	3,28	7,4
3	100	30	6,02	3,28	7,3	6,11	3,30	7,3
4	120	30	6,16	3,31	7,1	6,57	3,34	7,0
5	80	60	6,06	3,28	7,4	6,17	3,32	7,3
6	100	60	6,25	3,33	7,1	6,09	3,36	7,0
7	120	60	6,38	3,35	6,9	6,48	3,41	6,8
8	I-80	30	6,15	3,30	7,3	6,25	3,33	7,3
	II-100	30						
9	I-80	30	6,29	3,34	7,1	6,38	3,38	7,0
	II-120	30						
	<i>LSD</i> ₀₅		0,10	0,01	0,11	0,12	0,02	0,16

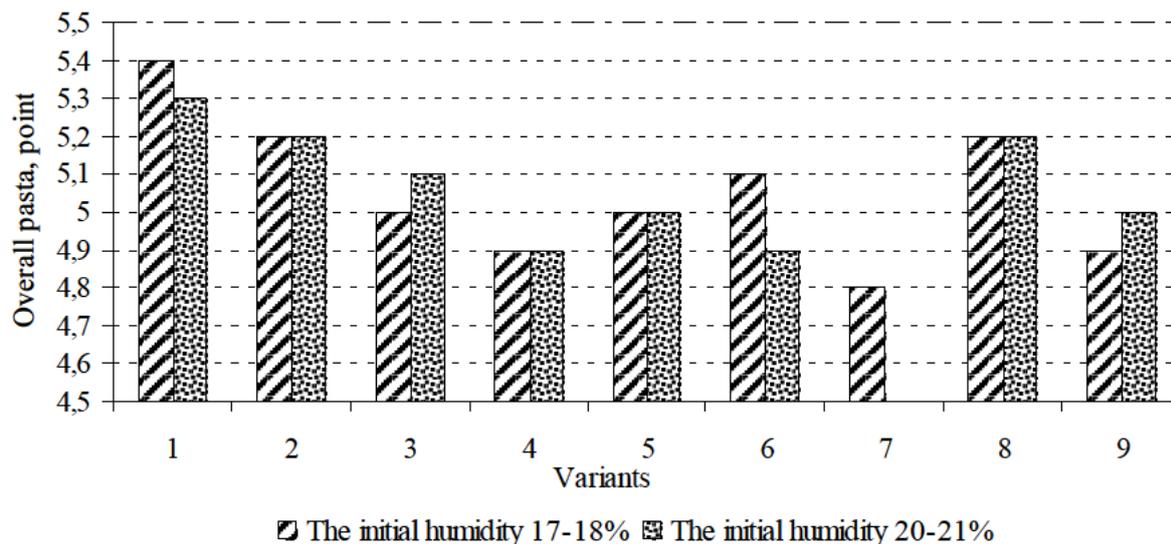


▨ The initial humidity 17-18% ▩ The initial humidity 20-21%

Quality pasta regimes depending on grain drying and initial moisture content, sort Kharkiv 23



Quality pasta regimes depending on grain drying and initial moisture content, sort Woodland 90



Quality pasta regimes depending on grain drying and initial moisture content, sort Early 93

Conclusions. So when drying grain, depending on its purpose, to prevent deterioration of technological skills necessary to consider the initial grain moisture, temperature and exposure carrier heat drying. During the processing of grain to pasta can also be noted that the heating temperature grain drying technology affects performance, increases the coefficient of cooking, increase dry matter losses during cooking, deteriorating color pasta.

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Voytsekhovskiy V., Nasikovskiy V., Khostomaha I.
THEORETICAL SUBSTANTIATION OF PREDICTION STORABILITY
POTATOES

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Войцеховский В., Насиковский В., Костомаха И.
ТЕОРЕТИЧЕСКОЕ ОБОСНОВАНИЕ ПРОГНОЗИРОВАНИЯ
ЛЕЖКОСТИ КАРТОФЕЛЯ

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The article is selected the complex factors to forming long storage of potato tubers. Classification of factors and improve their analysis methods allow to solve an important problem - the implementation of integrated search reduction of losses of different types of long-term storage of potatoes.

Key words: potatoes, suitability for storage, factors of influence

В статье выделен комплекс факторов формирующих к длительному хранению клубней картофеля. Классификация факторов и совершенствования методики их анализа позволяют решить важную проблему - осуществление комплексного поиска снижения потерь разных видов при длительном хранении картофеля.

Ключевые слова: картофель, пригодность к хранению, факторы влияния.

World potato production trends characterize it as the fourth most widespread and important crop after rice, wheat and maize. Even today, the world's potato area exceeded 20 million ha. Potatoes are an integral part of the global food system is nezlakovym food commodity №1 in the world. Over recent years global potato production exceeded 450 million. tons. Potato consumption is becoming more common in the developing world, which now accounts for more than half of the global harvest and where the ease of cultivation and high energy content of the potatoes turned into the most important crop, bringing real income [2,3,4].

The largest potato producers are Asian countries, which annually produce more than 145 million tons of potatoes. The second on this indicator are the European country in which more than 110 mln tons of tubers. Comparatively small amounts of potatoes harvested in North and South America, Africa and Oceania countries. In Ukraine, the volume of potato production was over 20 million tons in 2016. Constant demand for capacity used by manufacturers to expand areas and improve the cultivation and storage technology [5, 6,9].

World potato crop losses only from diseases account for more than 90 mln. Tons, or 17% gross yield, which is 2 times more than the loss of crops, vegetables and sugar beet. Should also consider the that the quality and weight loss depending on the type and quality of harvesting, storing and processing operations for use and consumption of up to 50-60% [1,7,8,10].

The aim of our research was the generalization and systematization of knowledge of the factors affecting the formation of weight loss and quality of



potatoes from the harvest to implementation.

Forecasting keeping quality is of great practical importance, especially for large volumes of production, storage and processing of potatoes. Its role is greatly increased in market conditions, when taking into account the price conjuncture it is necessary to decide on the implementation of the potato time: autumn, winter or spring. During the period of mass harvesting often prices are set extremely low, does not pay the actual costs of farms for the cultivation and transport. In this regard, the question arises of the realization of the product in the winter or spring. However, without knowing the keeping quality leaves on the long-term storage of potatoes parties, such a decision involves a significant risk because the losses during storage (decay, mass loss) could be at the cost higher than the difference between the prices of autumn, plus the cost of electricity in the process of storage. Keeping quality forecasting is a complex problem whose solution is based on an assessment of a number of factors, both external and internal. However, despite the complexity, it is possible to predict with some certainty, the level of which depends on the number of factors and thoroughness recorded analysis. The more factors into account, the higher the accuracy of the forecast, the higher the cost-effectiveness of adopted on the basis of decisions [3,4].

On the basis of summarizing the results of years of research of domestic and international experience, a list of the main factors determining the keeping quality of potatoes, its suitability for long-term storage. At the same factors conventionally divided into external and internal to the five-point assessment of their significance. They characterize the conditions and technology of cultivation, harvesting, bookmarks tubers for storage, and high-quality features of the tubers. Based on the average score as measured by the sum of the factors taken into account, divided by their number, made the forecast of appropriate retention period, in which the total loss will not exceed the regulatory permissible level.

The external factors include: soil type, its moisture in the pre-harvest period; humidity and temperature at the time of harvest; the general background of the development of disease in the pre-harvest period; cleaning method (harvester, digger); tubers loading technology in the store (threading, transshipment, co-current); temperature and relative humidity in the loading period and the first month of storage; the duration of the download store.

The internal factors include: varietal characteristics; resistance to late blight; mechanical damage; potential keeping quality; Group of ripeness; the average size or mass of the tubers; the maturity of the tubers during harvesting (peel strength); the projected storage period.

On the characterization of the tubers are (determined by analysis of the tubers) affected by the disease, the level of mechanical damage (total and by species), turgor (limp or elastic), the temperature during the laying of the deposit. The internal factors are also concerns a method of storing (in bulk, in bins, containers), the possible intensity of ventilation (passive or active), based on the performance of installed fans, that the system of mixing chambers and valves, storage technology and, above all, the ability to dry the tubers in layers in during loading or in the first 2-3 days after loading. On the basis of these factors is determined by the average score in



accordance with the below given estimates.

After gathering the information you need to start drawing up the forecast. First, make a preliminary forecast, and then, a month later, the final, which is determined for each batch of potatoes (field grade, and so on).

Average is defined as the number of votes divided by the number of discounted factors (presence of wet rot, tubers defeat late blight, the level of mechanical damage, varieties resistant to late blight and mechanical damage, the potential keeping quality, group of maturity, the average size of tubers, the degree of maturity, harvesting conditions (weather, soil moisture, temperature) Alignment Operation working parts of harvesting machinery, loading technology in storage, the planned method of storage, use of drying tubers, the use of active ventilation, a tendency to grade functional disorders during storage, high-quality features of the dormancy period. There can be considered more than 14 factors and the role of each forms a cluster of general safety.

Preliminary forecast should be updated as a result of the storage at the end of the month after loading, taking into account the conditions and the quality of drying, the treatment period, the intensity of ventilation, the conditions of the cooling temperature of the potato mound and its status in the initial period of storage.

According to the results of domestic and foreign research level allowable losses during prolonged storage - more than 6 months - is considered normal within 10-12%, including natural decline in weight in the range of 6-8%. Large losses of weight loss suggests an inflated rate of ventilation, which leads, in addition to weight loss and reduce tuber quality (loss of turgor) to inflated energy costs.

Evaluation of the reliability of the forecast the keeping quality of tubers with the above characteristics carried out in a number of varieties of domestic and foreign selection at specialized enterprises. Extension of shelf life as compared with the forecast, especially with low initial quality of tubers, associated with a significant increase in the total loss from 5-7 to 10-15 percent or more.

During the research a direct relationship has been established between the keeping quality and yield of seed potatoes. The higher the keeping quality, in line with forecasts, the higher the potential yield. Therefore, you should not use the landing seed stored in the spring with great loss if the forecast of its short shelf life was determined. Furthermore diseased potato storability also has a significant impact level of mechanical damage tubers, which depends on the conditions and the cleaning method of the load in the storage technology.

Statutory loss weight loss during storage of potatoes in different conditions imposed in the table.

Based on the calculations bookmark products in specialized storage with active ventilation for 7-8 months, the natural decline will amount to 5%, and in the repository without forced ventilation and cooling to 6.5%, on the condition Share high-quality products. According to the data of many years of specialized institutions it varies from 6-20%, and the average for most varieties grown in the forest-steppe Ukraine, when stored in a potato storage facilities - is 7,5-8,9% [5111].

In conclusion, we can say that the potato storage is a strategically important component of food security of Ukraine. Development and improvement of methods



Month	Kind of repository / The loss of weight,%		
	with artificial cooling	without artificial cooling	piles and trenches
October	1,4	1,3	1,0
November	1,0	0,9	0,6
December	0,7	0,7	0,5
January	0,4	0,5	0,5
February	0,4	0,5	0,5
March	0,4	0,5	0,5
April	0,7	0,9	0,5
May	0,9	1,1	0,8
June	1,5	1,8	0,8
July	–	2,0	0,8
August	–	2,5	0,8

of forecasting keeping quality an important part of increasing economic efficiency in trade and processing industries. This material is useful in potato plants with storage and processing, in order to minimize various types of losses and overall quality.

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**THEORETICAL EXPLANATION OF PERSPECTIVE DIRECTIONS
 IMPROVING THE EFFICIENCY OF PRIMARY FRUIT PROCESSING
 COMPONENT OF FOOD INDUSTRIES UKRAINE IN CONDITIONS OF
 CRISIS**

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**ТЕОРЕТИЧЕСКОЕ ОБОСНОВАНИЕ ПЕРСПЕКТИВНЫХ НАПРАВЛЕНИЙ
 ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ПРЕДПРИЯТИЙ ПО ПЕРВИЧНОЙ
 ПЕРЕРАБОТКЕ ПЛОДОВО-ЯГОДНОГО СЫРЬЯ ВИРАЩЕНОГО В УКРАИНЕ В
 УСЛОВИЯХ КРИЗИСА**

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The main areas that improve production efficiency are: accelerating the pace of scientific and technological and organizational progresses (creating new and improving existing technologies of cultivation and processing of fruit and berry raw materials of labor and finished goods; mechanization and automation of production processes, the introduction of advanced methods and forms of production and labor, construction and regulation of market economy mechanism). Classification of factors and improving methods of analysis, can solve an important problem - implementing a comprehensive search of reserves in order to improve fruit processing industry.

Key words: fruit processing industry, classification, factor, efficiency.

Основными направлениями, которые повышают эффективность производства, являются: ускорение темпов научно-технических и организационных разработок (создание новых и совершенствование существующих технологий: выращивания и переработки плодово-ягодного сырья, механизация и автоматизация производственных процессов, внедрение передовых методов и форм производства и труда, строительства и регулирования механизма рыночной экономики). Классификация факторов и совершенствование методов анализа, может решить важную задачу – поиска и внедрение незадействованных резервов с целью улучшения плодоперерабатывающей отрасли пищевой промышленности.

Ключевые слова: плодоперерабатывающая отрасль, классификация, фактор, эффективность.

Introduction. Ukraine has a very strong potential for production of fruit and berry raw materials, currently at 2015 - gross yield reached more than 2 million tons, with the prospect of growth. Consumption of fruit production in Ukraine for the scientific and reasonable standards of 76-78 kg per year, and the reality the



population consumers 60% of this norm. According to the branch program "Fruits and berries Ukraine - 2017" Ministry of Agrarian Policy of Ukraine forecasted increase in production of processed products and semi-finished products by 2017 in terms of categories of a natural juice 30-40% concentrate - 25-30%, dried fruit - 7-8 times, mashed and semi - 20-25% natural fruit drinks and fruit wines with a high content of bioactive substances by 20-25% [1]. Especially important is the task of creating the processed products of high quality and biological value, treatment, preventive and functional purpose [7].

Economic potential industrial gardening and viticulture is sufficient for a significant expansion of the domestic market of fruits, berries, grapes and products of industrial processing. This is due to a large population density, the concentration of it in the big cities and industrial centres and the availability of a wide network of fruit processing enterprises. With increasing material welfare will certainly increase the demand for fruits, berries and grapes. Also, there are real opportunities for a significant increase in production of products for export. Given the competitiveness and improving the economic mechanism of realization of these products will have unrestricted market in Russia and other countries. A good example for this is the neighbouring Poland, which in less favourable natural conditions for the development of horticulture produces twice as many apples than Ukraine, and in a lot of exports to Russia, Finland, the Baltic countries and others [4].

An important problem the effective development of the domestic market offers fruits are unstable, due to a combination of factors related to seasonal features and the crisis in horticulture. Layoffs fruit orchard enterprises is due to their low financial support, the almost complete absence of borrowed funds, failure cultivation of fruit farming, particularly in the application of mineral and organic fertilizers, protection of plants against pests and diseases, due to inflation processes in country (prices fuel and agrochemicals significantly increased), lack of modern storage facilities for storage, deficiencies in marketing activities, low purchasing power of the population and so on. Thus, by farm size of the market formed by 15%. To fully meet consumer demand for high quality fruit products during the year, increasing and diversifying the range and assortment important expansion of production [2].

Currently fetal development processing component of the food industry is under the influence of objective and subjective factors, including: organizational, technical, economic and social, which needed a complex generalization and systematization. The production process as a whole must take into account the most important institutional and economic factors [4].

Purpose of the work. The purpose of work is research and compilation of national and international experience in the functioning of fruit processing industry, as well as the analysis of the system of interrelated factors shaping its efficient operation.

The research results and discussion. Economic efficiency - a complex of economic categories, which reveals it's essence by a number of natural and cost indicators. However, should clearly separate the notion of "efficiency" and "effect." The latter should be understood as a consequence or outcome effectiveness. The effectiveness of any production can describe a limited number of indicators, but these



figures are affected by other factors. Therefore, a systematic approach is needed comprehensive assessment of the impact of various factors for their study. Knowledge of the factors of production, the ability to determine the magnitude of their impact on performance will form their level metrics with management factors.

Economic theory identifies factors which include production activity resources - land, labor, capital and entrepreneurship features. The term "factor" - interpreted as a term describing the reason for the change of any phenomenon. Factors - elements causes exercising direct influence on performance or events. In this sense, economic factors like economic categories displayed indicators are objective. While the term "index" - is treated as a numerical value used to measure or calculate certain factors [3].

Factors in the economic analysis can be classified according to various criteria. Classification of factors improving the efficiency of production allows to identify the causes of the phenomena studied accurately assess the place and role of each factor in shaping the values of performance indicators. Thus, the factors may be common, that influence the number of indicators, or private-specific index. The general character of many factors explained conditionality and mutual bond that exists between individual performances. Over the period of influence factors are divided into fixed and variable and the degree of influence - main and minor. The nature of the factors are divided into intensive and extensive, first ensure changes associated with quantitative growth in the effective rate; the second increase in the effective rate given by high-quality components of the manufacturing process. Depending on the origin of produce internal and external factors that are dependent and not dependent on the enterprise.

Inside the main factors determine the theoretical results of the company. Domestic non-core factors influencing although general indicators, but not directly related to the essence of the analyzed indicator. External factors independent of the company, but quantitatively determine the level of production and use of financial resources of the company.

The main areas of improvement in production efficiency are: accelerating the pace of scientific and technological and organizational progress (creation of new and improvement of existing technologies of cultivation and processing of the fruits of labor and finished goods; mechanization and automation of production processes, the introduction of advanced methods and forms of production and labour, creating and regulating market economy mechanism). Technological innovations, particularly modern biotechnology and resource saving technologies, forms automation and information technology significantly affect the level and dynamics of production efficiency. For a chain reaction they cause significant changes in the technological level and productivity of technological equipment, methods and forms of work processes, training and skills development, etc.

Determining factor in increasing efficiency are employees - executives, businessmen, professionals, workers. The productivity of labour is largely determined by the methods, techniques, personal skills, knowledge and attitude to work and ability to perform certain tasks. Business quality employees are the most complete in terms of powerful and flexible motivation mechanism. Productivity increases when the management company financially and morally stimulating the use of creative



abilities of all categories of workers, is interested in their personal problems, helps create and maintain favourable social microclimate within their power and capabilities of the enterprise, provides social protection of people, guaranteeing their employment etc.

To increase the efficiency of the processing industry enterprises tinned significantly influenced by changes in the market, industrial and social infrastructure. In modern conditions the company in the process of innovation, production and business can not do without the services of innovation funds, commodity exchanges, labour exchanges, stock exchanges, commercial banks and other market infrastructure institutions. The direct impact on the performance of businesses and the efficiency of production as a whole gives proper development and operation of high-quality industrial infrastructure - communications, transport, wholesale and retail trade, specialized information systems and so on.

In production efficiency at different levels of management often affect structural change in society based on quality management of individual companies. And these interactions in the long run time - always bilateral. Structural changes are reflected in the level of overall efficiency and productivity improvements can contribute to modifying the structure of social production.

The main criterion for product quality should be a particular focus on the interests of the buyer, the degree of satisfaction of his needs, which are often expressed in terms of the appearance in it of additional income. The rigid focus on vendor specific buyer in advance allows the manufacturer to determine the quality parameters of products, creating conditions for better use of the potential of increasing the competitiveness of semi-finished and finished products.

The essence of planning, development and management product range is to offer producers a timely set of goods, answering a whole profile of its production activities that best meet the requirements of specific categories of consumers.

One important factor in favour is withdrawing from the production of cost-effective products [5].

Product range now precedes the development of product line concept. It seeks unification assortment structure, product offering, with a basis for taking on the one hand, the needs of specific groups of consumers, and the other - the need to ensure the most effective use of enterprise commodity, technological, financial and other resources in order to produce products with low cost . Range management involves coordinating interrelated activities of science, technology and design, comprehensive market research of sales, service, advertising, stimulate demand [9,10].

A special place with cultural and demographic factors: the structure of consumption, tastes and lifestyle of the population as a whole and its individual demographic groups, literacy level, history, cultural traditions, religion, cultural needs, livelihoods, work, leisure, sports, etc. [6,8].

The low life expectancy, high mortality (especially of working age), low birth rate and aging population difficult transition to intensive forms of economic development, reducing the impact on economic growth, the lack of quality and reducing workforce productivity; limiting wage growth and therefore lower income working population.



The reduction of fertility gives an obvious effect on the sales of products and ultimately affects the provision of public pensions as retirees should receive support from the limited number of people of working age. Similarly, changes in the ethnic composition of the city or the concentration of population (given that only a few people live in the centres of large cities) because changes in the demand for local products and retailers as well (not so great) changes in the type of goods and services that are demand.

In agriculture the efficiency of enterprises have a decisive influence soil and climatic factors, as the cultivation of fruits and berries is carried out in the most favourable natural and climatic conditions. The duration of the growing, demanding to heat, light and as grants in certain crop variety, different and hence limits the spread of cultures and the possibility of joint cultivation. Advances in science and technology allow reduction in the natural environment, but only to a certain limit and if the influence of other factors (for example, irrigation in drought conditions in the presence of heat and provision of basic macro- and micronutrients can extend the area of distribution of crops). Analysis and synthesis of different sources allows you to organize and establish ways to increase efficiency.

Internal and external factors are divided into group and individual. Internal group include: scientific, technical, organizational, economic, social and psychological; external: external economic, political, cultural, demographic, soil and climate.

Scientific and technical internal factors have the individual performance: accelerating scientific and technological and organizational progress, comprehensive mechanization and automation of production, modernization of equipment and machinery, expansion innovation component, application resource of innovative technologies, modern information technology, investment, and their rational use, improve product quality, standardization and certification of products, new technologies and advanced cultivation and processing of raw materials, work tools and finished products, the establishment and regulation of market mechanisms of management and organization of work.

Organizational-economic factors have the internal unit parameters: quality management, specialization and cooperation of production, rational distribution of productive forces, exchanging between structural units and information products, services and financial assets, improving inter-economic relations, improvement of economic relations, economic and financial independent businesses, return on costs and profitability, economic responsibility of labour collectives fulfilment, increasing production volumes and competitive withdrawing from the production of unpopular products, formation of optimum assortment and supply, reducing the cost of finished products, improve competitiveness and efficiency, increase the output per unit of raw material replacement of imported raw materials - domestic rationalization conduct of the inventory, development of effective methods of delivery and economic structural changes.

Social and psychological factors have the internal unit performance: professional training and retraining of workers, improving the use of human resources, to ensure a balance between overall supply and demand, improve the



efficiency of the educational and professional level of personnel, establishment of career prospects, improving the quality of living conditions, management free time and the rational use and structural changes in the formation of social character.

External economic external factors have the following individual indicators: the practical activity of state institutions and structures, improvement of the legislative framework, setting and monitoring of economic rules and regulations, mutual assistance and cooperation of, the international division of labour, the creation of a competitive market, industrial and social infrastructure, monitoring macroeconomic changes and monitoring taste and style of the population.

Cultural external factors have the following individual indicators: formation of a certain level of literacy tradition of most people, especially your tastes and lifestyle and cultural needs of consumers and the level of security of life (health, leisure, sports, etc.).

Demographic external factors have the following individual indicators: age structure, income level of the population, the level of culture and education, availability of social benefits, especially the range of consumption, especially the employment of the population (the conditions and quality of life), the peculiarities of social infrastructure in the periphery, especially the ratio of the multitude of the city and the rural population, the level and availability of medical areas, accessibility and impact of recreation and social organizations, radio, television, Internet and others.

Soil and climatic external factors have the following individual parameters: climatic conditions (precipitation and active temperature, duration of vegetation); intensity of solar radiation; rainfall frequency of adverse conditions (drought, frost, wind erosion, etc.); availability of hydro (possibility of irrigation); transportation and logistics and the availability of sufficient land resources and others.

Conclusions. Using the proposed model factors and improving methods and methods of analysis can solve important tasks, including the main highlight important indicators of the impact which the external adverse factors are taken to evaluate the performance of the company, objectively reflect its condition and prospects. Thoroughness of complex factors classification is that based on it is possible to simulate any production activities, and implement a comprehensive search for internal reserves to enhance production efficiency.

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IRREGULAR MOVEMENT AIR-MIX FOR FLUIDS IN FLUID DISPENSING SYSTEM SPRAYERS*National university of life and environmental sciences of Ukraine**Heroyiv Oborony st., 15, Kyiv, Ukraine*

Abstract: One of the ways to reduce rates of application of pesticides at improving the quality of treatment is the use of atomizing spray of working liquid. For dispensing low standards of working fluid flow said fluid developed a system in which, however, under certain conditions, may cause movement of unstable ordnance air-liquid mixture, which negatively affects the quality of treatment. A study of the uneven motion the air-liquid mixture in a fluid dispensing system. It was found that the greatest impact on the unevenness of the supply of hydraulic fluid to provide sprayer layout dispenser-distributor.

Keywords: said fluid dispensing system, the unevenness of the movement, the sprayer, air-liquid mixture

Introduction. To improve the efficiency of agricultural production must be put into practice intensive technologies of cultivation of field crops, which leads to increase in the use of crop protection chemicals. Thus developed technology and technical means to ensure the possibility of reducing pesticide consumption rates by improving the quality of their application.

Literature review. One of the ways to reduce rates of application of pesticides at improving the quality of treatment is the use of atomizing spray of working liquid. Application of fine droplets determines the improvement in the quality of treatment. In addition, the use of low rates of application of the working fluid provides increased performance sprayers field crops [1].

Norms for dosing small working fluid flow has been proposed said fluid dispensing system, in which the central liquid dosing nozzles on the group of its mixing with the air flow, the distribution and transportation of the air-liquid mixture to the dispensers on separate pipelines. The aerosolized liquid occupies a large volume. At the same time for her dosing is possible to use a dosing hole larger, allowing preclude obstruction and provides high-quality spraying with an application rate of the working fluid from 10 to 70 l/ha [2].

However, under certain conditions, the fluid dispensing system may cause unstable slug motion the air-liquid mixture, which adversely affects the uniformity of the sputtered area of drugs. Therefore, **the aim of our research** is to determine the uneven motion of air-liquid mixture fluid in the system working fluid dispensing into the sprayer.

Input data and methods. Research carried out for two variants: when driving the air-liquid mixture up and down. Methods of determining the non-uniformity of motion of air-liquid mixture fluid in the working fluid dispensing system is as follows. The dispenser-distributor joined pipes with nozzles of variable diameter. One of the pipelines by a motor with gear corrugated moved over the surface by



spraying liquid through the nozzle. The atomized liquid flowing down the corrugated surface, fell into special containers (weighing bottles) and then froze its volume occurred.

To determine the effect of non-uniformity of motion of air-liquid mixture fluid in the working fluid dispensing system on uneven spraying the working fluid spray, the dispenser-distributor pipes joined 3 m long with an internal diameter of 15,5 mm for the transport. The five pipes joined to the nozzle inner diameter of 5 mm. These pipes lowered into a tank for collecting the working fluid. Sixth pipe nozzles with variable diameter of the rotor to the spray gun, which was placed on a special stand.

Variable factors in the study of the uneven motion of air-liquid mixture in fluid dispensing system and the limits of their variation as follows: the angle of inclination of the dispenser-distributor θ – -90° and 90° ; the air pressure P_c – 0,04-0,07 MPa with 0,1 MPa; inside diameter nozzle into the pipeline for transporting the air-liquid mixture – 4,5 mm, 6,5 mm, 8,6 mm, 15,5 mm and without packing.

Results. Discussion and Analysis. As a result of uneven motion studies air-liquid mixture fluid in the working fluid dispensing system function changes was obtained liquid spray volume from the transport pipe through the nozzle over time. Coefficients of variation of random functions describing the working fluid dispensing unevenness in time are shown in Fig. 1, from which it is clear that a reduction in air pressure and nozzle diameter on the pipe volume coefficient of variation sprayed on the corrugated surface of the liquid increases slightly for the case when the direction of action of the aerodynamic drag forces and opposing gravity ($\theta=90^\circ$), and then, when they match ($\theta=-90^\circ$). However, it should be noted that not such a sharp $\theta=90^\circ$ to 6,5 mm in nozzle diameter and coefficient of variation of less volume spray water dramatically increased (Fig. 1, a), whereas the $\theta=-90^\circ$ growth (Fig. 1, b). A significant reduction in the coefficient of variation (2-4 times) is observed in the case when the direction of the air resistance and gravity coincide. The degree of influence of these parameters the fluid dispensing system of the working fluid in the sprayer turnover coefficient of variation of the volume of atomized water, which has been investigated by us through our analysis of variance, the following: the angle of inclination of the dispenser-distributor – 82,4%, the nozzle diameter of the pipeline to transport air- liquid mixture – 14,5%, the air pressure in the fluid dispensing system – 2,7%, the combined effect of these factors – 0,4%. Provided that the diameter of the nozzle on a conduit for conveying the air-liquid mixture is 4,5 mm, the effect on other parameters of variability of the coefficient of variation of the volume of sprayed liquid surface corrugated as follows: the angle of inclination of the distributor-dispenser – 98,8%, the air pressure in pneumohydraulic dosing system – 1,2%.

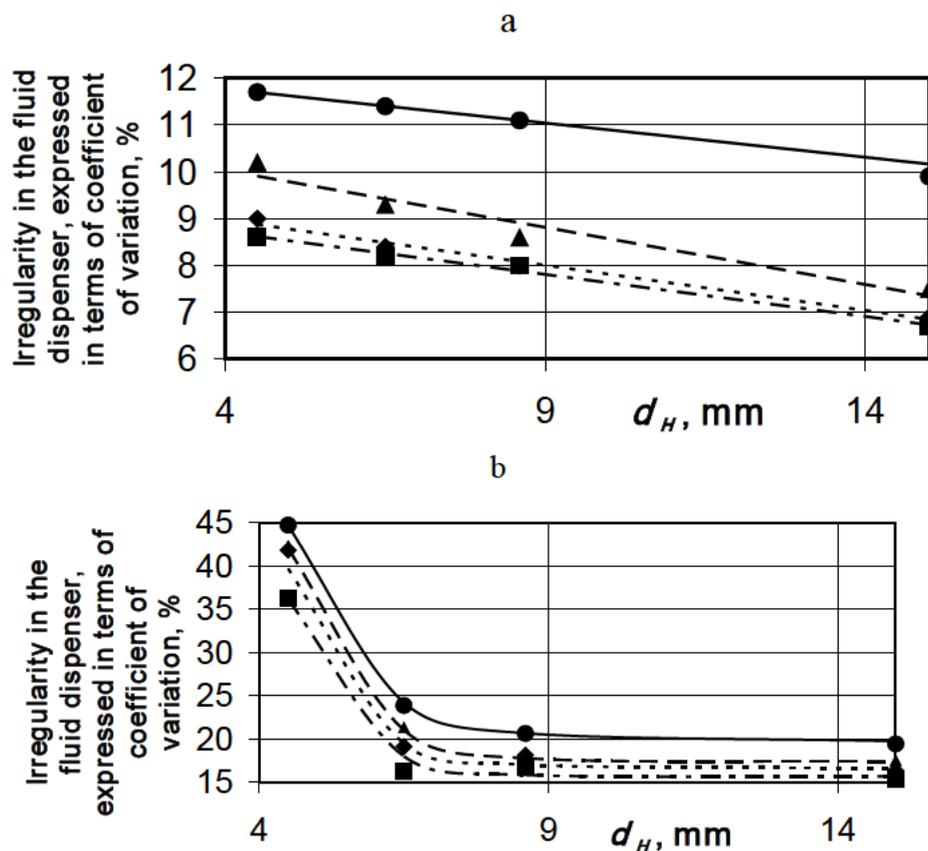


Fig. 1. The uneven liquid supply to the spray gun, expressed as the coefficient of variation sprayed above the liquid surface, depending on nozzle diameter of the pipeline: experimental:

■ – $P_c = 0,07$ MPa; ◆ – $P_c = 0,06$ MPa; ▲ – $P_c = 0,05$ MPa; ● – $P_c = 0,04$ MPa; curve approximation: — – $P_c = 0,07$ MPa; — — – $P_c = 0,06$ MPa; - - - – $P_c = 0,05$ MPa; - · - · – $P_c = 0,04$ MPa; a – $\theta = 90^\circ$; б – $\theta = -90^\circ$

Summary and Conclusions

On the uneven supply of hydraulic fluid to the nozzles in the rotor system has the greatest impact dosing layout dispenser-distributor.

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DETERMINATION OF ENERGY VALUES OF SAUSAGE ON BOMB CALORIMETER*National university of life and environmental sciences of Ukraine**Kyiv, Heroyiv Oborony, 15, 03041*

Annotation. The results of determining the energy value of the test sample sausages experimentally. The experimental method for determining the energy value of the fuel or its combustion heat is the most accurate way to that produced in the laboratory using a special device, a so-called bomb calorimeter. Justify use of program developed by the authors to calculate the data obtained at calorimetric studies. Visualized report form used to display the results of the study.

Keywords: calorific value, calorimetric bomb, sausages, software, experiment

Introduction. The food composition comprises protein, fat, carbohydrates, vitamins, minerals (macro and trace elements) and water. However, the energy value (calorific value) have only proteins, fats and carbohydrates. They and we should take into account when assessing the caloric content. The joule, or kilojoule (kJ), reflects the standard international unit (SI unit) for expressing energy. To convert kilocalories to kilojoules, multiply the kilocalorie value by 4.184. The kilojoule value for 1/2 cup of peanut butter, for example, would equal 759 kCal 3 4.184, or 3176 kJ. The composition of the food indicated in the tables calories and always on the product packaging. Ingredients are always indicated in grams of component (separate proteins, fats and carbohydrates) per 100 grams of edible part of the product (ie bananas peeled, plums, pitted, eggs without shells, boneless meat and fish, etc.). Caloric also indicated in kcal per 100 g of edible portion of the product. In addition to the composition indicated on the product label and its energy value. The discrepancy between the results of the calculation of the composition and said energy value should not be surprising. Sometimes the energy value of the product is determined by direct incineration in a special apparatus, which gives slightly different matter, since the fiber contained in products with burning heat, but it does not have the energy value [3]. Calculation method for determining the energy value, based on the composition of the product, it is recommended to use only estimations and gives an approximate result. The experimental method for determining the energy value of the fuel or its combustion heat is the most accurate way to that produced in the laboratory using a special device, a so-called bomb calorimeter.

Differences exist in the energy value of foods when comparing the heat of combustion determined by direct calorimetry (gross energy value) to the net energy value actually available to the body. This pertains particularly to proteins, because the body cannot oxidize the nitrogen component of this nutrient. Rather, nitrogen atoms combine with hydrogen to form urea (NH₂CONH₂) for excretion in the urine. Elimination of hydrogen in this manner represents a loss of approximately 19% of the protein molecule's potential energy. This hydrogen loss reduces protein's heat of combustion in the body to approximately 4.6 kCcal per gram instead of 5.65 kCal per



gram released during oxidation in the bomb calorimeter. In contrast, *identical* physiologic fuel values exist for carbohydrates and lipids (which contain no nitrogen) compared with their respective heats of combustion in the bomb calorimeter [5].

Analysis of the latest research results. In Ukraine, every year, all the more significant difficulties arise in the field of thermal measurements. This is due to shortage of funds in the new standardized instruments for measuring the heat of combustion, which are very expensive. The majority of the exploited water calorimeters, obsolete and worn out physical resource. Contrary to expectations, they are exploited in research universities, laboratories, chemical companies, quality control laboratories, production, laboratories and other arbitration. In such calorimeters measurement processes are not automated. Therefore, most of analyzed sources, which describes the results of calorimetric studies, the authors use the program, created in Microsoft Excel or specially designed for a specific calorimeter.

The purpose of work – experimental determination of the energy content of sausages in the calorimeter.

Research results. At the Department of thermal power in the National University of life and environmental sciences of Ukraine for research to determine the energy value (calorific value) of different prototypes used of the laboratory calorimeter [1]. Studies to determine the calorific properties of various types of biomass allowed to acquire practical experience in the bomb calorimeter and develop a phased technology determine the heat of combustion of solid and liquid biofuels.

In cooperation with the Faculty of Food Technology and Quality Control of Agricultural Products were carried out joint studies determining the energy value of different types of sausage recipes, which are developed by masters of the Faculty. For the experimental determination of the energy value of the samples were provided by various sausages. This article presents the results for the sample of cooked sausages "Podolyanka".

Crucial moment in determining the energy value of food or products of combustion heat food experimental method is the post-processing of the experimental results. For the processing of the experimental data, we use any copyrighted software that is made in Microsoft Excel. Calculations of the results of calculations carried out according to the procedure described in the works [2, 4]. Figure 1 is a graph curve obtained in the calorimeter temperature changes over time.

The next stage of the analysis of the data obtained with the calorimetric studies showed that the treatment of an array of experimental results, a significant factor in the final result, there is the human factor. It is not excluded that the admitted error when calculating the fuel calorific value, as a result of the experience can greatly affect the end result and distort it from reality.

For the analysis and clarity of the calculations in the program provides a visual step-step calculation of formulas, designed as a window of the program produced by the calculations (Fig. 2).

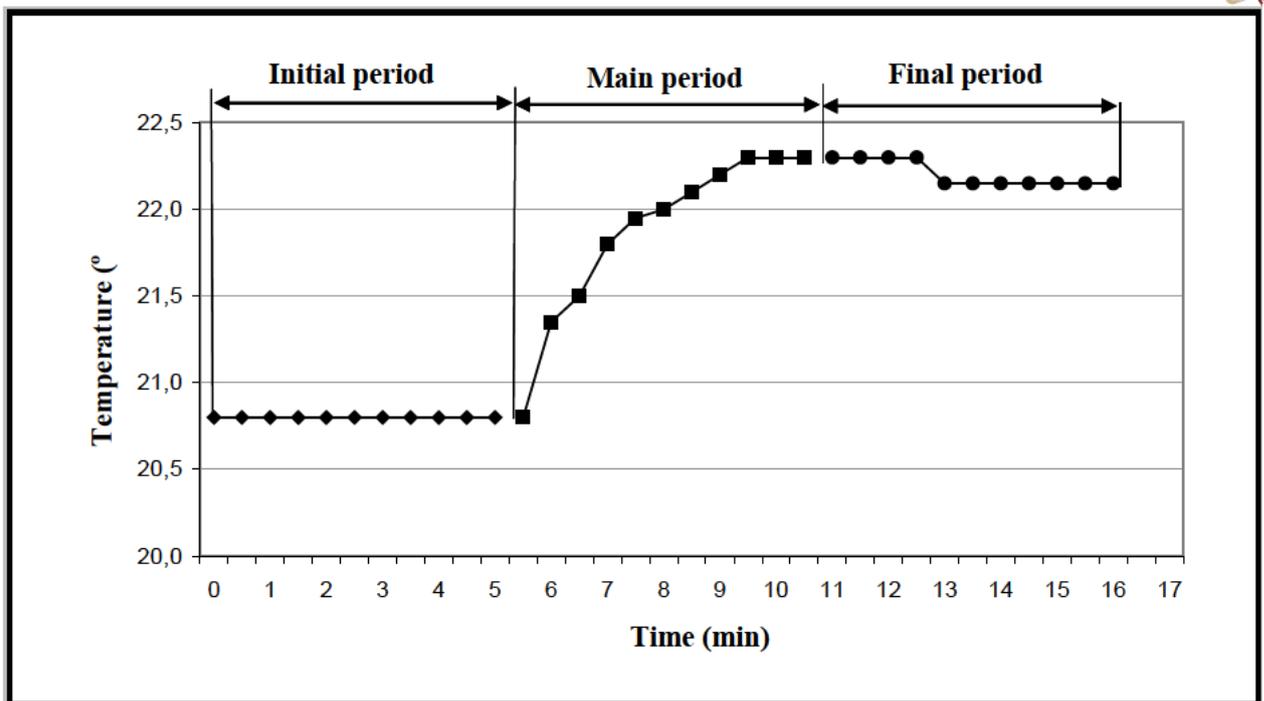


Fig. 1. Results of change of temperature during calorimetric experience

3. Definitions of combustion heat of the substance as a result of the experience

3.1. Determining amendments Δt on heat exchange to calorimeter with the external environment

$$\Delta t = \frac{m}{2} \left[\frac{(t_1^H - t_{11}^H) + (t_1^K - t_{11}^K)}{10} \right] + \frac{r}{2} \left(\frac{t_1^K - t_{11}^K}{10} \right) = 0,083 \text{ } ^\circ\text{C}$$

m =	2
r =	9

Sequential stage computing

$$\Delta t = \frac{2}{2} \left[\frac{20,8 - 20,8}{10} + \frac{22,3 - 22,2}{10} \right] + \frac{9}{2} \left[\frac{22,3 - 22,2}{10} \right] = 1 \left[\frac{0,0 + 0,2}{10} \right] + 4,5 \left[\frac{0,2}{10} \right] = 1 \left[\frac{0,2}{10} \right] + 4,5 \times 0,015 = 1 \times 0,015 + 0,0675 = 0,015 + 0,0675 = 0,083 \text{ } ^\circ\text{C}$$

3.2. Definitions of combustion heat of the substance

$$Q_b^a = \frac{K \cdot H \cdot [(t_K + h_K) - (t_0 + h_0) + \Delta t] - q_{np} \cdot G_{np}}{G_T} = 1877 \text{ cal/g} = 7851,58 \text{ kJ/kg}$$

Sequential stage computing

$$Q_b^a = \frac{1646,5 \times 1 \times [(22,3 + 0,1) - (20,8 + 0,1) + 0,083] - 500 \times 0,142}{1,35} = \frac{1647 \times [22,4 - 20,9 + 0,083] - 71,0}{1,35} = \frac{1646,5 \times 1,583 - 71,0}{1,35} = \frac{2605,6 - 71,0}{1,35} = \frac{2534,6}{1,35} = 1877 \text{ cal/g}$$

Fig. 2. The program window with a visual step-step calculation

Workbook program consists of several sheets of empty forms of protocol and the summary table for the sheet produced by experiments. This program allows the user to selectively print or a protocol or just finished a summary table of the results of all the experiments.

Conclusion

Software has been developed in Microsoft Excel software package to reduce the labor intensity of the experience and colorimetric exclusion of human error in the calculation from the data of the experiment. As a result of the experience determined



that the energy value of the provided sample boiled "Podolyanka" sausage is 1877 kal/g or per 100 grams of the product - 187 kcal, which is consistent with calorie sausages of this type.

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IMPROVEMENT OF THE CALORIMETRIC STANDARD*National university of life and environmental sciences of Ukraine**Kyiv, Heroyiv Oborony, 15, 03041*

Abstract. In the article the improvement method for determining the calorific properties of granulated biofuel energy value of feed supplements and other solid combustible materials. The method is to use the package (tissue paper) to wrap it in an experimental sample tests, strap defined thread length and further define the heating fuel properties. Advanced mode enables realistic and better define the calorific property biofuels and granulated sulfur in it. An improved method for expanding calorimetric standards to determine the energy equivalent of calorimeter by determining the energy of combustion of other substances, namely, powdered sugar using batch mode of combustion.

Key words: calorific value, energy value, calorimeter, pack, method.

Introduction. For the most efficient use of biofuel and feed supplements need them preconditioning, namely the reduction of high humidity and increased bulk weight, drying and pressing needs for easy transport. The most effective type of training is granulation. This final moisture content of the finished product is 8.12%, and the starting material is compacted by 5-10 times. Granulated biofuel and feed supplements also have constant quality characteristics, easy storage, used in heating systems. In the countries of Western Europe, USA, Japan and Ukraine in recent years, biofuels and granulated feed supplements are increasingly used as an industrial power, and for domestic heating installations. Dozens of companies offer heating equipment, which uses pellets as fuel and food supplements. Most used pellets from waste wood, straw, sunflower husk.

In 50 years of XX century in the coal preparation and briquette factories mandatory final operation was a technical analysis of the quality of products in the processing and enrichment fuel. One of the main objectives was to determine the energy value of the fuel or heating properties. Therefore closest to the technological merits achieved effect is the way to determine the heating properties of solid fuel, including the use of solid fossil fuels and the device, called a bomb calorimeter [5]. This method of determining the properties of solid fuel heating following: sample weight of 0.9 - 1.5 g crushed solid fuel is loaded into the crucible calorimetric bomb fuse wire end of a length of 12 cm is connected to electrical contacts of the crucible and the middle of the wire deepened in powder fill bomb oxygen to 24-30 atm. Combustion of the sample is by passing electric current voltage of 8.12 V and 6.10 A current wired fuse (iron, Nichelino, Constantine, copper) under conditions of excess oxygen and high pressure in the bomb, which is submerged in water, fuel heating value property is determined to improve water temperature. The disadvantage of this method is that the crushed solid fuel weight 0,9- 1,5 g directly loaded into the crucible calorimetric bomb. Subsequent operation, namely filling bombs with oxygen at a pressure of 24-30 atmospheres lead to cutting samples and as a result of



inaccurate measurement of heating fuel properties. In addition to cutting fuel internal volume bombs complicates further the process of determining sulfur in the fuel. A similar drawback occurs when calorimeter calibration using benzoic acid, which is also in the powdered state. This is made using a special press for each bomb briquettes weight of benzoic acid ($1,00 \pm 0,01$) g in Western Europe, especially in Germany and made ready to use offering packaged compressed tablets, if used as a powder, then offered a long list of expensive equipment [2].

Purpose of work is to create a rational method of determining the heating properties of granulated biofuel Calorimeters and expanding the list of standards to determine the energy equivalent of calorimeter by determining the energy of combustion of other substances, namely, powdered sugar using batch mode of combustion.

The standard material used for calibrating calorimeters, often referred to as reference material or primary standards (the English term - standard reference material). The use of standard materials allows calibration to approximate the conditions to the terms of these Calorimeters. For example, the thermal value calorimeters designed to determine the energy of combustion of organic matter, often determined by reference combustion of benzoic acid, which is specially produced for this purpose leading metrology institutes around the world. This method not only is simple, but has certain advantages over electric because the curves of temperature change in the combustion of benzoic acid and other organic substances, similar in shape and it can reduce system error. At the same time, high accuracy, which established energy of combustion of benzoic acid (error not exceeding 0.01%), makes it possible to determine the energy of combustion of other organic substances with about the same accuracy

Benzoic acid, which is used calorimetry as standard power should have a very high purity. Reference benzoic acid brand K-I, which produces the All-Russian Research Institute of Metrology named. D.I. Mendeleev (VNYYM, city. St.Petersburg), a purity of 99.997%. [3]. Approximately the same certified benzoic acid, produced by the US Bureau of Standards (now the National Institute of Standards and Technology) as standard calorimeter under a certificate of purity - 99.997% moisture content of about 0,002% . Calibration calorimeters designed to determine the heats of dissolution and the heats of reactions in solution, can be carried out using as a standard substance (NOSN2) 3SNH2 or reduced TRIS). This substance is proposed, as a standard in the 60s and since then many termohimikamy investigated in detail. As standard energy in this case suggested using TRIS reaction with dilute aqueous solutions of NaOH or HCl. Standard TRIS sample was prepared in the US National Bureau of Standards. Reaction enthalpy of the standard sample with a solution of HCl at 298.15°C , according to the certificate is $-(245.76 \pm 0,26)$ J / g. However, the accuracy with which the standard is set this energy is still significantly lower than, for example, the accuracy with which the combustion temperature of reference set benzoic acid. Therefore, in most experimental work in thermochemistry solutions preferred electrical calibration calorimeter. The standard sample TRIS often used to verify the correctness of the calorimeter.

Basic requirements for model substances are:



- Substances should be easily accessible in a clean condition;
- They must be stable and not hygroscopic;
- A substance should not be volatile;
- Thermodynamic quantity which is used to control must be securely installed.

Secondary standards for combustion calorimetry should have a form suitable for burning, and their combustion in the bomb should not present any technical difficulties. Circle substances used in calorimetry as secondary standards, expanding the development of experimental work, and their characteristics are specified, so the thermochemical literature can often find other substances that are offered as secondary standards other than mentioned above. It is important that they meet the requirements listed earlier. Furthermore, it should be noted that currently the main primary calorimeter standard, namely, benzoic acid, produces both close and distant countries, but Ukraine, that have another addiction [1]. A method of calibrating calorimeter in isothermal mode at constant volume using standard calorimetric as powdered sugar, makes it possible to expand the list Calorimeters standards and offer to ISO as a standard substance use powdered sugar with the calorific property of 3980 cal / g;

At the Department of thermal power in the National University of life and environmental sciences of Ukraine Experimental research on determination calorific properties of substances proposed secondary standard, namely, powdered sugar. The results showed that the sample of powdered sugar 1 g weight at full combustion in a bomb calorimeter in an environment of compressed oxygen under pressure of 30 atm., 25 ° C gives the calorific properties of analytical tests on bomb 3980 cal / g. This sample is wrapped in thin paper (eg tissue) and bound thread a certain length. The resulting package is loaded into the crucible calorimetric bomb, paper weight and yarn before it is weighed and determine their calorific properties. The middle part of the wire is passed through a formed package. Heating property granulated biofuel and feed supplements determined to raise the temperature of water from which is deducted calorific properties of paper and thread.

Conclusion

The proposed batch method has the following advantages:

- Allows accurately determine the calorific property biofuels and granulated sulfur in it;
- Expanding list Calorimeters standards to determine the energy equivalent of calorimeter, by determining the energy of combustion of other substances, namely, powdered sugar placed in the package.

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REVIEW OF TECHNOLOGY AND TECHNICAL MEANS TO PRODUCE BIODIESEL

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Abstract: Ukraine exports its agricultural products to many countries. However, for agricultural works Ukraine annually is necessary to have about 1900 ths. tons of diesel fuel and 620 ths. tons of gasoline, which are produced from the 4500 ths. tons of oil, mostly imported. Replace petroleum diesel fuel with biodiesel can be that for the needs of farms can be produced from own raw materials on mini-plants and small farm installations. There are two manufacturing biodiesel technology: the supercritical state of methanol which is complex, but does not need to be cleaned, and traditional, which is much easier biodiesel necessarily need to be cleaned from the catalyst and methanol residues. Today, increasingly used the traditional technology of biodiesel. For the production of biodiesel reactors are used with mechanical and cavitation stirring. The advantage of cavitation reactors is their high performance, high quality mechanical – high quality of biodiesel.

Keywords: biodiesel reactor, cavitation, catalyst

Introduction. Ukraine has a huge wealth – ground. However, for the harvest of the land it must be processed. At present, for agriculture Ukraine annually is necessary to have about 1900 thousand. Tons of diesel fuel and 620 ths. Tons of gasoline, which are produced from the 4500 ths. tons of oil, mostly imported [1].

Replace diesel oil fatty acids can be esters (methyl or ethyl), which are called biodiesel. The raw material for the production of biodiesel are vegetable or animal oils, waste food processing industry. In recent years, biodiesel production is-used oils derived from algae. At present, the day of Ukraine is well developed raw material base for the production of biodiesel, so there are all conditions for the establishment of its production on the mini-plants and small farm installations [2].

Therefore, **the aim of our research** is to identify the prospects, technologies and trends in the development of technical means of production of biodiesel.

Results. Discussion and Analysis. To date, the methyl ester is produced in two main technologies: traditional and supercritical state of methanol.

The technology with supercritical methanol condition characterized by would-strotoy (biodiesel produced in a few minutes), held without the presence of catalysts, so the final product does not require any further purification. However, it is complicated, since it requires the presence of 240°C temperature and pressure of 80 atm. So increasingly used traditional technology for producing methylester fat esterification with methanol using a alkali or acid catalysts. The reaction takes place at atmospheric pressure and 35-40°C. After the reaction, methyl necessarily need to be thoroughly cleaned from the remnants of methanol and catalyst time education biodiesel depends on the type of reactor in conventional technology [3].

At the present time for the production of methyl ester of the traditional



technology used reactors with mechanical and cavitation stirring.

Work cavitation reactors based on the effect of cavitation (the formation of fluid cavities filled with gas) resulting from local pressure reduction in the fluid, which can occur either by increasing its speed (hydrodynamic cavitation) or with passing acoustic waves of high intensity. Moving along with the flow to the higher pressure or during the half-cycle compression, cavitation bubble bursts, causing the appearance of these shock waves. Cavitation reactors are hydrodynamic, inkjet, speakers and magnetic pulse.

Hydrodynamic cavitation reactor, acting as a pump is pumped Vaeth mixture of liquids through the annular gap between the rotor and the stator, and due to the presence on their surfaces of the longitudinal grooves, the intersection of the pro-stroke it grows, is reduced, which causes a pressure fluctuation, and as a consequence, the occurrence of cavitation effect, causing intense mixing components. Another type D hydrodynamic cavitation jet reactor – jet – bottom nozzle is a Venturi in which the diffuser by increasing the sectional area, a sharp decrease in pressure, which causes the occurrence of cavitation. Acoustic cavitation occurs in the emission of sound in the liquid with the amplitude of the sound pressure that exceeds a certain threshold value. During the half-periods vacuum cavitation bubbles appear on the so-called cavitation nuclei, which often are gas inclusions contained in a liquid, and on the surface of the acoustic transducer. Therefore cavitation threshold increases with decreasing gas content in the liquid by increasing the hydrostatic pressure in the liquid cooling and with increasing frequency of the sound. Magnetic Pulse Cavitation differs from usual cavitation process of the magnetic field on the microplasma formations arising with active cavitation.

The advantage of cavitation reactors is their high-productivity. However, it may decrease the quality of biodiesel, as those fractions of a second, during which there is a mixing of the reactants, do not always provide a quality education biodiesel.

Another type of reactor for the production of biodiesel is a mechanically agitated reactor, which is a cylindrical container, the height of which is 2-2.5 times the diameter. To maintain the temperature in the unit has a water jacket or heat exchanger type "coil". The reactor is equipped with fittings and piping for feeding reactants and removing the reaction products. The degree of mixing of the reactants is a determining factor in the quality of the final product. For their effective use mechanical stirring mixer, the shape of which can vary.

The performance of the reactor with mechanical stirring inferior cavitation reactors, but due to a larger residence time of a reagent in the mixing zone is achieved yield higher quality biodiesel.

Summary and Conclusions

1. There are two manufacturing biodiesel technology: traditional and supercritical methanol state technology. Traditional technology is much easier, but the resulting biodiesel necessarily need to be cleaned from the catalyst and methanol residues. The technology of supercritical methanol state is much more difficult, however, since it takes place without the presence of a catalyst, the resulting biodiesel is sufficiently clear, precise only on methanol residues. Today, increasingly used traditional technology of biodiesel production.



2. For the production of methyl ester used reactors with mechanical agitation and cavitation. The advantage of cavitation reactors is their high productivity, mechanical – high quality of biodiesel.

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**REVIEW OF THE LOW THERMAL CONDUCTIVITY MEASURING
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**ОГЛЯД МЕТРОЛОГІЧНОГО ЗАБЕЗПЕЧЕННЯ
НИЗЬКОТЕПЛОПРОВІДНОЇ ОБЛАСТІ ВИМІРЮВАНЬ***Національний університет біоресурсів і природокористування України**Київ, Героїв Оборони 15, 03041*

Abstract. In this article the world modern condition review of the measuring unity metrology providing of modern low heat-conducting insulators effective thermal conductivity is presented.

Key words: insulation, thermal conductivity, standard unit, international comparison.

Анотація. В роботі представлено огляд сучасного стану метрологічного забезпечення єдності вимірювань коефіцієнта ефективної теплопровідності сучасних низькотеплопровідних ізоляційних матеріалів в світі.

Ключові слова: теплоізоляція, коефіцієнт теплопровідності, еталонна установка, міжлабораторні звірення.

Entry. In Europe, America and Russia much attention is spared to the metrology providing of thermal conductivity coefficient measuring that is based on traditional system of the discrete measuring in the separate points of thermal conductivity range with the help of Standard unit and Reference materials.

Basic text. One of leading metrology centers of the European union there is the National physical laboratory (NPL) of National Institute of Measuring of Great Britain. It is equipped by a complex of standard unit of thermal conductivity and thermal resistance of construction and building materials measuring [1] (Fig. 1) including low thermal conductivity insulators, in accordance with the requirements of CEN, ISO standards, BIPM and EURAMET working groups and has an UKAS accreditation for Reference materials and Transfer standard certification for calibration of measuring working devices.

In the USA in the National Institute of Standardization (NIST) the Line Heat-Source Guarded Hot Plate [2] (rice. 1) for the absolute measuring of thermal resistance of thick low-density test samples is designed, that are used as certificated Standard Reference Materials (SRM) for calibration or verification of the guarded hot plate devices according to the requirements of the ASTM C 177 and ASTM C 518 standards.



Name, original appearance	Test sample	λ , W/(m·K), or other property	Temperature range, °C	Sample size, mm	Standard
NPL (England)					
Low-Temperature Guarded Hot Plate	 Insulators 60 mm thick	< 0,15	-170...50	305×305× ×(25...50), 2 ps.	ISO 8302 EN 12667
Guarded Hot Plate	 Insulators 250 mm thick	< 0,1	5...40	610×610× ×(25...250)	ISO 8302 EN 12667 EN 12939
Vacuum Guarded Hot Plate	 Insulators, constructions and construction materials	< 2; thermal resistance >0,025 m ² ·K/W	-20...70	305×305× ×(25...50)	ISO 8302 EN 12667 EN 12664
NIST (USA)					
Line Heat-Source Guarded Hot Plate	 Building insulators	0,02...0,05	5...60	Ø1016 or 610×610(min) ×(13...225)	ASTM C 518 ASTM C 177
		0,05...0,15	25		

Fig. 1. Basic descriptions of standard devices for thermal conductivity measuring of insulators [1, 2]

In Russia research-and-development for providing thermal conductivity measuring unity of heterogeneous solids in a range from 0,02 to 20 W/(m·K) are terminated by claim of new standard GOST 8.140-2009, 10 countries of the CIS spoke out for the acceptance of that, on the modernized State standard thermal conductivity unit GET 59-2007 [3]. The State standard unit is complemented by the standard devices – middle temperature A-1, low temperature A-2M and high temperature A-3M, also by the set of heat conductivity Transfer standard and manager instrumentation-calculable complex (Fig. 2).



Fig. 2. The Russian State primary standard unit of thermal conductivity GET 59-2007 [3]



For thermal conductivity measuring of effective insulation the standard device A-1 was developed. The stationary method of the guarded hot plate is realized in it in the symmetric variant of implementation according to GOST 7076-99 and ISO 8302. Range of measuring from 0,02 to 0,2 W/(m·K) at the temperature value from 250 to 350 K, sample size – 200...250 mm, 25 mm thick. The State primary standard unit of thermal conductivity is passes its size with standard deviation $S_0 \leq 0,2\%$ and with the non-exceptional systematic error $\Theta_0 \leq 0,6\%$ for standard device A-1 and 2% for other standard devices.

A variety of thermal conductivity measuring methods and facilities is the main reason of necessity of measuring results interlaboratory collation realization. The aim of international interlaboratory comparison of thermal conductivity measuring results are an measuring results authenticity evaluation in the laboratories of different countries and further unitization of thermal conductivity measuring methods and devices [4].

Results of thermal conductivity measuring collations, conducted from 1993 to 1995 by the leading laboratories of the USA, Canada, Finland, Lithuania and Russia in a range from 0,03 to 0,05 W/ (m·K) showed divergence between the results of foreign laboratories measuring not more than 2%, and between Russian and foreign in limits from 13% to 22%. The results of thermal conductivity measuring key collations, conducted from 2007 to 2009 with participation of the USA, France, Great Britain, Germany, China, Mexico and Russia, laid down less than 1,5%.

Conclusions. The analysis of international collations results shows the positive dynamics of insulation materials conductivity measuring results authenticity increasing, that characterizes the high modern level of the low thermal conductivity measuring area metrology providing in the world.

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**НИЗЬКОТЕПЛОПРОВІДНІ СЕРТИФІКОВАНІ ЕТАЛОННІ МІРИ ТА
РОБОЧІ ЕТАЛОНИ***Національний університет біоресурсів і природокористування України**Київ, Героїв Оборони 15, 03041*

Abstract. In the article the review of modern materials, certificated as Standard Reference Materials and Transfer Standard in world practice of the low heat-conducting measuring area metrology providing is presented.

Key words: heat conductivity, Standard Reference Material, Transfer Standard, low heat-conducting insulators.

Анотація. В статті представлено огляд сучасних матеріалів, сертифікованих у якості еталонних мір та робочих еталонів у світовій практиці метрологічного забезпечення низькотеплопровідної області вимірювань.

Ключові слова: коефіцієнт теплопровідності, еталонна міра, робочий еталон, низькотеплопровідні ізолятори.

Entry. In metrology the most widespread backer-up unity of materials and products properties measuring are transfer standards that come forward as a material carrier of corresponding units.

Basic text. In the table Fig. 1 an information about thermal conductivity standard reference materials and transfer standard, certificated in world practice of the low heat-conducting measuring area metrology providing is systematized [1].

As follows from a table (fig1), basic reference materials among heat-insulation are expanded polystyrene and glass-fibre board which are certificated by leading world laboratories on the large samples according to the requirements of functional international standards.

According to an operating interstate standard GOST 8.140:2009 [2], the transmission of solids thermal-conducting unit size to working measuring devices carried out by means of transfer standards set that are reference materials – the samples, made from materials that are examined on a state standard unit and ratified in accordance with established procedure.

To the GET 59-2007 [3] standard reference materials set the heat-conducting single-valued and multiple-valued standards are being involvement for a units recreation, transmission of her size and control the stabilities of standard, attested and attorneys in accordance with established procedure in the range of measuring with the confidence borders of transfer standards relative errors from 2% to 5% at confidence probability 0,95. Single-valued heat-conducting standards MTO 01.01.001...008



listed in to Catalogue of standard materials MT 2590-2008 [4], are given in the table Fig. 2.

Reference material, number of certificate	λ , W/(m·K) (T=300K)	Temperature range	Uncertainty	Sample size, mm	Certification organization
Resin bonded glass fibre board, CRM 440	0,03	(-10...50)°C	0,00028 W/(m·K)	300×300×35; 500×500×35; 600×600×35	IRMM
Expanded Polystyrene, TS	0,02	(-10...70)°C (-5...40)°C	±2% ±2,5%	305×305× × (25...50) 610×610× × (25...50)	NPL
Polymethylmethacrylate (Perspex), SRM and TS	0,2	(-10...60)°C	±3,0%	305×305	
Glass fibre board, TS	0,03	(-10...80)°C	±2%	610×610	NIST
Expanded polystyrene board, NIST SRM 1453	0,03	(281...313) K	±1%	930×660×13,4	
Fumed silica board, NIST SRM 1449 and 1459	0,02	279 K	±1%	300×300×25,4 600×600×25,4	
Fumed silica blanket, NIST SRM 1452	0,04	(100...330) K	±1%	600×600×25,4	
Fibrous glass board, NIST SRM 1450c	0,03	(280...340) K	±1%	610×610×25,4	

Fig. 1. The thermal conductivity Standard Reference Materials (SRM or CRM) and Transfer Standard (TS) [1]

The laboratories of the leading European countries and USA are provided with standard units for attestation and certification of the thermal conductivity standard reference materials and transfer standard that are used in future for calibration or verification of working devices for low heat-conducting insulators heat-conducting coefficient measuring.

Registration number	Type	Temperature range, K	Range of the recreated values of heat-conducting, W/(m·K)
01.01.001	Organic glass	90 – 350	0,143 – 0,200
01.01.002	Optical glass TΦ1	90 – 500	0,354 – 0,899
01.01.003	Optical glass KB	90 – 500	0,651 – 1,663
01.01.004	Optical glass JK5	90 – 500	0,563 – 1,474
01.01.005	Stainless steel 12X18H10T	290 – 600	14,65 – 19,88
01.01.006	Foamplex	283 – 350	0,024 – 0,035
01.01.007	Isotherm	283 – 300	0,030 – 0,040
01.01.008	KBF-210	283 – 300	0,048 – 0,060

Fig. 2. The thermal conductivity Transfer Standard [4]

In Russia with statement GOST 8.140:2009 standard on the modernized State standard thermal conductivity unit GET 59-2007 and by creation of middle



temperature standard device A-1 the problem of low heat-conducting reference material certification is also decided.

Conclusions. In Ukraine interstate standard GOST 8.140:2009 accepted by the method of confirmation with limit area of application, as a device base for the heat-conducting coefficient measuring metrology providing is in Russian Federation. An exception is a secondary standard unit for heat-conducting of solids BETY 06-59-01-98, that is kept in SE «Ukrmetrteststandard», its heat-conducting coefficient range of values is $0,1...20 \text{ W/(m}\cdot\text{K)}$, that is recreated with the total relative error S_{Σ} from 0,7% to 1,4%.

However, in connection with disparity the BETY lower limit measuring range to the effective heat-conducting coefficients value the most modern heat-insulation materials, that folds $0,02...0,05 \text{ W/(m}\cdot\text{K)}$, and also because of small standard size – a 15 mm diameter disk, it is useless for attestation of low heat-conducting test samples as reference materials or transfer standard. Therefore problem of creation the State standard thermal conductivity unit in Ukraine for Standard Reference Materials and Transfer Standard certification now is actual.

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СПЕЦІАЛІЗОВАНІ ПРИБОРИ ДЛЯ ДОСЛІДЖЕНЬ РАДІАЦІЙНОГО ТЕПЛООБМІНУ

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Abstract. In this article small measuring devices for research heat exchange constituents during the power equipment monitoring realization by a contact and noncontact method are presented.

Key words: heat flow, temperature, heat exchange, sensor, monitoring, power object.

Анотація. В роботі представлені малогабаритні вимірювальні пристрої для дослідження складових теплообміну при проведенні моніторингу енергетичного обладнання контактним і безконтактним методом.

Ключові слова: тепловий потік, температура, теплообмін, сенсор, моніторинг, енергетичний об'єкт.

Entry. Electing measuring devices for the power equipment thermophysical parameters monitoring realization for the unforecast heat losses determination it is necessary to take into account specific descriptions of object, its functional parameters, type and composition of constructions envelope, condition of heat exchange with an environment and others like that.

Basic text. At the additional caloradiance sources presence (such as radiators, emitters, powerful lamps, working power equipment and other) for experimental determination of total surface heat flux density, its convective and radiation constituents and heat exchange coefficients between object and environment by a contact method easier to apply two primary heat flux sensors (HFS), that have identical heat resistance ($R_1 = R_2$), but contrasting thermal-radiation characteristic (emissivity $\varepsilon_{t_{h_1}} \neq \varepsilon_{t_{h_2}}$ and absorptive ability $A_1 \neq A_2$), and temperature sensors for measuring of ambient (T_A), the construction envelope surface (T_{EC}) and open surfaces temperature both HFS (T_1 and T_2).

For the power objects continuous monitoring realization more comfortable is to use the specialized devices, for example, the unstandardized radiation convective thermometrical device PKTP (Fig. 1) [1] in a complete set with the standard voltage



measuring device, that must have entrance resistance not less than 10 MΩ and not exceeding error 0,5 % in HFM measurable signals values area.

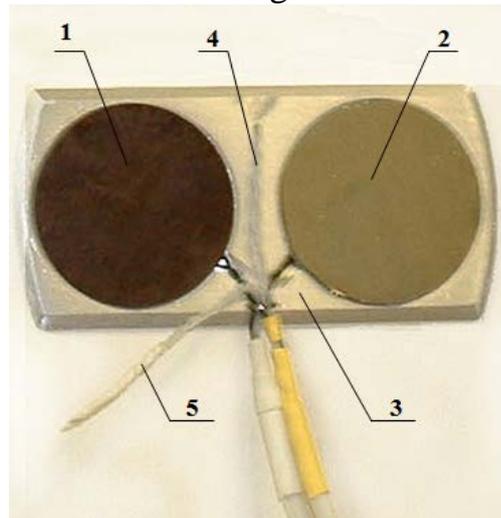


Fig. 1. Thermometrical device PKTII-2

Device PKTII- 2 is a flat construction 40×100×4 mm sizes, that contains two HFM, 1 and 2, mounted on the general isothermal lining 3. The HFM front surfaces have contrasting emissivity ranges: from 0,85 to 0,90 for "black" and from 0,02 to 0,25 for "white" HFM. Also a device is provided with a temperature sensors for a lining 4 and an ambient air 5 temperature measuring.

Measuring information through an electronic block is given to computer treatment by the corresponding program. By measuring results the surface falling caloradiance density value, q_{CR} in W/m^2 , can be calculated by a formula [2]:

$$q_{CR} = \left(\left(q_1 + \sigma \cdot \varepsilon_{th_1} \cdot T_1^4 \right) - \frac{\Delta T_1}{\Delta T_2} \cdot \left(q_2 + \sigma \cdot \varepsilon_{th_2} \cdot T_2^4 \right) \right) / \left(A_1 - A_2 \cdot \frac{\Delta T_1}{\Delta T_2} \right); \quad (1)$$

where $\sigma = 5,67 \cdot 10^{-8} \text{ W}/(\text{m}^2 \cdot \text{K}^4)$ – Stefan-Boltzmann constant;

$$\Delta T_1 = T_A - T_1, \quad \Delta T_2 = T_A - T_2.$$

Device PKTII-2 allows to carry out the heat exchange coefficient and radiation heat flux density contact measuring, however measuring come true locally, that is the lack of this device. The refixturing of device on the new object surface point requires the time charges on assembly and the objects and device thermal mode stabilizing.

Therefore most productive are the non-contact measuring of falling caloradiance density value by the specialized device, for example, by the radiometer PAII-12Д (Fig. 2) [1].

This device is the absolute cavity semispherical caloradiance detector built by a differential chart on the thermo-electric HFM base. Going out by heat sensitive cavity radiometer PAII-12Д geometrical sizes correlation an equality $A_{RAD} = \varepsilon_{RAD}$ is valid, that is why the surface falling caloradiance density value can be calculated by measuring results by a formula [2]:

$$q_{CR} = \frac{q + q_{RAD_0}}{A_{RAD}} = \frac{\overline{E}_{RAD} \cdot K_{RAD}}{A_{RAD}} + \sigma \cdot T_{RAD}^4, \quad (2)$$



Fig. 2. The radiation-measuring device PAИ-12Д

where $q = K_{RAD} \cdot \bar{E}_{RAD}$ – the heat flux density, measured by a radiometer; where K_{RAD} i \bar{E}_{RAD} – calibration coefficient and radiometer signals mean arithmetic value, measured in a stable thermal mode; T_{RAD} – own thermodynamics temperature of radiometer.

Conclusions. Using of the small specialized devices considerably simplifies the researches process of heat flux convective and radiation constituents and heat exchange coefficients calculation during the power equipments thermal state monitoring and inspection realization. Combination of the contact and noncontact measuring allows to get complex information and qualitatively to estimate the thermal state of object.

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Ochkolyas E.N.¹, Lebskaya T.K.²**CHANGES OF THE QUALITY OF BUTTER WITH SEAWEED DURING THE STORAGE**

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Очколяс Е.Н.¹, Лебская Т.К.²**ИЗМЕНЕНИЯ ПОКАЗАТЕЛЕЙ КАЧЕСТВА СЛИВОЧНОГО МАСЛА С МОРСКИМИ ВОДОРОСЛЯМИ В ПРОЦЕССЕ ХРАНЕНИЯ**

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Abstract. The aim is to investigate the influence of algae on the change of indicators of quality of butter during storage. Addition of algae to butter slows as well as the processes of oxidation and hydrolysis of fat during storage both at low and high temperatures.

Keywords: butter, laminaria, fucus, spirulina, cystoseira, storage, quality indicators.

Аннотация. Целью работы является исследование влияния морских водорослей на изменения показателей качества сливочного масла в процессе хранения. Исследования показали, что обогащение сливочного масла морскими водорослями замедляет процессы окисления и гидролиза жира при хранении как при плюсовой, так и минусовой температуре.

Ключевые слова: сливочное масло, ламинария, фукус, спирулина, цистозира, хранение, показатели качества.

Introduction. One of the important directions of the food industry development is the use of natural antioxidants in technology of dairy products production to increase their storage life. Butter is a product containing a large amount of fat, which is subjected to hydrolytic and oxidative damage in the process of storage. Addition of natural antioxidants in butter contributes to maintaining high consumer performance of the product by blocking the accumulation of free radicals and free fatty acids. Numerous studies have shown, that the addition of herbal supplements improves the organoleptic characteristics of the product, has a positive effect on the formation of its structure and consistency, gives the product a high ductility index, thermal stability and spreadability, and slows oxidation processes during storage [1-6].

Currently, there is increased attention to algae, which contain a complex of organic and mineral substances essential for our body. Chemical composition of algae is characterized by containing high-molecular polysaccharides such as alginic acid (25%), mannitol (up to 21%), fructose (4%), vitamin B₁,



B₂, B₁₂, a, C, D, E, pigments, bioflavonoids, iodine, selenium, etc. Thus, the use of algae as supplements (additives) can solve the problem of the storage life prolongation and increase the biological value of the product.

The main objectives of this study is to determine the effect of algae supplements on the organoleptic characteristics and lipid indicators of quality during the storage under different temperature conditions.

Materials and Methods of the study. Butter with algae was produced using the method of high fat cream whipping. Adding those prepared additives was provided before the thermomechanical processing of fat cream. They used algae powder made of laminaria, fucus, spirulina, cystoseira. Control sample of butter with fat content of 62.5% was produced from the same raw material by the conventional technology.

The samples were stored under two temperature conditions: $3\pm 2^{\circ}\text{C}$ (above) and $7\pm 2^{\circ}\text{C}$ (below). Accumulation of primary oxidation products was determined by peroxide value [7]. The acid value was determined by titration of the fat sample by the solution of potassium hydroxide with phenolphthalein indicator [8].

Results of the study. Dynamics of changes in peroxide value of the butter with laminaria, fucus, spirulina and cystoseira during the storage at a temperature of $3\pm 2^{\circ}\text{C}$ is shown in Fig. 1.

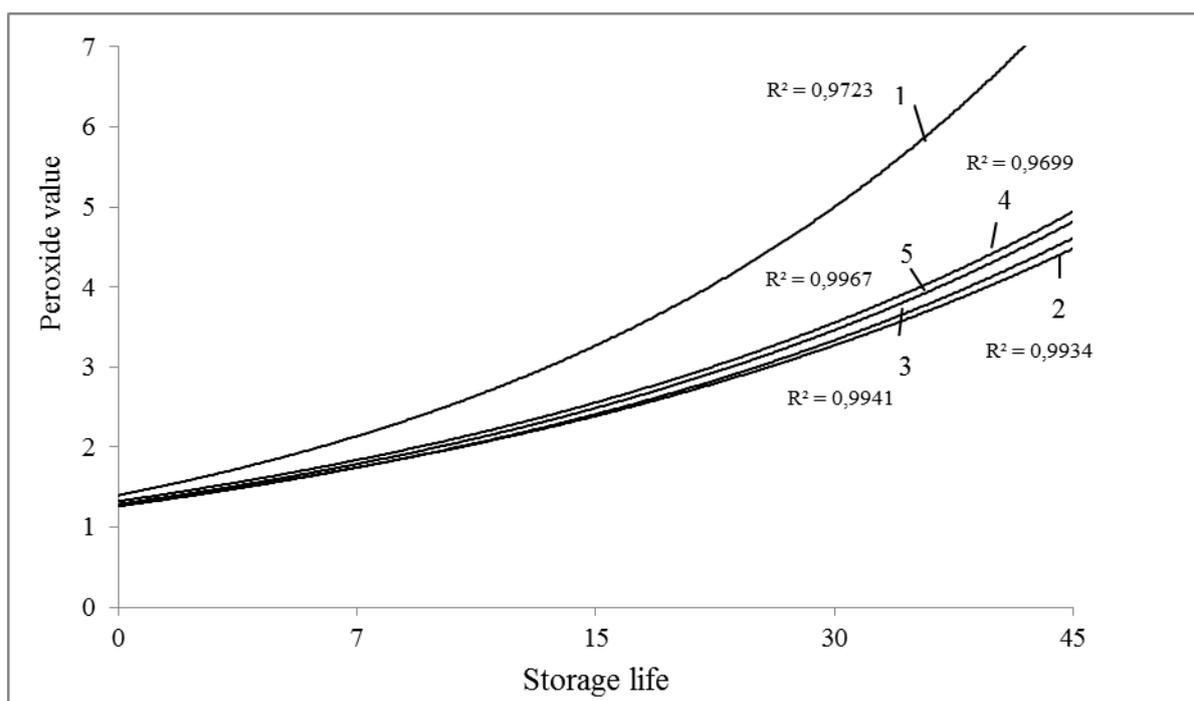


Fig. 1. Dynamics of peroxide value of fat in butter samples during the storage at a temperature of $3\pm 2^{\circ}\text{C}$;
butter: 1 - control; 2 - with laminaria; 3 - with fucus;
4 - with spirulina; 5 - with cystoseira

The processes of butter samples' oxidation are going along with identical dynamics of accumulation of primary products in all samples, but these changes are much greater in control samples compared to those samples with algae. Thus, algae



supplements in butter slow the processes of primary fat oxidation.

During the first 15 days of storage the peroxide value increased in the experimental samples and was from 2.89 to 3.23 O $\frac{1}{2}$ mmol/kg (so the butter is still fresh), and in control samples the peroxide value was 3.52 $\frac{1}{2}$ O mmol/kg (unfit for the further storage).

On the 30th day of storage, the peroxide number in the test samples was: butter with laminaria – 3,44 $\frac{1}{2}$ O mmol/kg, with fucus – 3.48 O $\frac{1}{2}$ mmol/kg, with spirulina – 3.78 O $\frac{1}{2}$ mmol/kg, and with cystoseira – 3.52 O $\frac{1}{2}$ mmol/kg. These indicators show the freshness of the butter samples, but at the same time they show their unfit for the further storage. The control sample had substantially higher peroxide value – 5,51 $\frac{1}{2}$ O mmol/kg; which supposes that the butter is characterized as the product is not to be stored.

The effect of algae on the deceleration of fat oxidation processes is also observed in the process of storage of samples at a low temperature (Fig. 2).

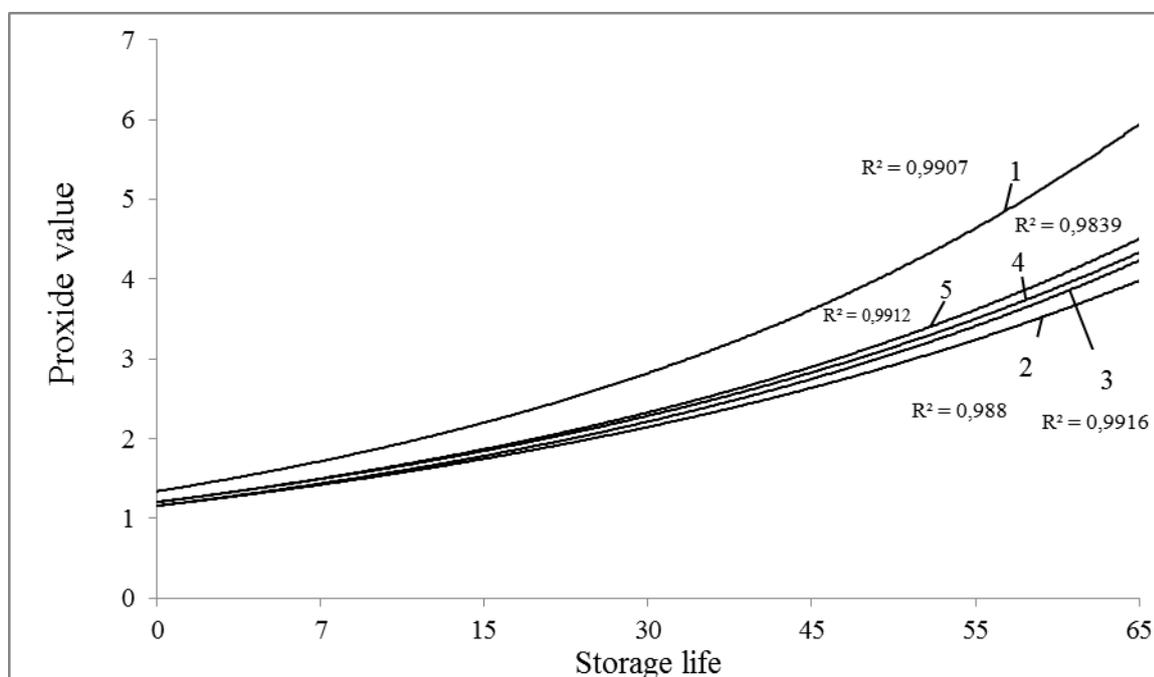


Fig. 2. Dynamics of peroxide value of fat in butter samples during the storage at a temperature of $-7 \pm 2^\circ\text{C}$;

*butter: 1 - control 2 - with laminaria; 3 - with fucus;
4 - with spirulina; 5 - with cystoseira*

It should be noted, that low temperatures affect on the intensity of oxidation processes in butter samples with algae compared with the control samples, and these indicators become lower.

Hydrolysis of fat with formation of free fatty acids can accelerate oxidation processes, because free, and not bounded in triglycerides, acids are oxidized first [3]. Dynamics of changes of fatty acid value of butter with algae during the storage at a temperature of $3 \pm 2^\circ\text{C}$ is shown in Fig. 3.

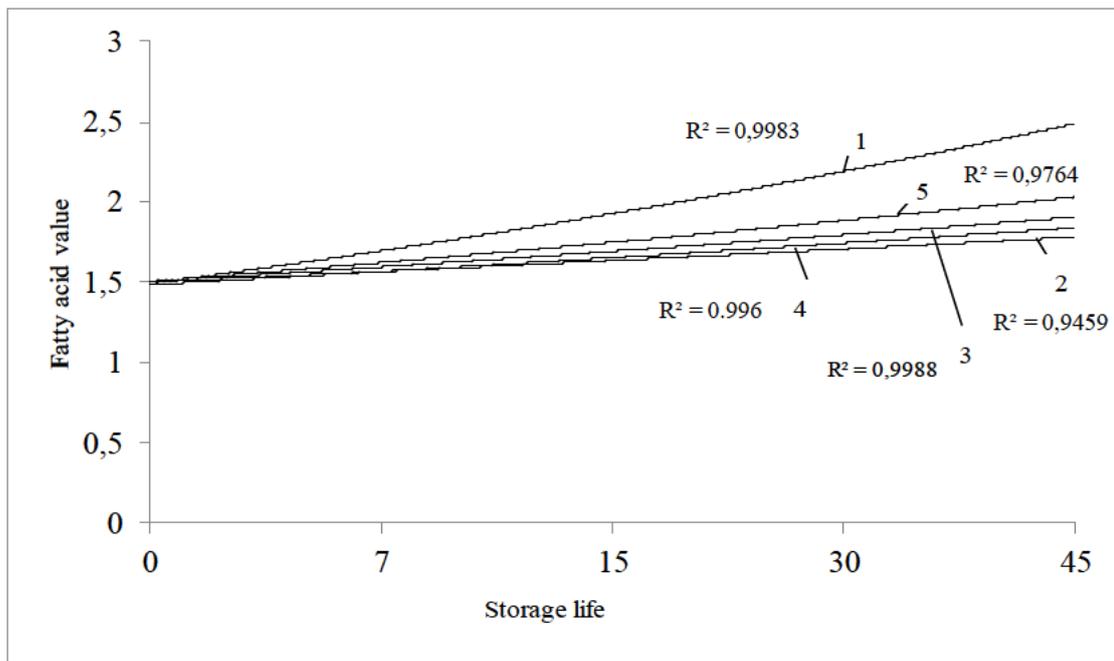


Fig. 3. Effect of algae addition on changes of fatty acid value of butter at a storage temperature of $+3 \pm 2^\circ\text{C}$;
butter: 1 - control 2 - with laminaria; 3 - with fucus; 4 - with spirulina; 5 - with cystoseira

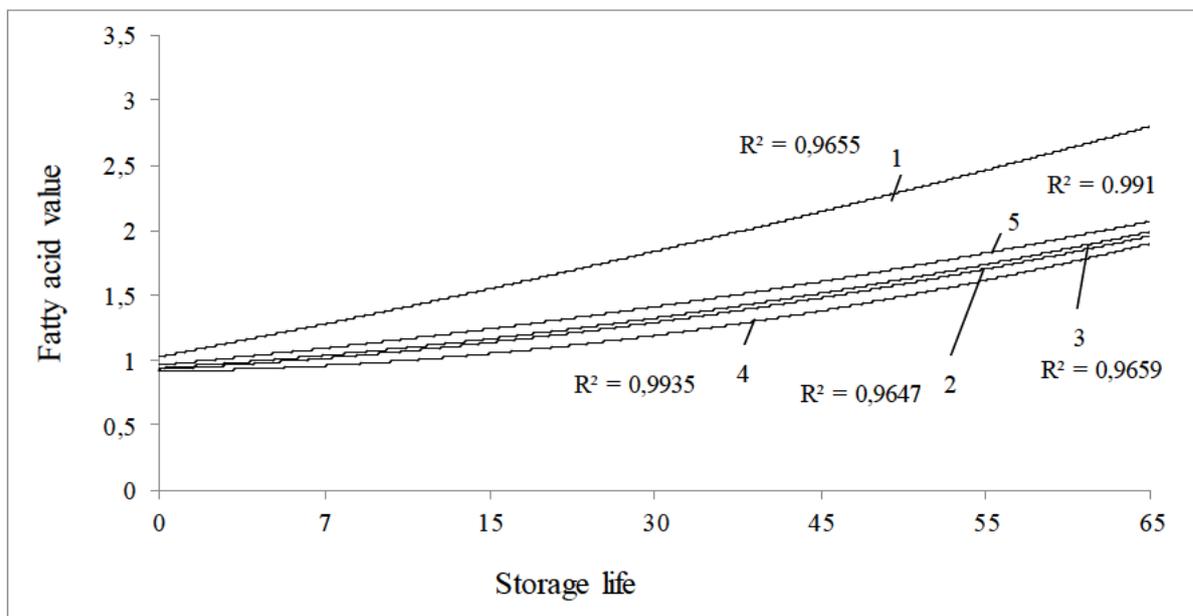


Fig. 4. Effect of algae addition on changes of fatty acid value of butter at a storage temperature of $-7 \pm 2^\circ\text{C}$;
butter: 1 - control 2 - with laminaria; 3 - with fucus;
4 - with spirulina; 5 - with cystoseira

The results of these studies show that the hydrolysis of the butter fat with algae is slower than in control samples. Algae has no significant effect on the rate of flow of lipid hydrolysis process. The acid value of the control butter sample reaches 2.4 ml of KOH/g of fat on the 45th day of storage. By that time, the lowest indicator of fat



value is observed in butter sample with laminaria – 1.8 ml of KOH/g of fat; and the highest – the sample with cystoseira – 2.0 ml of KOH/g off at.

Storage of butter at a temperature of $-7 \pm 2^{\circ}\text{C}$ discovers a slowdown in the product's hydrolytic processes (Fig. 4). The intensity of the hydrolysis of fat under these storage conditions is lower in butter samples with spirulina.

Thus, algae added in butter slow down the process of deterioration of organoleptic characteristics, changes in oxidation and hydrolysis processes, and storage conditions also influence the changes of these indicators. Our findings largely prove previous studies that have shown the effect of herbal supplements on the complex quality parameters of a butter [2].

Research results suggest a protective role of algae against oxidation and hydrolysis processes resulting in deterioration of butter; thus, it contributes to a prolonged storage life of a product and its organoleptic characteristics under conditions of both low and high temperatures.

Conclusions. Addition of algae to butter slows the deterioration of the organoleptic characteristics, as well as the processes of oxidation and hydrolysis of fat during storage both at low and high temperature conditions. The effect observed may be caused by the presence of selenium element in algae, pigments, bioflavonoids, as well as the formation of polysaccharide-lipid complexes on the surface of nanograins, which protect the fat phase from oxidation and hydrolysis processes.

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Gudzenko M.N. , Vasilenkov V.E.

ANALYSIS OF STRUCTURES OF OIL PRESS WITH ADDITIONAL CHAMBER REFINEMENT OF OILSEEDS

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УДК 665.3.002.5

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АНАЛИЗ КОНСТРУКЦИЙ МАСЛОПРЕССОВ С ДОПОЛНИТЕЛЬНОЙ КАМЕРОЙ ИЗМЕЛЬЧЕНИЯ ИСХОДНОГО МАСЛИЧНОГО СЫРЬЯ

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Annotation. In this paper summarizes the review produced in the scientific literature, as well as among the descriptions of inventions to patents for designs of screw presses for extraction of vegetable oil, combining in one machine operation grinding the input of oilseeds and its expression.

Keywords: oil expeller, screw press, vegetable oil, construction, grinding

Аннотация. В работе приведен анализ произведенного обзора в научной литературе, а также среди описаний изобретений к патентам по конструкциям шнековых прессов для извлечения растительного масла, совмещающих в одной машине операцию измельчения исходного масличного сырья и его отжим.

Ключевые слова: маслопресс, шнековый пресс, растительное масло, конструкция, измельчение

Introduction. Modern equipment design method of pressing vegetable oils due to the use of screw presses, allowing to carry out the process continuously. Currently, the oil industry of Ukraine, Russia and Belarus are used for oil extraction presses of various types and designs. The main types of modern designs presses for the extraction of vegetable oils which are used in the agricultural processing plants, shops and oil mills described in [1,2,5].

In the current economic conditions of great importance in the oil production process plays selected raw processing technology, as well as the choice of the necessary equipment for the realization of the goal. In classical flowsheets have operations grinding and wet-heat processing of oilseeds before squeezing in screw presses. The oil contained in the cells of the seeds or cores, so to extract oils must destroy the cellular structure of the oilseed material. As a result of the grinding machines Roller on oilseed material formed a new structure – myatka. The objective is to maximize the crushing destruction of cells and obtain uniform particles of the optimum size for further processing. In the literature [2] described in detail design of the P3-MOA domestic forging machine, which is equipped with a roaster. Similar designs of presses to produce roasters and other foreign countries (USA, China, India, etc.). The roaster, usually served myatka prepared. In this regard, there are many proposals to combine preparatory operations (milling, wet-heat treatment of oilseeds) in one machine - oil press. These proposals are in part realized in the form of a series of press units, twin-screw press-extruders, or more frequently in the form of



descriptions of inventions to patents.

The aim of the work is the analysis produced in the review of educational and scientific literature, as well as among the descriptions of inventions to patents for designs oil press combining in one machine the operation of grinding the original oilseeds.

Research results. Ideas of a universal machine to extract vegetable oil seizes the minds of scientists and engineers for decades. As a result of their work, the light appears sometimes extraordinary design solutions that are different from traditional operating bodies vseobscheprinyatyh screw presses or structure. For example, in materials Y.P. Kudrin, Y. Tolchinsky, V.K. Lozheshnika et al. (1975-1997) shows some of the ways to increase the efficiency of oil screw presses and increase their productivity. Namely, they have proposed the replacement of the penultimate turn of the press screw shaft cams triangular shape with flat side faces. This changes the channel shape, and operating conditions for such a channel performance improvement achieved by the press for 10-12% while reducing the oil content meal [5]. Subsequent improvements cams triangular form found in the implementation of the twin-screw press-extruders. The operation of moisture-heat treatment directly into a screw press are more likely arrangement of heaters around the working chamber. Much attention is attracted engineers implementation of simultaneous milling of oilseeds to extraction. But more often, there are designs of presses in which first an operation of grinding raw oilseeds. In the first case the grinding process is implemented in the hopper in small rolls. Second - in the area of transporting coils directly to the author's working bodies of special designs or the introduction of more complex mechanisms. Often, however, patentable ideas constructively in creating complex, which significantly increase the complexity of execution, service design, and accordingly the final price of the product. Therefore, they are rarely translated into real production models. An example is the work [3, 4]. In the work [3], the authors proposed to implement the design Oil-presses (Figure 1) of the two chambers, the first chamber is a chamber of grinding and heat treatment of the original oilseeds 6, and the second - the chamber is pressed oils 9. The chamber 6 is divided into three zones, which are shown in Figure 1. Attracting attention to the fact that the zone is realized only water supply (without temperature and heating source), and the grinding zone consists of two screws rotating in opposite directions, the ends of which abut in oil extraction chamber 9 raw material feed zone 8.

In the work [4] the authors also proposed to implement the construction of oil presses (Figure 2) from three chambers, in which the first is the grinding chamber 8. The grinding chamber has two parallel sides 2, 4 and a central shaft 3, on the surface of each of the three knife shafts mounted crescent 11, performed along a helical path and the coils passing into solid central screw 3.

From the hopper 6 oil seeds enter the grinding chamber 8, where crushed using sickle knives 11, while further mixing up to obtain a homogeneous mixture. Due to the fact that the sickle-shaped blades made along a helical line pass into the turns of the screw solid, ground mixture is injected into the oil removal chamber

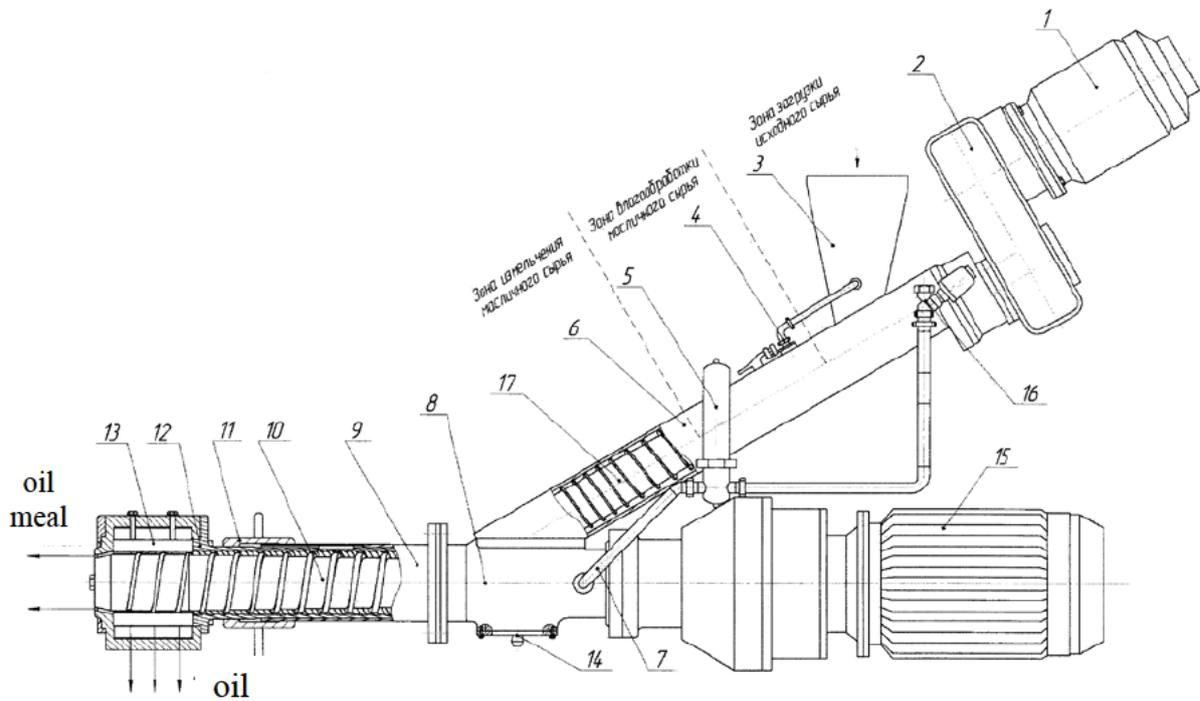


Fig. 1. Front view of the Oil-presses [3]:

1 – drive, 2 – gearbox, 3 – hopper, 4 – water inlet, 5 – traps, 6 – grinding chamber and heat treatment of the original oilseeds, 7 – pipeline, 8 – the raw material feed zone, 9 – oil extraction chamber, 10 – screw, 11 – tightening washer, 12 – oil outlet chamber, 13 – oil outlet plate, 14 – cover, 15 – motor-reducer, 16 – valve, 17 – screw.

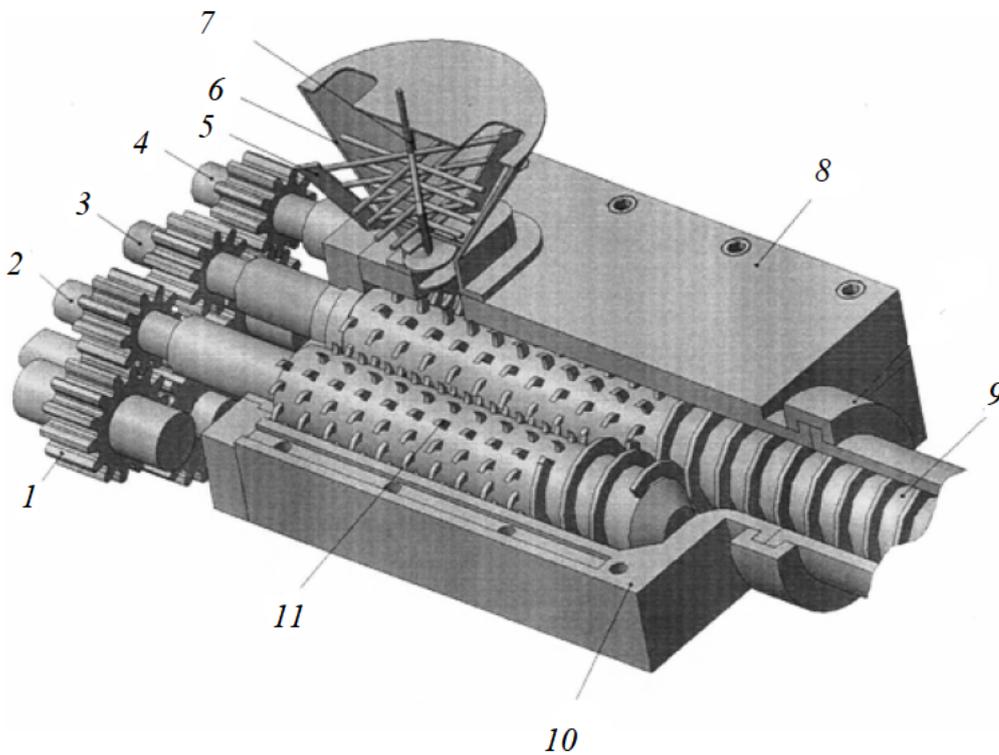


Fig. 2. Front view of the Oil-presses [4]:

1 – driving gear, 2 – side stub shaft, 3 – gear wheel of main screw, 4 – side stub shaft, 5 – mixer, 6 – feeding hopper, 7 – blade, 8 – grinding chamber, 9 – screw, 10 – housing, 11 – crescent knife.



Conclusion

In the scientific literature there are many different proposals to improve the design Oil-presses united by one central idea. The idea of creating a universal Oil-presses, combining not only the dehydrating operation, but also the presence of the auxiliary chambers (grinding, moisture-heat treatment) or a bundle of separate copyright bodies of workers leading to an increase in oil output and performance of the press and a simultaneous decrease in production areas at the expense of auxiliary equipment.

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DEFINITIONS THEORETICAL COMPRESSION RATIO MATERIALS IN TWIN-SCREW EXTRUDER PRESS

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УДК 665.3.002.5

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ВИЗНАЧЕННЯ СТЕПЕНІ СТИСНЕННЯ ОЛІЄВМІСНОГО МАТЕРІАЛУ В ДВОГВИНТОВОМУ ПРЕС-ЕКСТРУДЕРІ

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Annotation. In the works presented results of determining the theoretical compression ratio in the working chamber twin-screw extruder press for two sets of workers, in particular for sunflower seed and rapeseed. The peculiarity of geometrical parameters of working bodies twin-screw extruder press.

Keywords: compression ratio, twin-screw extruder press, vegetable oil, geometric profile screw

Аннотація. В роботі приведені результати визначення теоретичної степені стиснення в робочій камері двогвинтового прес-екструдера для двох наборів робочих органів, а саме для переробки насіння соняшнику і ріпаку. Відмічені особливості геометричних параметрів робочих органів двогвинтового прес-екструдера.

Ключевые слова: степень стиснения, двогвинтовой прес-экструдер, оля, геометрический профиль, шнек

Introduction. Most companies producing oil major machine that carries oil is screw extrusion press. worm press for oil pressing machines belong to the continuous main working body of the cylinder which is placed in it by one or more worms called as screws [3]. To machine in demand and interest in it not was lost, scientists and mechanical engineers working on its continuous improvement. Knowledge rational relationship between productivity and depth screw press vidtyskannya oil is very important from a practical side to work, and particularly important in solving the problem of a universal design of screw press.

Compression oily material in the screw press during its advancement through the cooking chamber is made by reducing the amount of free channels working zone screw shaft. The numerical values of the geometric parameters of the working press tract largely affect the characteristics of the process of pressing oil: productivity, output of oil, product quality, reliability and durability of cost and power density. Therefore, the study of geometrical parameters of working bodies remains very important issue for further study of rational values. In classical literature [1, 2, 4, 6] scientists cited examples of results of research material compression oil only single-rotor presses. On the basis of our work methods in the analysis of the geometric parameters of working bodies twin-screw extruder press.

Purpose of work - summarize the features of the geometric parameters of



working bodies Twin-screw extruder press and hold theoretical calculations to determine the degree of compression in the chamber for the two sets of workers, in particular for sunflower seed and rapeseed.

Research results. In twin-screw extruder press at constant diameter cylinder and spiral nozzles and turns at a constant depth along the length of the working of the screw shaft, press mode depends on the profile and volume changes of the law in the area of feed screw auger shaft.

The degree of compression - the ratio of volume of the first round to the last volume. To clearly understand the difference volume in pairs of helical coils of the first and the last section will result graphic work of Twin-screw extruder press (Fig. 1). Seals mass in Twin-screw extruder press with unidirectional rotation of turns made by reducing the volume of closed C-shaped section. Full C-extrusion volumes due to mutual engagement screw shaft ensures equality residence time of material in screw attachments channels, especially important to oil material is not overheated. Reducing the volume of closed C-shaped section carried a stepped reduction step turns screw attachment and change the width of the ridge round [4]. Moreover, the latter option may change from larger to smaller and vice versa, and therefore, there are many options for changing configuration options for finding rational. It should be noted that the presence of gaps between the screw cap and between the turns and the housing leads to poor performance, but on the other promotes better mixing mass. Overflows weight of a C-shaped volume to another depends on the pressure difference between the volumes. The material, which was in such volume transported during rotation of the shaft toward the matrix and on one turn squeezed two C-shaped volumes almost regardless of resistance in the cone of the matrix. This performance is independent of the extruder of resistance, and cutting depth can be relatively large, which reduces the strain rate and, accordingly, the intensity of dissipation, and thus increases the proportion of heat that rises from the wall buildings.

In terms of mathematical modeling of twin-screw extruder press is much more complex than single-screw press, so long developing geometry and the choice of modes of processing were based on practical experience and experimental data and, in addition, they have limited application due to more complex designs. The technical level of oil presses leading engineering companies achieved significant quality indicators, however, ways to improve technology to increase oil output has not been exhausted.

As a result of the theoretical analysis of the collected and processed information based on the measurement of working sets (for sunflower and rapeseed) press extruder EK 75/1200 ("Extruder" c. Kharkov) in Figures 2 and 3 shows the diagram showing the results of calculation geometric parameters of working media path in each conjugate pair of screw attachment (СІВ) and group cam nozzles (ГКН).

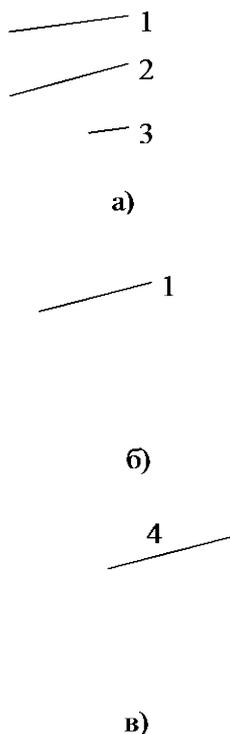


Fig. 1. Cutting the working bodies twin-screw extruder press:
a and б - in the area of the first and last pair of spiral nozzles respectively, в - in the area of the triangular cam nozzles; 1 - screw cap, 2 - shaft, 3 - body press extruder, 4 - Claw triangular nozzle.

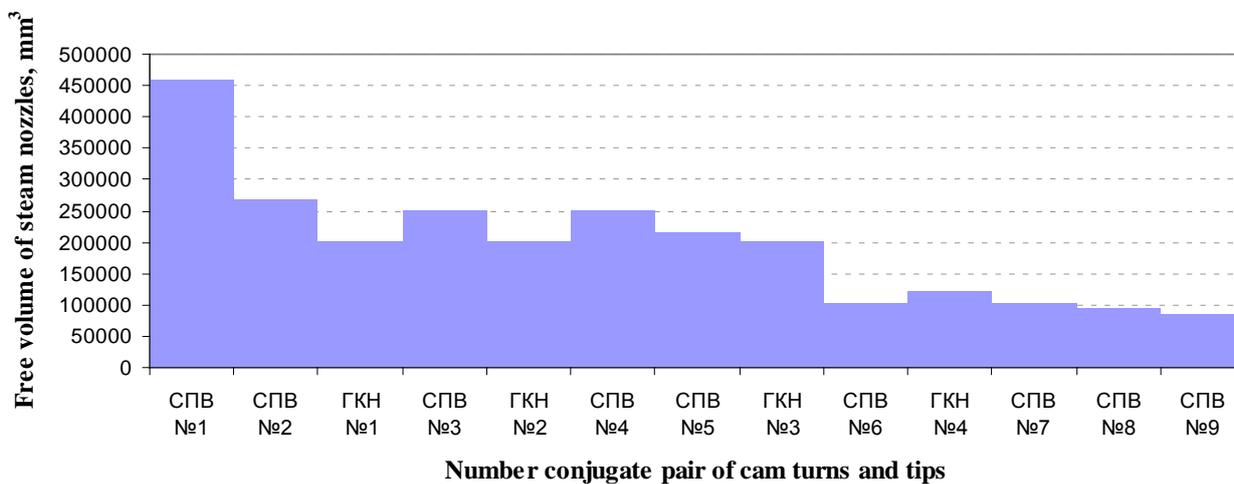


Fig. 3. Change in operating free volume of the length of the screw shaft (a set of working for sunflower seeds)

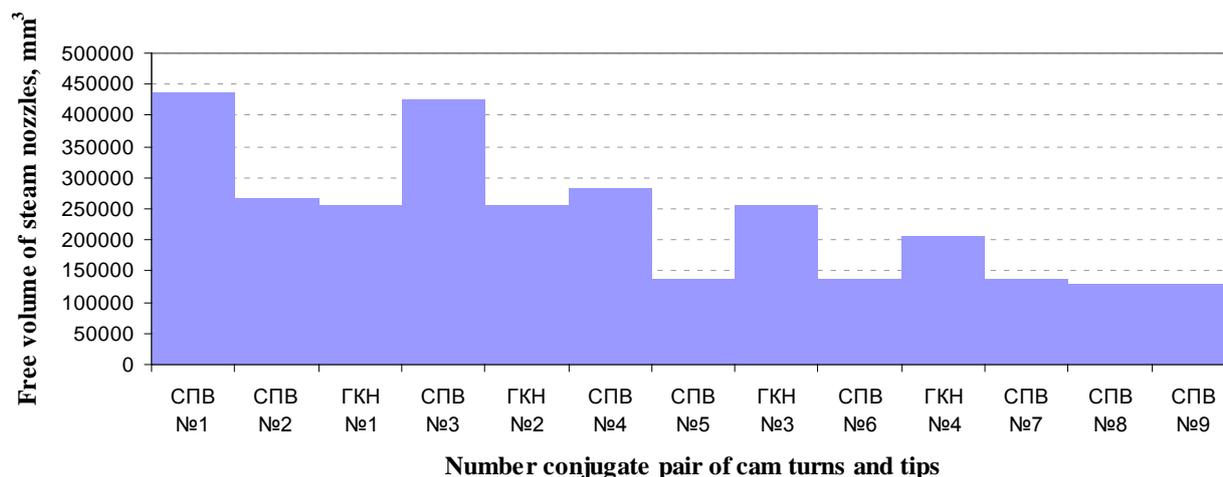


Fig. 3. Change in operating free volume of the length of the screw shaft (a set of working seed rape)

From step helical screw cutting efforts depends on the pressure, creating a screw attachment. Greater efforts can create pressure reducing step, but with reduced performance.

Conclusion

The general nature of the change in the areas of free volume groups accompanied by uneven nozzles 40-80% reduction in the output side of cake. The theoretical power for compression sets of working for sunflower seed and rapeseed is respectively 5.37 and 3.36. Selection of rational geometrical parameters of working together with other structural parameters will intensify the process of pressing oil.

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UDC 662.763.3.2

Polischuk V.N., Tarasenko S.E. **BIOGAS PRODUCTION WITH PERIODIC REGIME FERMENTATION
SUBSTRATE***National university of life and environmental sciences of Ukraine**Kiev, Heroes of Defense, 12, 03041**Полищук В.Н., Тарасенко С.Е.* **ПОЛУЧЕНИЕ БИОГАЗА ПРИ ПЕРИОДИЧЕСКОМ РЕЖИМЕ
СБРАЖИВАНИЯ СУБСТРАТА***Национальный университет биоресурсов и природопользования Украины**Киев, Героев Оборона, 12, 03041*

Abstract: This paper describes the case for the search for alternative energy sources due to the exhaustion of traditional fossil fuels. Indicated that replacement of one embodiment of fossil energy sources, such as natural gas, biogas has, with the formation of these gases nature identical. We consider the phase of biogas in a batch method of production, marked the most productive and non-productive phase from the point of view of the yield of biogas. It is noted that the production of biogas most productive at logarithmic and stationary phases, however, during these phases in comparison with the withering away of the phase is small, which reduces the efficiency of batch process for methane fermentation of biomass.

Keywords: biogas, methane fermentation phase fermentation biogas plant, digester

Аннотация: В статье приведено обоснование поиска альтернативных источников энергии в связи с исчерпыванием традиционных ископаемых источников. Указано, что одним из вариантов замены ископаемых источников энергии, в частности, природного газа, есть биогаз, причем природа образования этих газов идентична. Рассмотрены фазы образования биогаза при периодическом способе его производства, отмечены наиболее продуктивные и непродуктивные фазы с точки зрения выхода биогаза. Отмечено, что производства биогаза наиболее продуктивное при логарифмической и стационарной фазах, однако время этих фаз в сравнении с фазой отмирания мало, что снижает эффективность периодического способа метанового сбраживания биомассы.

Ключевые слова: биогаз, метановое сбраживание, фаза сбраживания, биогазовая установка, метантенк

Introduction. Due to the shortage of energy resources are being sought alternative forms of energy, which could not only replace conventional mineral fuels, but also to be more environmentally friendly. One of these forms of energy is biogas, which is a mixture of methane, carbon dioxide, small amounts of hydrogen sulfide and hydrogen. As a raw material for biogas production using municipal solid waste, waste water, waste production and animal husbandry. Depending on the composition of the feedstock, we can expect a different level and the energy value of biogas yield. Biogas is produced by methane fermentation occurring in the digester, which is part



of a biogas plant. Biogas can be used after cleaning to produce electricity for domestic purposes (for cooking), for heating residential and industrial buildings, including most livestock buildings, compressed methane cylinders suitable as fuel for cars and tractors.

Analysis of recent research. Description of the stages and methods of production of biogas from various substrates shown in [1; 2]. The results of studies of the effect temperature digester biogas output are given in [3], substrates property – in [4]. Studies effect of temperature, kinds of substrates, the substrate stirring biogas output power characteristics and presented in [5]. Description of the stages the production of biogas in a batch mode shown in [5].

The results of research. The processes taking place in a batch methane fermentation of manure in the digester biogas plant were examined for laboratory bioconversions organic raw National university of life and environmental sciences of Ukraine. They are fully consistent with the processes that occur in the cultivation of microorganisms in bioreactors. At the initial stage, after addition of new substrate, there is a lag phase, or phase of habituation to the new conditions of microorganisms. The digester slurry is added about 1/3 of its volume. Methane bacteria that remain in the "seed" of the substrate portions in the digester, some time getting used to the new substrate. Addition process may take up to 3-4 days, depending on temperature, raw materials and others. If you add the same type of substrate in the digester under conditions of constant temperature during the lag phase is significantly reduced and amounts to several hours.

After getting used to the bacteria to new conditions, they are beginning to grow and multiply, highlighting at the same time a large number of biogas. The process becomes exponential (logarithmic) and the phase of 4-6 days.

As nutrient depletion and accumulation properties of the substrate therein metabolic products, growth rate is reduced and the process proceeds to the stationary phase in which the dividing and dying off processes in the population of bacteria are in dynamic equilibrium. Time duration of stationary phase - 1-2 days. When exhaustion of nutrients in the substrate and overcome the accumulation of metabolic products threshold concentration phase begins dying out, and the number of bacteria in a population gradually declines. The phase of the withering away may take quite a long period of time, but in terms of production of biogas is not productive, since biogas is released at the same time a little bit.

Summary and Conclusions

In batch fermentation substrate for biogas production the most productive in the final stage of the logarithmic phase and stationary phase. However, the duration of these phases is insignificant, that determines the low efficiency of batch fermentation substrates.

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ANALYSIS OF QUALITY INDICATORS BIODIESEL ACCORDING TO DOMESTIC AND WORLD STANDARDS*National university of life and environmental sciences of Ukraine**Kiev, Heroes of Defense, 12, 03041*

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АНАЛИЗ ПОКАЗАТЕЛЕЙ КАЧЕСТВА ДИЗЕЛЬНОГО БИОТОПЛИВА СОГЛАСНО ОТЕЧЕСТВЕННЫХ И МИРОВЫХ СТАНДАРТОВ*Национальный университет биоресурсов и природопользования Украины**Киев, Героев Оборона, 12, 03041*

Abstract: In this article the substantiation of the need to replace fossil fuels with alternative energy. It indicated that can use biodiesel (methyl ester) for the replacement of petroleum diesel. However, the use of modern diesel engines of other fuels, the characteristics of which differ slightly, can lead to engine damage. Therefore it is necessary to adhere to the quality parameters in the production of biodiesel, which are specified in the standards for diesel biofuel. Results of international and Ukrainian standards for biodiesel and some quality indicators are presented in them.

Keywords: biodiesel, methyl ester, a reactor, methanol, the catalyst

Аннотация: В статье проведено обоснование необходимости замены ископаемых источников энергии альтернативными. Указано, что для замены нефтяного дизельного топлива можно использовать биодизель (метиловый эфир). Вместе с тем, использование в современных дизельных двигателях других топлив, характеристики которых несколько отличаются, может привести к поломке двигателя. Поэтому при производстве биодизеля необходимо придерживаться показателей качества, которые указаны в стандартах на дизельное биотопливо. Приведены международные и украинские стандарты на биодизель и некоторые показатели качества, представленные в них.

Ключевые слова: биодизель, метиловый эфир, реактор, метанол, катализатор

Introduction. In connection with the emergence of a global energy crisis of the world, humanity is actively searches for alternatives to fossil energy sources. Particular attention is paid to the search for light oil substitutes, because no cars, planes, trains, humanity does not see its continued existence. Much of vehicles, the majority of tractors and other mobile and stationary machines are driven by diesel engines, which are at present, basically operate on diesel oil, one of which is a biodiesel substitutes.

However, modern diesel engines during their evolution have been adapted to the properties of diesel oil. The use of these alternative fuels, the characteristics of which are slightly different, can lead to engine damage, the cost of which amounts to a significant cost of the machine itself.



In operation of diesel engines on biodiesel, optimal parameters of biodiesel, compliance with which most of its properties closer to those of petroleum diesel, which significantly reduces the risk of engine failure. These optimal parameters are presented in diesel biofuel standards.

Analysis of recent research. For rapid and complete methanolysis reaction is taken with excess methanol, methyl ester so obtained contains 1.5% of methanol, from which biodiesel must be cleaned because it corrodes non-ferrous metals, and rubber gasket engine [1]. In the production of biodiesel according to conventional technology to accelerate the reaction, the catalyst necessarily is applied which itself does not react, and only accelerates it. Therefore, in the manufactured biodiesel it remains completely, causing corrosion of the engine. The corrosion products entering the gap between the cylinder and the piston, they cause abrasion. In case of contact with the fuel system, they can clog fuel filters, fuel or block the work of the equipment due to the inability to spray fuel through nozzles [2; 3].

The results of research. For biodiesel standards developed by the European Organisation standard EN 14214:2012 "Liquid petroleum products Fatty acid methyl esters (FAME) for diesel engines and heating requirements and test methods." Apart from these, there are standards EN 590: 2000 and DIN 51606. The first describes the physical properties of diesel fuels sold in the EU, Iceland, Norway and Switzerland. This standard allows for the content of 5% biodiesel in mineral diesel fuel; in some countries (eg France), all diesel fuel contains 5% biodiesel. German standard DIN 51606 – designed to be compatible with engines of almost all leading car manufacturers, so it is the most severe. The DIN 51606 standards, some more severe than in the EN 14214:2012.

To biodiesel quality requirements established in Ukraine DSTU 6081:2009 "Motor fuel. Methyl esters of fatty acids, fats and oils for diesel engines. Specifications "and its mixture up to 5% with conventional diesel fuel – DSTU 4840: 2007" Diesel fuel high quality. Technical conditions" national standard is also designed to DSTU 7178: 2010 "Fuel Alternative ethyl esters of fatty acids, oils and fats for diesel engines Technical requirements and methods of control".

Quality parameters of biodiesel and mineral diesel fuel of higher quality, in accordance with international and domestic standards establish certain fuel parameters including: a flash point in closed crucible 90-120°C, the mass fraction of methanol – no more than 0,2%, mass fraction of alkali metals – less than 5 mg/kg, free glycerol – less than 0,25% phosphorus – not more than 5 mg/kg and an acid number of – not more than 0,5 mg KOH per g, water mass fraction – less than 0,05% and others.

Summary and Conclusions

To obtain high-quality methyl ester is necessary to sustain a number of requirements, which raises the need for additional processing of the biodiesel, in particular it is necessary to carry out the removal of the methanol and catalyst residues.

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DIESEL BIOFUEL

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ДИЗЕЛЬНЫЕ БИОТОПЛИВА

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Abstract: The article brought the feasibility of replacing petroleum diesel fuel derived from renewable raw materials. The characteristic of alternative diesel fuels: synthetic diesel fuel, dimethylether, oils and biodiesel. These advantages and disadvantages of using oil as an alternative to petroleum diesel. Notified that the application of pure oil may reduce the life of the engine. It is noted that of all the biofuels most adapted for use in diesel engines is biodiesel, which in its physical properties close to the oil diesel fuel.

Keywords: biodiesel, oil, dimethyl ether, methanol, the catalyst

Аннотация: В статье доведена целесообразность замены нефтяного дизельного топлива на топлива, полученные из возобновляемого сырья. Приведена характеристика альтернативных дизельных топлив: синтетического дизельного топлива, диметилового эфира, растительных масел и биодизеля. Указаны преимущества и недостатки использования растительного масла в качестве альтернативы нефтяному дизельному топливу. Доведено, что применение чистого растительного масла может привести к уменьшению срока службы двигателя. Отмечено, что из всех биотоплив наиболее адаптированным к использованию в дизельных двигателях является биодизель, который по своим физическим свойствам приближается к нефтяному дизтопливу.

Ключевые слова: биодизель, растительное масло, диметиловый эфир, метанол, катализатор

Introduction. Scientists predict that the world's proven oil reserves will last for 45 years of production. Moreover, the smaller reserves of fossil fuels remains, the greater will be the price for them. This is especially important for our country, because Ukraine has great wealth - land, but to obtain from it the harvest needs to be processed. At present, for agriculture Ukraine annually is necessary to have about 1,9 million tons of diesel fuel and 620 thousand tons of gasoline, which are produced from 4,5 million tons, mainly imported. Ukraine can provide themselves with their own oil production is only 20% [1]. It is therefore advisable to use as much as possible the maximum fuel that can replace fossil diesel.

The results of research. Alternate fuels which may be used in diesel engines, include synthetic diesel, dimethyl ether, oil, biodiesel and fuel mixtures.

Synthetic diesel fuel and at least dimethyl ether and can be made from renewable raw materials, are currently produced mainly from fossil resources (natural



gas and coal, respectively).

Oils can be used as liquid biofuels for diesel engines in unprocessed or processed to form esters.

The heat of combustion of oil is 37 MJ/kg. It is, though slightly lower heat of combustion of fossil diesel, but is much higher than this indicator dimethyl ether. However, the density is high enough vegetable oils (916-1069 kg/m³), whereby when spraying in the cylinder formed large droplets. The oil is burned incompletely, however, it polymerizes by heating to form a film, which is coked nozzles, pistons and piston rings.

Some garages carried out renovations of car engines, which have already fulfilled their service life, for work on waste oil by reducing its viscosity by heating or dilution with diesel fuel and more efficient filtering through the installation of an additional filter. This provides it with a better mix of air and more complete combustion. But such engines eventually fail.

Most diesel engines adapted to alternative fuels from renewable sources is biodiesel. It is a fatty acid ester and is produced from raw materials containing fats (animal or plant). When added to fats alcohols (methyl, ethyl or isopropyl) for the presence of the catalyst extends the alcoholysis reaction resulting in the formation of triglyceride fat and glycerol esters, which are called biodiesel. A prerequisite is the reaction of alcoholysis presence of a catalyst and heating the reactants to 40-80°C temperature (according to the traditional technology). The catalyst can act as acids or bases [2]. After separating glycerol from biodiesel need to clean the catalyst and the residual alcohol which is fed with an excess to complete the reaction. Only after that biodiesel can be used as fuel for diesel engines.

The technology with supercritical methanol state, developed by Japanese scientists, provides for the reaction of alcoholysis creating temperature and pressure 240°C about 80 at. When this catalyst is not used, and the reaction proceeds for 2-4 min. The advantage of this technology is the absence of a catalyst, and consequently the finished product purification requirements from it [1].

Biodiesel is produced in Ukraine in accordance with national standards DSTU 6081:2009, which is harmonized with the European standard EN 14214:2003 mixtures of biodiesel fuel in Ukraine is carried out according to DSTU 4840:2007, which provides for the production of blends with diesel fuel B5 with 5 percent biodiesel additive. Requires the development of national standards for blends with diesel fuel containing biodiesel 10, 20 and 30 percent, which will sell it in the market is similar to traditional.

Summary and Conclusions

Of all the biofuels most adapted for use in diesel engines is biodiesel, which in its physical properties close to the oil diesel fuel. Use of pure oil may reduce the life of the engine.

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j1110-060

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USE OF WASTE MATERIALS AS FEEDSTOCKS FOR ALCOHOL PRODUCTION*National University of Food Technologies*

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ВИКОРИСТАННЯ ВІДХОДІВ ЯК СИРОВИНИ ДЛЯ СПИРТОВОГО ВИРОБНИЦТВА*Національний університет харчових технологій,
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Анотація. В статті розглядаються питання використання відходів для виробництва спирту етилового, у тому числі біоетанол.

Ключевые слова: відходи виробництва, спирт, біоетанол, абсолютування.

Abstract. In this article we describe the use of Waste as a raw material in ethanol production.

Key words: waste, ethanol, fermentation, distillation.

Introduction

Since the beginning of the U.S. fuel ethanol industry in 1978, production capacity has increased from approximately 200,000 gallons per year to the present level of more than one billion gallons per year. During this time span, the majority of the growth has been as wet-milling capacity, with a rapid expansion occurring during the period from 1981 through 1987. The optimistic outlook for the fuel-ethanol industry during the early 1980's was led by a strong ethanol market with relatively stable pricing. This allowed a number of dry-milling fuel-ethanol facilities to acquire funding. The sizes of these plants ranged from farm-based operations with a capacity of less than 200,000 gallons per year, to grass-roots plants producing in excess of 60 million gallons per year.

Unlike wet-milling facilities, which are able to distribute the cost of operations and feedstock over a wide variety of products based on the starch, fiber, protein and fat components of the grain, dry-milling plants are limited to ethanol and distillers dried grains. They are, therefore, held hostage to market prices of these two commodities. Further complicating this issue is the fact that there is no economic correlation between fuel-ethanol pricing (which is linked to the rack price of gasoline), and grain pricing. Thus, the financial stability of a number of fuel-ethanol producers fluctuated dramatically as grain and fuel-ethanol prices rose and fell from 1980 to 1990 (Figure 1).

With small producers lacking the economies of scale available to larger facilities, and with grain comprising in excess of 60% of the cost of producing a gallon of ethanol in a dry-milling plant, it becomes easier to understand why a large number of small ethanol facilities production in the mid-to-late 1980's (Figure 2).

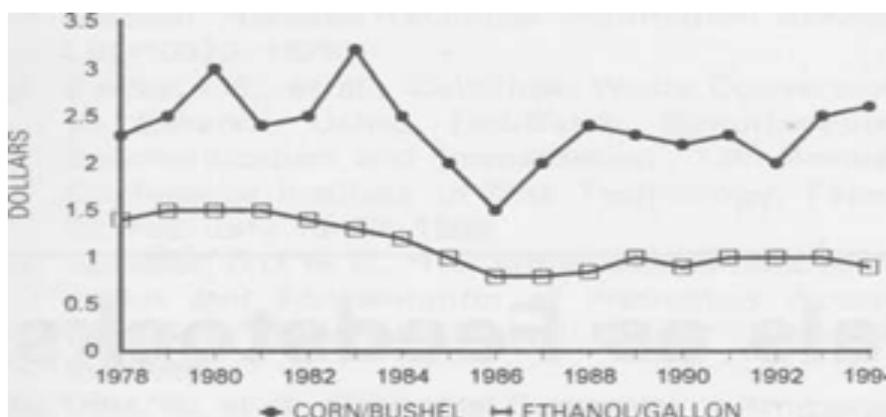


Figure 1 Monthly average price of grain and fuel-ethanol

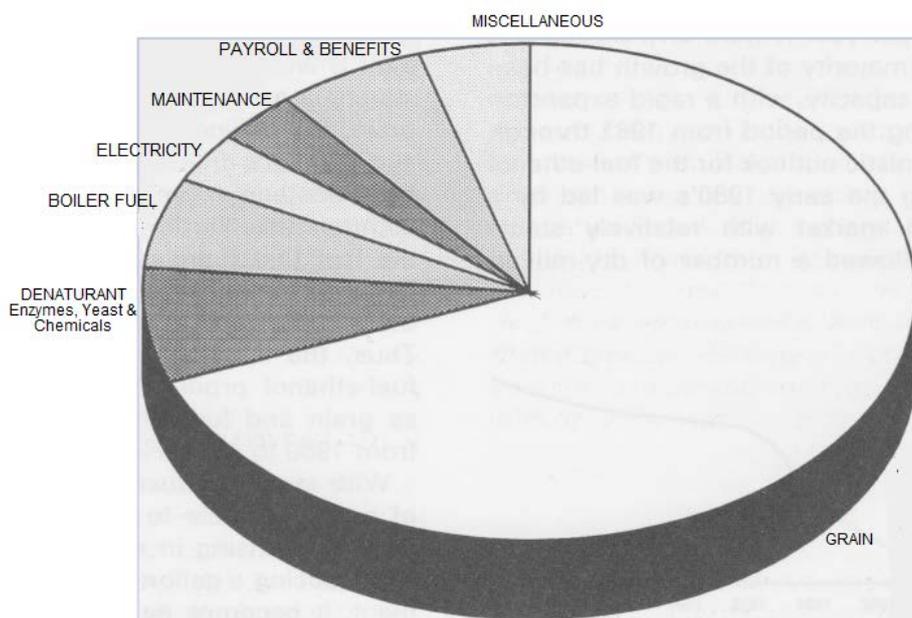


Figure 2 Corn dry-mill operating cost

The driving force for this was a soft ethanol market, combined with several consecutive years of poor growing conditions in the corn belt. Many small plants which had been driven into bankruptcy were able to re-start production later due to the reduced debt service resulting from the low purchase price to the second owners. This was possible in plants located in the mid-west, which typically could acquire corn at less than Chicago Board of Trade prices and at low freight costs. In the late 1980's, many plants with annual production capacities approaching 45 million gallons were incapable of achieving a positive cash flow even with zero debt service, due to low ethanol pricing combined with high delivered-corn pricing. It should, however, be noted that a number of these plants also had serious design deficiencies.

One might, therefore, be led to conclude that all small ethanol producers outside the central states ceased production, but this, in fact, was not the case. Several small producers continue operating through what can be called 'creative acquisition of feedstocks'. Since feedstock purchasing comprises such a large portion of the cost of ethanol production, small producers can maintain profitability even during periods of low ethanol pricing, by significantly reducing feedstock cost.



Alternative Feedstocks

A well-designed dry-mill facility will contain most of the equipment required to handle many types of starch or sugar-bearing feedstocks. Often, only minor modifications are required in feedstock-handling operations. For example, a plant designed to process a dry feedstock, such as corn, may require only minor feedstock - receiving equipment changes to handle slurried or liquid feedstocks. Table 1 gives a partial list of available potential feedstocks.

Typically, the supplies of most of the feedstocks are available in small or unpredictable quantities, making it impossible to economically justify a dedicated fuel-ethanol production facility. Exceptions exist in many large food-processing plants which generate significant quantities of sugar and starch- containing residues. In these cases, dedicated fuel-ethanol production facilities serve as a waste-remediation process, whereby high biochemical oxygen demand (BOD) effluent streams are converted to a liquid product, ethanol, with a significant market value. This differs from typical waste-treatment processes, where soluble BOD is converted to sludges, which then require costintensive transportation and disposal. These low-cost feedstocks are sufficiently attractive to entice many intermediate and large-scale fuel- ethanol producers to use them to supplement normal grain-processing operations, thereby reducing the net cost of feedstock to the facilities.

Table 1

Potential feedstocks

Offspec glucose and fructose syrups
 Offspec dry starches and starch solutions
 Low-value starches, such as 'B' starch from wheat processing
 Waste soft-drink syrups
 Brewer's spent grains
 Damaged or spoiled grains
 Expired seed grains
 Food-processing wastes, high in starches or free sugars
 Brewery-yeast slurries
 Waste candies
 Waste pet foods Spoiled food products
 Cheese whey
 Spoiled fruit, including apples, peaches, oranges and bananas
 Citrus molasses
 Honey
 Raw sugar
 Potatoes
 Sweet potatoes and yams
 Rice bran

Case study

The following case study will discuss, in greater detail, design and operational issues pertaining to a dedicated food-processing-waste-to-ethanol



facility. Much of this discussion is based on two potato-to-ethanol plants built for Simplot Development Corporation in the mid-1980's. These three million-gallon-per-year fuel-ethanol facilities were designed to receive potato processing waste, culled potatoes and plant washings high in starch, as a feedstock.

The general processes required for a potato- waste, fuel-ethanol production facility are similar to those required in a corn dry-milling operation. As is the case with many speciality- feedstock industries, processes must be custom designed, with the properties specific to the feedstock in mind. In the case of potato waste, the properties requiring close attention included:

1. High water content
2. High sand and soil content
3. High fibrous tuber and vine content
4. Unique starch chemical and physical properties
5. Minimal storage life
6. Seasonal or erratic supply

Feed Preparation

The feed preparation system, like a significant portion of the front-end unit operations, must be designed for peak hydraulic and solids flows. These flows vary both hourly, daily and seasonally.

The feedstock, which is a dilute starch slurry, containing potato peelings, as well as whole cull potatoes, vines and other residues, passes through a milling device. The purpose of the mill, like that in the grain plant, is to reduce the maximum particle size for cooking and subsequent processing. The incoming feedstock is heavily contaminated with soil microorganisms, and therefore, cannot be stored for any appreciable time without a significant loss in ethanol yield.

Due to the high water content in the cull potatoes, and other process streams, the milled feed flows directly to the slurry tank without the need of any additional dilution. This is critical, since the starch and sugar concentration of the incoming feed results in beer-ethanol levels significantly lower than typically found in a grain dry-milling plant. Minimizing water addition to the process reduces the necessary size of process equipment, as well as its energy consumption required for cooking, distillation and stillage processing.

The slurry tank is heated by recirculating the contents through the slurry heater which receives flash steam from downstream processes. Precautions are required since gelatinization temperature of potato starch is much lower than that of corn starch (Whistler, et al., 1984). Alkali is added to the slurry tank to control the pH at the alpha-amylase optimum. Mash from the slurry tank is continuously pumped through a jet cooker which begins the starch-conversion process, as well as providing a thorough sterilization of the incoming feed. Again, this is critical, due to the extremely high concentration of soil-borne bacteria in the feedstock. All pumps and process piping must be designed to withstand erosion associated with mash-entrained sand. The mash, leaving the cooker, is flash cooled to liquefaction temperatures prior to the addition of liquefying enzymes and entering the liquefaction tank. The flash cooling serves a secondary function of cost-effectively providing a small degree of mash dehydration (Figure 3).



In the liquefaction vessel, the process of converting complex starches to dextrins is completed by holding for a suitable time period. The mash is then acidified and cooled during transfer to the fermentation system. The pH adjustment, which, in grain milling plants, is normally accomplished with backset stillage, must be performed by the addition of acid. This is necessary to control water input into the fermentation system, to maximize the ethanol concentration in the beer stream to distillation.

Mash coolers must be of a design which allows thorough cleaning. Plate-and-frame and spiral heat exchangers, which are often used in wet-milling and dry-milling facilities, are to be avoided in this instance. Due to the presence of tubers and vines, which become entrapped in the exchangers, normal cleaning-in-place (CIP) systems are incapable of removing deposits and debris from these types of coolers. Thorough cleaning then requires labor-intensive dismantling of the equipment. For this reason shell-and-tube exchangers are preferred, as they can be easily back flushed during the CIP. It is also advisable that spare mash coolers be installed, so that the process can continue uninterrupted during cleaning cycles.

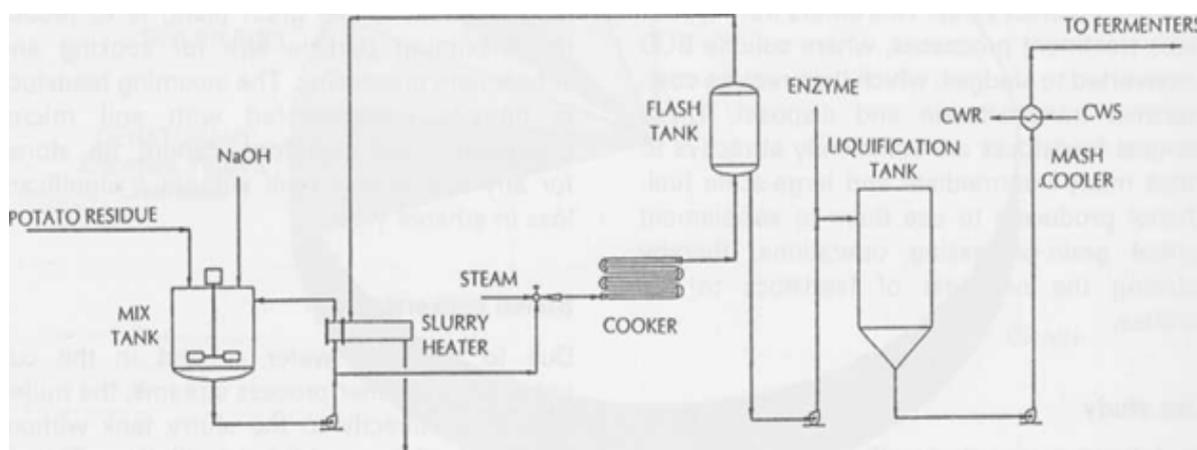


Figure 3 Mashing and cooking

Fermentation

The cooled mash enters the fermenter which already contains the yeast inoculum and the saccharifying glucamylase enzyme (Figure 4). The liquefied starch is then converted by the glucamylase enzyme to glucose which is then fermented to ethanol in a simultaneous saccharification and fermentation process. This minimizes process-equipment and capital investment requirements, and reduces the potential for bacterial contamination, while maximizing yields. The fermentation vessels are typically fabricated of carbon steel with sloped bottoms for ease of cleaning and their contents are circulated through external shell-and-tube heat exchangers for temperature control. Steeply-sloped bottoms are recommended for the tanks, to assist in removing accumulated soil and sand on emptying the fermenter.

Upon completion of the fermentation process, the contents are transferred to the beer well, which provides additional surge capacity for the process. Residues are washed to the whole- stillage tank or to the sewer with the initial rinse. The fermenters and coolers are then chemically cleaned with a mild caustic solution in preparation for the next fill.



YEAST

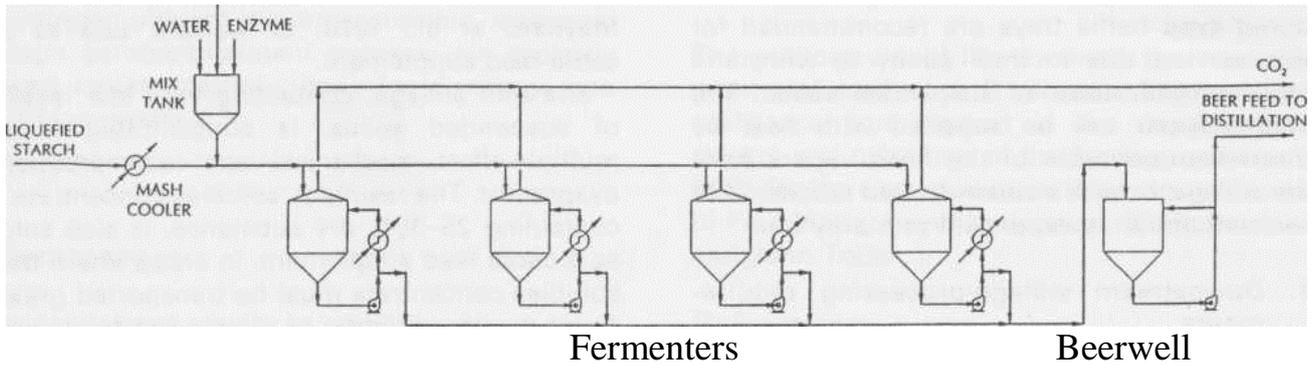


Figure 4 Simultaneous saccharification and fermentation

Distillation and Dehydration

Fermented beer is preheated in shell-and-tube heat exchangers prior to entering the beer still (Figure 5). Due to the low ethanol concentration in the beer, an energy-integrated distillation-and-dehydration system is necessary, to minimize energy consumption. The beer enters the stripper section of the distillation column, which removes the ethanol from the beer, so that the residue, or stillage, which emerges from the base of the column, contains less than 200 ppm of the ethanol. 'Disc-and-donut'-type baffle trays are recommended for this service, due to their ability to withstand high concentrations of suspended solids. The beer stripper can be supplied with heat by thermo-compression of the flash vapors from the stillage, or with a steam-heated reboiler. The selected option is dependent primarily on:

1. Downstream stillage-processing requirements
2. Energy cost
3. Regional environmental issues

The stripped ethanol is concentrated up to about 90 proof (95° GL) in the rectifying section prior to entering the molecular-sieve unit for dehydration to 199+ proof (>99.5° GL), to meet fuel-grade ethanol specifications.

190⁰ PROOF VAPOR

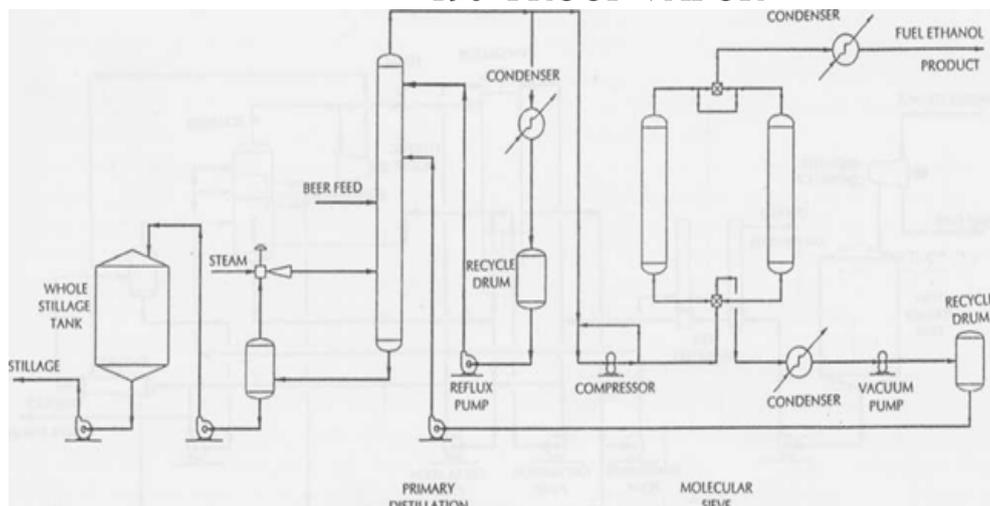


Figure 5 Distillation/dehydration with molecular sieve

Stillage Processing Evaporation



The stillage or residue from distillation is pumped to the whole-stillage surge tank, which provides surge capacity between the distillation system and the stillage-processing operations. Whole stillage is processed in a decanter-centrifuge, which separates the majority of the suspended solids from the 'thin stillage' liquid (Figure 6). The solids, with the consistency of wet sawdust, have sufficiently high protein and fat concentrations (Cullison et al., 1987; Maynard et al., 1979) to warrant sale as a cattle-feed supplement.

The thin stillage, containing very low levels of suspended solids, is concentrated in a multiple-effect, mechanical-vapor-recompression evaporator. The resultant 'solubles concentrate', containing 25-30% dry substance, is also sold as a cattle feed supplement. In areas where the solubles concentrate must be transported great distances, the addition of a forced-recirculation evaporator can increase the solids concentration to 35-45%, reducing freight costs and improving the value.

Due to the limited ethanol-production capacity of plants of this type, the physical properties of the dissolved solids, and the low fiber content of the stillage, it is generally neither cost-effective nor technically attractive to install dryers for the wet stillage cake and the solubles concentrate.

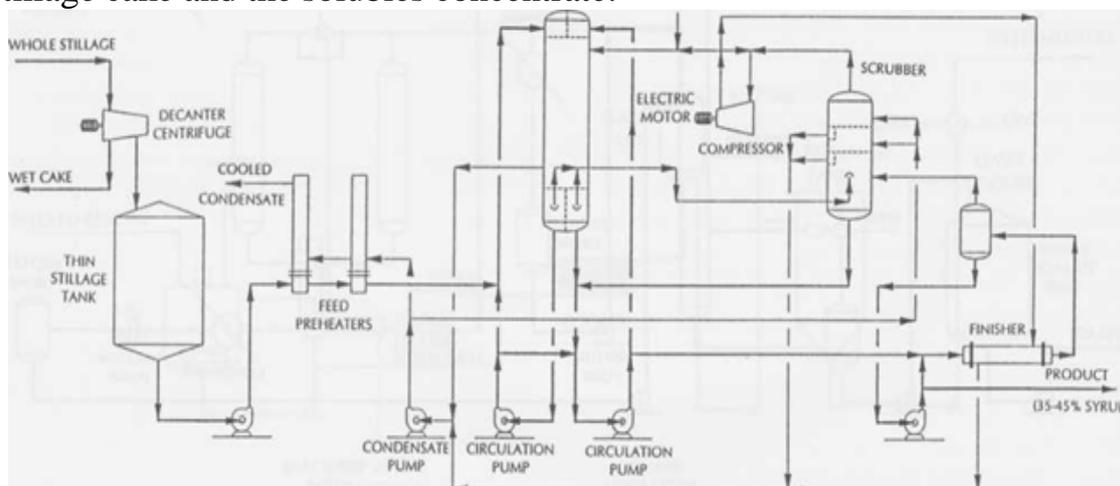


Figure 6. Mechanical-evaporator-recompression electric drive with integral finisher

Biological treatment

An alternative to stillage evaporation is biological treatment. This is often warranted in areas which lack sufficient cattle to consume the recovered solids. Recent advances in anaerobic treatment processes have allowed this technology to achieve up to 95% reduction in BOD of high strength (10,000-50,000 mg/L) effluent streams. With this level of treatment, the processed effluent may be used for irrigation (Tchobanoglous et al., 1979; Miorin et al., 1977). If land application of primary anaerobic treatment effluent is not permissible, a second-stage aerobic-treatment process will typically meet environmental criteria for discharge into surface waters.

Summary

Plant designs, such as that described here, provide a cost-effective solution to the ever-growing need to conform to environmental regulations. Converting waste-



carbohydrate streams to a renewable, oxygenated-fuel component provides a double environmental benefit. The choice of technology must provide energy efficiency with low manpower and maintenance requirements, while producing maximum yields, if it is to remain a cost-effective solution. With these goals in mind, the small fuel-ethanol producer can continue to operate in this highly cyclical industry.

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Аннотация. В статье рассматривается перспектива использования целлюлозы как сырья для производства этилового спирта (включая биоэтанол)

Ключевые слова: Целлюлоза, этиловый спирт, предварительная обработка

Abstract. In this article we describe the perspectives of ethanol (including bioethanol) production from cellulose as a raw material.

Key words: cellulose, pretreatment, fermentation

Introduction

The inevitable decline in petroleum reserves and the rise in demand for oil from rapidly growing economies have caused soaring oil prices, and coupled with climate change concerns have contributed to the current interest in renewable energy resources. In some parts of the world this interest has resulted in the introduction of legislations promoting the use of renewable energy resources and increasing government incentives for commercialization of renewable energy technologies. Development of science and technologies for efficient conversion of lignocellulosic biomass to renewable liquid transportation fuels has become one of the high priority research areas of the day, and bioethanol is the most successful biofuel to date.

Corn- and sugarcane-derived first generation bioethanol is currently in wide use as a blend-in fuel in gasoline sold in the United States, Brazil, and in a few other countries. However, there are a number of major drawbacks to these first generation fuels such as the effect on food prices as traditional food resources are utilized as raw materials, net energy balance, and poor greenhouse gas mitigation.

Cellulosic ethanol is a second generation biofuel produced from agricultural wastes, grasses, municipal wastes, and other feedstocks that do not double as food, so unlike traditional corn-based ethanol, it promises to avoid encroaching upon and destabilizing the human food supply. In addition, cellulosic ethanol can be produced from a variety of abundant lignocellulosic biomass feedstocks, and should be able to be produced in substantial amounts to meet the growing global energy demand. There are two fundamental routes to produce cellulosic ethanol from renewable biomass: the aqueous-phase biomass saccharification-fermentation route, and thermochemical gasification route. The thermochemical route can be divided into two paths as syngas produced from biomass can be converted to ethanol by chemical or enzymatic methods.

1. Cellulosic Ethanol Feedstock Types



Biomass feedstocks that can be used for cellulosic ethanol production can be broadly divided into five categories:

1. **Agricultural wastes** — crop residues after taking the edible portion of the plant and can be in the form of stalks, leaves, trunks, branches, peels, or husks; all these parts of the plants are suitable as feedstock. In addition to this, edible agricultural products that are not suitable for human and animal consumption and rejected due to spoiling or contamination are also suitable as feedstock in the bioethanol production.

2. **Forestry residue** — logging and mill residues such as wood chips, sawdust, and pulping liquor.

3. **Grasses** — hardy, fast-growing grasses such as switchgrass grown specifically for ethanol production.

4. **Trees** — fast-growing trees such as poplar and willow grown specifically for ethanol production.

5. **Municipal and other wastes** — plant-derived wastes such as household garbage, paper products, paper pulp, and food-processing waste. Nevertheless, production

of ethanol from starch- and sugar-containing food wastes requires first generation bioethanol technologies, which are in wide use in the current corn and sugarcane ethanol industries.

1.1 Potential of Agricultural Wastes

Agricultural industry waste is the byproduct of industries which use agricultural products as raw materials. The major crops that produce large quantities of wastes on a global scale are rice, corn, barley, oat, wheat, sorghum, and sugarcane. The potential of producing ethanol from the crop residues as well as wasted agricultural products have been estimated. To avoid conflicts between human food use and industrial use of crops, only the wasted crop, which is defined as crop lost in distribution, is considered as feedstock.

There are about 74 Terra grams (Tg) of dry wasted crops in the world that could potentially produce 49 GL/ year of bioethanol.

Lignocellulosic biomass forms such as crop residues and sugarcane bagasse are the main components of agricultural waste, and about 1549 Tg /year of dry lignocellulosic biomass from these global crops is also available for conversion to bioethanol with a potential of producing up to 442 GL/ year of cellulosic bioethanol.

Thus, the total potential bioethanol production from crop residues and wasted crops is 491 GL /year.

Chemical composition of lignocellulosic feedstocks is a key factor affecting efficiency of biofuel production during the complex conversion process. The structural and chemical composition of lignocellulosic feedstocks is a highly variable factor, because of genetic and environmental influences and their interactions. Low lignin, globally abundant crop residues like rice and wheat straws are excellent biomass resources for the aqueous-phase cellulose hydrolysis-fermentation route. A comparison of major components: cellulose, hemicellulose, lignin and ash in major crop residues are shown in Table 1.1.

**Table 1.1**

A comparison of cellulose, hemicellulose, lignin and ash in major crop residues that can be used in cellulosic ethanol production (wt% on dry basis).

Crop residue	Cellulose	Hemicellulose	Lignin	Ash
Corn stover	38	26	23	5
Barley straw	42	28	7	11
Oat	40	20	18	8
Rice	40	23	15	13
Wheat straw	38	20	15	5
Sorghum	23	14	11	5
Soybean	33	14	14	6
Sugarcane bagasse	40	21	18	2

Dale and Kim [1] have studied the global potential in crop residues as well as agricultural wastes for bioethanol production, and the totals (Terra grams [Tg]) of seven major crops: corn, barley, oat, rice, wheat, sorghum, and sugarcane in five continents are shown in Table 1.2.

Table 1.2

Total quantities of wasted crops and agricultural wastes in different continents, that are potentially available for bioethanol production

	Africa	Asia	Europe	America	Oceania	Subtotal
Wasted crop (Tg)						
Corn	3.12	9.82	1.57	6.17	0.01	20.70
Barley	0.17	1.23	2.01	2.04	0.09	3.66
Oat	0.004	0.06	0.43	0.06	0.001	0.55
Rice	1.08	21.8	6.02	2.45	0.02	25.44
Wheat	0.83	10.28	4.09	1.17	0.82	17.2
Sorghum	2.27	0.54	0.004	0.31	0.001	3.12
Sugarcane	0.46	1.64	0.00	1.10	0.00	3.20
Subtotal	7.94	45.43	8.13	11.31	1.05	73.86
Crop residues (Tg)						
Corn stover	0.00	33.90	28.61	140.86	0.24	203.62
Barley straw	0.00	1.97	44.22	10.3	1.93	58.45
Oat straw	0.00	0.27	6.83	3.04	0.47	10.62
Rice straw	20.93	667.59	3.92	37.23	1.68	731.34
Wheat straw	5.34	145.20	132.59	62.34	8.57	354.35
Sorghum straw	0.00	0.00	0.35	9.65	0.32	10.32
Sugarcane bagasse	1.73	74.88	0.01	87.62	6.49	180.73
Subtotal	38.0	923.82	216.56	351.34	19.70	1549.42

The U.S. National Renewable Energy Laboratory (NREL) has estimated that 288–447 L of ethanol can be produced from a dry tonne of corn stover [2]. The



ethanol yields from other forms of agricultural wastes can be calculated by using composition data of these materials and an “ethanol yield calculator” developed by the U.S. Department of Energy [3]. Even though the ethanol production efficiency depends on the form of biomass, in many of these calculations they have assumed that the ethanol production efficiency of other crop residues is also similar to that of corn stover [1].

Potential for bioethanol production from crop waste and crop residues around the globe by different continents is shown in Table 1.3.

Table 1.3

Potential of bioethanol production from crop waste and crop residues around the globe in giga liters (GL) per year.

	Africa	Asia	Europe	America	Oceania	Subtotal
From waste crop (GL)						
Corn	2.17	6.82	1.09	4.29	0.01	14.40
Barley	0.12	0.83	1.35	0.03	0.13	2.46
Oat	0.002	0.04	0.30	0.04	0.001	0.38
Rice	0.71	14.4	0.02	1.61	0.02	16.80
Wheat	0.55	6.78	2.70	0.78	0.54	11.30
Sorghum	1.55	0.37	0.003	0.12	0.0004	2.14
Sugarcane	0.23	0.82	-	0.55	0.0001	1.59
Subtotal (A)	5.33	30.10	5.45	5.00	0.70	49.10
From Crop residues (GL)						
Corn stover	-	9.75	8.23	40.50	0.07	58.60
Barley straw	-	0.61	13.70	3.15	0.60	18.10
Oat straw	-	0.07	1.79	0.79	0.12	2.78
Rice straw	5.86	186.80	1.10	10.41	0.47	204.60
Wheat straw	1.57	42.60	38.90	18.40	2.51	103.80
Sorghum straw	-	-	0.10	2.61	0.09	2.79
Sugarcane bagasse	3.33	21.30	0.004	24.87	1.84	51.30
Subtotal (B)	10.80	261.00	63.80	100.82	5.70	442.00
Subtotal (A+B)	16.13	291.10	69.25	105.82	6.39	491.10

2. Aqueous Phase Biomass Hydrolysis Route

2.1 Introduction – Two Ways to Produce Cellulosic Ethanol

There are two basic processes for conversion of lignocellulosic biomass to bioethanol:

1) cellulolysis process or aqueous-phase biomass saccharification and fermentation process;

2) gasification or syngas to ethanol conversion process.

The first method of aqueous-phase biomass saccharification and fermentation involves the hydrolysis of cellulose and hemicellulose in biomass to sugars and then fermentation of the sugar solution with yeast to produce ethanol.

The basic steps of this route are shown in Figure 2.1.

Saccharification of the biomass or hydrolysis of polysaccharides to



monosaccharides is the most challenging step in this process, and this can be accomplished by pretreatment of biomass followed by exposure to a cellulase enzyme cocktail, or by single-step direct acid hydrolysis using concentrated or dilute acid solution like aqueous sulfuric acid.

This route is known as biochemical process as well.

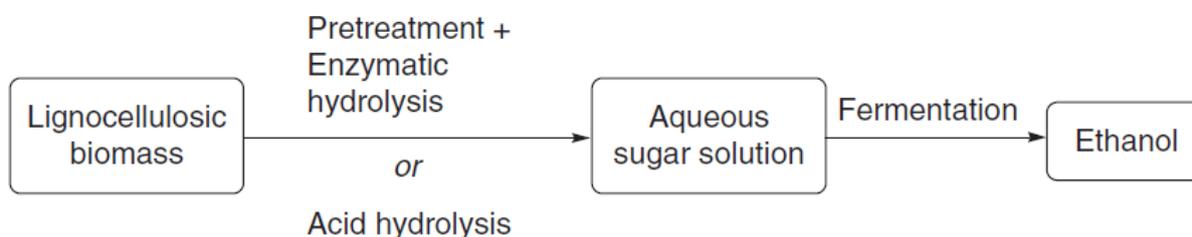


Figure 2.1 Basic steps of cellulolysis process or aqueous-phase biomass saccharification and fermentation process.

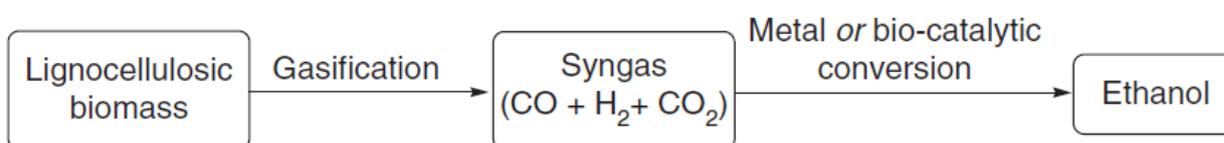


Figure 2.2 Basic steps of the gasification-syngas-ethanol process.

The second method is the gasification or syngas to ethanol conversion process, and the key steps in this process are shown in Figure 2.2. This method is known as thermochemical process as well since pyrolysis of biomass to syngas (a mixture of carbon monoxide, carbon dioxide, and hydrogen) is the first step and an essential feature of the process. Then the gas mixture is converted to ethanol by using either a metal or biochemical catalyst.

2.2 Challenges in Aqueous-Phase Biomass Hydrolysis

In the cellulolysis processes or aqueous phase process, the most challenging step is the depolymerization of cellulose and hemicellulose in the biomass to a fermentable sugar solution, or the saccharification. The resistance of lignocellulosic biomass to the hydrolysis by enzymes or acid is one of the most formidable barriers for the production of cellulosic ethanol. This resistance or non-susceptible nature of the lignocellulosic structures, which does not allow other molecules to easily penetrate or interact with the molecular structure, is known as the *recalcitrance* of cellulose. Insolubility of cellulose and lignocellulosic biomass in most of the common solvents is a direct consequence of recalcitrance property as well. Recalcitrance character is related to the structure of cellulose and lignocellulosic biomass.

Hence, a sound understanding of the molecular architecture of cellulose and lignocellulosic biomass is an extremely important aspect of cellulosic biomass science and a good launching point for biomass pretreatment and saccharification research.

2.3 Major Components of Lignocellulosic Biomass

Lignocellulose or lignocellulosic biomass refers to the dry plant matter, which is the most abundant organic substance on earth. The three major components in



lignocellulosic biomass and their typical percent compositions are:

1. Cellulose 35–50%
2. Hemicellulose 20–35%
3. Lignin 15–30%

The exact composition can vary in a wide range depending on the plant family, species and part of the plant. In addition to these, there are minor components like minerals, proteins, fats and oils in all plant materials.

2.3.1 Cellulose

Cellulose is a linear polymer of D-glucose molecules linked with $\beta(1\rightarrow4)$ -glycosidic bonds. The repeating unit of the polymer is D-cellobiose, which consists of two D-glucose molecules as shown in Figure 2.3.

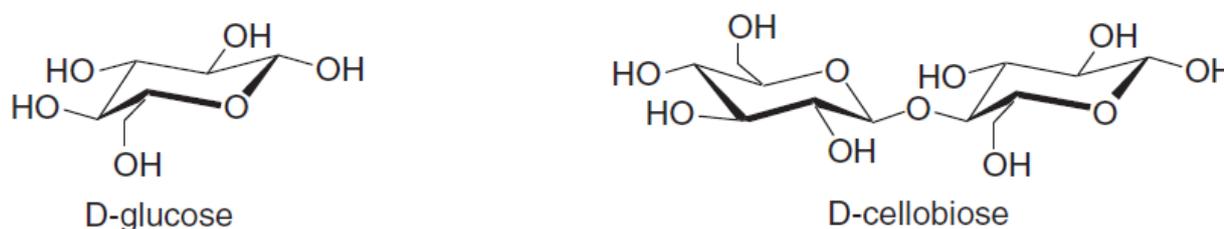


Figure 2.3 D-glucose, the basic unit in cellulose, and D-cellobiose, the repeating unit in cellulose.

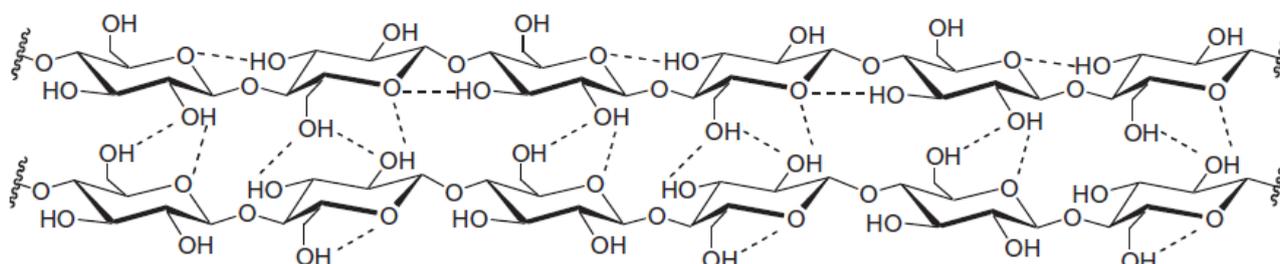


Figure 2.4 Linear polysaccharide chains in cellulose microfibrils. Inter- and intramolecular hydrogen bonds are shown in dashed lines.

The cellulose structure is composed of stacks of linear chains with D-cellobiose repeating units. These closely-packed chains form robust crystal structures with inter- and intramolecular hydrogen bonds, as shown in Figure 2.4.

This motif in cellulose contrasts with that of $\alpha(1\rightarrow4)$ -glycosidic bonds present in starch, glycogen, and other carbohydrates. Unlike starch, no coiling or branching occurs in cellulose, and the molecule adopts an extended and rather stiff rod-like conformation aided by the equatorial conformation of all the D-glucose units in the linear chains as shown in Figure 2.4. The chain length of a polymeric cellulose molecule varies in a wide range depending on the plant source. However, a typical value of a number of glucose units in the polymer is in the range 100 to 14,000. Each cellulose molecule consists of a linear chain of glucose residues that are covalently linked to one another to form a ribbon-like structure, which is stabilized by hydrogen



bonds within the chain. In addition, intermolecular hydrogen bonds between adjacent cellulose molecules cause them to adhere strongly, giving a high tensile strength to the material. The bundles of linear cellulose chains are stacked along the axial direction of the microfibril as shown in Figure 2.4.

Cellulose, which is the principle scaffolding component of all plant cell walls, exists in the form of a robust crystalline structure in solution or in solid state. This highly hydrogen-bonded complex molecular architecture of the cellulose molecules provides tensile strength to the primary cell wall. Such a cell wall polymer is neither soluble in water nor easily digestible in the gastrointestinal tract of humans. These cellulose microfibrils with a complex network of hydrogen bonding and van der Waals interactions resist deconstruction by solvent or by physical treatments.

2.3.2 Hemicellulose

Hemicelluloses are the second most abundant component in biomass and are composed of a combination of several heteropolymers.

The most common ones include xylan, glucuronoxylan, arabinoxylan, glucomannan, and xyloglucan. These are often branched polysaccharides. In contrast to cellulose, which contains only D-glucose, hemicellulose contains many different sugar monomers. Most of the sugars in hemicelluloses are 5-carbon D-pentose sugars and occasionally small amounts of L-sugars as well. In most cases xylose is the sugar monomer present in the largest amount, although in softwoods mannose can be the most abundant sugar. Not only regular sugars like xylose, but also carboxylic acid groups or their derivatives containing sugars like glucuronic acid and galacturonic acid can also be present in hemicellulose.

Some common molecular motifs found in hemicellulose are shown in Figure 2.5

2.3.3 Lignin

Lignin is the third major component in biomass, which is a crosslinked macromolecular material based on phenylpropanoid monomer units *p*-coumaryl alcohol, coniferyl alcohol (guaiacyl), and sinapyl alcohol (syringyl). Typical molecular masses of isolated lignins are in the range 1000–20,000 g/mol, but the degree of polymerization in nature is difficult to measure since lignin is invariably fragmented during extraction and consists of several types of substructures which repeat in an apparently random manner.

A representative section of the lignin structure is shown in Figure 2.6.

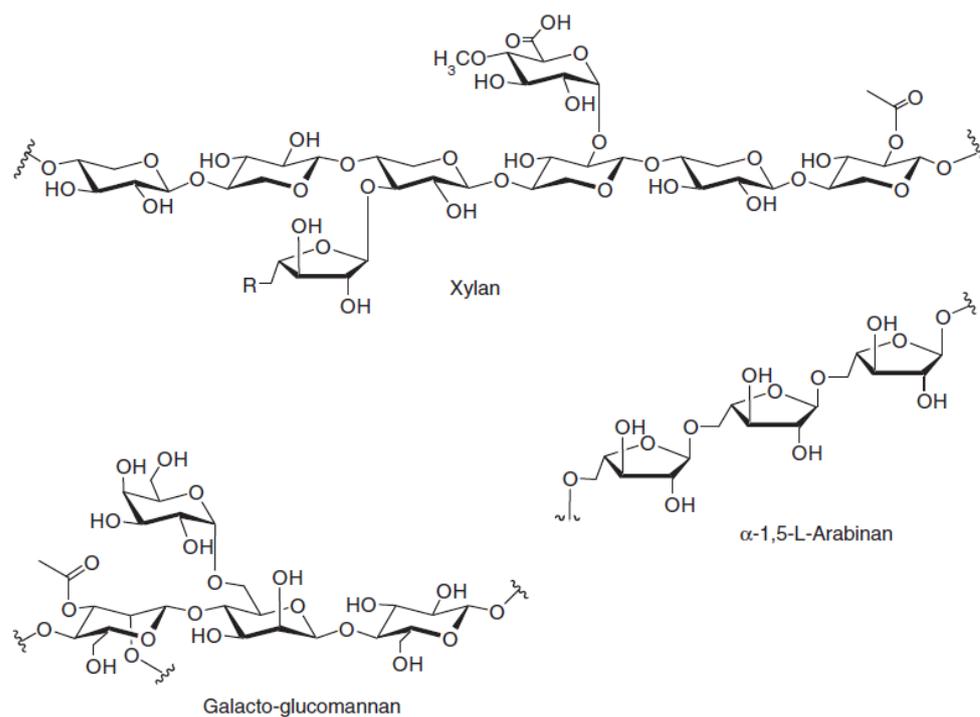


Figure 2.5 Some common molecular motifs found in hemicellulose.

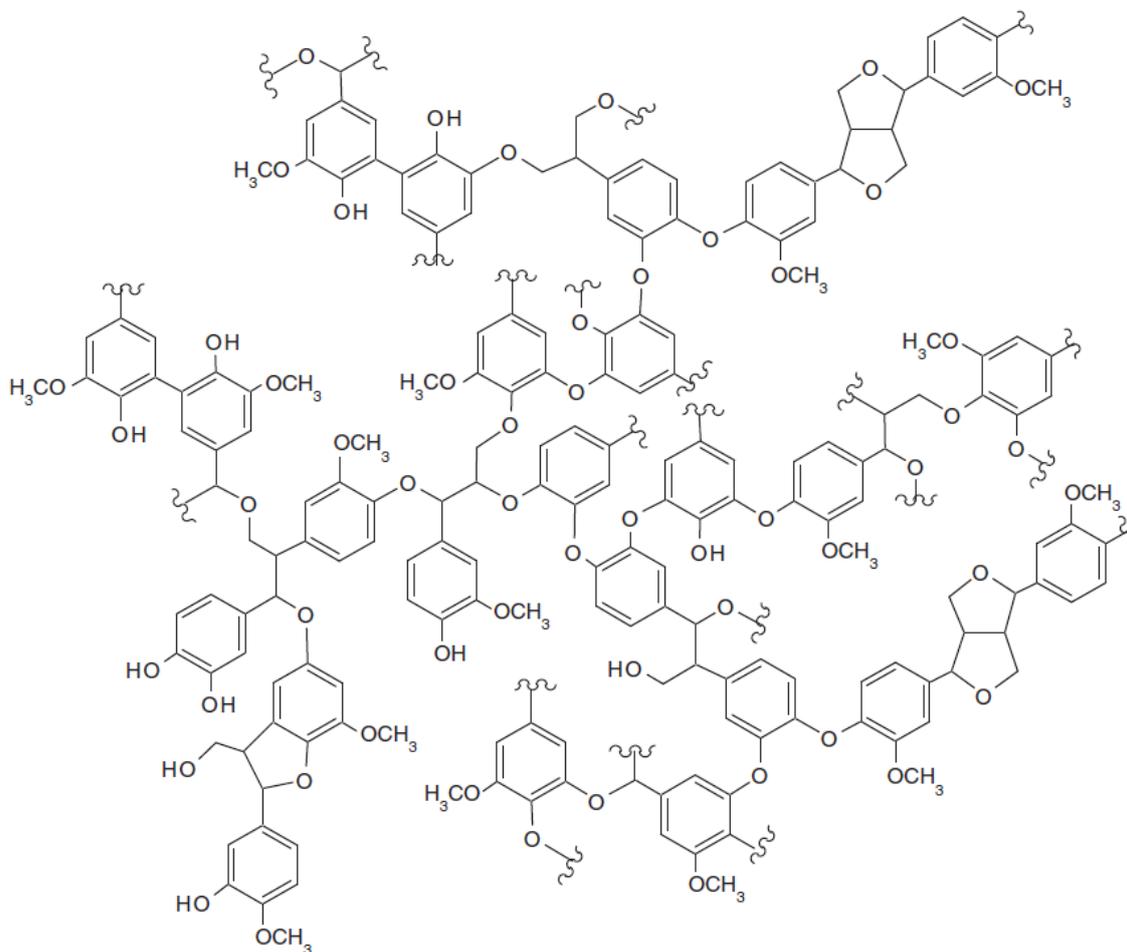


Figure 2.6 A representative section of the lignin structure.



3. Pretreatment of Lignocellulosic Biomass

3.1 Introduction

Pretreatment is the process used to liberate cellulose and hemicellulose from the lignin seal and its crystalline structure so as to render polysaccharides accessible for a subsequent hydrolysis step. The resistance of plant cell walls to deconstruction is known as the recalcitrance property, and pretreatment is the first step in overcoming biomass recalcitrance.

The main factors that contribute to the recalcitrance of lignocellulosic biomass to hydrolysis are poor accessible surface area, protection of cellulose by lignin, the heterogeneous character of biomass particles, and cellulose sheathing as shown in the schematic representation of pretreatment in Figure 3.1. As illustrated in this figure, pretreatment improves the accessibility to cellulose and hemicellulose by liberating them from the lignin shell.

In addition to this encapsulated arrangement, crystallinity of cellulose is also an important factor, because pure crystalline cellulose is difficult to hydrolyze without a pretreatment. Transformation between crystalline and amorphous forms of cellulose is reversible; both forms can break into glucose oligomers, however, the amorphous

form degrades faster than the crystalline form, as shown in the kinetics schematic in Figure 5.2, with rate constant $k_2 \gg k_1$. In principle, an effective pretreatment causes disruption of these barriers so that hydrolytic enzymes can penetrate and cause hydrolysis (Fig. 5.2) and also minimizes degradation of sugar to undesired degradation products shown in the last step of Figure 3.2.

Pretreatment of lignocellulosic biomass may produce degradation products with an inhibitory effect on the fermentation process. These undesired products are produced by the degradation of sugars as well as degradation of lignin. Pentose sugar monomers may dehydrate to the 5-carbon aldehyde furfural. Similarly, hexose sugars

like glucose may degrade to 5-hydroxymethylfurfural (HMF). Furfural and HMF affect cell growth and respiration, and HMF is considered less toxic than furfural and its concentration in hydrolyzates is usually low. A variety of compounds like aromatics acids, phenols and aldehydes may be released from the degradation of lignin fraction. Phenolic compounds have a significant inhibitory effect and are generally more toxic than furfural and HMF. Low molecular weight phenols are the most toxic. However, at temperatures lower than 180°C lignin degradation is not so significant if no strong acid or alkaline conditions are present in the pretreatment medium. Some of the common inhibitory compounds formed during the pretreatment step are shown in Figure 3.3.

These inhibitors have toxic effects on the fermenting organisms, thus reducing the ethanol yield and productivity. The level of toxicity depends in part on fermentation variables including cell physiological conditions, dissolved oxygen concentration and pH of the medium. In many cases it is essential to remove these inhibitors before exposure to cellulose and hemicellulose hydrolyzing enzymes.

Pretreatment of biomass for cellulosic ethanol process has been the topic of a number of excellent review articles in recent years.

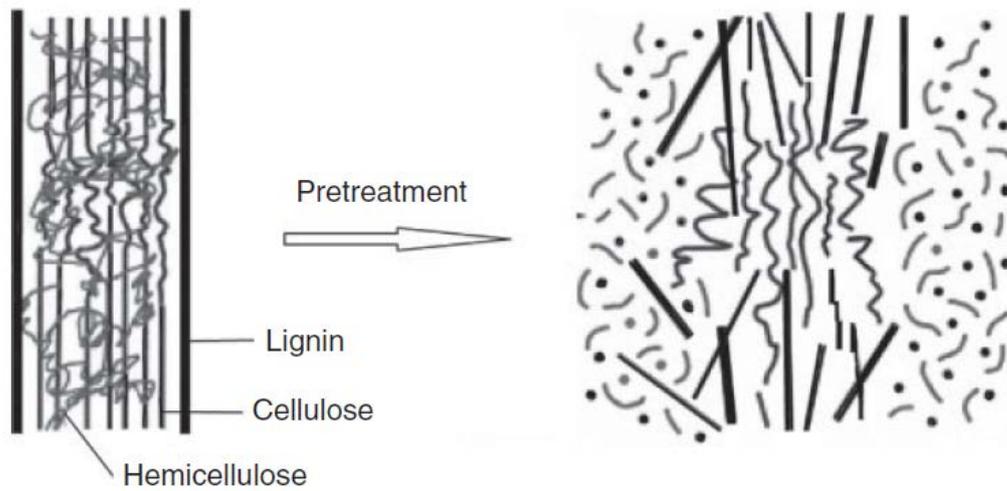


Figure 3.1 Schematic representation of the pretreatment process.

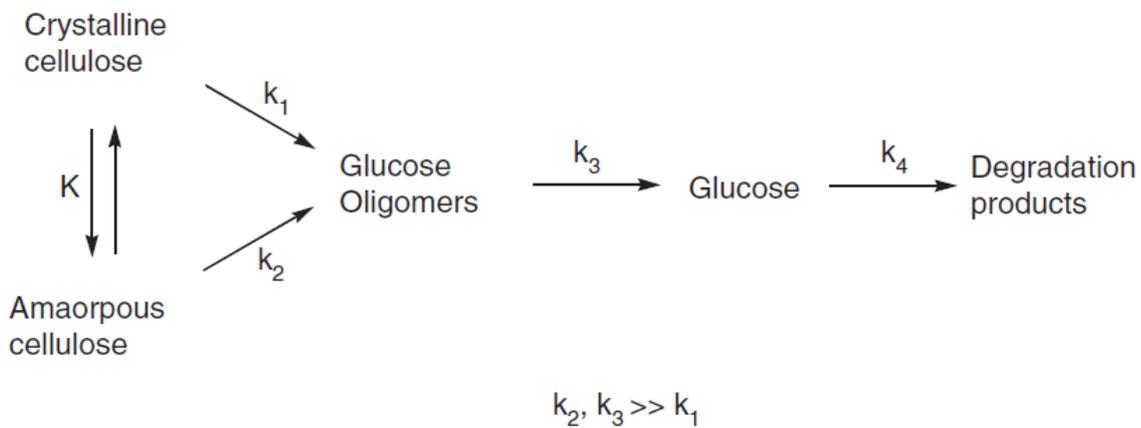


Figure 3.2 Schematic representation of transformations of crystalline and amorphous forms of cellulose to glucose oligomers, glucose, and to degradation products.

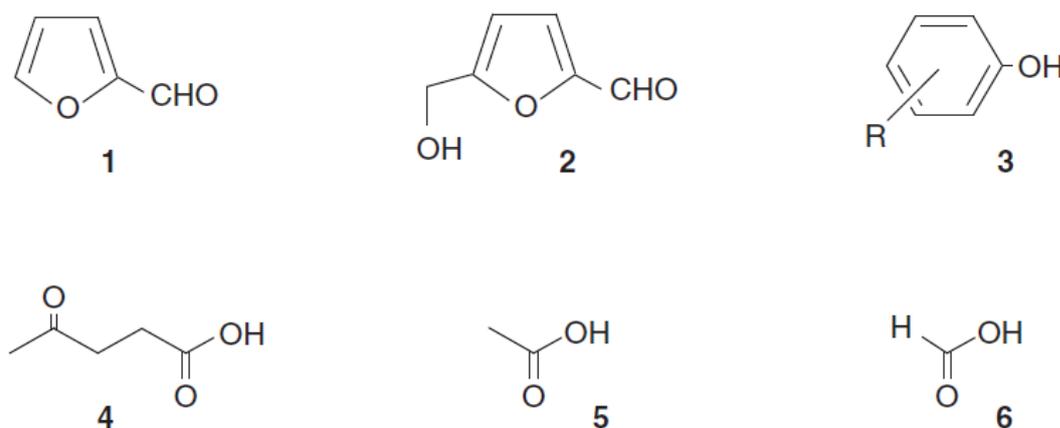


Figure 3.3 Common inhibitory compounds formed during the pretreatment of biomass: **1** - Furfural, **2**-5-Hydroxymethylfurfural, **3** - Phenols, **4** - Levulinic acid, **5** - Acetic acid, **6** - Formic acid.

There are a number of key factors in a good pretreatment method, which include the following:

1. Produces highly digestible solids that enhance sugar yields during enzyme



hydrolysis.

2. Avoids the degradation of sugars, especially the pentose derived from hemicellulose.

3. Minimizes the formation of inhibitors for subsequent fermentation steps.

4. Is cost effective by operating in reactors of moderate size and by minimizing heat and power requirements.

3.2 Different Categories of Pretreatment Methods

Pretreatment technologies can be basically classified into the following four categories:

1. Physical pretreatment
2. Physicochemical pretreatment
3. Chemical pretreatment
4. Biological pretreatment

Physical pretreatment is often called size reduction to reduce biomass physical size; it is also the first step in many other pretreatment processes as raw biomass comes in the form of larger pieces in most situations, except in a case like sawdust from a mill.

Chemical pretreatment utilizes chemical transformations to overcome the recalcitrance so that the enzymes can have access to cellulose for microbial depolymerization.

Biological pretreatment uses enzymes to achieve the accessibility for the hydrolysis step and is not as widely used as other methods.

Then there are multiple techniques within some of these classifications. In this chapter various pretreatment techniques are presented in detail under these four categories; however some of the techniques may have features of more than one category.

3.2.1 Biological Pretreatment

In biological pretreatment, microorganisms are used to degrade lignin and hemicellulose leaving cellulose, allowing cellulose to undergo facile hydrolysis when exposed to saccharification enzymes. The most common type of microorganisms used in this pretreatment is fungi.

In the early 1990s Hatakka *et al.* reported the selective delignification of wood and wheat straw by selected white-rot fungi such as *Phanerochaete chrysosporium*, *Phlebiaradiata*, *Dichmitus squalens*, *Rigidosporus lignosus*, and *Jungua separabilima*.

Lignin depolymerization by these fungi takes weeks to achieve significant results but can be very selective and efficient. White-rot fungi produce extracellular lignin-modifying enzymes, the best characterized of which are laccase (EC 1.10.3.2), lignin peroxidases (EC 1.11.1.7) and manganese peroxidases (EC 1.11.1.7).

Lignin biodegradation studies have been carried out mostly using the white-rot fungus *Phanerochaete chrysosporium*, which produces multiple isoenzymes of lignin peroxidase and manganese peroxidase but does not produce laccase. Many other white-rot fungi produce laccase in addition to lignin and manganese peroxidases and in varying combinations.

Based on the enzyme production patterns, white-rot fungi can be categorized



into three groups:

1. Lignin-manganese peroxidase group (e.g., *P. chrysosporium* and *Phlebia radiata*)
2. Manganese peroxidase-laccase group (e.g., *Dichomitussqualens* and *Rigidoporus lignosus*)
3. Lignin peroxidase-laccase group (e.g., *Phlebia ochraceofulva* and *Junghuhnia separabilima*)

When compared to other methods, biological pretreatments are normally conducted at low temperatures and atmospheric pressures without using expensive equipment, chemical reagents, and additional energy for lignin removal and biomass structure destruction.

Therefore, it is a green, safe, and inexpensive method. However, the enzymatic reaction rates are slow, therefore long pretreatment times are required compared to other pretreatment methods.

Even though biological pretreatment technique is relatively new, it has been reported for the pretreatment of corn stover, rice straw, beech wood, *pinus densiflora* and *eucalyptus globulus*.

White-rot fungi are mostly used for secreting ligninolytic enzymes in the biological pre-treatment process, and current research related to biological pretreatment is mainly focusing on the following five aspects:

1. Selection of white-rot fungi candidate strains for certain biomass materials.
2. Optimization of cultivation methods for white-rot fungi.
3. Characterization of fungal-treated materials.
4. Mutation breeding and crossbreeding of fungal mycelia to obtain engineered strains.
5. Integration of fungal pretreatment with simultaneous saccharification and fermentation to produce biofuels, and evaluation of combining bio pretreatment with chemical or physicochemical approaches.

Summary. Future Prospects of Cellulosic Ethanol

As of mid 2013, several indicators have shown a steady progress in the cellulosic ethanol industry, even though the earlier targets set in the United States have not been met, as expected. Technoeconomic analysis plays an important role in the realization of cellulosic ethanol. The overarching goal for the DOE's office of the biomass program is to demonstrate the cost-competitiveness of cellulosic ethanol with petroleum fuels. The 2011 NREL report on development targets predicted an *n*th-plant MESP of \$2.15/gal by 2012, as modeled by the NREL process design for a corn stover-acid pretreatment-enzyme hydrolysis plant [4]. This MESP value is comparable to current gasoline prices in the US, since a kilogram of ethanol has about 66% of the energy in a kilogram of gasoline. With continuous R&D efforts in enzyme technologies and energy efficient processing configurations, MESP value is expected go below \$2.00/gal in the coming years, boosting investor confidence.

The cellulosic biofuel industry 2012–2013 progress report is a more realistic and a vital indicator, which summarizes the global perspective of the industry [5]. This report gives a detailed snapshot of advancements made towards the commercial deployment of cellulosic ethanol. According to Sandia National Lab and the



cellulosic biofuel industry 2012–2013 progress report, the United States could produce 75 billion gallons of cellulosic ethanol without displacing food and feed crops [5]. For comparison, the US consumed 134 billion gallons of gasoline in 2011. According to the advanced ethanol council's 2012–2013 progress report, there are about ten commercial-scale (>20 million gallons/year) cellulosic ethanol plants in operation or under construction around the world in 2013 [5]. Of course this is a very small fraction in comparison with first generation corn ethanol production capacity in the United States, which is 13.9 billion gallons/year in 2011 [6]; clearly, cellulosic ethanol is an industry in its infancy. However, entering into a commercial operation phase is an encouraging sign and a testimony for investor confidence on cellulosic ethanol technology. The future of cellulosic ethanol looks promising and the goal of large-scale production of fuel ethanol from abundant lignocellulosic biomass to meet the global energy demand is realizable in the near future.

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CALORIMETRIC ANALYSIS OF FUEL BRIQUETTES AND PELLETS
QUALITY

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КАЛОРИМЕТРИЧНИЙ АНАЛІЗ ЯКОСТІ ПАЛИВНИХ БРИКЕТІВ ТА
ПЕЛЕТ

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Abstract. In this article the results of calorimetric analysis the fuel briquettes and pellets combustion value from agricultural produce wastes are presented.

Key words: fuel briquettes, pellets, calorimetric analysis, combustion value, ash content, humidity.

Анотація. В роботі представлені результати калориметричного аналізу теплотворної здатності паливних брикетів та пелет з відходів сільськогосподарської продукції.

Ключові слова: паливні брикети, пелети, калориметричний аналіз, теплота згоряння, зольність, вологість.

Entry. In basis of fuel granules technology production, as well as fuel briquettes, there is a pressing process under the temperature of the dried up and ground up wastes of woodworking and sawing production (sawdust, shaving, sliver, woodflour and dust) and biomass (straw, husk, hay, reed and others like that).

Arboreal fuel granules (pellets) are the small cylindrical pressed wares a 4...12 mm diameter and 20...50 mm long. The fuel briquettes have greater sizes and more easy technology of making, and similarly however pellets contain no artificial binding agents, except a natural lignin that is contained in the cages of vegetable wastes. Therefore such types of fuel consider ecologically safe, and a low cost in comparing to the diesel fuel or heating electricity predetermines them deployment in the systems of the individual heating with the use of solid-propellant caldrons.

Quality the fuel briquettes and pellets largely depends on humidity of initial mixture, an optimal index of that must be >10% for the achievement of the best mechanical descriptions. But the main index of quality is a combustion value of these types of fuel.

Basic text. The combustion value determination was carrying out for the products samples presented in a table 1, also the fuel briquettes and pellets.



Table 1

Results of fuel briquettes and pellets calorimetric analysis

Fuel			Density, kg/m ³	Humidity, %	Ash content, %	Higher CV, MJ/kg	Lower CV, MJ/kg
raw material	form						
Wood	briquette		1167	3,3	1,19	19,52	18,16
	pellet		1188	9,4	0,92	18,32	16,88
Serial straw	briquette		981	7,0	2,68	17,60	16,15
	pellet		920	11,0	3,93	16,21	14,72
Sunflower husk	briquette		886	8,3	2,21	18,58	17,20

The calorimetric analysis includes the higher and lower combustion value determination by technique according to ISO 1928: 2006 [1], the ash-content detection according to CEN/TS 14775: 2012 [2] and the humidity determination according to EN 14774-2: 2012 [3]. From every test sample part was selected to the humidity determination in the delivery state, other sample part was ground up and dewatered in laboratory terms during at least a 3 days to an air-dry state. From the ground up and dewatered material analytical probe were selected for combustion value and ash-content determination, and a remain was used for analytical probe humidity determination.

The test samples combustion value research took place in the process of it burning at pressure of 2,5...3,0 MPa in the oxygen atmosphere in the calorimetric



bomb БKY-2, which is located in the heat cell of modern waterless combustion heat calorimeter KTC-4 [4].

In the table 1 generalized measuring results and calculations for agricultural produce wastes processing products at briquettes and pellets form properties are given.

Nowadays there are not standards on pellets in Ukraine, that is why most producers are oriented on European standards. In a table 2 basic descriptions of pellets are erected, rationed by the European standards.

Table 2

Rationed descriptions of fuel pellets

Quality norms	Units	DIN Plus	EN plus-A1	EB plus-A2	EN-B	DIN 51731	ONorm M 7135
Combustion value	MJ/kg	≥18	≥16,5	≥16,5	≥16,0	≥18	17,5-19,5
Humidity	%	≤10		≤10		≤12	
Ash-content	%	≤ 0,5	≤ 0,7	≤ 1,0	≤ 3,0	–	–

Conclusions. The analysis of calorimetric researches results (table. 1) shows that Ukrainian fuel briquettes and pellets on their basic quality indexes are conform to the European standards. The briquettes combustion value is higher on 5...10%, than pellets from the same raw material, but the use of pellets gives possibility to solid-propellant caldron automation.

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Abstract. In this article the energy crop – *Miscanthus* calorimetric indexes researches results are presented and the prospects of its use as biofuel in Ukraine are considered.

Key words: biofuel, energy crop, *Miscanthus*, calorimetric analysis, combustion value, ash-content.

Анотація. В роботі представлені результати досліджень калориметричних показників енергетичної культури – міскантусу та розглянуто перспективи його використання у якості біопалива в Україні.

Ключові слова: біопаливо, енергетичні культури, міскантус, калориметричний аналіз, теплота згоряння, зольність.

Entry. The world considerable attention is spared to the problem of processing biomass with the purpose of biofuel production. Lately gets distribution cultivations of energy crop, that are the main carbon dioxide absorbent, diminishing his amount in an atmosphere, and form the high harvests of biomass that can be used on power aims for the production of biofuel. Energy crop are valuable exactly a large harvest and unpretentiousness to growing.

The energy crop culturing is in the stage of researches in Ukraine. For the biomass production it is envisaged to use different long-term grasses: canary reed, *Miscanthus* (silver grass, elephant grass), sorghum and other. From researches data, the canary reed crop capacity makes 5...7 tons of biomass on a hectare, productivity of *Miscanthus* is to 10...12 tons on a hectare (approximately equivalent 36 barrels of oil). The *Miscanthus* hybrids have been selected with the productivity to 60 tons from a hectare. Duration of plants growing on one field – 20 years, period of the commercial growing – about 15 years.

Basic text. The calorimetric analysis of *Miscanthus* includes the higher and lower combustion value, ash-content and humidity determination. A sample part was selected to the humidity determination in the delivery state, other sample part was ground up and dewatered in laboratory terms during at least a 3 days to an air-dry state. From the ground up and dewatered material analytical probe were selected for combustion value and ash-content determination, and a remain was used for



analytical probe humidity determination.

The humidity determination technique consists of the test sample weighing, drying it at a temperature (105 ± 2) °C to permanent mass and the dry sample weighing. After the found masses of moist and absolutely dry sample determine relative humidity by technique according to EN 14774-2:2009 [1].

The test sample ash-content was determinate by the slow ashing method by holding it during 60 min at a temperature 250 °C, and then during 120 min at a temperature 550 °C according to the requirements of CEN/TS 14775:2004 [2].

The combustion value determination technique is conform to standard methodologies for the hard types of fuel ISO 1928:1995 [3]. According to this standard at least two experiments of combustion value measuring are carried out and if the experiments results divergence exceeds the set level, carry out the third test, and for a result accept the mean value for to two nearest measuring. The hydrogen and nitrogen content values for correction determination at experimental data processing were used recommended in ISO 1928:1995 and in technical literature.

The test samples combustion value was determinate at the combustion heat calorimeter KTC-4 [4] in the process of it pressure burning in the calorimetric bomb BKY-2, filled by oxygen at pressure of 2,5...3,0 MPa, which is located in the calorimeter heat cell. During carrying out calorimetric tests samples were burned in a paper from with the known combustion value.

In the table 1 the generalized measuring results and calculations of Miscanthus properties in an analytical air-dry state, in the delivery state and in the dry state are given.

Table 1

The Miscanthus calorimetric analysis results

Parameter		Value
Humidity, %	analytical probe	10,6
	in the delivery state	12,0
Ash-content, %	analytical probe	1,90
	in the dry state	2,13
	in the delivery state	1,87
Higher combustion value MJ/kg (kcal/kg)	analytical probe	17,13 (4092)
	in the dry state	19,15 (4575)
	in the delivery state	16,86 (4027)
Lower combustion value MJ/kg (kcal/kg)	analytical probe	15,78 (3770)
	in the dry state	17,93 (4283)
	in the delivery state	15,49 (3700)

Conclusions. According to the European standards the combustion value of pellet from agriculture's wastes is $\geq 16,0 \dots 18,0$ MJ/kg. The energy crop – Miscanthus – calorimetric analysis results presents the mean value combustion heat 17,0 MJ/kg (or 4100 kcal/kg). It testifies to the high enough quality power indexes of this culture, and having regard to economic efficiency of its growing – about Miscanthus`



cultivation perspective for the decision making to the recreated biofuel sources providing in Ukraine.

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Martyuchenko I.G., Ivanov S.V., Ivanov V.V.
DETERMINING FORCES OF RESISTANCE TO GROUND THE
ISOLATION FROM THE EFFECTS OF REKLAMA ELEMENTS
MERCATORHALLE EQUIPMENT

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Abstract: *This article describes the process of destruction of frozen soil in the direction of the bottom from exposure to the elements Reklama Mercatorhalle equipment. This paper presents an analytical dependence of force of resistance of the soil separation distance between rychleski elements, the distance from the wall face, angle of the chip and the depth of the indentation.*

Keywords: *frozen ground, mercatorhalle equipment, reklamie elements, the gap, the resistance of the soil.*

When working Mercatorhalle equipment that the destruction of frozen soil major cleavage (Fig.1.) [1], the determining parameter affecting on Kalyway volume of soil in the direction of the open wall of slaughter is the resistance of the frozen soil separation from the effects of Reklama elements.

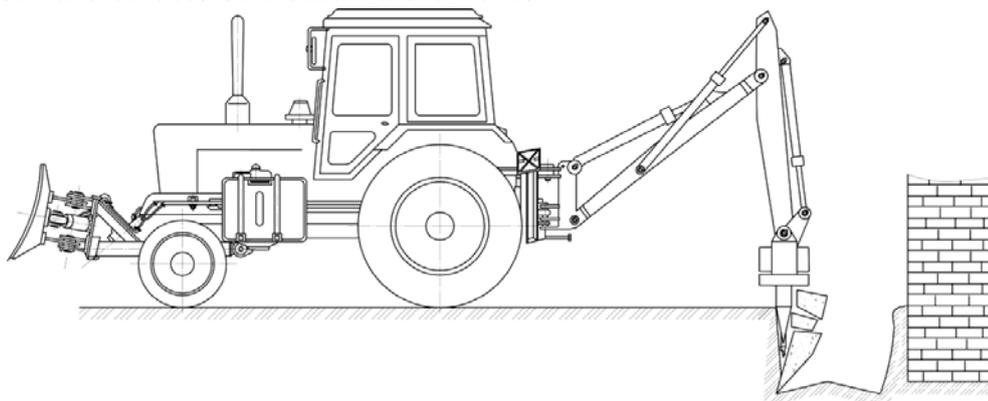


Fig.1. Mercatorhalle equipment on the basis of the excavator

Separation occurs at the moment of reaching the critical depth of implementation due to the increase of the cross section Reklama elements to the base that creates a wedging effect, leading to disruption of the integrity of the soil and the formation of fractures in this frozen soil offers resistance to impact loading which will be characterized by the marginal value of soil strength τ_{np} rupture [2,3].

Therefore the force of resistance of the soil to detachment, you can define an expression where the determining value is the square of the separation:

$$F_{omp} = \tau_{np} \cdot S_{omp} \quad (1)$$

where: τ_{np} – the limiting value of soil strength at break; S_{omp} – the area of separation.

The area of in-service exposure to one Riksdag element can be represented in



the form of a triangular pyramid, where the surfaces of separation are the two triangular surfaces which are equal. The area of isolation is determined by the following dependence (Fig.2):

$$S_{отр} = 2 \cdot S_{бок} \tag{2}$$

where: $S_{бок}$ – the area of the separation-side surface.

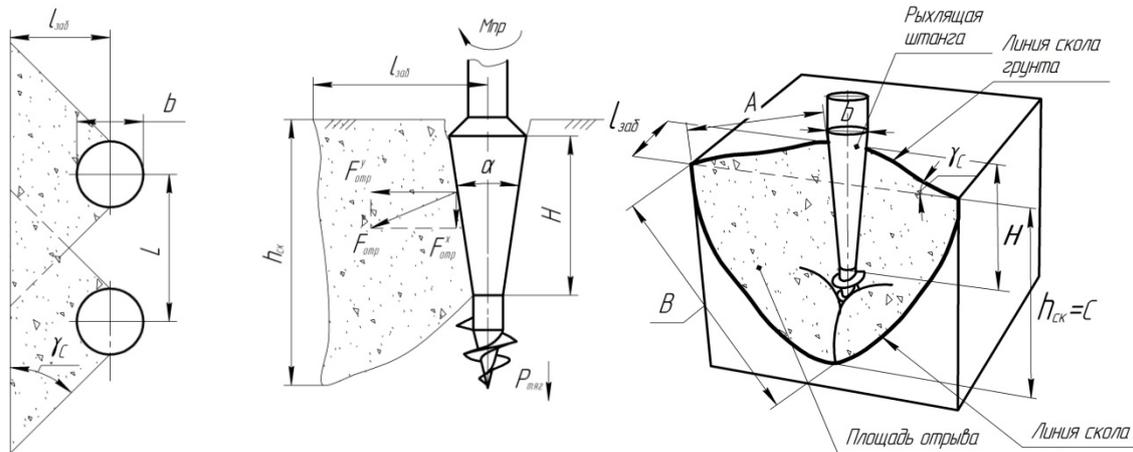


Fig.2. The scheme for determining the resistance of soil to detachment.

The area of the margin of one lateral surface of the triangular shape can be identified by three parties according to Heron's formula:

$$S_{бок} = \sqrt{p \cdot (p - A_1) \cdot (p - B) \cdot (p - C)}; \quad p = \frac{A_1 + B + C}{2} \tag{3}$$

where: A_1 – the length of the cracks of chips in the direction of the wall of slaughter; B – length of cleavage cracks in the depth direction of the chip slaughter; C – the crack length of the chip corresponding to the depth of the indentation $h_{ск}$; p – properiter.

The length of the cracks of chips in the direction of the open wall of slaughter A_1 is defined through the distance to the wall of slaughter $l_{заб}$ and the cleavage angle γ :

$$A_1 = \frac{l_{заб}}{\sin \gamma_c} \tag{4}$$

where: $l_{заб}$ – the distance from the open wall of slaughter; γ_c – the angle of cleavage.

The length of the cracks of chips C corresponding to the depth of the indentation $h_{ск}$, is made on the basis of experimental studies depending on the distance from the wall of slaughter $C = l_{паб} / h_{ск} = 0,6 \dots 0,7$.

Knowing the two sides of the triangle A, C and angle is easy to determine the third party B in accordance with the theorem of cosines:



$$B = \sqrt{(A^2 + C^2) - (2 \cdot A_1 \cdot C \cdot \cos \delta_c)} \tag{5}$$

where: δ_c — the angle opposite the required length of fracture cleavage B .

The angle is δ_c determined from the theorem of the triangle, where the sum of all the angles of a triangle always equal 180° :

$$\delta_c = \pi - \frac{\pi}{2} - \gamma_c \tag{6}$$

Substituting the values of the parties and the limit value of soil strength at break in the expression (1) will receive dependence for definition of resistance force of soil detachment from the impact of one Riksdag taking into account the distance from the bottom of l_{3a6} , the angle of cleavage us and depth of cleavage h_{ck} :

$$F_{\text{отр}} = \tau_{\text{отр}} \cdot 2 \sqrt{p \cdot \left(p - \frac{l_{3a6}}{\sin \gamma_c}\right) \cdot \left[p - \sqrt{\left(\frac{l_{3a6}}{\sin \gamma_c}\right)^2 + h_{ck}^2} - \left(2 \cdot \frac{l_{3a6}}{\sin \gamma_c} \cdot h_{ck} \cdot \cos \delta_c\right)\right] \cdot (p - h_{ck})}$$

$$p = \frac{\frac{l_{3a6}}{\sin \gamma_c} + \left[\sqrt{\left|\frac{l_{3a6}}{\sin \gamma_c}\right|^2 + h_{ck}^2} - \left|2 \cdot \frac{l_{3a6}}{\sin \gamma_c} \cdot h_{ck} \cdot \cos \left(\pi - \frac{\pi}{2} - \gamma_c\right)\right| \right]}{2} + h_{ck}$$

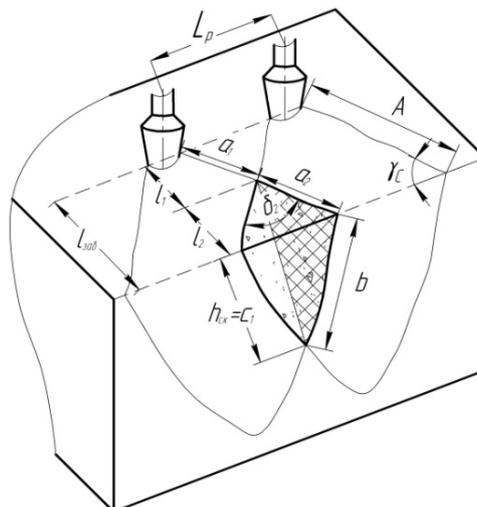


Fig.3. Scheme for determination of the area of separation.

When reducing the distance between rychleski elements of conical shape on the magnitude of L_p is the intersection of the lines of cleavage, thereby reducing the area of separation and skalyvanija volume element of soil, but this fact will reduce the resistance of soil to detachment, which depends on the square of the separation (Fig.3.).

The area of the soil, which after the reduction of the distance between rychleski elements is subtracted from the total area skalyvanija element of soil, is determined based on the distance between rychleski elements and distance from the wall of slaughter l_{3a6} .



This area also has the shape of a triangular pyramid with sides c_1, b, a_2 , and is determined by the above method, where the crack length A , is divided by a line of cleavage in the direction of the bottom wall into two sections, a_1 and a_2 . The length of the data sections depend on the distance between the working bodies:

The length of the cracks of chips, a_1 from Riksdag element to the intersection of the lines of cleavage:

$$a_1 = \frac{L_p}{2 \cdot \sin\left(\frac{\delta_2}{2}\right)} \quad (7)$$

where: the angle at the base of the pyramid $\delta_2 = \pi - (2 \cdot \gamma_c)$.

The distance to the open wall of slaughter l_{3a6} also splits into two sections of l_1, l_2 . Distance l_1 from Riksdag element to the intersection of the lines of cleavage between rychleski elements is determined by the dependencies:

$$l_1 = a_1 \cdot \sin \gamma = \frac{L_p}{2 \cdot \sin\left(\frac{\pi - (2 \cdot \gamma_c)}{2}\right)} \cdot \sin \gamma_c \quad (8)$$

Distance from l_2 the wall of slaughter to the intersection of the lines of cleavage between rychlak elements is determined by the dependencies:

$$l_2 = l_{3a6} - l_1 = l_{3a6} - \left[\frac{L_p}{2 \cdot \sin\left(\frac{\pi - (2 \cdot \gamma_c)}{2}\right)} \cdot \sin \gamma_c \right] \quad (9)$$

Based on the length l_2 length of cracks of chips, a_2 from the intersection of the lines of cleavage to open the walls of slaughter is determined by the dependencies:

$$a_2 = \frac{l_2}{\sin \gamma_c} = \frac{l_{3a6} - \left[\frac{L_p}{2 \cdot \sin\left(\frac{\pi - (2 \cdot \gamma_c)}{2}\right)} \cdot \sin \gamma_c \right]}{\sin \gamma_c} \quad (10)$$

Side c_1 corresponds to the depth of the indentation h_{2ck} and is determined from the ratio $c_1 = l_2/h_{2ck} = 0,3 \dots 0,35$

Knowing two sides of a triangle, a_2, c_1 and angle define a third party b based on the spherical law of cosines:

$$b = \sqrt{(a_2^2 + c_1^2) - (2 \cdot a_2 \cdot c_1 \cdot \cos \delta_2)} \quad (11)$$

The area of soil formed due to a decrease in the distance between rychleski elements is determined by:



$$S_2 = 2 \cdot \sqrt{p_2 \cdot \left[p_2 - \frac{l_2}{\sin \gamma_c} \right] \cdot \left[p_2 - \sqrt{\left[\left(\frac{l_2}{\sin \gamma_c} \right)^2 + c_1^2} \right] - \left(2 \cdot \frac{l_2}{\sin \gamma_c} \cdot c_1 \cdot \cos \delta_2 \right)} \right] \cdot [p_2 - c_1]} \quad (12)$$

where: p_2 – properiter.

$$p_2 = \frac{\frac{l_2}{\sin \gamma_c} + \sqrt{\left[\left(\frac{l_2}{\sin \gamma_c} \right)^2 + c_1^2 \right] - \left(2 \cdot \frac{l_2}{\sin \gamma_c} \cdot c_1 \cdot \cos \delta_2 \right)} + c_1}{2}$$

Then given the fact that in the workflow involves two richley element at some distance from each other, depending on the distance between the total area of separation of the soil will be determined by subtracting the square formed by reducing the distance between the tines (Fig.3.), then the dependence of the resistance of soil to rupture will be:

$$F_{2\text{отп}} = \tau_{\text{np}} \cdot S_{2\text{отп}} \quad (13)$$

where: the area of isolation from the effects of the two elements Reklama

$$S_{\text{отп}} = (4 \cdot S_{\text{бок}}) - S_2.$$

Substituting the values, we get:

$$F_{2\text{отп}} = \tau_{\text{np}} \left[4 \cdot \sqrt{p \cdot \left(p - \frac{l_{\text{заб}}}{\sin \gamma_c} \right) \cdot \left[p - \sqrt{\left[\left(\frac{l_{\text{заб}}}{\sin \gamma_c} \right)^2 + h_{\text{ск}}^2} \right] - \left(2 \cdot \frac{l_{\text{заб}}}{\sin \gamma_c} \cdot h_{\text{ск}} \cdot \cos \delta_c \right)} \right] \cdot (p - h_{\text{ск}})} \right] - \left[2 \cdot \sqrt{p_2 \cdot \left[p_2 - \frac{l_2}{\sin \gamma_c} \right] \cdot \left[p_2 - \sqrt{\left[\left(\frac{l_2}{\sin \gamma_c} \right)^2 + c_1^2} \right] - \left(2 \cdot \frac{l_2}{\sin \gamma_c} \cdot c_1 \cdot \cos \delta_2 \right)} \right] \cdot [p_2 - c_1]} \right]$$

This dependence reflects the change in the value of the resistance forces of the soil separation distance between rychleski elements and the distance from the wall of slaughter.

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j1110-065

УДК 624.139:624.132

Martyuchenko I.G., Ivanov S.V., Ivanov V.V., Bezrukov M.V.
EXPERIMENTAL STUDIES OF THE PHYSICAL PICTURE OF THE
INTERACTION PROCESS RICHLEY ELEMENTS WITH A SOIL
ENVIRONMENT

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Abstract: This article presents an experimental study of the influence of shape and geometrical parameters, reclaim elements Mercatorhalle equipment on the physical picture of the process of soil destruction.

Keywords: the destruction of large cleavage, face, Mercatorhalle equipment, reklamie elements.

Development of frozen soils is characterized by high energy intensity and complexity, since frozen soil is a complex, multicomponent system unstable with high abrasiveness and mechanical strength.

One of the promising mechanical equipments unstressed destruction is mercatorial (Fig.1.) [1,2] developed at the Department of SDM, Saratov state technical University named after Gagarin Yu. a., comprising reklamie elements with screw terminals.

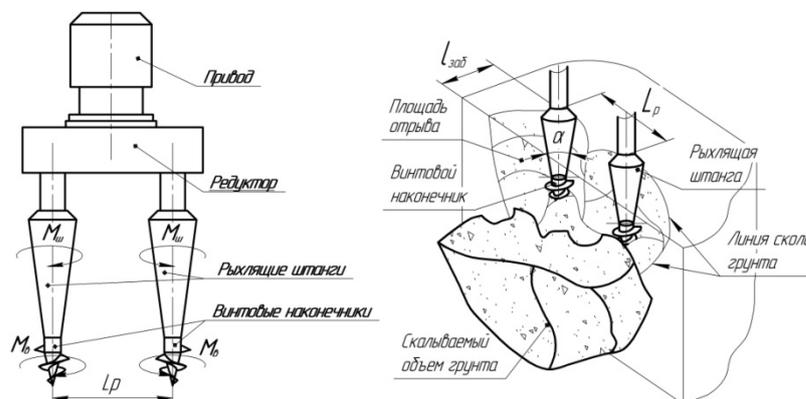


Fig. 1. Mercatorhalle equipment

The main differences in comparison with existing designs is that the combined working body, performs a traction function, and richleau. Traction function is performed by two screw tip, and richleau perform the function of the rod of variable cross section having the shape of a cone. Such constructive execution of the working bodies allows to exclude the influence on the metal structure of the reactive torque to reduce the energy intensity of the process of destruction, because the workflow involved two organs in the place of three or four as in existing designs.

The analysis of researches of process of interaction Reklama elements with the ground suggests that currently a significant lack of research aimed at creating Mercatorhalle equipment working bodies which are Reklama combination of elements of conical shape in the screw tips. Also, there are no studies of the effect of geometrical parameters Reklama elements of conical shape on the process of interaction with the ground for its destruction.



In this regard, have conducted experimental studies of the physical process of soil destruction richleski elements of conical and wedge-shaped to determine the influence of their geometrical and structural parameters on the efficiency of the process of soil destruction.

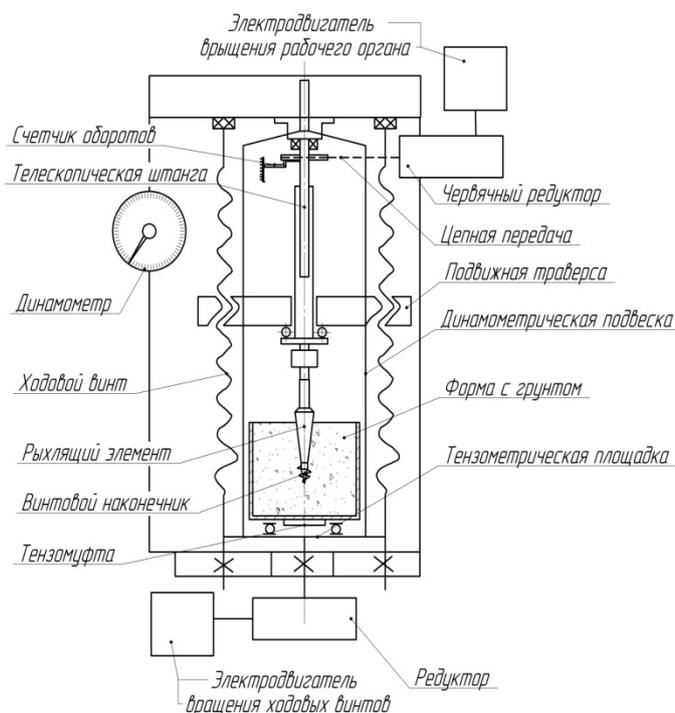


Fig.2. The scheme of the laboratory stand

Study of the system "richley working body – soil environment" was conducted on a special laboratory bench, created on the basis of the testing machine R-5 (Fig.2.) [4]. Used design of the stand allows to simulate the process of interaction of soil medium with the working bodies Mercatorhalle equipment having in its composition reklamie items and screw caps.

As a study of the working bodies used reklamie elements having a conical and wedge-shaped with no screw terminals and with the possibility of fastening them to the screw terminals (Fig.3.)



Fig.3. Reklamie elements of cone (2-8) and sphenoid (1,9) shape with angles of taper (1,5,7,8,9 – 25°; 2 – 10°; 3 – 15°; 4 – 20°; 6 – 30°.

Laboratory experimental studies were carried out as follows. The experimental stand was established form with the ground, after which was the introduction of richley elements with different shape and geometrical parameters due to axial forces, as well as a dip due to the traction capabilities of the screw tips. Under the action of axial traction or was the dip richley items before the cleavage of the element of soil in the bottom. In experiments were visually observed physical picture of the process of



destruction of the investigated parameters depending on the purpose and objectives of the experimental studies.

As the frozen soil was taken loamy soil, which had the following characteristics: humidity of $\omega = 10 \dots 15\%$, temperature 7-8 °C, grain size 0,2...0,6 mm. To obtain a homogeneous, durable, monolithic structure with equal physical properties of the crushed and moistened the soil in the form of a special metal layer was condensed and frozen in the refrigerating chamber with respect for the equal temperature 25-30 °C and time 48h. modes [3].

At the same time to provide a bonding layer, the surface is already pre-compacted soil evenly retriplate. The strength of the soil was controlled by the densitometer, DORNIE. The percentage of moisture in the soil was determined by drying and weighing the wet and dried weight of the soil after each series of experiments.

Experimental study of the effect of the form Riksdag object on the physical scene of destruction.

During the experiments was observed is equal to the physical picture of the process of soil destruction due to the impact of Reklama elements having the shape of a cone and a wedge. Picture of destruction was characterized by the occurrence of fractures in the direction of the bottom and cracks in the depth direction of cleavage leading to the destruction of the soil massif(Fig.4).

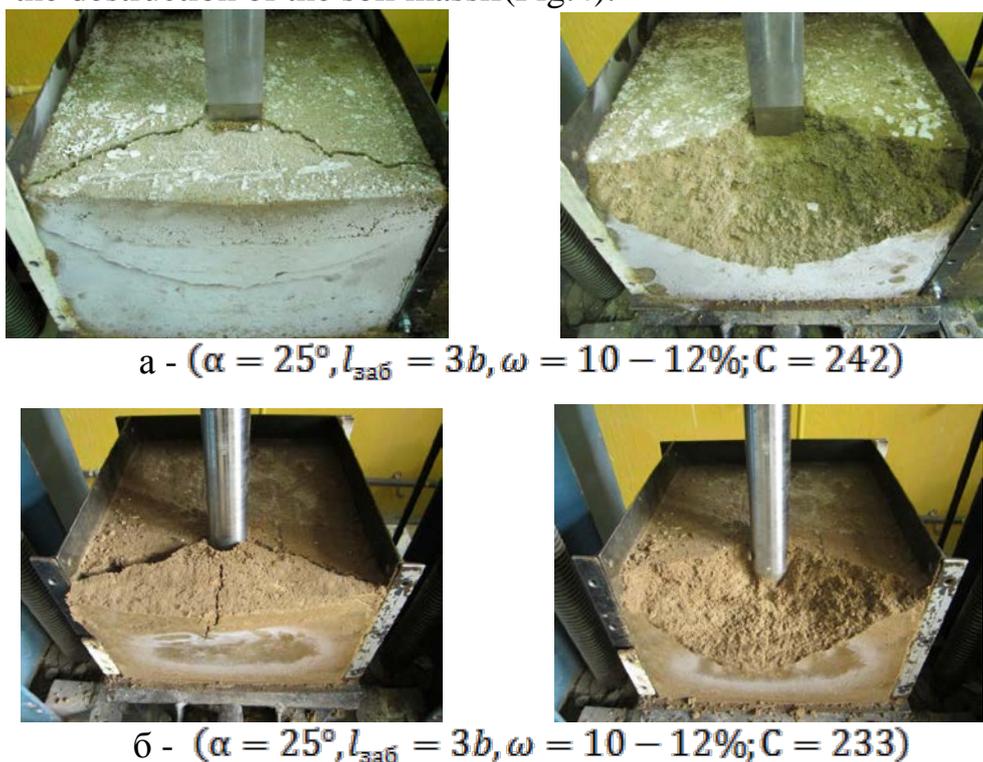


Fig.4. The destruction of frozen soil rychlak element in the form of:
a - cone; b – wedge

Analysis of the physical pictures of the process of destruction of soil medium, showed that the influence of the shape richley items on skalyvanija volume of soil is insignificant discrepancy does not exceed 8%.



Experimental study of the effect of the screw tip on the physical picture of the destruction.

When interacting Reklama elements in the form of a cone and a wedge with the soil in the screw tips where the immersion was carried out by the pulling force of the screw tips, as there was an equal picture of the destruction process (Fig.5.)



Fig.5. The destruction of soil rychlak element in the structure with screw tip and the cone, b - in the form of a wedge, with the angle of taper

$$\alpha = 25^\circ, l_{\text{заб}} = 3b; C = 240$$

The result of this experiment, where there was a joint interaction on the ground is like, screw tip, and Riksdag element indicates that the screw ferrule on the degradation process has no apparent significant effect, the cleavage of the soil occurred after complete immersion pointy Riksdag plot element.

Experimental study of the influence of the angle of taper Riksdag object on the physical picture of the destruction.

When comparing pictures of the physical process of soil destruction rychlak element in the form of a cone with different angles of taper $\alpha=10,15,20,25,30^\circ$ (Fig.6.), was almost identical picture of the destruction except one, the decrease in the angle increases the depth of immersion to the moment of cleavage of the soil in the bottom, while the volume skalyvaniya of soil is almost equal, the difference does not exceed 5%. This is because with a small taper angle of critical deformation is formed at a considerable depth of his immersion. Further implementation of the widened part of the leads to a sharp increase of compressive stress, which leads to cleavage of part of the soil from the array.

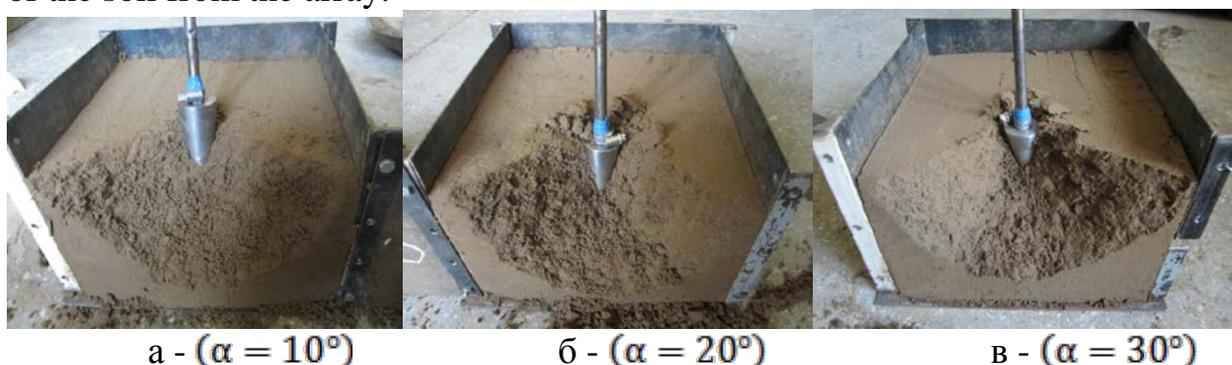


Fig.6. The influence of the angle of taper Reklama elements α° in a cone shape on the degradation process of soil model ($l_{\text{заб}} = 3b, C = 56 \dots 67$).



Experimental study of the influence of the distance between rychleski elements on the physical picture of the process of destruction is presented in figure 7. In the course of these experiments studied the effect of distance parameter between rychleski elements on skalyvanija volume of soil. When the location Reklama elements at a distance $L_p = 4b$ (Fig.7.a) two elements work as one, where the lines of cleavage were directed to the opposite side of Riksdag element at a right angle and in the direction of slaughter. When the location Reklama elements at a distance $L_p = 5,5b$ (Fig.7.b) two elements also correspond to the mutually beneficial effect of work items on top of each other, where the nature of the occurrence and distribution of fractures of the soil of one cone intersects a crack of cleavage the other of the cone and the volume of soil increases skalyvanija not much.

Increasing distance (Fig.7.b) $L_p = 7b$ destruction from exposure to Riksdag each element of conical form is independent, that is, when the destruction was not observed intersections of the lines of cleavage, thus there is a decrease in the volume of soil skalyvanija 11%. This is because the independent nature of the destruction of each object reduces the depth of the indentation, as it does not fracture the soil between rychleski elements.



a - ($L_p = 4b$, $\omega = 10 - 12\%$; $C = 249$);



б - ($L_p = 5,5b$; $\omega = 10 - 12\%$; $C = 250$);



B - ($L_p = 7b$, $\omega = 10 - 12\%$; $C = 254$);

Fig.7. The influence of the distance between rychleski elements in the form of a cone on the physical picture of the destruction of the soil, ($\alpha = 25^\circ$, $l_{\text{заб}} = 3b$).

Analyzing the nature of the destruction of the earth environment from the effects Reklama elements having different shape and geometrical parameters are the following:

-form and geometric parameter Reklama elements practically do not affect the volume of soil kalyaeva, the divergence of the compared volumes does not exceed 8%;

-screw tips do not have a visible impact on the physical picture of the process of soil destruction;

-the angle of the generatrix of the surface Riksdag element does not have a significant impact on the physical picture of the process of destruction of soil except that the angle when the reduction increases the depth of immersion at which the cleavage of a soil element with volume of soil skalyvanija not changed significantly;

-the distance between rychleski elements influences the volume of soil kalyaeva, when the values $L_p = 5 \dots 5,5b$ was observed skalyvanija the largest volume of soil.

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**j1110-066****Ivanov V. V., Ivanov S.V., Ivanov VI.V.****SIMULATION - TOOLS PROCESS CONTROL WATERJET MACHINING***The Yuri Gagarin State Technical University of Saratov**Saratov, 77 Politechnicheskaya street, 410054*

In order to create a unified approach to the construction of a simulation model of the process of waterjet cutting current it seems to describe the simulation mechanism, preferably in the process.

Simulation modeling on a computer used in the study and management of complex discrete systems and processes taking place in them. Using the simulation results from the fact that the dimension of the task and non-formalizable complex systems do not allow the use of rigorous methods of optimization.

The purpose of the simulation is to reproduce the behavior of the system under study based on the analysis results of the most significant relationships between its elements, or in other words - the development of the simulator study subject area for a variety of experiments [1, 2].

Simulation includes the following stages:

- Construction of a simulation model of a production system using the appropriate tools;
- The organization of simulations with the model for different values of controlled parameters;
- Analysis of the indicators of effectiveness of the system;
- Processing of simulation results and evaluation of alternative scenarios of the production process.

During the development of software for the prediction of waterjet cutting results in the process of processing necessary to use the following tools: Java platform, the NetBeans IDE 6.8, a programming language - Java [3].

Motivated choice of software tools development in the field of information technology for the following reasons below.

The platform was chosen as Java - platform due to the fact that it is designed for transportation and perform highly interactive, dynamic and secure applets and applications on networked computer systems. The main quality of the Java platform that distinguish it among others, is that it is located at the top level in relation to other platforms, allowing it to produce a compilation to bytecode, not tied to any one physical machine and representing machine instructions for a virtual machine (virtual machine).

A program written in the Java language, compiled into bytecode file, which is presented in the form of a diagram in Figure 2 and can run wherever the Java platform is present on any of the major operating systems. [3].

In other words, the same file will be run on any operating system, on which there is a Java-platform. This mobility is made possible by the fact that the Java-based platform is a virtual Java-machine. Because of this, Java platform can implement a single standard - a universal programming interface for applets and applications on any hardware.

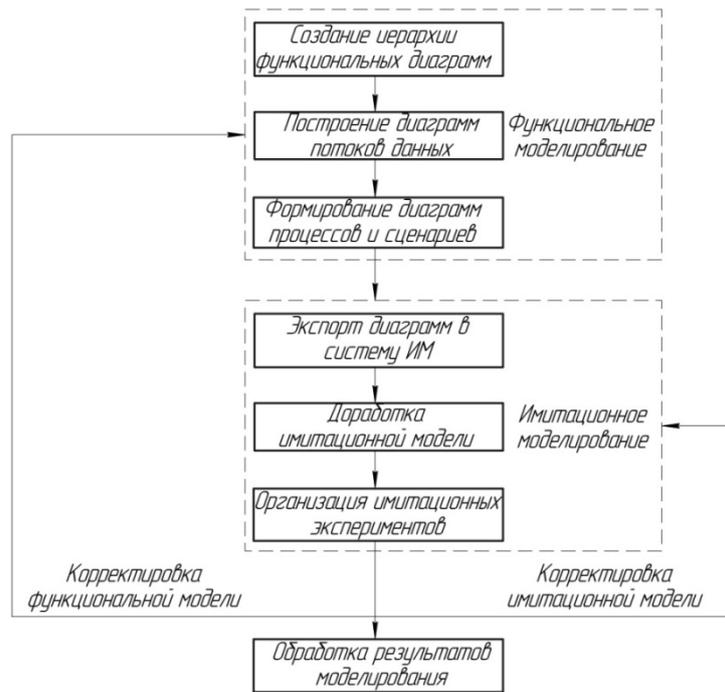


Fig.1. Stages of simulation

Developers use the Java language when writing source code for Java-based applications. They compile their code once and thus get rid of the need to compile it for each system separately. The original text of the Java language is compiled into an intermediate, portable form of bytecodes that will run anywhere Java-platform is present. In addition, it is possible to use a JIT (just-in-time) compiler (compilers "on the fly") and to accelerate the execution of the programs by converting Java bytecode into machine language.

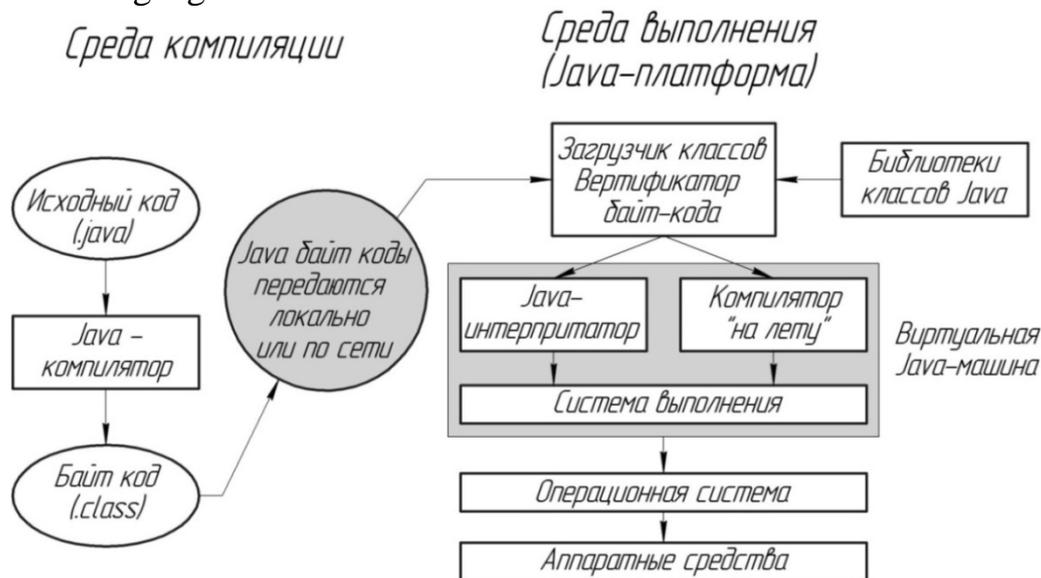


Fig. 2. Scheme of compiling source code into bytecode

Programs written in Java and then compiled to be run on Java - platform. The Java platform has two main parts:

- Java Virtual Machine (Virtual Java-machine);
- Java API (application programming interface Java).



The benefits of choosing the Java platform, as a software development tool set:

- Providing operational support, full interactive World Wide Web, through the «just-in-time» access to program resources. Applications developed on the Java platform are readily available on all operating systems simultaneously, which frees the user from having to select the operating system into the application availability;
- Easy to explore the system, equipped with an expanding set of comprehensive API. Developers can "Write Once, Run Anywhere", which gives the Java language a huge advantage over other languages in the market.

As a development environment chosen free NetBeans IDE 6.8 for the following reasons [3]:

- NetBeans IDE 6.8 is an advanced, flexible tool that provides convenient mechanisms for the rapid development of distributed applications;
- NetBeans 6.8 IDE provides a rich set of components for data access, making it easy to develop applications to work with databases.

When creating software systems are widely used multiple programming paradigms: procedural, modular, object-oriented. The most convenient approach for the design of complex programs is an object-oriented [4, 5]. According to the concept of object-oriented programming (OOP), the program is not seen as a set of sequentially executable instructions, as well as a set of objects with similar properties and a set of actions that can be done with them. Objects are instances of classes, the design of which is important encapsulation concealment implying internal representation of the object and the localization of all possible variations of its data in one place. This approach allows you to modify the implementation of a class without affecting its interface, ie, It does not require changes in the class of clients.

Object-oriented approach allows the developer to design a reliable and stable software products. Widespread patterns of the so-called object-oriented design, which simplifies the reuse successful design and architectural solutions. With the help of patterns, you can improve the quality of documentation and maintenance of existing systems, allowing you to clearly describe the interaction of objects and classes [4].

In this connection, selected as the Java programming language, for the reasons given as follows:

- Versatility of the Java language - is supported by the possibility of execution of Java-based applications running different operating systems;
- An important feature of Java is the ability to create Web-server application on the basis of JSP technology;
- The presence of a large amount of documentation on the work environment;
- Versatility and performance on different platforms such as Windows, Linux, Unix, Solaris, MacOS.

When writing software package is necessary to apply the following technologies: HTML 4.0, CSS, JavaScript.

HTML4 (English HyperText Markup Language, version 4.) - The fourth version of the basic language of web-pages layout, HTML. language version, in full compliance with the XML standard [6].

CSS (English Cascading Style Sheets -. Cascading Style Sheets) - Technology describe the appearance of a document written in a markup language. CSS is used the



creators of the web - pages to define colors, fonts, layout, and other aspects of the document. The main purpose of the development of CSS is the separation of content (written in HTML or other markup language) and the presentation of a document (written in CSS). This separation can increase the availability of the document, to provide greater flexibility and the ability to manage its performance, and reduce complexity and repetition in the structural content. [7]

JavaScript - object-oriented scripting language. JavaScript is commonly used as an embedded language for programmatic access to application objects. The most widely used is browsers like scripting language to make interactive web - pages [8].

By using the tools mentioned above as the output of the activities of programmers is the software system represents the intelligent information system to identify rational parameters Waterjet cutting process comprising input and correction of technological machining parameters, simulation of the cutting process, the generation and display of the information unit on the results of the simulation process.

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Orlov N.

**RECOMMENDATIONS FOR USE BLOCK LAYERED PROTECTIVE
INTERFERENCE IN CONDUCTING ROAD WORKS**

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УДК 355.554.2

Орлов М. М.

**РЕКОМЕНДАЦІЇ ЩОДО ЗАСТОСУВАННЯ БЛОЧНОЇ
БАГАТОЯРУСНОЇ ЗАГОРОДЖУВАЛЬНОЇ ПЕРЕШКОДИ ПРИ
ПРОВЕДЕННІ ДОРОЖНІХ РОБІТ**

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Анотація. У праці розглянуті рекомендації щодо застосування блочної багатоярусної загороджувальної перешкоди при проведенні дорожніх робіт. Подані підходи щодо використанні загороджувальної перешкоди без спеціального пристрою для вирівнювання її на нерівній ділянці дороги та математичний апарат визначення допустимий кут нахилу дороги на якій можна встановлювати загородження.

Ключові слова: блочна багатоярусна загороджувальна перешкода, дорожні роботи, математичний апарат, безпека дорожніх робіт.

Abstract. In the work considered guidelines for a multi-tiered barrier block noise during road works. Submitted approaches to use barrier obstacles without a special device to align it on an uneven stretch of road and mathematical tools allowed determining the angle of the road on which to install the fence.

Key words: block layered barrage barrier, road works, mathematical tools, safety of road works.

As described in the work [1, 2] proposed by the authors movable block stacked protective barriers (hereinafter - barrage barrier) to solve problems by the law enforcement had be applied various kinds of services in the course as planned and unplanned (emergency) road works. They have be use to "isolate" the place of road works to prevent the penetration of unauthorized persons or vehicles. This barrage barrier consists of a hollow connecting elements, which if necessary can be protective element front part (Fig. 1).



Fig. 1. Protecting the front of the hollow connecting element of penetration

Hollow connectors recommend to produce a polymeric material that will satisfy the following requirements:

- strong on impact or penetration by outsiders;
- flammable arson at (dangerous for road workers);
- frost when use at low ambient temperatures;
- light to transport to installation and dismantling of multi-tiered block fence barriers.

The author believes that obstacle barrier height can be 1.5 - 1.8 m. That can provide "isolation" places road works to prevent the penetration of unauthorized persons or vehicles.

Installation of road works barrier the workers carries installing hollow connecting elements, depending on the required perimeter (length) overlapping sections of the road. Depending on the required height of such obstacles hollow connecting elements are installed one another to form rows.

When installing the fence barriers to providing stability it is advisable to fill hollow fluid connectors. Filling fence obstacles by using connecting fire hydrant filler neck to the hollow connecting element with a centralized water supply of the settlement or special vehicles that can transport liquid (water).

When using a noise barrier at an ambient temperature lower 0°C recommended low freezing liquid, as an example of filling the salt solution (with the addition of liquid required percentage technical salt) or use a low freezing liquid, dilute liquid alcohols desired concentration. Table. 1 shows the dependence of the salt concentration in the liquid of the air temperature.

Table 1

The dependence of the salt concentration in the liquid of temperature

The concentration of salt, %	Air temperature, °C							
	0 ⁰	-5 ⁰	-10 ⁰	-15 ⁰	-20 ⁰	-25 ⁰	-30 ⁰	-40 ⁰
0	Ice	Completely frozen						
5	No	Ice, not	completely frozen					



	change	the entire solution is frozen					
10	No change	No change	Ice fragile	completely frozen			
15	No change	No change	Partial freezing	Almost frozen	completely frozen		
20	No change	No change	No change	Ice is not in the whole volume	Almost frozen	completely frozen	
25	No change	No change	At the bottom of crystallized salt, top ice		frozen 1/2	completely frozen	
30	No change	No change	No change	Partial freezing	Not completely frozen	Frozen almost all	completely frozen

In the case of noise barrier on slippery and uneven road surface area is necessary to apply a special device. It consists of two metal parts. One (upper) is appointed to establish her hollow connecting elements, and the other (lower) has teeth for tighter coupling device road. The lower part of the device has the ability to change the angle setting means barrier via holes adjustment depending on the angle of the road which should be installed barrage barrier. The device is set to each other and fixed to each other depending on the length of the overlap of the road.

When using a noise barrier without a special device to align it on an uneven stretch of road should be allowed to determine the angle of the road on which to install the fence.

To calculate the angle of static stability α fence barriers and the corresponding angle of inclination φ fluid in the hollow connecting elements (Fig. 2), according to the methodology [3, 4] using two equations: first - balance fence without interference fluid (empty) and the second - filling with fluid elements.

The equation of balance fence obstacles without filling it with liquid looks like (static stability α):

$$\alpha = \arctg \frac{b}{2H_{\kappa}}, \tag{1}$$

where: H_{κ} - is the distance from the center of mass of the liquid barrier obstacles without leaning to the surface.

The equation of balance fence barriers when filling it with liquid looks like (static stability α):

$$\alpha = \arctg \cdot \left(\frac{b}{2H_{\kappa}} - \frac{G_p \cdot H_p \cdot \varphi}{G_{el} \cdot H_{\kappa}} \right), \tag{2}$$



where H_{kp} – distance from the center of mass of noise barrier liquid to the surface leaning.

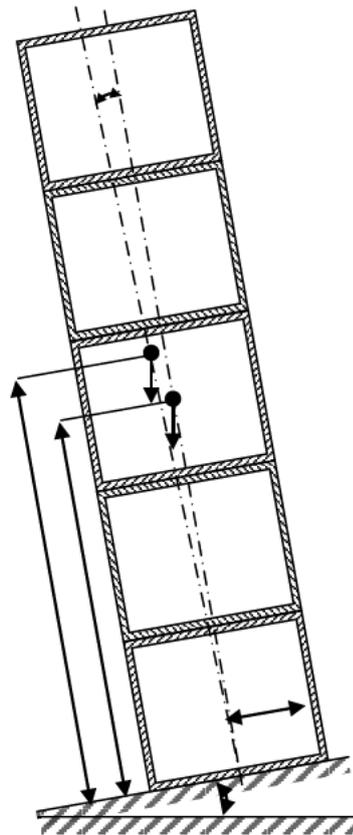


Fig. 2. Diagram static stability of multi-tiered barrier barriers block relative to the angle of inclination of the road

For certain obstacles fence maximum angle of inclination of the road (static stability α) is [3]:

- filling noise barrier fluid $\alpha \approx 21^\circ$;
- when filling multi-tiered barrier barriers block the upper hollow connecting element fluid $\alpha \approx 16^\circ$;
- when filling multi-tiered barrier barriers block the lower hollow connecting element fluid $\alpha \approx 26^\circ$.

The angle of the road α when installing fence barriers generally had determined by the width of the first (lower) hollow connecting element b and the height of the center of mass H_k . With the increase in the width of the first (lower) hollow connecting element b and decrease the value H_k static resistance barrier noise increases.

Changing the height of the coordinates of the center of mass H_k depends on the direction of filling multi-tiered block noise barrier fluid. When filling noise barrier element from the top center of mass fluid increases and its static stability decreases and when filling the lower element of the liquid center of mass decreases and its static stability increases.

Thus, the authors proposed noise barriers to solve problems by the enforcement



[1, 2] may be applied various kinds of services like road builders during planned and unplanned (emergency) road works. These protective barriers can be used to "isolate" the place of road works to prevent the penetration of unauthorized persons or vehicles, that is to ensure the safety of citizens of the state.

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