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Titova S.V.

CARTOGRAPHIC ENSURING OF RADIO-ECOLOGICAL MONITORING (ON THE EXAMPLE OF THE ZONE OF CHERNOBYL POWER STATION AVERAGE)

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Diverse investigations of Chernobyl catastrophe's consequences have been conducted for 29 years by now. Still there exist a number of insufficiently studied or new aspects which should be viewed in the context of other post-Chernobyl problems. A principally important one is the formation of *methodologically integral approach to the problems of interference of the society and environment*. Some important directions of research lack now in the execution of radio-ecological monitoring. It is necessary to determine them and outline the ways and forms of regulating the monitoring results for future.

It stipulates importance and necessity of working out system and complex approaches in researching the radio-ecological situation which has been formed and changed in certain periods of time in Ukraine. An important role in these researches belongs to cartographical modeling which is necessary for regulation, analysis and summarizing of diverse information about the radio-ecological situation. Due to complexity of the investigated object, the most representative kind of the results' embodiment is cartographical models, i.e. a series of maps or an atlas as a summary of knowledge about the peculiarities of the radiation polluted territory.

The goal of the research is substantiation of the integral concept of radio-ecological map-making at different time stages of monitoring of the ecological situation in radiation polluted regions, approbation of theoretic-methodological foundations of ecologic-geographical map-making and system cartographic modeling in researching the radio-ecological situation and rehabilitation of methodical regulations in subjects of maps, that ensure certain stages of monitoring, in particular in the shape of radio-ecological atlas of Polis'kiy region of Kyiv oblast. Aimed at this, certain stages of this cartographical research have been determined in this work.

According to the investigation order, *"population – environment"* was studied at first during the prior-cartographical stage, as an ecological subsystem in the global system *"society – nature"*. The deductive approach (from the most overall system on the earth, which is **"society - nature"**, to scrutinizing it within the limits of the subsystem **"population – environment")** has given an opportunity to go to a more detailed research of interference of the elements, that made for the negative post-damaged radio-ecological situation, as a substance of radio-ecological problems' origin. It has given problem directivity to the research. Following the usage of generally philosophical methods, approaches to examination of complex geographical systems (component and territorial ones) and of a complex of radio-ecological problems, parameters of cartographical research subject have been defined.

The object of investigation is a radio-ecological situation in the whole, in the theoretical aspect, and the situation in the catastrophe zone at Chernobyl nuclear

power station, violation of the overall geographical status of the territory, people health condition (their sickness-rate and death-rates), condition of the environment before and after the catastrophe, perspectives of overcoming radiation pollution, transformation of the economical activity in the zone influenced by the catastrophe, in the practical aspect.

The subject of investigation is a methodology of cartographic researches in the system of radio-ecological monitoring, principles, methods and ways of map-making the radiation polluted territory.

Such an understanding of the subject of investigation has allowed uniting generally philosophical, geographical and ecological methodologies with the cartographical one. As a result, it has been concluded that, based on the philosophical law of correlation and interaction in the reality, cartographical research should be founded on the understanding of the subsystems' interaction: of population and environment.

The usage of the system approach in radio-ecological research of the zone influenced by the catastrophe at Chernobyl nuclear power station has enabled studying the object as an integral system, with its defined structure, peculiarities of functioning, development specifics, a system that exists on the basis of internal correlation of elements and subsystems, put together. We refer "a system" as a totality of elements which are related and connected with each other, and establish defined integrity and unity. A system map-making is an element of the generally scientific cartographical methodology, it is based on its fundamentals and changes the way of using the cartographical method following specific peculiarities of the original system. Specific peculiarities are defined in two aspects of using the system approach in cartography. The first one is using the system approach as a basis for examination of complicated geographical systems, taking into consideration different ties of elements of the system which is cartographically investigated, and the second one is working out the system of cartographical representation directly during elaboration and making maps. An important requirement to a model of an atlas (to maps that compose it) is an internal integrity as in contents, so as in methods and means of map-making; therefore it is necessary to keep to logical and informational connection of the maps. It is achieved through the unified mathematical basis, generally geographical basis, overall principles of generalization, fullness of thematic contents and principles of selection of indices, affirmation of ways and means of cartographical representation.

Methodological investigations have allowed defining the system of notions which form the theoretical basis of cartographical ensuring the radio-ecological monitoring.

Cartographical research of radio-ecological situations is a specific kind of investigations, which are based on the cartographical method of cognition of complicated objects of the reality and information which fits in the results of ecological researches in the diverse scientific spheres.

Cartographical modeling is the method of systematization and visualization of the information on the system's parameters that among others define the radio-ecological situation at a certain territory. Interrelations of the system's elements, the

radio-ecological situation are viewed within the limits of a high rank system, "society – nature", where there are causal (man-caused) factors of radiation pollution of the environment and this action recipients (people, animals, plants).

The system approach to the object of cartographical modeling has given an opportunity to determine the circle of questions which directly outline the radio-ecological situation.

A radio-ecological situation is territorially defined consequences of the action of the radiation polluted environment which surround people (animals, plants).

A radio-ecological map-making is a direction of problem-oriented map-making, which realizes as a branch of ecologic-geographical map-making based on the method of system cartographic modeling, enabling generalization of the results of diverse radio-ecological investigations.

Examination of Chernobyl catastrophe's consequences has allowed defining the complex of not only environmental pollution with different radionuclids, but also of ecological problems: ecologic-economical, social-ecological ones and others.

Using the system approach and modeling allows giving the object a well-ordered appearance and exposing approaches to the cartographical representation the most. This theoretical provision has been approbated once again. In particular, it has been proved that usage of the structural-graphic modeling is appropriate in cartographical research of the radio-ecological situation. We have used the structural-graphical model of the original system "population – environment" within the limits of the general system "society – nature". For determining main parameters of the radio-ecological situation and its development processes at different time stages after the catastrophe at Chernobyl nuclear power station, we have analyzed available results of the radio-ecological researches held by different establishments and some researching teams and presented in the open scientific literature. Upon this factual basis, three structural-graphical models have been built, which represent objects that are subject to cartographical monitoring at each of three stages, in a system-regulated form.

The first stage is defined by a quickly running process of the radiation pollution expansion. Its time cut constitutes several days. This stage corresponds to the concept of *the operative map-making*. The objects of the radiation monitoring are geochemical anomalies in soils of different landscape elements, pollution of territories covered with woods, the hydro meteorological situation as an index of radionuclids' migration. Following the analysis of the characteristic traits of the radiation pollution in the zone influenced by the catastrophe at Chernobyl nuclear power station, a **structural-graphical model of the object of an operative cartographical monitoring** has been worked out.

An analysis of the characteristic traits of the ecological situation which appeared as the result of radiation pollution (the second stage) constitutes the basis for defining parameters of *the object of middle-term cartographical monitoring*. An uneven character of radionuclids' discharge from the ruined reactor, a complicated trajectory of polluted air masses' moves, a falling of atmospheric precipitation in this period, differences in landscape-geochemical and microclimatic conditions at the polluted territories caused formation of the complicated structure of pollution by territorial

configuration and activity, and also by composition of radionuclids. Defining borders and activity level of the pollution in certain zones, the composition of radionuclids are the main aim of the middle-term cartographical radio-monitoring. If during the first post-catastrophe years the ecological situation was changing at the account of natural dissociation of radionuclids with the short term of half-decay, and less, at the account of migration processes, then nowadays and in the near future (up to 2086), caesium-137 and strontium-90 represent a serious danger. It is worth noting that for the majority of other radionuclids there is no complete information about the scales of the territory pollution. The most complete information is available on ceasium-137, and full map-making for the territory of Ukraine has been done on it. We have taken into consideration the specialists' opinion that no detailed maps or any series of maps have been made till now, which would reflect more completely the essence of the radio-ecological situation not only by natural components' pollution, but by economical, social and medical consequences of the radiation pollution, and that is why we have directed the experimental part of our researches to these questions. Such consequences are also objects of middle-term cartographical radio-monitoring. It would be necessary also to evaluate damages after the catastrophe and its influence on the ecology, which are most weighty in Ukraine nowadays, in particular damages connected with minimization of the catastrophe's consequences. During the period after the catastrophe, its influence on the condition of Ukrainian economy has not diminished, but on the contrary, has increased, because it requires substantial financial and other expenses on recovery of the polluted territory and search for additional energy volumes, lost due to closure of Chernobyl nuclear power station and not reimbursed by the international community, as it was planned.

Defining parameters of *the third stage*, i.e. long-term radio-ecological monitoring, has been based on the system of notions, as ecological security, eco-policy etc. In order to find an exit out of the complicated ecologic-geographical situation, Ukraine needs a transfer to a new *ecological policy*, which would guarantee ecological security of life activity of people and society. Due to the territorial character of ecological problems, their solution requires deep knowledge of regional peculiarities of nature and the state, condition of natural and social territorial systems. Therefore an ecological insecurity is not only a geographical problem, but also an economical, political and technical one, which is made deeper by the complicated ecologic-economic situation in Ukraine. To our mind, stabilization of the environment condition requires execution of primary measures, as minimization of its anthropogenic transformations, a step by step liquidation of its negative consequences, a selective approach to taking nature-conservative measures aiming at increase of their effectiveness. These tasks have a precise geographical aspect and require classification of the country's regions by levels of technogenic loading on the environment, making maps of such loadings, execution of complex ecologic-economical estimation (zoning) of the territory with allocation of nature-conservative measures. An execution of land surveying of the territory, taking into consideration eco-situations, in particular, shut-down of radiation polluted territories out of processing, is necessary.

An ecological monitoring is a system of observations, estimations, forecast of

the environment condition and informational ensuring of the process of preparation and administrative decision-making. Its main task is informational, namely, cartographical ensuring of decision-making about environment protection and radio-ecological safety of the population. The actuality of this monitoring increases, because we deal with technogenic loading on the environment which appeared after the catastrophe at Chernobyl nuclear power station. The long-term radio-ecological monitoring is to be ensured by the following blocs: of cartographical information, the first one foresees making thematic maps of natural life conditions of the population (climate-weather conditions), geochemical-ecological one (soils, natural waters), social-economical life condition of the population (demographical, social, economical conditions, radiation pollution of environment and its components). The second one is an estimation-forecasted bloc of information, which includes maps of estimations of the researched object, in this case, of the radio-ecological situation in the system "population – environment". The main object of cartographical embodiment is the crisis eco-status of the environment, of people's health, who live in complicated ecological conditions, especially at the polluted territories, and measures for their recovery.

While proposing **the structural-graphical model of the long-term radio-ecological monitoring**, we understand, that coverage of all their directions depend on the state system of monitoring administration, which would ensure further development of the ecological monitoring system, establishing an automated system of the radio-ecological situation's evaluation, planning actions in emergency situations upon the estimations and scenarios of the event development, relevant coordination of the rational usage of the natural and socio-economical potential with consideration of radio-ecological indices on the principles of the stable (balanced) development.

We have proposed the themes of maps to ensure all three stages of the radio-ecological monitoring. These elaborations put together the methodic foundation for cartographical ensuring of the radio-ecological monitoring.

Deepening of the methodical foundation has been one of the primary tasks for experimental processing the source information in our investigations. The elaboration of the methods and their experimental approbation for making the system of research maps (mainly, calculation ones) ensure the user, firstly, transfer from the knowledge (reflection at the maps) of the current and forecasted situations to the system of measures directed to the improvement of the situation, then, a choice of specific decisions regarding social- and economic-ecological problems in the region, and finally, execution of measures in the places defined at the maps. This logical consecution of map-making and unity with the practical activity is a characteristic feature of the middle-term radio-ecological monitoring.

Polis'kiy region in the dissertation research is the object of the detailed cartographical modeling of the radio-ecological situation. Given in the thesis characteristics of the regional nature, population, economy and their transformations as a result of radiation pollution is the basis for choosing Polis'kiy region of Kyivska oblast as a "target ground" for reflection of the radio-ecological situation in the system of maps and in the shape of an atlas. Elaboration and making the *radio-*

ecological atlas of Polis'kiy region of Kyivska oblast (an atlas of certain rank in the administrative division) have been aimed not only at cartographical modeling of the polluted territory, but also at construction of the cartographical example model for generalization of ecologic-geographical information in ecologically polluted regions.

The atlas of Polis'kiy region is intended for solving problems of environment recovery, ensuring conditions favorable for human vital functions and economical recovery of the territory. It contains 26 maps.

If to compare the list of realized maps, their contents with theoretically proposed themes of all stages of radio-ecological monitoring, the necessity for modern regulation of the information on the basis of geo-informational technologies becomes clear. Each of consistent stages of radio-ecological monitoring has to go into the unified geo-informational system (GIS). The essence of the geo-informational system consists in its being a branchy informational model of a certain real (material) or ideal original system: objects, phenomena, processes which have certain geographical position data, which ensures time-spatial distinctness of this initial system. To our mind, while producing geo-informational systems it is necessary to use structural-graphical models of objects (original systems), which outline object's parameters of the system, information about this system should be the basis for the thematic structure of GIS. Proposed structural-graphical models and themes of maps may be put in the basis of producing GIS, appointed for every stage of radio-ecological monitoring, in particular for elaboration of the data base structure and thematic contents of the cartographical module of GIS.

In summary, it can be pointed out, that methodological instrument of researches and approbation of the cartographical ordering of the factual material have allowed to formulate theoretic-methodical foundations of cartographical ensuring the radio-ecological monitoring and, in such a way, to solve an actual scientific-practical task.

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POWER INTERACTION BETWEEN VISCOUS FLOW AND SOME PROFILES WITH FORWARD SHARP EDGE

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ВЗАИМОДЕЙСТВИЕ ПОТОКА ВЯЗКОЙ ЖИДКОСТИ С ПЕРЕДНЕЙ ОСТРОЙ КРОМКОЙ ПРОФИЛЯ

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ABSTRACT: This report deals with the contraction/expansion phenomenon in viscous flow under streamlining of bodies. Using simple hydraulic methods and early proposals [1-4] lets to decompose the problem.

KEY WORDS: viscous flow, lifting force, attack angle, contraction degree, influence radius.

АННОТАЦИЯ: В этом сообщении рассмотрено явление сжатия/расширения потока вязкой жидкости при обтекании тел. Использование простых гидравлических методов позволили упростить решение внешней задачи гидродинамики.

КЛЮЧЕВЫЕ СЛОВА: поток вязкой жидкости, подъемная сила, угол атаки, радиус влияния.

Outline of the problem. It is widely accepted that the external streamlining problem may be solved with the analytic functions, ideal fluid and viscous boundary layer theories as well as the virtual mass and bound vortex models. At the same time, the bound vortex model (Kutta-Joukowski) supposes that a finite velocity exists at back sharp edge but forward edge must be smooth for passing boundary streams from the lower side of wing profile to the more convex upper side according to the Magnus' phenomenon. Fixation of the separation point at the back sharp edge by the Joukowski-Chaplygin condition lets to find the circulation value.

Analysis of recent research and publications. In case of a forward sharp edge there is blocking the bound wortex but nevertheless we shall receive a lifting force more than Newton's impulse component correlated to $\sin^2\alpha\cos\alpha$ function of attack angle. For example, lifting force coefficient C_y and drag resistance coefficient C_x are presented as the sum in accordance with Betz and Fedyaewski works [1-4]:

$$C_y = \frac{dC_y}{d\alpha}\sin\alpha + 2\sin^2\alpha\cos\alpha \tag{1}$$

$$C_x = K\sin^2\alpha + 2\sin^3\alpha \tag{2}$$

where α = attack angle; $\frac{dC_y}{d\alpha}$ = differential of lifting force coefficient; K = constant of drag resistance coefficient considered for this approach [4].

At the present time we have only limited evidence of development of these early proposals regarding power interaction.

Impulse (newton's) component of interaction. Having received numerous experimental correlations of power interaction of non-circulation separated flow under great angles of attack we can see prevailing share of impulse (Newton's) component into drag resistance and lifting force [1-8]. So, drag resistance of struts, wires and building long-ware inclined to the wind direction depends on the $\sin^3\alpha$ function [7,8]. Yet Eiffel's experiments with plates in air flow stated that the share of impulse component of lifting force increases under lengthening plate along the wind direction (fig.1). Perhaps, such approach of the experimental curves to the theoretical function can be explained by decreasing influence of the unequal conditions of streamlining and local attack angles of the boundary streams.

Moreover, for finding out a "pure relationship" it was suggested to equip testing plates with the stream-forming longitudinal stabilizers and the upper stream-separating edge (fig.2). By means of equal influence of local attack angles and equal area of separation at such condition we could show the better correspondence with theoretical $\sin^2\alpha\cos\alpha$ function. On the other hand, the lifting force of the plane long wing equipped only with the upper stream-separating edge for the constant area of separation under great angles of attack corresponds with this function too. We have shown the confirmative results also in the previous paper [2]. To analyze the components of aero-hydrodynamic forces it seems like a reasonable way to find out the pure relationships without any shares of the accompanying factors or to take them into account and to level their influence.

Calculation of profile influence. To evaluate a possibility and origin of lifting force for an endless segmentary wing profile under attack angle $0 < \alpha_0 < \beta_0$ we consider a typical scheme (fig. 3). In this case the forward sharp edge divides the running flow into two parts: upper and lower. Obviously, the upper part of flow undergoes more intensive contraction by more convex side of the profile. The maximum degree of contraction is observed near the maximum deviation of boundary streams $\bar{y}_{max}$ but after this we can see an expansion of flow and some zone of separation. Contraction of the lower part of flow is less intensive and the maximum comes at the back sharp edge with the deviation y_{max}.

It is necessary to note the connection between the internal streamlining and external one is established with the influence radius. In fact, experimental data indicate that we have the immutable flow at some midship diameter distance from profile's surface. There are immutable aero-hydrodynamic parameters (pressure, velocity) out of the influence radiuses. Like the peculiar ring contraction considered before in [2.10] also the 2D flow around profile can be imaged as two 2D contraction between the influence radiuses (R_1 for lower side, R_2 for upper side) and the head surface of the profile. By this mean the external aero-hydrodynamics problem

transforms into the internal problem. Then solving can be found with simple hydraulic methods.

After determination of the maximum contraction degree s_m it is possible to find the specific lifting force per unit length by integrating the difference of pressures on the lower and upper sides:

$$F_y = \frac{\rho V_0^2}{2}\int_0^{x_b}\left(\bar{s}^2 - s^2\right)dx + \frac{\rho V_0^2}{2}\int_0^{x_b}\left[\int_1^{s_m}\sin^2\alpha d\left(s^2\right) + \sin^2\alpha_0\right]dx - \\ - \frac{\rho V_0^2}{2}\int_0^{x_p}\left[\int_1^{s_p}\sin^2\alpha d\left(\bar{s}^2\right) + \sin^2\left(\beta_0 - \alpha_0\right)\right]dx \qquad (3)$$

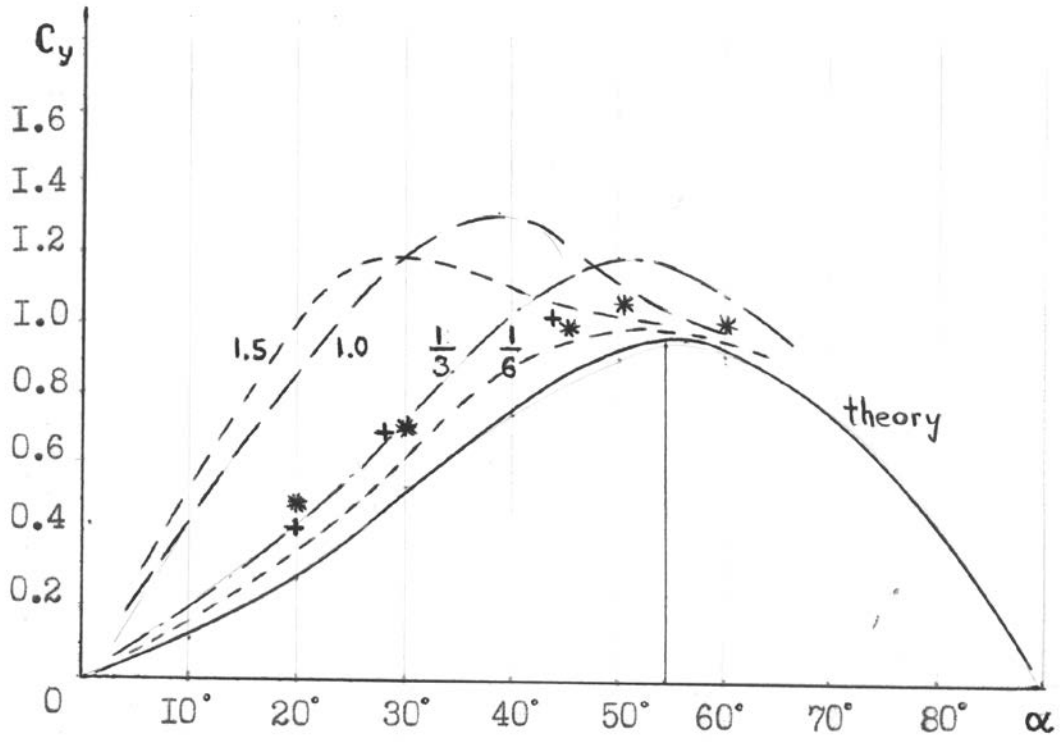
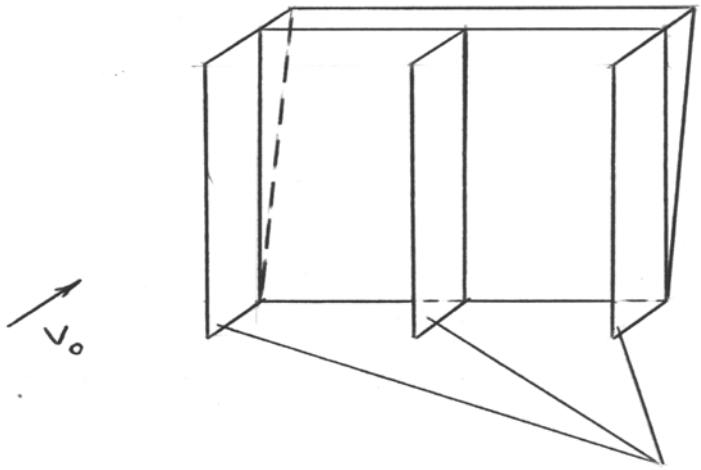


Fig.1 Approach of the lifting force coefficients to the theoretical function:
---- curves 1.5 ; 1 ; 1/3; 1/6; - Eiffel's experiments for different lengthening;
*** square plate with the stream-forming equipment;
+++ plane wing with the stream-separating edge.



stream-forming

Fig 2. Square plate with the stream-forming equipment.

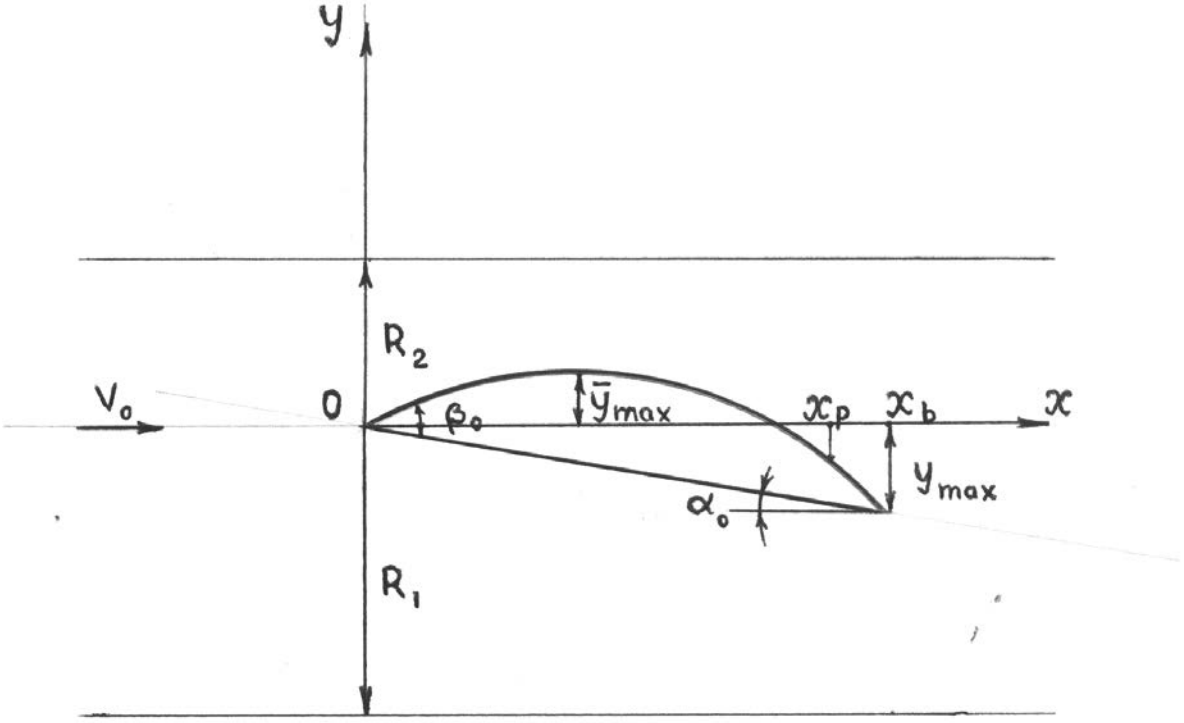


Fig.3 Scheme of profile influence.

where $s = \frac{R_1}{R_1 - y}$ = current contraction degree on the lower side;

$\bar{s} = \frac{R_2}{R_2 - \bar{y}}$ = current contraction degree on the upper side;

$s_m = \frac{R_1}{R_1 - y_{max}} = \frac{R_2}{R_2 - \bar{y}_{max}}$ = maximum contraction degree;

s_p = contraction degree at the separation point;

α = current attack (contraction/expansion) angle;

$\beta_0 > \alpha_0$ = contraction condition.

According to the presented model with the fixed maximum contraction degree, the influence radiuses are the constants definited by the maximum deviations of the boundary streams. The experimental data provide the reasons to suppose $s_m = 1.43$ [2]. Consequently, the influence radiuses will exceed the maximum deviations by 3.33 times:

$$R_1 = \frac{s_m}{s_m - 1} y_{\max} = 3.33 y_{\max} \tag{4}$$

$$R_2 = \frac{s_m}{s_m - 1} \bar{y}_{\max} = 3.33 \bar{y}_{\max} \tag{5}$$

A position of the separation point on the upper side may be found by analysis of the energy balance of boundary streams under the energy accumulation when $d(\bar{s}^2) > 0$ and the energy deliverance when $d(\bar{s}^2) < 0$. But this supposition needs to be accompanied with representative experimental data. At the same time, the excess energy balance of the boundary streams is confirmed by the experimental data of drag resistance coefficient for the axially symmetric bodies like submarine (see also: G. Fuhrmann “Jahrbuch der Motorluftschitt-Studiengesselschaft”, Bd. 5).

According to the experimental results the drag resistance of the body with sharp conical head is essentially more than the resistance of the analogous one with the convex paraboloid head under the fully identical lengthening stern (1.13 to 1). Evidently, it is caused by the more energy of the boundary streams in the second case and a displacement of the separation point along the flow to the stern tail point.

Conclusions.

- Asymmetric contraction/expansion phenomenon under asymmetric streamlining of bodies with forward sharp edge results in generation of the profile components of lifting force and drag resistance;
- The better agreement between the experimental data and the theoretical lifting force curve for impulse Newton’s component has been obtained with the auxiliary stream-forming equipment of the testing plate;
- In order to provide adequate experimental relations for influence of general attack angle, profile shape and contraction degree it is necessary to take into account the local changes of boundary streams trajectories and their local power interactions with flow.

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