RETURN PROBLEM OF AN INTERFACE FRICTION FORM — AS A VARIANT OF OPTIMIZATION OF PROFILE UNDERWATER OBJECTS

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ABSTRACT

At definition stability of movement a vessel usually are not considered hydrodynamic forces arising on its moistened surface in the presence of speed of movement, owing to them less in comparison with hydrostatic forces. The role hydrodynamic forces increases for ships with dynamics principles of maintenance (SDPM), it becomes defining. Offered graphic - analytical way of delimitation of area of steady hydrodynamic pressure by conditional a friction interface forms be resulted an example of optimization of the geometrical form of a screw blade by methods of computer modeling with AutoCAD, 3Dmax and MathCAD. The offered technique is not new, in the sense that at the point of its the assumption lies at calculation of cross-section loading − hypothesis of flat sections (in our case about not deformable contour of cross-section section), and influence of viscosity of a liquid at a longitudinal flow can be considered as method similar applied in the theory of a wing of the plane namely by means of Tchaplygin - Zhukovski known postulate on a smooth flow of a back edge. Its method may be use for creating an additional carrying power.

Keywords: *ships with dynamics principles of maintenance, the screw blade, displacement of the centre of hydrodynamics pressure*

1. INTRODUCTION[1]

As appears from definition, stability of vessel will possess on those parameters which variations monotonously decrease, or decrease amplitudes of their fluctuations. In this case speak about the general or so-called dynamic stability of ships with dynamics principles of maintenance (fig.1). The faster indignations in time, the above degree stability not indignant movement fade, i.e. steadier a vessel.

Besides dynamic stability of movement there is still a concept of static stability which specifies in ability of a vessel to aspire (not necessarily to achieve) to a starting position of balance or a condition of movement after cancellation of revolting factors. Mathematical static stability is investigated on the basis of the equations in which forces, depend from speeds of change of kinematic parameters, and force of the inertial nature are not considered. Thus, the condition static stability is obligatory, but is not a sufficient condition of dynamic stability. «Dynamic stability» should not confuse to concept known theory which statics methods estimates ability of a vessel to accumulate created by the operating external inclining moment kinetic energy which will be transformed to potential energy of the inclined vessel.

[1] This paper was translated from Russian with computer software and may be difficult to read in English. As the National Committee did not have resources for professional translation of this paper, Russian text was used for peer review and included in the electronic version of the proceedings for further references.

2. CONCEPT OF STABILITY OF THE GEOMETRICAL FORM

2.1. The point of resultant hydro-aerodynamic component

Let's allow to enter the term or concept of stability of the geometrical form depending only from the form of profile underwater objects and external loading not dependent on a kind.

We will explain on an example. It is area near to the centre of gravity in which limits operating with out of centre compressing loading causes pressure of one sign, otherwise the considerable bending moments concerning the main axes of inertia can lead to a longitudinal bend and accordingly to loss of stability of balance.

If to assume by analogy that there is a certain area (we name its area of steady pressure) in which limits the co-ordinate of a resultant of a high-speed pressure causes the safe overturning moments it is possible to recommend some optimum architectural forms of a design of the case etc.

Being guided by a successful technique of import – export of the data to format XML we will stop on practical recommendations about creation of contours. Traditionally resultant a hydro-aerodynamic component of a high-speed pressure put under N.E. Zhukovski's theory in centre of the similar as a wind formed conditional «liquid wing».

The interface theory in a hydromechanics assumes friction presence on a surface of streamline object. In case of a continuous flow and a thickness of an interface conditionally accepted equal unit can receive co-ordinates of the theoretical centre of hydrodynamic pressure on the basis of hydrodynamic analogy of circulation of speed of a stream on border of «a liquid wing» with tangents pressure in thin-walled sections at a bend.

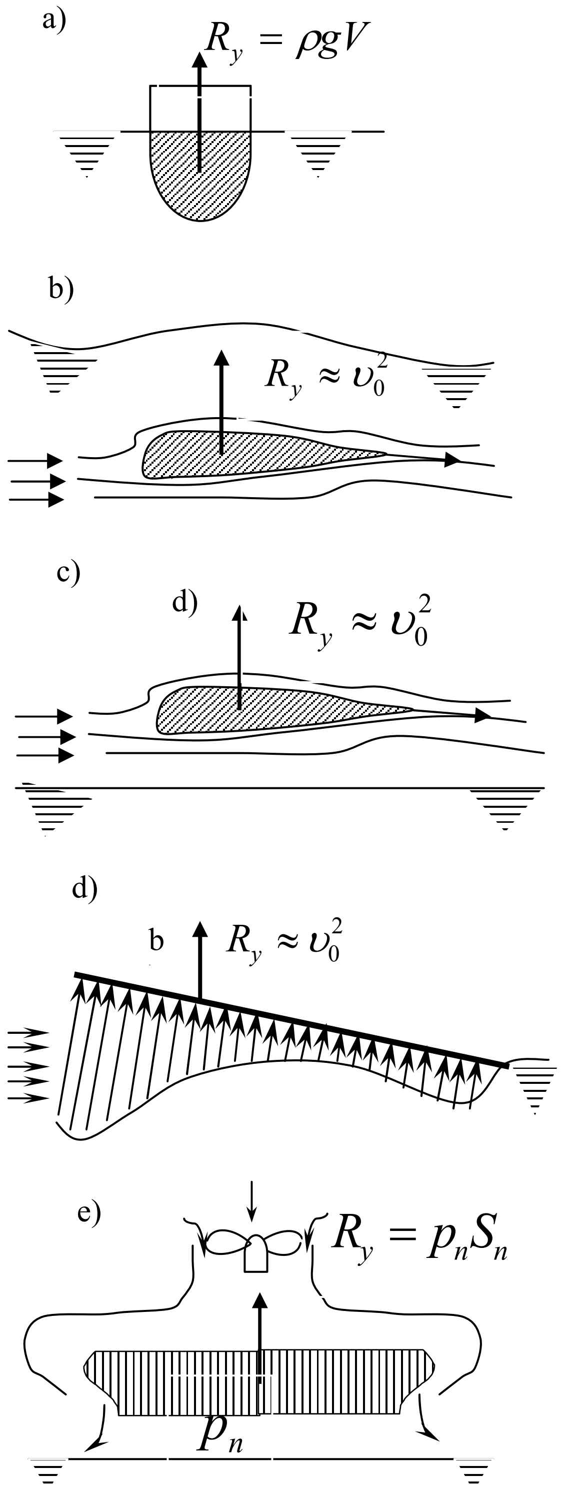

Figure 1. The creation of force of maintenance: a – hydrostatic force, b – hydrodynamic force on slide surfaces; c – hydrodynamic force on an underwater wing; d – hydrodynamic force on a wing near to a basic surface; e – aerostatic force of maintenance at the expense of an air cushion.

The offered technique of definition of the centre of a resultant of a carrying power is similar to a technique of definition of the centre of shear for a thin-walled profile. In both cases position of the centre of shear, as well as the pressure centre depends only on the geometrical form of thin-walled section or in our case of the form of an interface.

In case of discrepancy of the geometrical centre of gravity and the theoretical centre of hydrodynamic pressure of a volume figure there is an overturning moment having essential value at a high-speed mode of movement.

Combination of both centers can achieve change of the form of cross-section sections of object, to a decrease similar case bending-torsion fluctuations for thin-walled cores.

2.2. Some practical recommendations about creation of contours objects

One of balance and movement stability conditions: *the main sector coordinates of boundary layer by water's mass concerning the* main *center inertial axes should be aspire to zero*. It is expedient to use the triple integration by volume by means of program MathCAD:

$$S_{Щv} = \sum_{i=0}^{n-1}\left[\int_{0}^{K_{i+1,0}}\int_{K_{i,1}\cdot\frac{x}{K_{i,0}+Д}}^{K_{i+1,1}\cdot\frac{x}{K_{i+1,0}+Д}} v^2\cdot u dy dx + \int_{K_{i+1,0}}^{K_{i,0}}\int_{K_{i,1}\cdot\frac{x}{K_{i,0}+Д}}^{\frac{(K_{i+1,1}-K_{i,1})\cdot x+K_{i+1,0}\cdot K_{i,1}-K_{1+1,1}\cdot K_{i,0}}{K_{i+1,0}-K_{i,0}+Д}} v^2\cdot u dy dx\right]$$

$$б_u = \frac{S_{Щv}}{J_u} \to 0 \qquad (\text{ as the same } S_{\omega u}, \alpha_v)$$

where $K_{i,0}$, $K_{i+1,0}$, $K_{i,1}$, $K_{i+1,1}$ – elements matrixes of counter co-ordinates X_i, X_j, Y_i, Y_j accordingly; Δ = 0,00001 – conditional amendment for an exception in a limit of integration of equality of a denominator to zero; n – quantity of counter points, taking into account that number of the first point 0; $S_{\omega u}$, $S_{\omega v}$ – sector-line characteristics of boundary layer water's mass concerning the main axes of inertia also co-ordinates of the centre; main central co-ordinates:

$$u = (x - x_C)\cdot\cos\alpha + (y - y_C)\cdot\sin\alpha$$
$$v = (y - y_C)\cdot\cos\alpha - (x - x_C)\cdot\sin\alpha$$

J_v, J_v, u , v – main moments inertia and co-ordinates .

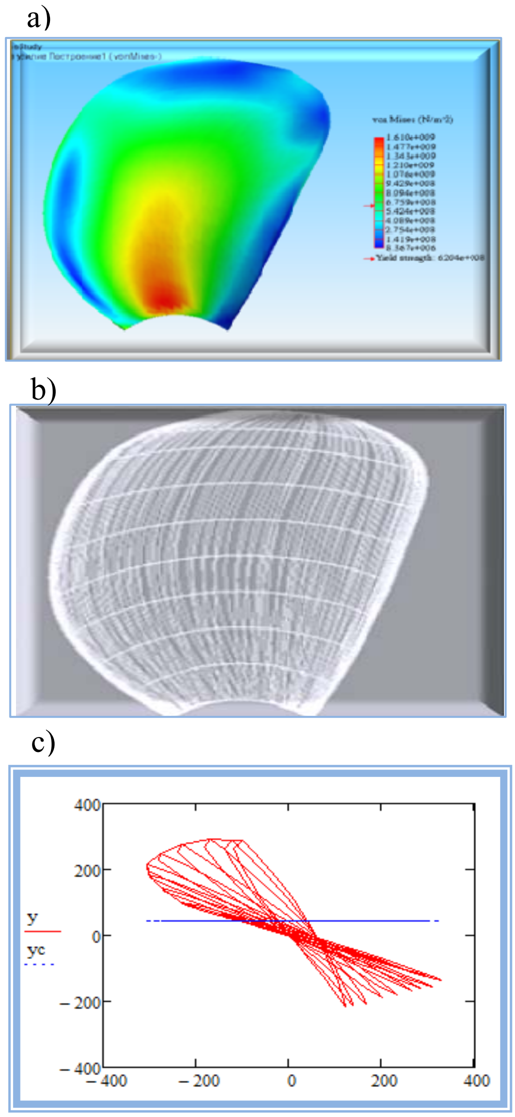

Figure 2. Results of exercises: a – COSMOS Express [Solid Works]; b - converting of a settlement grid [AutoCAD]; c – account by MathCAD.

As a result for the elementary geometrical objects it is possible to receive optimum forms corresponding to steady movement in thickness of water.

For the screw blade usually it is considered that the blade centre of gravity coincides with the centre of hydrodynamic pressure accordingly in case of an ideal interface of an individual thickness and parameters αu, αv →0 should aspire to zero too (fig. 2).

Probably in addition to investigate on dynamic stability of vessels body at the expense of change of form contours.

Last years, designing and building of flyboats, and fleet especially of small size became more active. Carrying out of full-scale hydrodynamic researches (modeling, bench, trumpet, natural etc.) is represented for new firm owing to financial difficulties inconvenient. Thereupon application of numerical methods in designing SDPM is most expedient and preferable. Contours of the body of a vessel are appreciably defined by semi empirical methods and depend on experimental base. However prompt development designing of new classes of ship of fleet especially of small size forces to approach to a question of optimization of the case from the theoretical party. Undoubtedly, numerical methods it is more preferable as allow to combine the saved up empirical data with settlement characteristics.

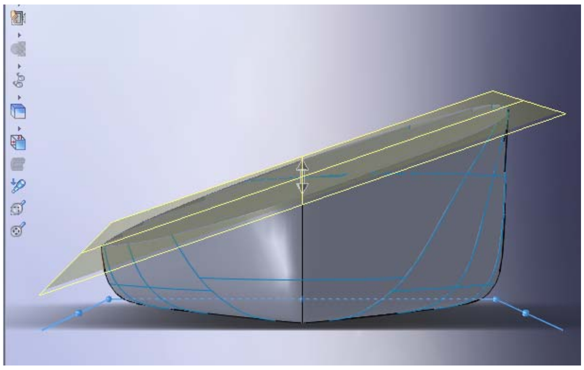

Figure 3. Modeling of vessel counters boundary layer.

Interface co-ordinates can be defined analytically:

$$K1_{i,0} = (K_{i,0} - x_C)\cdot(1 + Д) + x_C;$$

$$K1_{i,1} = (K_{i,1} - y_C)\cdot(1 + Д) + y_C$$

where δ – thickness an interface, conditionally accepted for 1 (fig.1).

Decrease in height of an interface of essential value on results of calculation does not render, as the defining factor on co-ordinates of a resultant of a high-speed pressure the form and the sizes of a streamline body renders.

Presence of a free surface at a vessel flow essentially does not influence the received results, but can be considered by a difference in interface height.

The wing analogy profile undoubtedly is more preferable as provides a smooth flow and big in comparison with flat a carrying power.

Contours of flyboats most correspond to the assumption of aspiration of the centre of hydrodynamic pressure to the centre of gravity.

The high-speed pressure as a rule is considered at a list or a trim however on cruiser speed pushing out force creates a wave in a forward part of the ship in a scope of a high-speed pressure.

Definition of the operating forces on the vessel, can be carried out in three ways: the theoretical; an experimental - with vessel's model; the settlement - on processing of results tests on a regular series of models.

3. CONCLUSIONS

Influence of cavitations demands the further research.

4. REFERENCES

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