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MODELING OF DETERMINING DEVELOPED CAVITATION IN A WATER RESERVOIR

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Abstract: This article considers stationary problems of hydrodynamics, in particular, cases where the composition of water does not change over time. The article presents in detail specific examples of cavitation flow, such as flows using the theoretical Ryabushnsky or Zhukovsky – Roshko schemes, and their mathematical formulas. Along with Sh, the asymptotic result of Garabedian is obtained. New scientific achievements and practical applications of computational fluid dynamics (CFD) and its integration with artificial intelligence are given. The possibilities of application in engineering and environmental fields are clarified through graphs and diagrams.

Keywords: Hydrodynamics, steady flow, continuity equation, Ryabushnsky equations, Bernoulli equation, potential flow theory, Zhukovsky-Roshko scheme, laminar flow, environmental problems.

Introduction: Two main methods are used to solve the problem of cavitation flows: the method of integral equations and the method of finite differences. Theoretical Ryabushinsky or Zhukovsky-Roshko schemes of cavitation flow are used.

As is known, in the finite difference method, the flow field is covered with grids, and the values of the velocity potential of the function - ϕ or the current function - ψ are set at the nodal points. In this case, we pass from a continuous function and argument to a discrete function and argument. The values of the function at each node and the values of the first and second derivatives of the function around the nodes are found. In this way, we construct a finite difference analogue of the differential equation obtained for the given function - ϕ or current ψ -. To find the values of the function ϕ or current ψ - in finite differences, we bring the finite difference analogue of the equation to a system of algebraic equations. The solution of the system of algebraic equations is worked out together with the finite analogues of the boundary conditions.

The finite difference method requires a deep understanding of the physical meaning of the problem, that is, how the function changes at special points in the considered area and increasing the accuracy of the calculation.

We solve the cavitation flow problem in the Ryabushinsky scheme, for which we construct the odd function on a surface consisting of continuous vortices or in a vortex layer in the following form:

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$$\psi = \frac{r}{4\pi}{}_{S_T} \frac{\varsigma_T \cos(\theta-\vartheta)}{\Delta} ds + \frac{r\varsigma_\kappa}{4\pi}{}_{S_\kappa} \frac{cos(\theta-\vartheta)}{\Delta} ds \qquad (1)$$

$$\Delta = \sqrt{(x-\xi)^2 + r^2 + r^{\ 2} - 2rr\ \cos(\theta-\vartheta)} \text{ -}$$

The distance between the points (x, r, θ) and $(x\ , r\ , \theta\ )$. S_T - the surface of the body (cavitator); S_κ - the surface of the cavity; ς_T and ς_κ - the intensity of the layer in which the body and the cavity lie. The intensity of the vortex layer is equal to the velocity of the flowing flow and is taken with the opposite sign.

If we combine the function current $\psi = \frac{V\ r^2}{2}$ of a uniform flow with formula (1), we obtain the following system of equations consisting of two integral equations:

$$ {}^{N}_{n=1} {}_{S_T} \frac{\varsigma_{Tn} \cos(\theta-\vartheta)}{\Delta} ds - V_\kappa {}_{S_N} \frac{\cos(\theta-\vartheta)}{\Delta} ds = -2\pi V\ r_i \qquad (2)$$

$$R = \frac{V_\kappa}{2\pi V} {}_{S_N} \frac{\cos(\theta-\vartheta)}{\Delta} ds - \frac{1}{2\pi V} {}_{S_T} \frac{\varsigma_T \cos(\theta-\vartheta)}{\Delta} ds, \quad (x, r) \quad S_\kappa \qquad (3)$$

We take the initial shape of the cavern from equation (2), and find the propagation velocity ς_{Tn} and the velocity V_k of the vortex. Substituting the obtained values into the right-hand side of equation (3), we find the new size of the cavern, i.e. the new radius R, and find its other dimensions. This process is continued.

In determining the results, there is a problem of expressing the values and results found in modern computational hydromechanics in a certain and precise manner, even when the problem is multidimensional. L.G. Guzevskiy obtained results for approximation formulas in navigable flows, and these results give the dimensions of the cavern in front of the cones and allow us to find the resistance coefficients:

$$\frac{R_\kappa}{R_н} = \sqrt{\frac{C_x}{k\sigma}}, k = \frac{1+50\sigma}{1+56{,}2\sigma}$$

$$\frac{L_\kappa}{2R_н} = \frac{1{,}1}{\sigma} - \frac{4(1-2\alpha)}{1+144\alpha^2} \sqrt{C_x \ln\frac{1}{\sigma}} \qquad (4)$$

$$C_x(\sigma) = C_x(0) + (0{,}524 + 0{,}672\alpha)\sigma_T \qquad 0 \quad \sigma \quad 0{,}25; \qquad \frac{1}{12} \quad \alpha \quad \frac{1}{2}.$$

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$$C_x = \begin{cases} 0,5 + 1,81(\alpha - 0,25) - 2(\alpha - 0,25)^2, \frac{1}{12} \quad \alpha \quad \frac{1}{2} \\ \alpha(0,915 + 9,5\alpha)..0 \prec \alpha \prec \frac{1}{12} \end{cases} \tag{5}$$

Here $\alpha\pi$ is the angle of half rotation of the cone. If there is a disk in the flow path, we get the following formula for its resistance:

$$C_x(\sigma) = 0,8275 + 0,86\sigma$$

In this formula, if σ=0, Garabedian's asymptotic result follows.

The solution of the problem of cavitation flows was carried out by the iteration method. In the initial step, a simple shape of the cavity is taken and the correct problem is solved. In this case, the condition that the pressure does not change in the section of the flow where the cavity is located is not met. In the next step, a correction is made to the shape of the cavity without damaging the physical shape, and the cycle of calculations is repeated. The calculations are stopped when the limit value of the shape of the cavity is reached.

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