**Experimental Investigations of Concave Cavities**

I.Nesteruk. Proposals of cooperation

If a device is covered by the cavity shown in Fig.1 (see [1]) and its second part ( $x > 0$ ) is close to the cavity shape, its pressure drag have to be near to zero (due to Dalambert paradox). Only the friction in the boundary-layer determines the body drag.

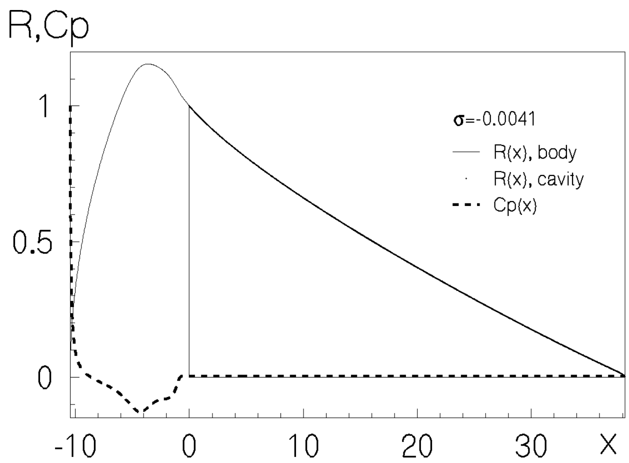


Fig.1 Axisymmetric cavitator (x<0) and cavity (x>0). Shape and pressure distribution.

This fact differs this device from bodies located in cavities after a disc or a cone, which have a significant pressure drag. The comparison of the volumetric pressure drag

$$C_{dV} = \frac{2D}{\rho U_\infty^2 (V')^{2/3}}$$

of these standard supercavitating bodies (located in cavities after a disc or a cone) with the volumetric friction drag of shapes without separation and cavitation (see [1-3]) shows that unseparated shapes are preferable for $\mathrm{Re}_V > 10^7$ ,

$$\mathrm{Re}_V = \frac{U_\infty (V')^{1/3}}{\nu} = \mathrm{Re}_L V^{1/3}$$

For example, with $V' = 0.5 m^3$ , $U_\infty = 100 m/s$ the value of $\mathrm{Re}_V$ is $6.1 \cdot 10^7$ ( $\nu = 1.3 \cdot 10^{-6} m^2/s$ ). Therefore, in this case a disc or a conical cavitator cannot cover a body of small volumetric drag (in comparison with the shape without separation and cavitation).

Nevertheless, the advantage of cavitation can be used with bodies shown in Fig.1, since they have near to zero pressure drag (such as unseparated shapes), but their friction drag is smaller (in comparison with the unseparated shapes) due to the smaller area of contact with the water. To estimate the values of this advantage, the following formulae can be used for the laminar boundary-layer, [2]:

$$C_{dV} = \frac{4.708}{\sqrt{\mathrm{Re}_V}} \sqrt{\frac{V_b}{V}} \qquad (1)$$

and for the turbulent one:

$$C_{dV} = \frac{0.073\ V_b^{6/7}}{\mathrm{Re}_V^{1/7} V^{13/21}} \qquad (2)$$

where $V_b$ is the volume of the part wetted by water (in Fig.1 this part is located at $x < 0$ ).

For example, for body shown in Fig.1 $V_b = 2.6 \cdot 10^{-4}$ , $V = 5.5 \cdot 10^{-4}$ , eq. (1) gives the drag diminishing of 31% (in comparison with the unseparated flow pattern $V_b = V$ ). For the pure turbulent boundary-layer (eq. (2)) the advantage is 47%. Eq. (2) yields the estimation $C_{dV} \approx 5 \cdot 10^{-4}$ for the body shown in Fig.1. This value is 14 times less than the volumetric drag of the underwater apparatus "Dolphin" measured at $\mathrm{Re}_V = 8.5 \cdot 10^6$ (see [4]).

The diminishing $V_b / V$ leads to the drag reduction. Nevertheless, short cavitators have more deep pressure minimum at their surface. This fact can cause separation (and cavitation) upstream to the point $x = 0$ and another flow pattern with a large pressure drag. The investigation of separation behavior is very important and has to be a main part of water tunnel tests. Some results of wind tunnel tests with unseparated shapes are presented in [5-8].

Since most of references are in Ukrainian, I am ready to prepare a series of 4-5 lectures to be presented in English.

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