Experimental Investigations of Axisymmetric and 2D Shapes without Separation and Cavitation

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The pressure distribution over the surface is the main reason of separation. In turn, unseparated flow patterns can prevent the cavitation inception [1, 2]. The investigation presented in [2] seems to be a pure experiment proving the fact that separation is the main reason of cavitation. Therefore, the shapes with a special pressure distribution can prevent both separation and cavitation.

Some theoretical results of wind tunnel tests with unseparated axisymmetric shapes are presented in [3-6]. There are two types of pressure distribution, which can prevent separation, and accordingly two types of the axisymmetric body form. It must be noted that only special shaping was used in [3-6] to prevent separation (in comparison with [7], where a boundary-layer suction was applied).

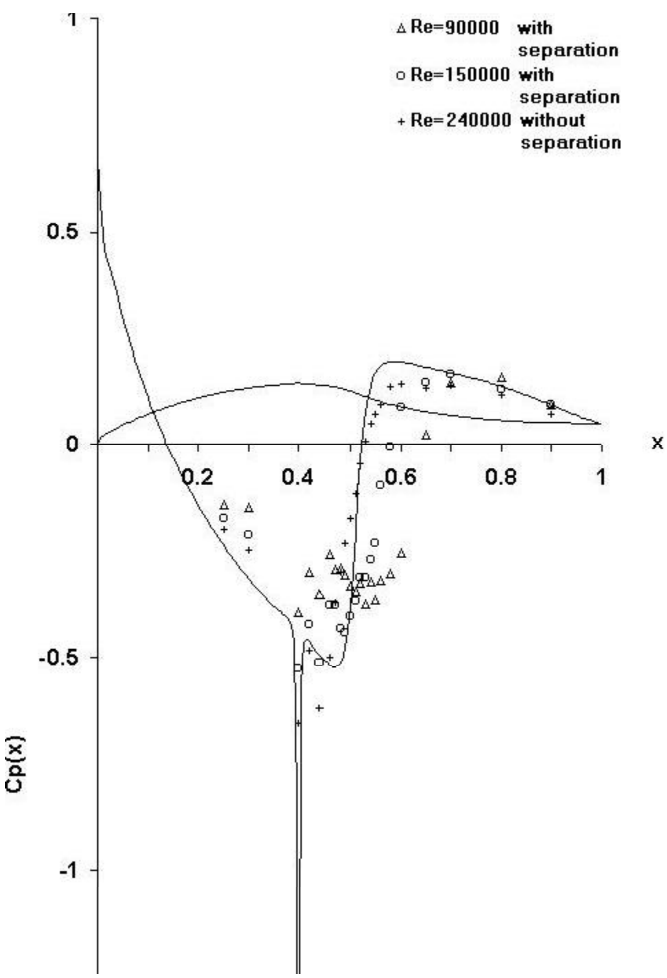

Fig. 1. Body U-1. Radius, theoretical and experimental pressure distributions.

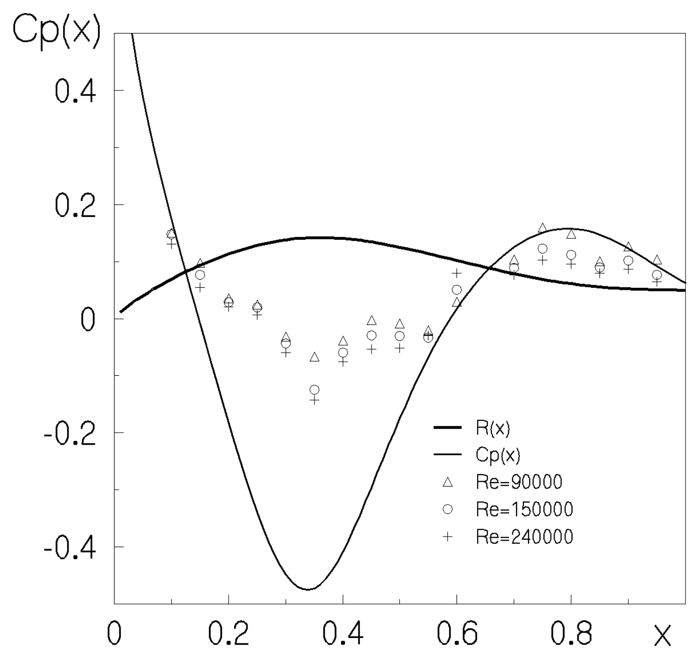

Fig. 2. Body UA-2. Radius, theoretical and experimental pressure distributions.

An example of the first type shape is the body U-1, see [1,4,5] and Fig. 1. The second one (shape UA-2, [7]) is shown in Fig. 2. The body U-1 revealed no separation at higher performance velocities (see [1, 5]). The shape UA-2 ensured an unseparated flow pattern at all Reynolds numbers available in the wind tunnel of Kyiv Institute of Hydromechanics.

Such shapes are both of theoretical and practical interest. In particular, according to the standard opinion, there must be a separation at or downstream of the minimum pressure point. Nevertheless, the absence of separation, which was revealed by the tests in [1,4-6], probably leads to the absence of cavitation as well. To substantiate this conclusion, the experiments in a water tunnel are required.

Progress in design of the axisymmetric unseparated shapes aroused interest in appropriate 2D forms. Symmetric profiles similar to the axisymmetric bodies of first type (with a short zone of a positive pressure gradient, see Fig.1) have been obtained in [8] with the use of the exact solution for an inviscid incompressible fluid. An example is presented in Fig. 3. To make shape peculiarities more visible, the curve $Y(x)\cdot 10$ is also shown in Fig. 3. The thickness ratio equals 16.4% for profile presented in Fig. 3. The calculations and the examples presented in [1, 8] show that the region with a positive pressure gradient can be very short both for thin and thick profiles.

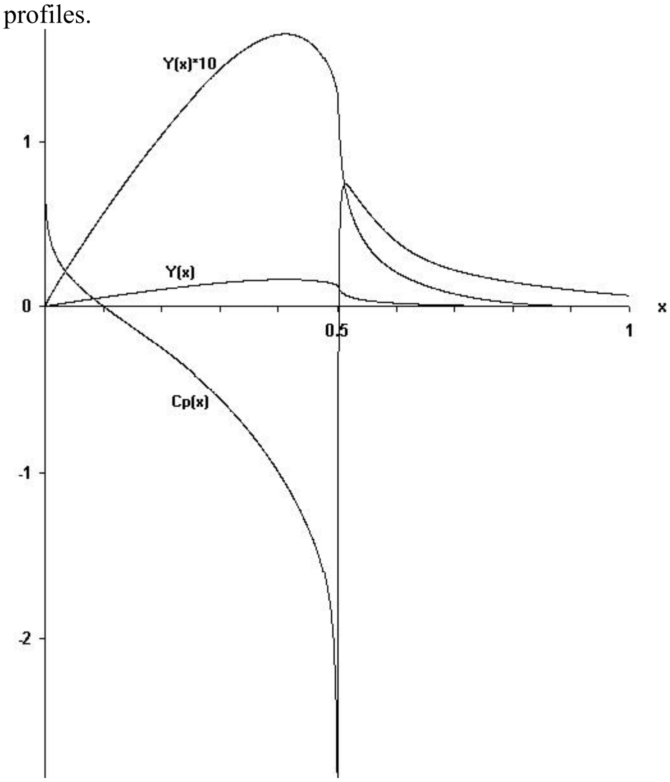

Fig.3. Symmetric 2D profile P3. Coordinate of upper surface Y(x), Y(x) 10, theoretical pressure distribution.

The 2D profiles similar to the axisymmetric shape of second type (see Fig.2) are also calculated. In comparison with the axisymmetric bodies U-1 and UA-2 (which especially for the tests were calculated and manufactured as unclosed ones to be connected with a cylindrical support tube), the 2D profiles are closed. Both types of the 2D shapes are of interest as means of preventing the separation and improving the cavitation characteristics.

AREAS AND STAGES OF COOPERATION

Presented axisymmetric and 2D shapes probably provide no cavitation at arbitrary small cavitation numbers and their investigation is an extremely interesting problem. The unseparated flow pattern gives an opportunity to reduce the total grad of bodies moving in gas or liquid. According to your interest in axisymmetric or 2D shapes the following stages of cooperation can be proposed:

- For the presented axisymmetric bodies, tests a water tunnel have to be carried out to investigate the cavitation inception characteristics and to prove the existence of the unseparated flow pattern at higher Reynolds numbers. Unfortunately, there is no water tunnel in Ukraine. Probably, it is possible and interesting for you carry out such experimental investigations in your water tunnel. As a first step, my models can be used. They are of approximately 56.5 mm diameter and of 200 mm length + 300 mm or 400 mm support tube. They are manufactured in aluminium alloy and could be used in water. The only problem is the measurements of the static pressure at the surface. The only one point can be measured during one experiment with the use of my models. To measure the pressure at another point, the flow must be stopped to close the previous orifice and to open the next one. It might be expensive, nevertheless the pressure can be measured at the most interesting points and compared with my tests in the wind tunnel. Moreover, to see cavity inception, there is no need to measure pressure distribution.

- For the presented 2D profiles, there were no wind tunnel tests to investigate their separation behavior at different angles of attack. Such experiments could be carried out in the wind tunnel of Kyiv Institute of Hydromechanics. Its cross section is 200 x 500 mm and the maximum velocity equals 15 m/s. There are facilities to measure the drag and lift forces. If this stage will be successful, the tests in your water tunnel have to be carried out to investigate the cavitation inception characteristics and to prove the existence of the unseparated flow pattern at higher Reynolds numbers. The next stage could be the experimental investigation of presented hydrofoils in radial pumps.

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