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Analysis of supercavities formed in water by a group of strikers during high-speed motion

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The analysis of supercavities formed during the high-speed motion in water of two closely spaced supercavitating strikers is performed. By comparing geometric characteristics of supercavities, the possibility of qualitative assessment of influence degree of closely spaced strikers on each other is shown. By the example of two strikers, the characteristic distance between them was determined, at which the minimum mutual influence of the strikers on each other is observed.

Keywords: supercavity, group throwing, cavity sizes, high-speed video recording, mutual influence

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In this work, we have studied high-speed in-water motion of several simultaneously launched closely spaced supercavitating strikers. When a group of elongated axisymmetric strikers enters the water at a a distance of several cavitator diameters (up to 10–20 diameters) their active mutual influence on each other is observed on the trajectory of movement. During motion, the strikers move away from each other. Preliminary analysis of that mutual influence performed in [1] showed that deviation of the trajectories from the aiming axis strongly depends on the striker weights.

Here the main attention is paid to analyzing supercavities [2–4] formed by two simultaneously starting closely spaced strikers. Comparison of geometric parameters of the cavities in several sections of their motion allowed qualitative assessment of the degree of the strikers mutual influence depending on their positions with respect to each other. The cavities were compared by superimposing the contours of their profiles. For the sake of better accuracy of studying variations in the parameters of cavities obtained during the group motion of strikers, cavities obtained during in-water motion of similarly shaped single strikers were involved in the comparison.

The experiments were performed using conical complex-shaped strikers with the 12 mm extension and cavitators 1.2–1.3 mm in diameter fabricated from the tungsten-nickel-iron (TNI) alloy. The strikers were located in the vertical plane one above another at the distance of 12 mm between their axes. The strikers made from the TNI alloy were 34 g in weight. The strikers' velocities at the entry into water were 400–500 m/s.

Formation of supercavities during high-speed motion in water was studied at a hydroballistic track using high-speed video recording [5]. Fig. 1 presents typical photos of in-water motion of a single striker (a) and two simultaneously starting strikers (b) and also of the cavities arising during their motion. The Fig. 1 inserts depict typical thrown assemblies with drivers.

Fig. 2, a presents a photo of motion of two TNI strikers with the water-entering velocity of 480 m/s. Their velocity at the distance of 0.7 m from the entry into water was 470 m/s, the distance between them was 12 mm. Fig. 2, b demonstrates the relevant contours of profiles of the cavities being compared. For comparison, there is shown a contour of the cavity obtained in motion with the 489 m/s velocity of a single striker with the same cavitator diameter.

One can see that in the case of the upper striker the shape of the profile lower part *3* changes essentially with respect to the profile of cavity induced by motion of a single striker. The cavity lower boundary adjoins the striker aft. Vice versa, in the case of the lower striker the upper cavity profile changes significantly *2* as compared with the cavity profile obtained in motion of the single striker, and now the upper boundary of the cavity adjoins the striker aft. Those

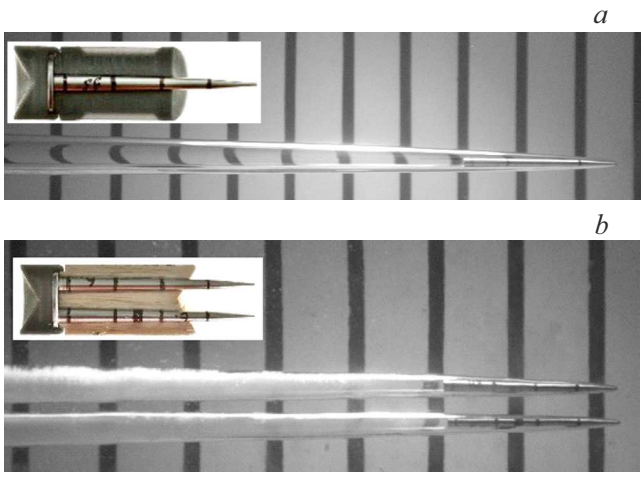

Figure 1. Photos of motion in water of a single striker (a) and two simultaneously starting strikers (b).

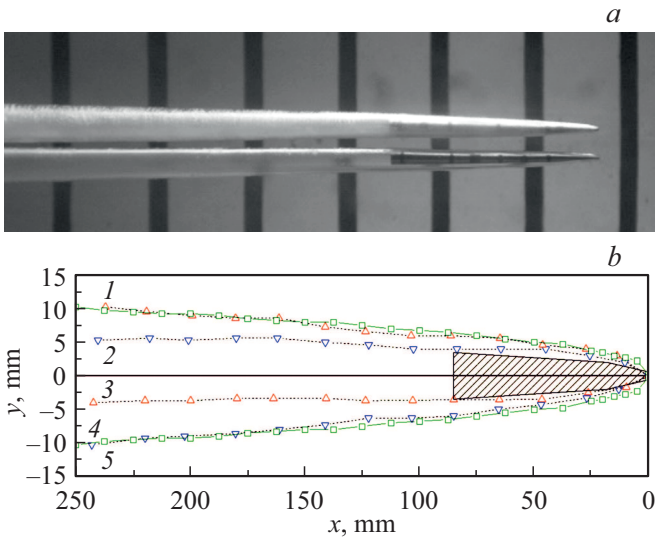

Figure 2. *a* — a photo of motion of two supercavitating strikers with the velocity of 470 m/s. *b* — profile contours of cavities formed by strikers separated by the distance of 12 mm. *1*, *3* — the upper and lower contours of the upper striker supercavity, respectively; *2*, *4* —the upper and lower contours of the lower striker supercavity, respectively; *5* — the contour of the single striker supercavity.

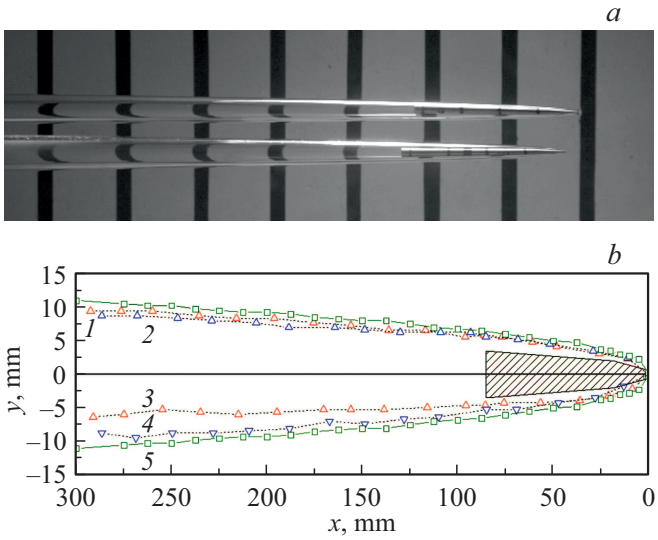

Figure 3. *a* — a photo of motion of two supercavitating strikers with the velocity of 450 m/s. *b* — profile contours of cavities formed by strikers separated by the distance of 24 mm. *1*, *3* — the upper and lower contours of the upper striker supercavity, respectively; *2*, *4* —the upper and lower contours of the lower striker supercavity, respectively; *5* — the contour of boundaries of the single striker supercavity.

deformations of the cavities might be caused by a pressure increase in the inter-striker space. The cavity deformation looking like approaching the striker aft can result in early „wash down" of the strikers and termination of their motion in the supercavitating mode.

Fig. 3 presents the photo and contours of the cavity profiles obtained in the same experiment on their motion trajectory after the distance between the strikers moving away from each other has become 24 mm. For comparison, here is also given the contour of the cavity induced by a single striker. One can see that the radial size of the cavity formed by a single striker is somewhat larger, which is caused by the higher velocity of the striker (489 m/s).

Comparison of profiles of the upper and lower cavity *1* and *2* shows that the cavity profiles become almost identical when the distances between the strikers reaches 24 mm. This means that the force impact on the cavities and, hence, the strikers mutual influence, become essentially weaker at this inter-striker distance.

The accomplished analysis of the contours of formed cavities showed that, with increasing distance between the jointly starting strikers with the cavitator diameter of 1.2–1.3 mm, their mutual influence becomes weaker and almost fully disappears at the distance of about 30 mm. The proposed method for qualitative assessment of the strikers mutual influence may be used in analyzing the underwater group motion of a great number of simultaneously starting strikers.

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Conflict of interests

The authors declare that they have no conflict of interests.

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