APPLICATION OF PIV TECHNIQUE FOR THE STUDY OF CAVITATING FLOWS ABOUT A CASCADE OF 2D HYDROFOILS

A.YU. KRAVTSOVA[1,2], D.M. MARKOVICH[1,2,c], K.S. PERVUNIN[1,2], M.V. TIMOSHEVSKIY[1,2]

[1]Institute of Thermophysics SB RAS, Novosibirsk, 630090, Russia
[2]Novosibirsk State University, Novosibirsk, 630090, Russia

[c]Corresponding author: Tel/Fax: +73833309040; Email: dmark@itp.nsc.ru

KEYWORDS:
Main subjects: turbulent structure, cascade of hydrofoils
Fluid: steady and unsteady cavitating flows, partial cavities
Visualization method(s): Particle Image Velocimetry, high-speed photography
Other keywords: NACA0015, cavitation cloud shedding, flow separation

ABSTRACT: The paper is devoted to experimental study of turbulent structure of an unsteady cavitating turbulent flow around a cascade consisting of three NACA0015 series hydrofoils with chord length of 100 mm and its comparison with turbulent structure of the flows about single 2D hydrofoils. In case with the cascade, the distance between the adjacent foils was 60 mm. The experiments were carried out at Cavitation tunnel in Kutateladze Institute of Thermophysics SB RAS. In order to have optical access to the central foil that is the most representative in the present case from the standpoint of modeling, the upper foil was made of plexiglass, the others were of brass. The experiments were performed for different angles of incidence α with variation of the mean flow velocity U_0. Cavitation number $\sigma = 2\cdot(P_{inlet} - P_{vap})/\rho U_0^2$ defined by the difference between the value of static pressure in inlet part of the working section and the pressure of saturated water vapour divided by the flow velocity head was the key parameter of the present configuration and was varied from 6 down to 0.6. In the work, dynamics, type and extents of occurring cavities were determined by high-speed visualization. Besides, instantaneous velocity and vorticity fields around the models were measured by means of PIV technique using "PIVIT" PIV-system. In PIV-measurements, fluorescent seeding particles were utilized and camera lens was equipped with an appropriate optical filter to avoid glares arising in registered images due to reflection of laser light by micro-bubbles in cavities directly to the camera. Instantaneous velocity fields were calculated by using an iterative cross-correlation algorithm with continuous window shift and deformation (interrogation area size – 64x64 pixels, 50% overlap). Thereafter, Peak Validation (the ratio of signal to noise peaks – 2) and Adaptive 7x7 Median Filter procedures were applied for the vector fields validation and outliers removal. Basing on the ensemble of 5000 instantaneous velocity fields, two-dimensional distributions of the mean flow velocity and the full set of statistical moments (including the third-order ones) were calculated for different regimes, starting from cavitation-free (i.e. single-phase) flow up to cloud cavities. As an example of the results obtained, visualization of partial cavities appearing at the cascade is demonstrated in Fig. 1-A. 2D distributions of a second-order moment are presented in Fig. 1-B for two values of cavitation number. The effect of cavity type on turbulence can be clearly seen on the fields of transversal component of turbulent kinetic energy: transition to cloud cavity leads to a drastic growth of liquid velocity fluctuations. Comparing with cavitation-free flow, level of the fluctuations for developed cavitation regimes rises drastically (approximately in one order). This is caused by the fact that cloud cavity is unsteady and characterized by large-scale quasi-periodic natural fluctuations of its length.

The full-length paper will contain detailed description of the experimental setup and experimental conditions. Sufficient set of the experimental results will be presented and more extended discussion will be given. Besides, the flows around a single NACA0015 series hydrofoil and the cascade will be compared; similarities and discrepancies of the flows will be shown.

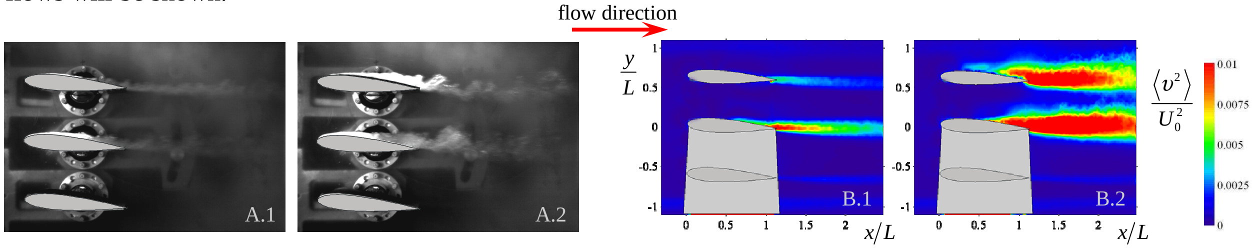

Fig. 1 (A) Instantaneous photos of partial cavities (side view) and (B) two-dimensional distributions of transversal component (y-direction) of turbulent kinetic energy for (1) σ = 1.7 and (2) σ = 1.6.