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THE VORTEX FLOW VISUALIZATIONS ISIDE AND AFTER SURFACE DIMPLES OF DIFFERENT SHAPE AND CONFIGURATION

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ABSTRACT: The results of vortex flow structure experimental studies are given at the water flow over the «shallow» surface spherical and cylindrical dimples on the flat plate. The flat plate length is 1220 mm, while the width is 381 mm. The experimental program was carried out in the water tube of the U.S. Air Force Academy (Colorado Springs). The water mass flow rate was 0.7 m^3/s, the upstream water speed was 0.05…0.5 m/s, the laminar flow was in front of dimples. Both spherical and cylindrical dimples had the surface diameter of 25.4 mm and the depth of 2.54 mm (h/D=0.1). To register the vortex flow structures overall five different water color jets were injected into the flow from the dimple bottom. Two digital cameras SONY-DSR VX2000 were employed to visualize the vortex flow structures, to provide the vortex flow analysis Adobe Premiere 6.5 computer program was used. The axial flow velocity profile was measured using LD measuring system connected with computer.

The in-dimple vortex structures influence greatly on the velocity profile in front of the dimple; as detected, the velocity profile has the «wavy» character at the z=±D/4 line, while at the other lines it has the shear stress form. After the single dimple the laminar-turbulent flow transition happens at the Reynolds number ranged from 6600 to 8000, where the lesser magnitude is for the cylindrical dimple. At the lower water speed the twin vortex forms in the dimple, while at the higher speed the unsteady mass-vortex structures were occurred discharging from in-dimple separation line. The diagrams for the Strouhal number and separation line depth were obtained as a function of the external Reynolds number and the dimple shape. As found, the Reynolds number corresponding to the maximal Strouhal number is greater for the spherical dimple. The flow regime map was developed for the single spherical dimple and the conditions of the oscillating vortex flow mode was determined for different Reynolds numbers.

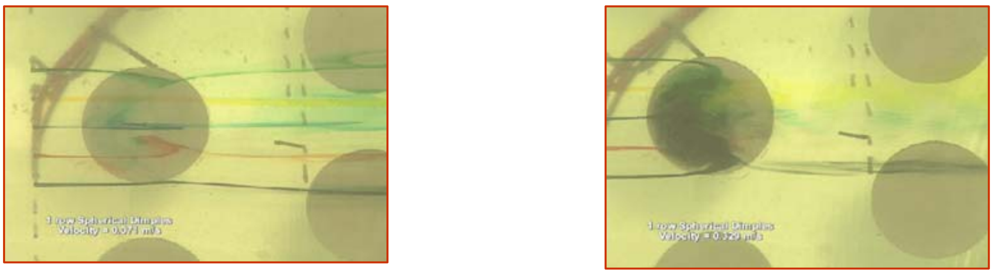

Fig. 1 Flow visualization for the one-row of spherical dimples. a: water speed is 0.071 м/c, b: water speed is 0.33 м/c (here the second row is «closed» by means of plastic material).

To assess the effect of vortex interactions between dimples additional experimental program was established with dimples arranged in one- or two-row. The wide range of experimental data was obtained characterizing the Strouhal number, laminar-turbulent flow transition, as well as in-dimple flow separation line depth. As found, the turbulent Reynolds number after one-row of dimples is 6700…8000, while after two-row it is 6000…9500. Here, the lower Reynolds number corresponds to the cylindrical dimple. At a lower water speed (fig. 1a) the periodic twin vortex forms inside the dimple, while at higher speed the in-dimple separation line is clear seen (fig. 1b).