Typical Peculiarities of Transition from Regular Two-Dimensional to Three-Dimensional Wave Motion on Vertically Falling Liquid Films

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In the present work the results of experimental investigation of major regularities of transition from two-dimensional to three-dimensional motion as a result of natural transverse instability of two-dimensional waves, and because of their forced destruction on vertically falling liquid films are presented. The comb with equally spaced needles touching the film surface in the upper part was used to disturb regular two-dimensional waves. Water and water-glycerol solution (WGS) were used as working liquids. Investigated Reynolds numbers were $18<Re<70$ for water and $10<Re<50$ for WGS. The high-speed laser-induced fluorescence technique (LIF) [1] was used for registration of instant distribution of film thickness on the plate with high spatio-temporal resolution.

It is shown that natural formation of three-dimensional structures from regular 2D waves occurs when $Re>30$ for water and $Re>12$ for WGS. For these cases the redistribution of liquid in the horizontal direction at the bottom of the flow was revealed on the time-averaged fields of film thickness. When 2D waves were artificially disturbed by the regular comb with needles 3D structures are formed in the initial section of film flow, and time-averaged distribution of the liquid has a jet nature immediately after the comb. The redistribution of liquid (formation of jet-like structures) in the case of isothermal film flow has been revealed in the first time.

For all investigated cases observed 3D waves have non-horseshoe shape (Fig 1). They have shape close to the elongated 3D waves observed in [2]. Fig 1 shows the part of registered wave pattern for case close to the conditions of the calculation [3] based on the Navier-Stokes equation. The form of the waves pattern (Fig 1) at the certain moment is in good agreement with results of the calculations [3].

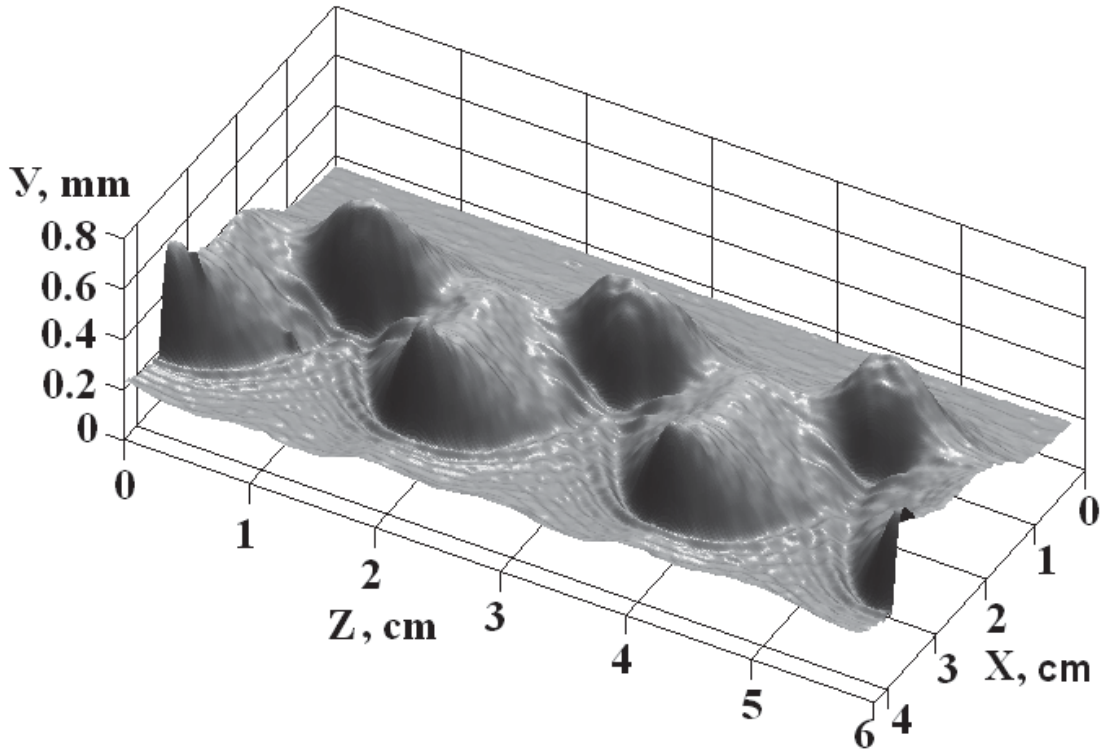

Fig. 1. The shape of film surface when 2D waves disturbed by regular comb with distance between the needles of 2 cm. Water, Re=65, f=16Hz.

References

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