Visualization of vortices and free-surface contours in gravity-driven channel flow over undulated bottoms

by

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ABSTRACT

We study the flow of silicone oil down an inclined channel with a sinusoidal bottom profile with a particle image velocimeter (PIV) using fluorescent tracers. Besides velocity measurements, we use the PIV system for flow visualization. At highly undulated bottom contours, we observe vortices in the valleys of the undulations. Using fluorescent particles allows us to detect the critical conditions for the generation of these vortices. We visualize the separatrix of the vortices by injecting oil highly doped with the fluorescent particles or by visualizing the pathlines. Surface waves that are created beyond a critical Reynolds number induce a material exchange between the vortex and the overlying film. The time scales of this exchange were determined with the same system.

We apply this system also to visualize the free-surface contour in three-dimensional or instationary flow regimes. In this case, the fluorescent particles serve to "colour" the liquid. The reemitted light from the particles that pass through a laser light sheet is detected with a CCD camera while the laser light is suppressed with a low-pass filter. Fluorescent particles and a low-pass filter serve to suppress the light reflected from the bottom. The camera is inclined at small angles with respect to the horizontal and images the light sheet from the airside enabling quantitative surface-contour measurements in three-dimensional flows. Fig. 1 shows an example of a hump in a film on the flat side of an undulated bottom.

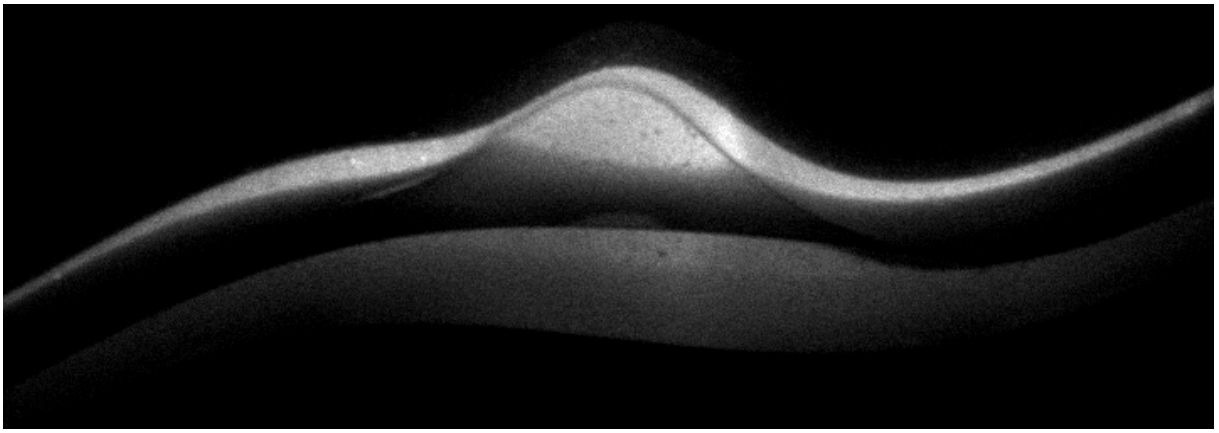

Fig. 1. Side-view of a hump in open channel flow over wavy bottoms detected with the inclined camera. The flow is from the right to the left.