Flow Pattern Comparison of Miscible and Solid Markers in Compound Vortex

Eugenia Stepanova
Laboratory of fluid mechanics, IPMech RAS, Russia.
step@ipmnet.ru

Abstract

Presented work contains investigations of the structures formed from a drop of dye in stationary or rotating fluid, although in a rotating fluid the effects that occur on the free surface are of lofty interest. The traditional method of visualization of fluid flows - adding soluble dye - assumes that the dye moves along with the basic flow. However, it was mentioned [7] that the drop, falling on the free surface of the fluid at rest, forms cascade of vortex rings in the fluid depth. These experiments replicated by the author showed that in addition to the vortex cascade in the fluid depth part of the dye is caught in the thin surface layer in the region of drop contact with the free surface. Subsequently, depending on the marking admixture type, secondary vortex rings are separated from the surface dye patch and immersed into the fluid depth. The drops of soluble admixture placed on the rotating free surface in the experimental setup VFT (detailed description of the experimental setup can be found here [2]) dye demonstrates the behavior that is different from the observed previously. The explored volume of fluid located in the vertical cylinder with the flow inductor (flat disk) at the center of the bottom. From the top the cylindrical volume of fluid is not limited to enable free surface. The flow induced in the experimental setup has a complex structure, and consists of a combination of two vortices, one with a vertical axis and the other toroidal with circular axis. This flow distorts the free surface of fluid, the form of which is parameterized by complex functions [3]. The symmetric trough is formed in the center of the free surface, it is distorted with surface waves in particular flow regimes. Two spiral arms

begin to stretch out from the soluble dye drop that has fallen on an inclined part of the free surface near the central vertical axis. One of the spiral arms starts to rise along the inclined free surface in the direction opposite to the general flow and the vector of the gravity force. Even on the large time scales the spiral arms revolutions are visible like the filaments which stay separated one from the other with the clear strips of fluid. In the fluid depth of compound vortex dye forms dye walls [6], which form a separate vertical cylindrical dyed surfaces, when observation time exceeds several periods of inductor rotation. Dye is distributed only in some specific areas, while in other areas the main volume of fluid remains not tinted [4]. The light immiscible admixture introduced into the flow to compare distribution patterns forms the finite volume right under the surface trough and reduces its depth. Also the spiral arms of admixture are stretched out on the free surface of flow and in case of intensive rotation the central admixture volume is shattered into invert emulsion [5]. For more detailed investigation of the surface flow pattern the solid markers of positive buoyancy are placed on the free surface [1]. Their movement on the compound vortex free surface is a combination of two rotations, one around the vertical axis of the vortex, and other around its own mass center.

Keywords: vortex, dye, flow, filaments.

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