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Streamwise Vorticity in the Wake of a Sliding Bubble

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Abstract : In many practical situations, bubbles are dispersed in a liquid phase. Understanding these complex bubbly flows is therefore a key issue for applications such as shell and tube heat exchangers, mineral flotation and oxidation in water treatment. Although a large body of work exists for bubbles rising in an unbounded medium, that of bubbles rising in constricted geometries has received less attention. The particular case of a bubble sliding underneath an inclined surface is common to two-phase flow systems. The current study intends to expand this knowledge by performing experiments to quantify the streamwise flow structures associated with a single sliding air bubble under an inclined surface in quiescent water. This is achieved by means of two-dimensional, two-component particle image velocimetry (PIV), performed with a continuous wave laser and high-speed camera. PIV vorticity fields obtained in a plane perpendicular to the sliding surface show that there is significant bulk fluid motion away from the surface. The associated momentum of the bubble means that this wake motion persists for a significant time before viscous dissipation. The magnitude and direction of the flow structures in the streamwise measurement plane are found to depend on the point on its path through which the bubble enters the plane. This entry point, represented by a phase angle, affects the nature and strength of the vortical structures. This study reconstructs the vorticity field in the wake of the bubble, converting the field at different instances in time to slices of a large-scale wake structure. This is, in essence, Taylor’s ”frozen turbulence” hypothesis. Applying this to the vorticity fields provides a pseudo three-dimensional representation from 2-D data, allowing for a more intuitive understanding of the bubble wake. This study provides insights into the complex dynamics of a situation common to many engineering applications, particularly shell and tube heat exchangers in the nucleate boiling regime.

Keywords : bubbly flow, particle image velocimetry, two-phase flow, wake structures
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