Liquid film falling around taylor bubbles rising inside tubes slightly inclined from the vertical

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The present work reports an experimental study of single elongated bubbles rising in water-glycerin mixtures inside vertical and slightly inclined round tubes. The bubble velocities were measured by using a visualization technique with high speed video camera and a pulse-echo ultrasonic technique. The thicknesses of the liquid films falling around the bubbles were also measured by using a pulse-echo ultrasonic technique. Four transducers were mounted with a radial separation of 90^o between them at the top of the tube to detect the rising bubble, allowing the determination of the bubble profiles representatives of the central vertical and horizontal planes of the tube. The inclination angles studied were 0^o, 2.5^o, 5^o, 7.5^o, 10^o and 15^o from the vertical (Figure 1). The experimental results indicated that the bubble velocity increased when the tube inclination increased, for all liquids studied. Additionally, it was observed that, for a given inclination angle, the bubble velocity decreased when liquid viscosity increased. Concerning the liquid film thicknesses, a loss of symmetry in relation to the tube axis was observed, when the bubble moves inside an inclined tube (Figure 2). The bubble was pushed towards the upper wall of the tube by the radial component of the buoyancy force, losing the symmetry in the vertical direction, i.e. the film thickness above the bubble became smaller than that below the bubble. On the other hand, the lateral film thicknesses showed to be the same, indicating a lateral symmetry of the bubble with respect to the tube axis. Differences was observed in behavior and shape of Taylor bubbles rising in different viscosity conditions inside inclined tubes (Figure 3), which suggest different intensities of the liquid flow reorganization around the bubbles, as the tube is inclined. These differences should be taken into account to explain the increase of bubble velocity when inclination angle increases and the smaller inclination influence on the bubble velocity when viscosity increases.

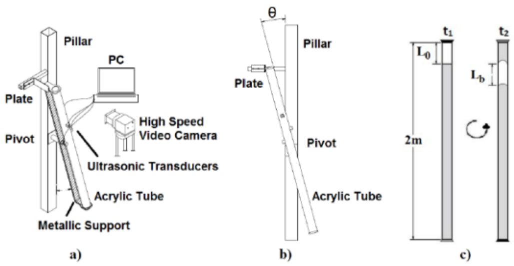

Figure 1. Schematic of the stagnant liquid vertical and inclined column: a) Apparatus; b) Front view; c) Bubble formation.

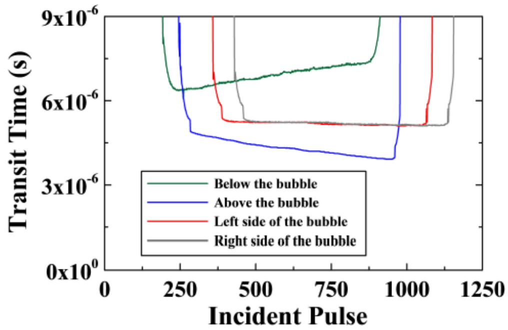

Figure 2. Ultrasonic signals from gas-liquid interfaces of a bubble rising in pure glycerin inside a 2.5^o inclined tube with D = 0.034 m.

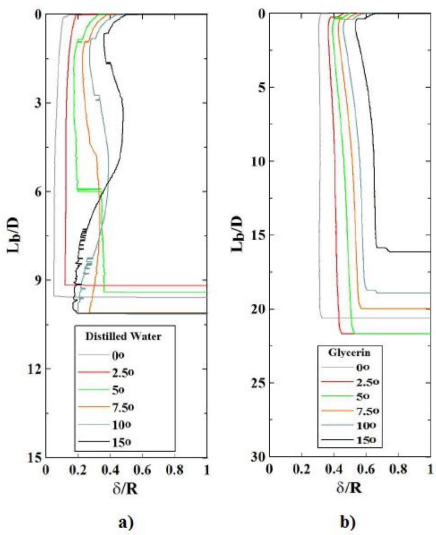

Figure 3. Bottom film profiles of bubbles rising in inclined tubes with D = 0.024 m containing: a) Distilled water b) Glycerin.

References

[1] AZEVEDO et al. Liquid film falling around Taylor bubbles rising inside tubes slightly inclined from the vertical. In: INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE, - ENFIR - Meeting on Nuclear Reactor Physics and Thermal Hydraulics, 10., 2017, Belo Horizonte. **Anais…** Rio de Janeiro: ABEN, 2017. Não paginado.