Experimental study of the shapes of single Taylor bubbles rising in stagnant liquid inside vertical and slightly inclined columns by using a pulse-echo ultrasonic technique

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This paper presents an experimental study of single Taylor bubbles rising in vertical and slightly inclined tubes containing stagnant mixtures of water and glycerin, using a pulse-echo ultrasonic technique, [1]. The bubbles were generated by inverting the tubes partially filled with liquid (Figure 1). The rising velocity of the bubbles and the bubble profiles (bubble length vs film thickness) on its bottom, top and sides were measured. Differences were found between the profiles usually described in literature, mostly characteristic of two-dimensional bubbles, and those observed in cylindrical tubes. Differences in the behavior of bubbles rising in more viscous and less viscous liquids were also identified. When the tube is inclined, the bubble is compressed against the upper wall of the tube and tends to deform, expanding to its sides. For bubbles rising in less viscous liquids such lateral expansion of the bubbles encountered a resistance that tends to increase with increasing inclination angle θ. In the case of more viscous liquids, the bubbles found freedom to deform laterally (Figure 2). The results allow a better understanding of the behavior of bubbles, inside inclined cylindrical tubes, and their influence on interfacial parameters such as the bubble velocities.

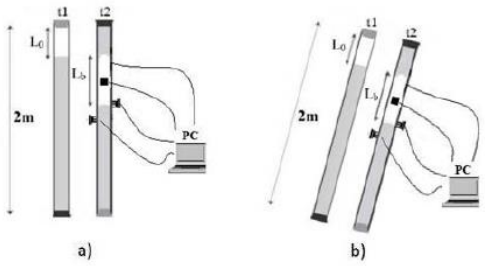

Figure 1. Schematic of the stagnant liquid column: a) vertical, and b) slightly inclined.

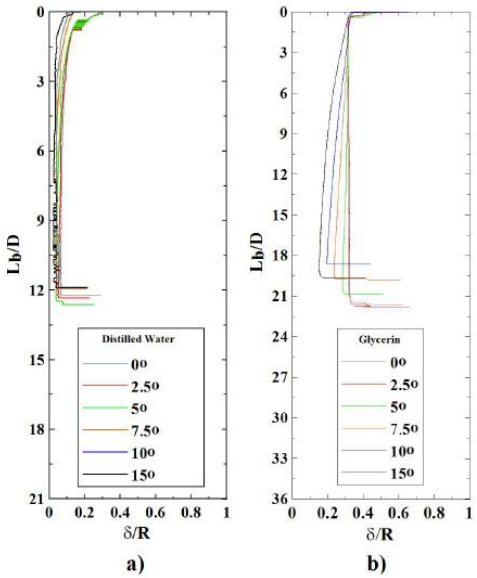

Figure 2. Dimensionless lateral profiles of bubbles rising in inclined tubes with D = 2R = 0,019 m and θ = 0° to 15° containing: a) pure water, and b) pure glycerin.

Figure 3 shows that the bubble velocity increased when inclination angle increased and the θ influence on velocity tends to decrease when the liquid viscosity increases. The solid lines correspond to the best linear fits of the measured Froude number Fr for each liquid mixture. This behavior was observed for all tube diameters D studied (0.019, 0.024 and 0.034 m).

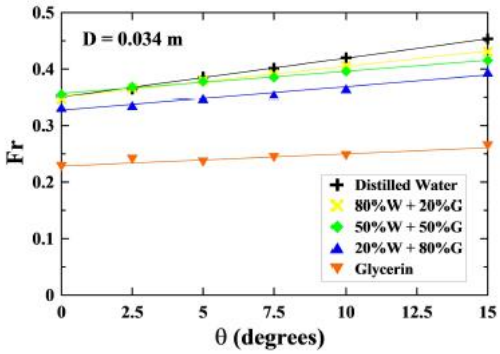

Figure 3. Variation of Fr with θ for the different liquid mixtures inside a tube with D = 0.034 m.

References

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