Experimental study of single Taylor bubbles rising in vertical and slightly deviated circular tubes

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The present paper [1] reports an experimental study of single Taylor bubbles (Figure 1) rising in vertical and slightly deviated tubes ($\theta \leq 15^o$) containing different stagnant mixtures of water and glycerin. The bubble shapes or its contours at two vertical orthogonal planes that intersect at the tube axis and the bubble velocities were measured by using a non-intrusive pulse-echo ultrasonic technique (Figure 2). The use of four ultrasonic transducers made it possible to observe the liquid film draining not only at the top and at the bottom of the bubbles, but also at their lateral sides, which allowed an experimental verification of the liquid film integrity at these radial positions and of the lateral symmetry of the bubbles. Based on the velocity measurements, the influence of liquid properties and of tube diameter on the bubble movement and shape were evaluated for inclinations ranging from 0^o to 15^o from the vertical. Finally, the performance of different correlations to predict the drift velocity were tested for this particular range of inclination.

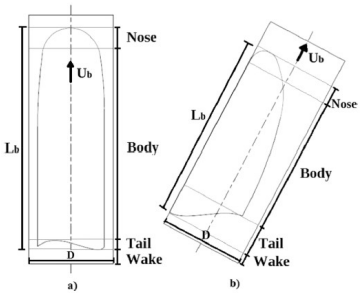

Figure 1. Geometry of Taylor bubbles in a vertical tube (a) and in an inclined tube (b).

The obtained results allowed not only to verify the lateral symmetry of the bubbles, but also the integrity of the films flowing around them and some differences between the shape and the flow of liquid around bubbles ascending in liquids of low and high viscosity at angles up to 15^o.

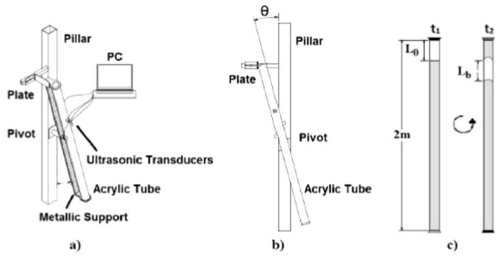

Figure 2. Schematic of the liquid column: a) apparatus; b) front view; c) bubble formation.

In Figure 3, it can be seen that almost all studied correlations have predicted Fr_θ with relative differences in the range of -10% to +20% for low viscosity liquids inside tubes with D = 0.034 m. On the other hand, for higher viscosity liquids most of the correlations did not presented well predictions of Fr_θ.

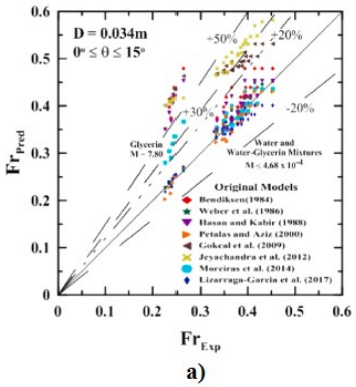

Figure 3. Fr_{exp} vs Fr_{pred} for bubbles rising in slightly deviated tubes with D = 0.034 m.

Our analysis of different correlations led us to recommend the correlation of Lizarraga-Garcia et al. [2] as an appropriate correlation to be used as slug flow closure relation for mechanistic models in slightly deviated tubes.

References

[1] DE AZEVEDO, M. B.; FACCINI, J. L. H. and SU, J., Experimental study of single Taylor bubbles rising in vertical and slightly deviated circular tubes In: Experimental Thermal and Fluid Science, 116, 110109, 2020.

[2] LIZARRAGA-GARCIA, E.; BUONGIORNO, J.; AL-SAFRAN, E.; LAKEHAL, D. In: A broadly-applicable unified closure relation for Taylor bubble rise velocity in pipes with stagnant liquid, International Journal of Multiphase Flow 89, 345–358, 2017.