Developed liquid films falling around Taylor bubbles inside vertical stagnant columns

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The present work [1] reports an experimental study of developed liquid films falling around single Taylor bubbles inside vertical tubes containing stagnant liquids (Figure 1). Experiments were carried out in acrylic tubes with 2.0 m length and inner diameters of 0.019, 0.024 and 0.034 m. Five water-glycerin mixtures were used, corresponding to film Reynolds number (Re_f) ranging from 2 to 7650. A pulse-echo ultrasonic technique was applied to measure the rise velocity of the bubble and the equilibrium thickness of the liquid film. These parameters together with the calculated standard deviation of the equilibrium film thickness provided information about the development of waves on the gas-liquid interfaces, which could be related with the laminar-turbulent transition of liquid films falling around Taylor bubbles.

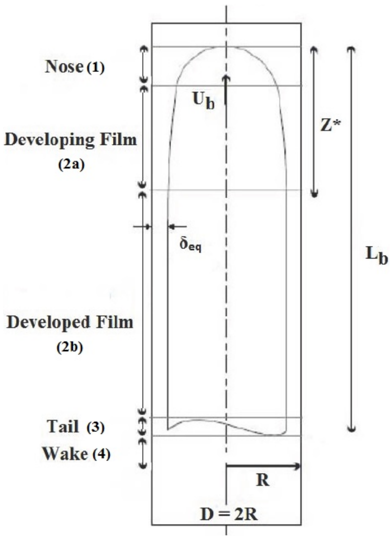

Figure 1. Schematic of a Taylor bubble flowing in a liquid.

The equilibrium thickness of the liquid film δ_{eq} is defined by an average value with a small relative discrepancy, which can represent the presence of waves at the gas-liquid interface. This relative discrepancy can be defined by the coefficient of variation (C_v), also known as relative standard deviation:

$$Cv = \frac{\sigma}{\delta avg}, \quad (1)$$

where, σ is the standard deviation and δ_{avg} is the average value of the film thickness at the developed region.

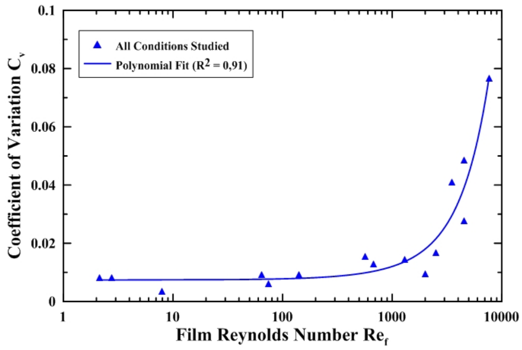

Figure 2. Coefficients of variation vs Re_f for the conditions studied in the present paper.

Figure 2 shows that up to values of Re_f around 1000, the coefficient of variation C_v did not change significantly, but a sharp increase on C_v can be observed for Re_f higher than this value, which suggests a change in the flow regime on the liquid film falling around the bubbles. This is in agreement with literature concerning the laminar-turbulent transition for free falling films on vertical surfaces [2,3]. The results obtained also suggest that the pulse-echo ultrasonic technique is feasible to identify the formation of waves at the gas-liquid interfaces of Taylor bubbles moving in liquid columns.

References

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