EXPERIMENTAL ANALYSIS OF THE BUBBLE-SLUG TRANSITION IN A MINICHANNEL IN MICROGRAVITY CONDITIONS

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Extended abstract

Three main different flow patterns were found for two-phase gas-liquid flow in microgravity conditions: bubble, slug and annular flow [1,3]. Each of these patterns presents unique features that made it interesting for variety both scientific and technological applications. And even if several method have been proposed in the past to define the two-phase flow patterns [4,7], a better understanding of it is still required. To such end, further studies regarding the mechanisms of transition between regimes are essential.

This work is focused in the experimental study of the bubble-slug transition in minitubes on ground in microgravity conditions. A previously presented injector [8], where water and air are injected in a 1 mm capillary T-junction, was used. The generation and detachment of the minibubbles is provided by the liquid cross-flow (Fig. 1-a). In nominal conditions small Bond number and small Weber number are achieved for an air/water mixture flow. Therefore, capillary forces dominate over buoyancy and inertial forces [9].

We performed experiments at several water volumetric flow rates values ranging from Q_l = 2 up to 80 ml/min. For each value of Q_l a large number of values of air volumetric flow rates Q_g, ranging typically from 0.25 to 80 ml/min, were employed. For each chosen couple of values Q_l, Q_g images were taken by the high velocity camera. Analysis of the films permitted to measure the gas velocity, U_G, and additionally to classify the obtained flows in bubble or slug type. Churn and annular flows were also observed, but are not considered here.

The bubble-slug transition is very susceptible to the investigator subjectivity. In order to overcome this difficulty, we considered that the bubble-slug transition occurs when the minibubble diameter is larger than 1 capillary diameters, according with the classification proposed by Dukler et al [1]. Fig. 1-a and 1-b show representative photographs of slug and bubbly flows. No pattern with simultaneously the characteristics of bubbly and slug flow was observed in our experiments in any case.

Fig. 2 shows the gas velocity, U_G, with respect to the mixture velocity, $U_{SG}+U_{SL}$, being U_{SG} and U_{SL} the superficial gas and liquid velocities, respectively. A simple linear relation holds in its dependence on the mixture velocity and therefore a drift-flux relationship can be assumed [3]:

$$U_G = C_0\left(U_{SG} + U_{SL}\right) \quad (1)$$

where C_0, the distribution coefficient, fits to the value 1.22. A consequence of the previous conclusion is that the transition may be expressed as

$$U_{SL} = U_{SG}\,\frac{1 - C_0\alpha_c}{C_0\alpha_c} \quad (2)$$

being α_c the required critical value of the void fraction for the bubble-slug transition to occur. A two-phase flow bubble/slug patterns map based on the gas/liquid superficial velocities is plotted in Fig. 3 by using our experimental data. As shown, the data fit well for the bubbly and slug regions of the map for α_c = 0.2.

Finally, with U_{SG} and U_G known, the mean void fraction can be determined as follows:

$$\varepsilon = \frac{U_{SG}}{U_G} \quad (3)$$

Fig. 4 shows the void fraction calculated with Eq. 3 vs. the gas/liquid superficial velocities ratio, U_{SG}/U_{SL}. Again, the data corresponding to the bubble and slug flow fit well to the plotted 0.2 void fraction line.

Further details and comparison of the experimental data with nowadays data and models will be provided at the congress.

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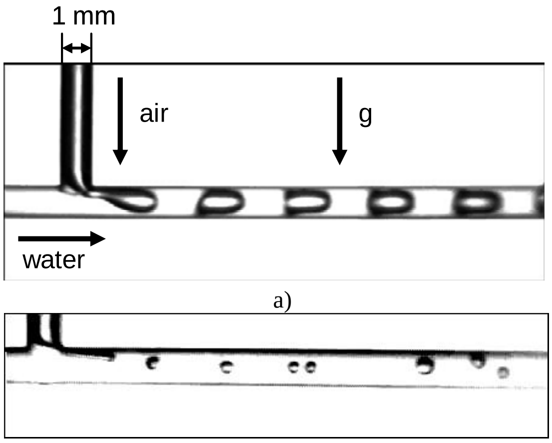

b)

Figure 1. Representative photographs of flow patterns in the 1 mm circular diameter tube: a) slug flow; b) bubbly flow.

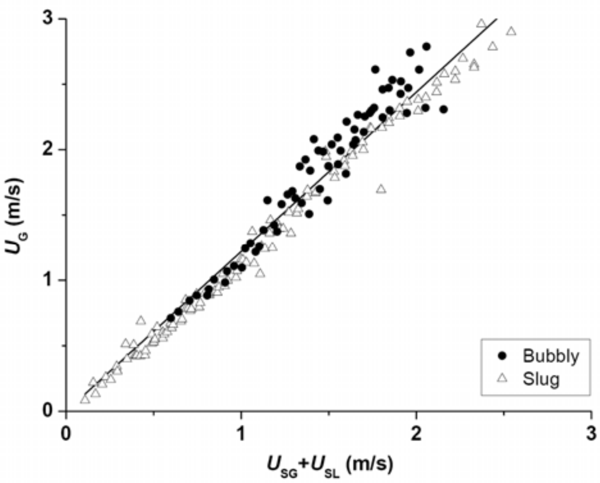

Figure 2. Gas velocity vs. mixture velocity. *Symbols:* experimental results, *line:* linear fit.

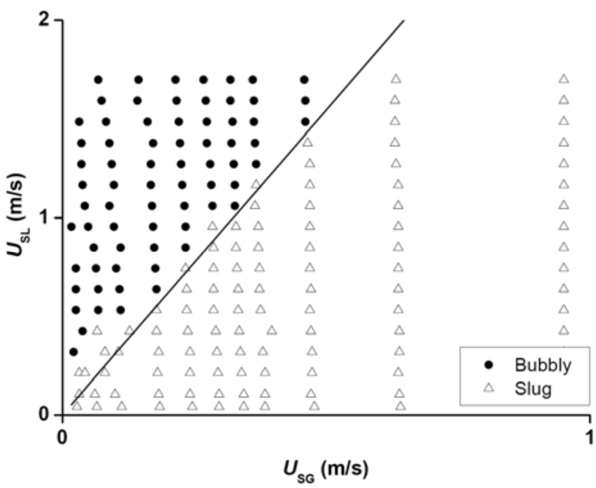

Figure 3. Bubbly and slug flow patterns. *Symbols:* experimental results, *line:* transition line corresponding to void fraction equal to 0.2.

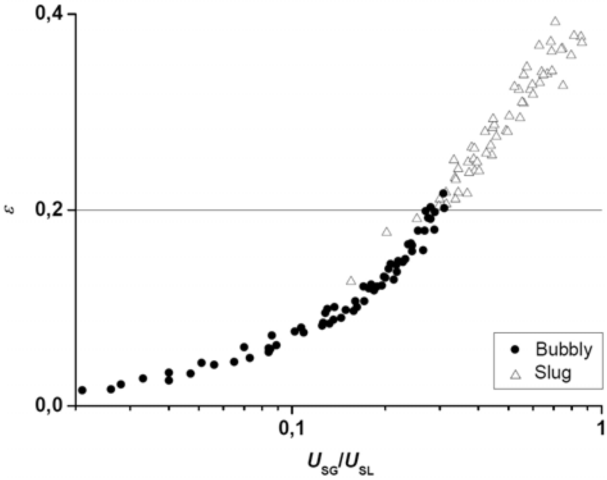

Figure 4. Void fraction vs. gas/liquid superficial velocities ratio, U_{SG}/U_{SL}. *Symbols:* experimental results, *line:* void fraction corresponding to 0.2.

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