Characterization of velocity and shape of rising bubbles in a stagnant liquid vertical column by ultrasonic and visualization techniques

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Introduction

In this work two nonintrusive techniques were used to measure the rising bubble velocities in a stagnant liquid vertical column sealed on the top: the pulse-echo ultrasonic technique and the visualization technique with high speed video camera. The parameters measured by this technique were presented and discussed, especially the rising velocities of the bubbles, which are compared with the theoretical velocity predicted by and Davies and Taylor (1950) [1]:

$$u_0 = 0.35\ (gD)^{1/2},$$

where D is the inner tube diameter and g is the gravitational acceleration.

Experimental Facilities

The data analysed in this work were obtained from a stagnant liquid vertical column sealed on the top located at the Thermo-Hydraulic Laboratory of the Nuclear Engineering Institute (LTE/IEN). The vertical column consists of a glass tube of 1.5 m long with inner diameter of 24.37 mm connected by flanges with a system of air injection. The bubbles are formed by acting on a control valve to inject air at the glass tube filled with distilled water. The high speed video camera and de pulse-echo transducers are located near the top of the glass tube to measure the terminal velocity of the bubbles. (See Ref. [2])

Experimental Results

Four different types or shapes of air bubbles are used in this work. The Fig.(1) shows pictures to visualize this different shapes.
Tables (1) and (2) present the bubbles rising velocities measured by ultrasonic and visualization techniques for the different bubble types.

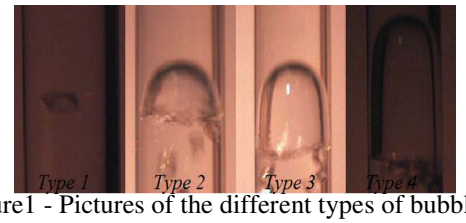

Figure1 - Pictures of the different types of bubbles

Table 1 - Ultrasonic technique measured velocities for different bubble types

Bubble	Velocity (m/s)	Stand. Dev.	Discrepancy to u_0
Type 1	0.2425	0.0069	0.4175
Type 2	0.2073	0.0094	0.2120
Type 3	0.2061	0.0048	0.2048
Type 4	0.2064	0.0077	0.2065

u_0 = 0.1711 m/s Samples: 50 per type of bubble

Table 2 - Visualization technique measured velocities for different bubble types

Bubble	Velocity (m/s)	Stand. Dev.	Discrepancy to u_0
Type 1	0.2047	0.0056	0.1964
Type 2	0.1698	0.0013	0.0076
Type 3	0.1707	0.0008	0.0023
Type 4	0.1716	0.0015	0.0029

u_0 = 0.1711 m/s Samples: 30 per type of bubble

Conclusion

For bullet-shaped bubbles, the rising bubbles velocities showed to be independent of their lengths, in good agreement with Nicklin (1962) [3].

References

[1] Davies, R. M. and Taylor, G. I., 1950. "`The Mechanics of Large Bubbles Rising Through Extended Liquids and Through Liquids in Tubes"'. Proceedings of the Royal Society of London, Series A, 200, pp. 375 - 390.

[2] De Azevedo, M.B., Vinhas, P.A.M., Faccini J.L.H. and Su, J.; Proceedings of 14th Brazilian Congress of Thermal Sciences and Engineering, 2012, Rio de Janeiro, RJ, Brazil. Paper ENCIT2012-108.

[3] Nicklin, D. J., Wilkes, J. O. and Davidson, J. F., 1962. "`Two-Phase Flow in Vertical Tubes"'. Transactions of the Institution of Chemical Engineers, Vol.40, pp. 61-68.