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Vertical movement of gas bubbles in liquid phase is of enormous significance in a number of industrial operations such as electrolytic cells, filtration devices, and heat exchangers.[1] The movement of these gas bubbles is capable of providing the stirring required for fluid mixing. However there is very little published data on the hydrodynamic behavior of such bubbles in inclined rectangular channels.

We present results of laboratory experiments investigating the dynamics of air bubbles rising in stagnant or co-flowing liquid (water) in inclined channels of rectangular cross-sections. The experiments were conducted in a basic Plexiglas channel ($1300 \times 240 \times 20$ mm, in length (L), width (W), and height (H), respectively). Different channel geometries ($H = 5$, 10 and 20 mm; $W = 20 \div 240$ mm) were obtained by insertion of suitably varied plates into the basic channel. Channel inclinations were ranging from $\alpha = 5°$ (almost horizontal) to 90° (vertical). Measurements and data analysis were carried out with the use of a high speed video camera system and image processing technique providing information on the bubble shape (bubble length L_B and volume V_B and bubble rise velocity U_B. The specific impact of channel geometry, orientation and inclination on the shape, stability, and velocity of rising bubbles was studied and discussed.

The results obtained in all studied channel configurations suggest that large bubbles (with $L_B/W < 1/2$), reach a final rise velocity U_B, which is no more sensitive to further increase in the bubble size. In vertical channels, this final bubble velocity depends on the channel perimeter P and a universal velocity scaling based on the Froude number $\mathrm{Fr} = U_B/\sqrt{gP}$ can be recommended. In inclined channels with thin slots, this scaling remains valid. But in this case only the axial component of gravity is considered $\mathrm{Fr} = U_B/\sqrt{g \sin \alpha P}$. In inclined channels with large slots, where bubbles are more deformed and streamlining effect more pronounced, this scaling does not hold. To obtain universal scaling in this case, it becomes necessary to also take into account the transverse component of gravity. The velocity of bubbles rising in co-flowing liquid exhibits a linear dependency on the mean liquid velocity ($U_{TB} = C_L \cdot U_{TB} + U_{TB,0}$)[2] with the distribution coefficient C_L ranging between 1 and 1.5, depending on the inclination angle and channel height.

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References

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