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The vertical movement of gas bubbles in a liquid phase is of enormous significance in a number of industrial operations such as electrolytic cells, filtration devices and heat exchangers. The movement of these gas bubbles provides in these devises vigorous fluid mixing. However, there is very little published data on the hydrodynamic behavior of such bubbles in inclined rectangular channels.

We present the results of experimental investigation on the dynamics of air bubbles rising in stagnant liquid inside an inclined channel. The experiments were conducted in a Plexiglas channel having a rectangular cross-section (240×20 mm). Different channel geometries were then obtained by insertion of suitable plates into this basic channel. The measurements using a high speed video camera were done for channel inclinations ranging from $\alpha = 5°$ (almost horizontal) to 90° (vertical). Subsequent image processing provided information on the bubble shape, size, and rise velocity U_B. The specific impact of channel geometry 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 sufficiently large bubbles reach a final rise velocity U_{TB}, which is no more sensitive to further increasing in the bubble size. In vertical channels, this final bubble velocity U_{TB}^v is controlled by the channel perimeter P and a universal velocity scaling based on the Froude number $Fr_v = U_{TB}/(g \cdot P)^{1/2} \cong 0.2$[1] was confirmed to be valid. In horizontal channels, the final translating velocity U_{TB}^h is controlled by the channel height H and the scaling based on the Froude number $Fr_h = U_{TB}/(g \cdot P)^{1/2} \cong 0.5$ is recommended for large tubes and channels[2] U_{TB}^h values obtained in our experiments by data extrapolation suggest that surface tension plays important role in flat channels and Fr_h decreases with increasing $\sum = 4\sigma/\rho g H^2$. In inclined channels, the bubble velocity scaling based on a weighted superposition of U_{TB}^h and U_{TB}^v was proposed[3]. Our experimental data suggests a relationship in the form $U_{TB} = U_{TB}^v \sin^m \alpha + U_{TB}^h \cos^n \alpha$ where two power parameters (m and n) are dependent on the channel geometry. The first parameter distinct between flat ($m = 1/2$ for $H < 10$ mm) and tall ($m = 1$ for $H > 20$ mm) channels, whereas the second parameter is sensitive to the aspect ratio of tall channels and thus ranging between $n = 1$ (for narrow channels with $H/W >> 1$) and $n = 2$ (for wide channels with $H/W << 1$).

Our next experiments will be focused on shear stresses induced by rising bubbles on the channel walls. The electrodiffusion measuring technique will be used for this purpose. The results of our preliminary measurements confirmed that the two-strip probe is able provide valuable information on near-wall flow around the bubble, including the detection of near-wall flow reversal under the bubble.

References

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