Dynamics and dissolution of bubbles in microchannels

J. Rivero-Rodríguez[a], B. Scheid[a]

[a] *Transferts, Interfaces et Procédés - Physique des fluides, Université Libre de Bruxelles*

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This work focuses on the dynamics of a train of unconfined bubbles flowing in microchannels [1]. We numerically investigate the transverse position of a train of bubbles, its velocity and the associated pressure drop when flowing in a microchannel depending on the internal forces due to viscosity, inertia and capillarity. Despite the small scales of the system, the inertial migration force plays a crucial role in determining the transverse equilibrium position of the bubbles. Beside inertia and viscosity, other effects may also affect the transverse migration of bubbles such as the Marangoni surface stresses and the surface deformability. We look at the influence of surfactants in the limit of infinite Marangoni effect which yields rigid bubble interface. The resulting migration force may balance external body forces if present such as buoyancy, centrifugal or magnetic ones. This balance not only determines the transverse position of the bubbles but, consequently, the surrounding flow structure, which can be determinant for any mass/heat transfer process involved. We look at the influence of the bubble deformation on the equilibrium position and compare it to the inertial migration force at the centred position, explaining the stable or unstable character of this position accordingly.

We also investigate how the mass transfer is affected by the channel and bubble sizes, distance between bubbles, diffusivity, mean velocity, deformation of the bubble, the presence of surfactants in the limit of infinite Marangoni effects and the transverse position of the bubbles. We study the effects of the dimensionless numbers, specially the Pe number, which we vary among eight decades and identify four different regimes. These regimes can be classified by either the importance of the streamline diffusion or by the interaction between bubbles. For small Pe the streamline diffusion is not negligible as compared to convection whereas for large Pe, convection dominates in the streamline direction and, thus, crosswind diffusion becomes crucial to determine the dissolution through a boundary layer or of the remaining wake behind the bubbles. Bubbles interaction takes place for very small Pe number for which the dissolution is purely diffusive or for very large Pe numbers in which case long wakes eventually reach the next bubble. Transitions and asymptotic behaviours are finally explored.

Références

[1] J. Rivero-Rodriguez and B. Scheid. Bubbles dynamics in microchannels : inertial and capillary migration forces. *Journal of Fluid Mechanics*, Accepted for publication :–, 2018.