Effect of surfactant re-distribution on the flow and stability of foam films

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Despite its industrial importance, such as in the oil recovery, medical products and soil remediation, the flow of foam in narrow channels with complex geometry is technically challenging to model. The viscous froth model, based on the balance of film curvature and adjacent bubble pressure with the friction experienced by the film, is used to model such flow system. However, this model has limitation since it assumes uniform and fixed surfactant concentration along the film surface [1].

The generous support from the UK Fluids Network allows Dr Vitasari to visit Dr Grassia and Mr Rosario at Department of Chemical and Process Engineering, the University of Strathclyde, to continue the previous work conducted when Mr Rosario visited her and Professor Cox in Aberystwyth. Based on the results of the previous work, the surfactant surface concentration varies, hence the surface tension, due to the stretching and contraction of the film. The current work investigates the effect of such distribution of surface tension due to the film deformation.

The preliminary results show that allowing surfactant re-distribution along the film, by applying the Marangoni law, governing the surfactant re-distribution along the film due to the gradient of concentration, together with the viscous froth model, give significant effect on its deformation. The model examines a 2D lens structure, consists of a single bubble attached to one side of the wall, connected to a single film attached to the other side of the wall, within a periodic boundary. The films are deformed when a driving velocity is applied to the lens. The leading film of the bubble will shrink, and at high velocity the junction between three films will eventually touch the wall and the spanning film will be detached from the bubble. As the leading film contracts, it has a higher surfactant concentration, thus lower surface tension, causing the film more stiff and less deformed. As the effect, the foam structure is stable in a longer time compared to the one modelled using the fixed and uniform surfactant concentration as can be seen in Fig. 1.

During her visit Dr Vitasari also had an opportunity to give a seminar about her current work on modelling the flow of foam in a constricted narrow channel, attended by the staffs and PhD students at the department, allowing the exchange of knowledge to improve her work. The collaboration work will be continued, a publication from the results of the study will be prepared and submitted to a reputable journal.

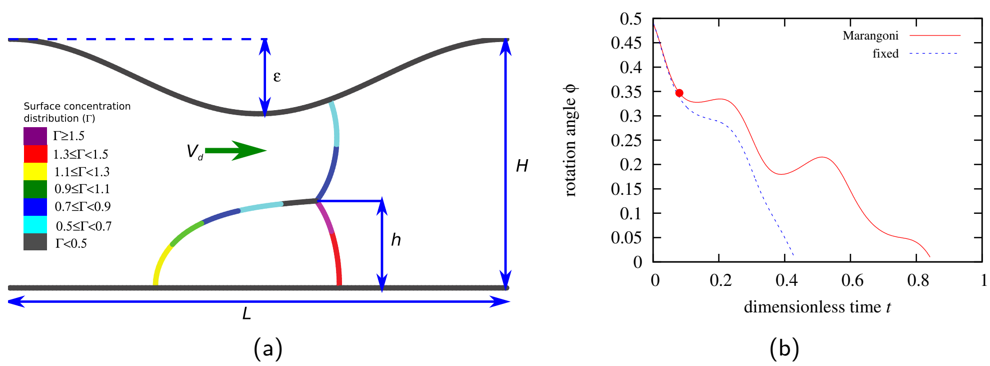

Figure 1: Film deformation in foam flow predicted using the viscous froth model and Marangoni law: (a) diagram showing the distribution of surfactant concentration along the film after moving the lens for 0.08 unit time (the red dot on the graph) using the dimensionless driving velocity $V_d = 6$ (the black lines on the top and bottom sides of the graph represents the channel walls), (b) the change of relative height of the junction between three films due to deformation, comparison between the case with the Marangoni surfactant re-distribution (solid line) and that with uniform and fixed surfactant concentration (dashed line). The oscillatory impression on the graph is due to the lens passing the same constricted wall geometry for several times within the periodic boundary. The parameters of the simulation are: initial relative bubble height $h_0 = 0.5$, constriction size parameter $\varepsilon = 0.3$ and dimensionless driving velocity $V_d = 6$.

References

[1] Denny Vitasari and Simon Cox. A viscous froth model adapted to wet foams. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 534:8–15, 2017.