Thin liquid film in polymer tubing: dynamics and dewetting in partial wetting condition

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Polymers such as PVC and Silicone are low cost materials widely used in industry to produce tubing for fluid transport. Most of these applications involve repeated, intermittent flow of liquids which can lead to unwanted contamination. This study aims at better understanding contamination mechanisms during intermittent flow in polymer tubing, and at elucidating the relation between flow, wetting and contamination.

We experimentally and theoretically investigate, flow regimes as well as dewetting process at the triple line induced by gravity flow of a vertical liquid slug in a cylindrical geometry. We have observed that a moving liquid slug can lead to liquid film deposition at the inside wall of the tube, whose dynamic is controlled by the dewetting of the film, Fig. 1. (left). In the literature, Taylor's experiment [1] has revealed that the remaining liquid film after a slug has been displaced through a tube presents a film thickness scaling as $Ca^{2/3}$. Bretherton [2] derived a model to describe a Taylor bubble based on a lubrication approach coupled with surface deformation of the bubble. In contrast, we do not recover the Taylor and Bretherton prediction, and we have found a linear relationship between the rear meniscus velocity and the dewetting triple line velocity. Based on the film thickness measurement by absorption, we show that this scaling results from gravity driven drainage.

Our results on dewetting are in agreement with the classical work of Redon [3]: dynamic dewetting is dependent on liquid viscosity and surface tension and highly dependent on the contact angle with the material.

Finally, we will present a phase diagram of more or less complex dynamical processes, such as hydraulic jump creation in the thickness profile, an oscillatory regime and the destabilization of the liquid film which may lead to substrate contamination, Fig. 1. (right).

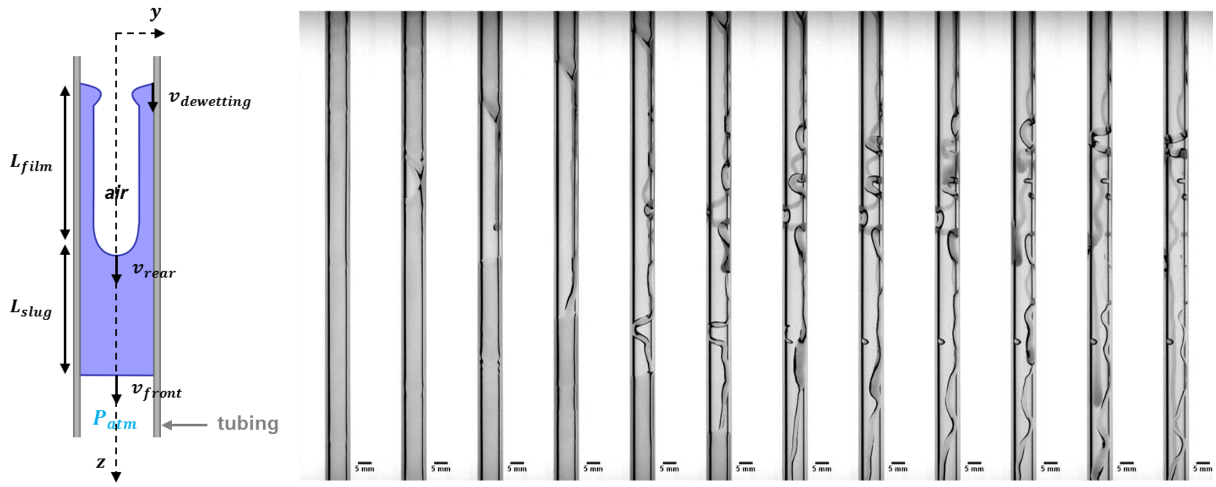

Fig. 1. Drawing of a slug with a liquid film and images sequence of thin liquid film destabilization, drops formations (500 frames/sec, flow velocity 0.6 m/s)

References

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