Towards an universal criterion of stability for a dry patch in a flowing film

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Stability of a dry patch in a liquid film flowing down an inclined plate is a subject of industrial interest. In many processes (heat exchangers, coating flows) one needs to avoid their appearance or at least to force their healing. Previous studies [1, 2] propose criterions for the stabilty of dry patchs which are not compatible with experiments. The shape of a dry patch in the Stokes limit [3, 4] is well known but its stability still remains a challenge. In a previous paper,Podgorski *et al* show that the shape results from an equilibrium between capillarity and the weight of the rim and that the radius of curvature at the apex follows :

$$R = m\frac{(1-\cos\theta)^4}{\theta - \sin\theta\cos\theta}\frac{l_c^2 U_c}{\Gamma \sin\alpha}$$

where Γ is the flow rate, α the angle of inclinaison, m a constant taking into account the flow in the rim, U_c the capillary speed and l_c the capillary length. Altought this shape is in excellent agreement with experimental shape of a dry patch, the Podgorski *et al* model does not predict any stability criterion.

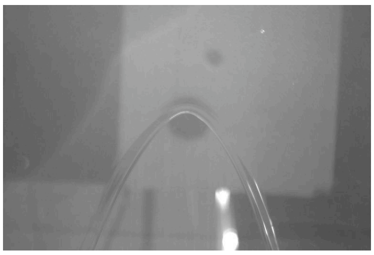

Fig. 1 – Photo of a dry patch in a $\eta = 11,55 cP$ oil film

In the present work, we improve the model in the Stokes limit by adding capillary effects due to the radius of curvature at the apex, inertia effects in the rim and hydrostatic pressure effects. This improved model predicts two possible radius of curvature at the apex for the same flow rate with one of them unstable (see figure2). This allows us to derive a stability criterion for a dry patch in a flowing film in the Stokes limit, which corresponds a critical value for the radius of curvature $R_c \sim 3l_c$ (and also to a critical flow rate Γ_c).

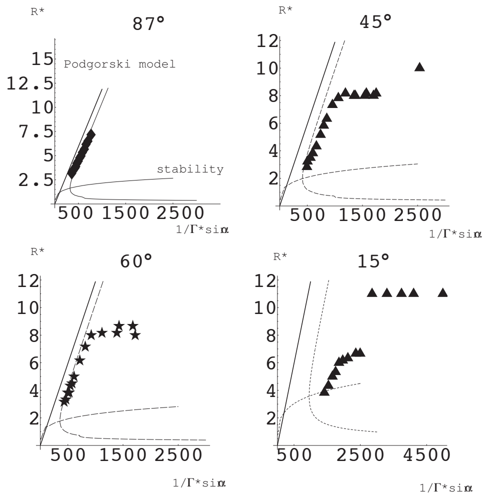

FIG. 2 – Theorie and experiments for a ($\eta = 18,5cP$) oil. $\Gamma^* = \frac{\Gamma}{U_c l_c}$ *and* $R^* = R/l_c$

In this work, we also investigate less viscous fluid where inertia plays an important role in the flow of both the film and the rim. This allow us to derive a new equilibrium shape and as for the viscous case we can introduce the capillary forces due to the radius of curvature to predict the loss of stability of the dry patch. A full model combining both inertial and Stokes limit is still on the progress

Références

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