Film flows over topography – Recent advances

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The study on film flows over topography is a key feature for many coating technologies, e.g. for spin coating. Detailed studies on two-dimensional free surface flows has been performed in the past, most of them based on the lubrication approximation of the equations of motion. In the present paper recent simulation techniques are used in order to study generalized cases like e.g. 3D films over topography, two-layer flows and films of non-Newtonian liquids.

Recently, by introduction of an auxiliary potential field [1,2], a first integral of the two-dimensional Navier-Stokes equations has been constructed which can be used for coating flows in beneficial ways. It has been shown that by application of this alternative approach to free surface flows the dynamic boundary condition is reduced to a standard Dirichlet-Neumann form, which allows for an elegant numerical treatment. Discretization of the new formulation via a least-squares FEM delivers an efficient method producing accurate results [1], shown for instance by fig. 2a. The procedure is naturally extendable to multilayer film flows. Furthermore the mentioned auxiliary potential field is connected with a stress potential and a modified version of the method is also applicable to fluids with a generalized stress tensor, e.g. power law fluids (fig. 2b). Also perspectives toward the simulation of 3D film flow over topography are discussed.

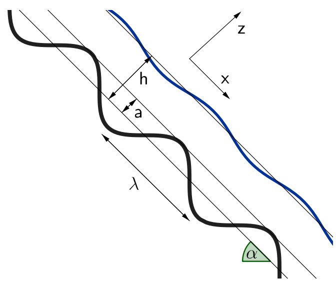

Fig. 1: Principle set-up for gravity-driven film flow over topography.

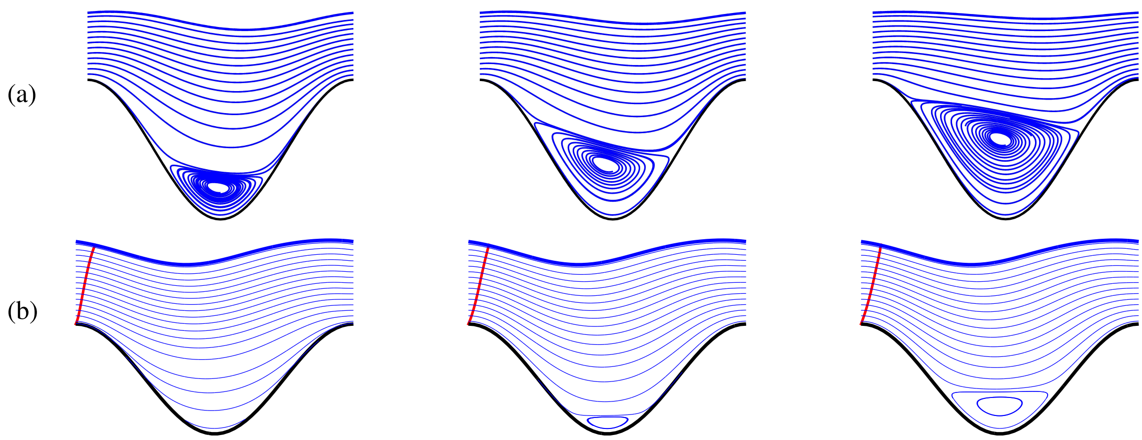

Fig. 2: Different film flow examples. (a) Varying Reynolds number effect at constant geometry data: $\alpha = 45°$ and $h/a = 1$. The Reynolds number from left to right is Re = 30, 50, 100. (b) Shear thinning / thickening effect of a power-law fluid under Stokes conditions. The constant geometry data is: $\alpha = 15°$ and $h/a = 1.5$ and the power-law exponent from left to right is ε = 0.2, 1.0, 1.8 ($\varepsilon = 1$ corresponds to a Newtonian fluid).

References

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