Steady Flow of a Uniform Rivulet Down a Vertical Wall

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Abstract. We investigate the steady flow of a uniform rivulet down a vertical wall. This problem has many applications, which are easily found in everyday life, such as paint running down on a canvas and chocolate syrup flowing over a cake. In nature, examples can be seen in the lava flow from an erupting volcano and melting glaciers. Initial studies, such those of Towell & Rothfeld [1] and Allen & Biggin [2], employed a thin-film approximation to determine the free surface profile, as a function of the static contact angle, and the velocity field. Duffy & Moffatt [3] have also studied the problem within the framework of the lubrication theory. In the present study, we have mapped the physical domain (free-surface profile) onto a rectangular computational domain and then solved the full problem (Navier-Stokes equations) numerically using a finite difference method. The code was validated with an exact solution presented by Perazzo & Gratton [4]. Furthermore, a new lubrication approximation was formulated using gradient dynamics based on the recent work of Lopes et al. [5]. The results were compared with the ones obtained previously in the literature and it was found that the new developed model is not only the most accurate among the reduced models, but also that it works well beyond the range of applicability of the standard lubrication theory.

References

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