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RIMMING FLOW AROUND AN ELLIPTIC CYLINDER

André von Borries Lopes[1,*], Vinícius Coutinho da Silva[1]

[1] *Department of Mechanical Engineering, University of Brasília (UnB), Brasília, DF, Brazil*

ABSTRACT

This work studies rimming flow around an elliptic cylinder, a configuration in which a viscous liquid film is transported by the motion of a solid boundary while gravity and capillarity compete to redistribute the free surface. Although rimming flow around circular cylinders has been widely used as a reference problem for thin-film dynamics, the elliptic cylinder introduces a spatially varying curvature and a non-uniform distance from the rotation center to the wall. These geometric effects can produce significant changes in the film thickness, the position of accumulation regions, and the conditions under which steady or nearly steady configurations are maintained.

The analysis considers a two-dimensional incompressible viscous film attached to the exterior of a rigid elliptic cylinder. The governing equations are expressed in a curvilinear description associated with the cylinder boundary, so that the local metric and curvature terms are included in the pressure and momentum balances. In the thin-film limit, the resulting model leads to a lubrication-type equation for the free-surface profile along the perimeter. This framework makes it possible to compare the effects of eccentricity, angular motion, gravitational forcing, and surface-tension regularization on the rimming layer.

A set of representative computational cases is presented to demonstrate how the elliptic geometry modifies the behavior expected from the circular-cylinder limit. In particular, the film tends to respond strongly near portions of the boundary where curvature and gravitational projection vary rapidly, producing asymmetric profiles even when the imposed motion is uniform. The study emphasizes the role of geometry in rimming-flow stability and in the redistribution of liquid around non-circular rotating bodies. The results may support future analytical investigations and can serve as benchmark solutions for reduced-order descriptions of thin films on curved moving surfaces.

***K*eywords** rimming flow · elliptic cylinder · thin films · lubrication theory · free-surface flow

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[*] *Corresponding Author's E-mail: andre.lopes@unb.br*