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COATING FLOW AROUND AN ELLIPTIC CYLINDER

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ABSTRACT

This work investigates coating flow around an elliptic cylinder as a canonical configuration for free-surface viscous transport over curved bodies with non-uniform curvature. The elliptic cross-section introduces a geometric variation that is absent in the circular-cylinder case and therefore modifies the local balance between viscous stresses, capillary pressure, gravity effects, and the imposed motion responsible for carrying the liquid layer along the solid boundary. The main objective is to describe how the film distribution is affected by the aspect ratio of the ellipse and by the orientation of the major and minor axes, with particular attention to the formation of thin regions, accumulation zones, and possible loss of uniformity along the perimeter.

A two-dimensional model is considered in which the coating layer is treated as a viscous incompressible fluid surrounding a rigid elliptic cylinder. The formulation is written in a coordinate system adapted to the solid boundary, allowing the local curvature and metric factors to enter the governing equations explicitly. Under conditions in which the film thickness is small compared with the characteristic cylinder size, the flow can be reduced to a lubrication-type description for the evolution of the free surface. This reduced formulation provides a direct way to examine how geometric asymmetry changes the pressure gradient and the tangential velocity field along the wall.

Representative computational cases are used to illustrate the sensitivity of the coating thickness to eccentricity and to changes in the operating parameters. The results highlight that the elliptic geometry can enhance spatial variations in the film profile, especially near regions of stronger curvature. These observations are relevant for coating processes involving non-circular components and provide a basis for future analytical studies that may use the present solutions as benchmark cases for asymptotic or reduced-order models.

***K*eywords** coating flow · elliptic cylinder · thin films · viscous flow · free-surface flow

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