Seminário de Mecânica

Understanding the production of multifunctional thin films: The fluid mechanics of free surface coating flows

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Abstract.

Coating processes are the main step for manufacturing multifunctional films that find important applications in many areas, like optics, electronics, energy storage, and biomedicine. Among the many coating methods available, slot coating is one of the preferred options for high-precision coatings. Slot coating flows are highly complex because of the presence of free surfaces and moving boundaries. As such, their dynamics rely on an intricate balance between viscous, pressure, and capillary forces with the potential inclusion of inertial and non-Newtonian effects. In this talk, I introduce the fundamentals of slot coating flows and its operating limits. The model consists of the equations of motion for a Newtonian liquid coupled with an elliptic mesh generation strategy to capture the free surfaces. The resulting set of equations is solved with Galerkin's finite element method, Newton's method, analytical Jacobian, and first-order pseudo-arclength continuation in the parameter space. The simulations reveal many interesting features of slot coating flows, such as the eventual formation of large recirculation zones in the coating bead when the prescribed film thickness is sufficiently thin. The onset of the low-flow limit – that is, the minimum film thickness that can be coated at a given web speed maintaining the operation stable and the delivered liquid layer uniform and free of defects – is also discussed in detail. In addition, I present some of the recent advances in the field of coatings research. For instance, predictions of slot coating with yield-stress materials show that viscoplasticity suppresses the formation of vortices in the flow. As a result, the operating window of the process becomes larger, suggesting that one can use viscoplastic materials to coat either thinner or faster in comparison to the Newtonian standards.