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# Implementation of an ALE-based FE method for additive manufacturing processes

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## Abstract

Additive manufacturing allows for on-demand production of functional constructs through an accurate layer-by-layer deposition of filaments. These are generally made of polymer-based materials that exhibit shear-thinning and viscoelastic features. The shear-thinning behavior eases the extrusion process inside the nozzle, while viscoelasticity plays a significant role as the material flows outside, where the extrudate-swell phenomenon occurs. This latter causes a loss in printing resolution since the relaxation of polymer chains.

To accurately describe variations in the extrudate configuration beyond the nozzle outlet, a free-surface problem should be addressed. Modeling viscoelastic flows with moving boundaries is demanding since the intricate interplay between elasticity and capillarity. This complexity can result in localized and significant changes in surface curvature, as well as abrupt alterations in stress distribution within these regions.

In this framework, the aim of the present work is to investigate the extrusion process by means of finite element (FE) formulation. The free-surface problem is addressed by numerically solving the incompressible and isothermal Cauchy equations coupled with viscoelastic differential constitutive models. An Arbitrary Lagrangian-Eulerian (ALE) description is adopted to track moving boundaries alongside the numerical solution. Numerical predictions of this ALE-based FE formulation are presented for various additive manufacturing applications.

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