INJECTION OF A BUBBLE INSIDE AN ELASTIC YIELD-STRESS FLUID

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ABSTRACT

The formation of gas bubbles inside yield-stress materials takes place in various industrial processes, such as mineral, chemical or biological ones. The peculiarity of yield-stress materials to behave both as solids and fluids, depending on the applied stress magnitude, makes the gas bubble injection in them non-trivial. Moreover, the innate elastic response of those materials adds further complexity. We examine the transient inflation of an air bubble through a nozzle inside an elastic yield stress material. We fit the Saramito/Herschel-Bulkley[1] model to a dense 0.5% aqueous Carbopol solution. We solve the governing equations assuming axial symmetry by using the stabilized finite element formulation by Varchanis et al.[2], PEGAFEM-V, and we compare our results with respective experiments[3]. Our simulations can capture accurately the transient experimental shapes of the cavity, which initially grows and then expands radially. The pressure of the bubble exhibits a non-monotonic behavior, increasing as the bubble starts to form, and then decreasing after the bubble has become large enough, due to capillary phenomena being weakened. We analyze the flow and stress fields around the growing cavity, as well as the yielded/unyielded regions. Due to the elastic deformability of the medium, yielded material appears only in a region near the bubble front. Finally, we conduct a parametric analysis on the radius of the nozzle and the air flowrate, as well as some fluid properties of interest.

KEYWORDS: Yield stress, Injection, Bubble, Elasticity

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