Residual-based variational multiscale simulation of viscoplastic flows

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ABSTRACT

Non-Newtonian fluids are of high importance for many science and engineering applications. They occur in industry, as well as, in nature processes. Examples are polymer melts, paints, coatings, lava and mud flows. Due to the high complexity and non-linearity of computations of such flows, a robust formulation is needed for stable and effective simulations[1, 2, 3].

In this study we apply the residual-based variational multiscale method (RB-VMS) to viscoplastic fluids. The VMS method decomposes primary variables, such as velocity and pressure, into a finite element component and subscale component. As viscoplastic fluids we consider constitutive models of a Bingham and a Power Law fluid. We use an edge-based Navier-Stokes solver combined with an advection-diffusion transport equation, including the RB-VMS formulation, adaptive time step control and inexact Newton solvers [4].

As an example a free surface flow is computed using the volume-of-fluid method (VOF) formulation with modifications of the interface capturing variable which is derived from the coarse and fine velocity field component [5]. Two different cases are studied. First, a 3D benchmark lock exchange is computed using a Power Law fluid. In the second case the same geometry is used considering a Bingham fluid. Results are compared to previous studies, analyzed and discussed [6].

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