AN ADAPTIVE DISCRETE NEWTON METHOD FOR REGULARIZATION-FREE BINGHAM MODEL IN YIELD STRESS FLUIDS

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ABSTRACT

Developing a numerical and algorithmic tool which correctly identifies unyielded region in the yield stress fluid flow is a challenging task. Two approaches are commonly used to handle the singular behaviour at the yield surface, i.e. Augmented Lagrangian approach and the regularization approach, respectively. Generally in the regularization approach, solvers do not perform efficiently when the regularization parameter gets very small. In this work, we use a formulation introducing a new auxiliary stress [1]. The three field formulation of yield stress fluid corresponds to a regularization-free Bingham formulation. The resulting set of equations arising from the three field formulation is solved efficiently and accurately by a monolithic finite element method. The velocity and pressure are discretized by higher order stable FEM pair Q_2/P_1^{disc} and the auxiliary stress is discretized by Q_2 element.
Furthermore, this problem is highly nonlinear and presents a big challenge to any nonlinear solver. We developed a new adaptive discrete Newton's method, which evaluates the Jacobian with the directional divided difference approach [2]. The step length in this process is an important key: We relate this length to the rate of the actual nonlinear reduction for achieving a robust adaptive Newton's method. The resulting linear sub problems are solved using the geometrical multigrid solver. We analyse the solvability of the problem along with the adaptive Newton method for Bingham fluids by doing numerical studies for two different prototypical configurations, i.e. "Viscoplastic fluid flow in a channel"[2] and "Lid Driven Cavity", respectively.

References

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