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Stabilized mixed formulation for an implicit Material Point Method for viscoplastic fluids by using the variational subgrid-scale framework

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The solution of solid mechanics problems in large displacement and large deformation regime, dealing with incompressible or nearly incompressible materials, is a topic of paramount importance in the computational mechanics community. Many engineering problems requires the simulation of complex materials under such conditions.
In particular, simulation of granular flows remains a challenge under the mathematical and computational perspective. In some specific cases, the standard Galerkin displacement-based formulation fails, because the formulation is unable to evaluate correctly the strain field. For this reason, in this work a mixed formulation is chosen. However, this formulation does not satisfy the well-known inf-sup condition and therefore a stabilization technique is required to obtain stabilized results.

This work presents two main contributions: on the one hand the development of a mixed formulation for free surface viscoplastic fluids in a nonlinear solid mechanics framework considering both a weakly-compressible and an incompressible regime. On the other hand, two different stabilization techniques are employed for solving the dynamic problem in mixed formulation. Both stabilization techniques are based on the variational multiscale (VMS) method. In order to deal with large material deformation, an implicit Material Point Method is employed. This framework has many advantages that allows to avoid the classical limitations of the Finite Element Method, for example the element tangling and extreme mesh distortion. The proposed mixed formulations, with displacement and pressure as primary variables, are tested through classical benchmarks. Further, the stabilized mixed formulation based in the VMS method is compared with other stabilization techniques such as the Polynomial Pressure Projection [1], to assess their accuracy.

REFERENCES

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