6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

An upwind cell centred Total Lagrangian scheme for nearly incompressible explicit solid dynamics in OpenFOAM

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Keywords: *Large strain dynamics, Finite Volume Method, Riemann solver, OpenFOAM*

A computational framework is presented for the numerical simulation of large strain explicit solid dynamics with particular emphasis on near incompressibility [1]. A set of first order hyperbolic conservation equations [1, 2] expressed in terms of the linear momentum and the minors of the deformation, in conjunction with a polyconvex nearly incompressible constitutive law, is presented. From the spatial discretisation standpoint, a cell centred finite volume algorithm is employed where discontinuity of the conservation variables across the control volume interface leads to a Riemann problem. This requires special attention when attempting to model materials with nearly incompressible behaviour by employing an acoustic Riemann solver combined with a preconditioning procedure. A global a posteriori angular momentum projection procedure together with a monolithic TVD Runge-Kutta time integrator ensures the conservation of angular momentum. Additionally, an adapted Total Lagrangian version of the nodal scheme of Kluth and Després [3] is also implemented in OpenFOAM and presented for comparison purposes.

The proposed methodology has been implemented from scratch in the modern Computational Fluid Dynamics code "OpenFOAM", with the aim of bridging the gap between computational fluid and solid dynamics. It is further ensured that the implemented solid solver can be run on a parallel architecture by utilising the in-built parallel capabilities of OpenFOAM. Finally, a series of challenging numerical examples are examined.

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