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COUPLED THERMO-MECHANICAL FINITE ELEMENT TECHNOLOGY FOR STRESS ACCURATE ANALYSIS

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This work exploits the concept of mixed finite element methods to formulate a stress accurate technology to handle isochoric (preserving the original volume) deformations. A velocity/(deviatoric) stress/pressure formulation with linear interpolation for the three fields is stabilized via Variational Multi Scale (VMS) method. The final goal is to design a robust finite element technology able to tackle highly non-linear analyses, which can show both stress and strain localizations. This is a mandatory requirement in the majority of numerical simulations of industrial manufacturing processes, where large plastic deformations are induced by metal forming operations.
Numerical analysis of both Frictional Stir Welding (FSW) and extrusion processes are addressed, adopting and Eulerian/ALE kinematic framework together with a fluid-like behaviour such as non-Newtonian power-law type or more sophisticated Carreau type models. The thermal effects induced by the plastic dissipation are also considered by means of a coupled thermo-mechanical formulation solved using a staggered time-stepping algorithm based on an isothermal operator split of the governing equations.
Numerical instabilities induced by the convective term are controlled with VMS stabilization method.
The final finite element technology is demonstrated in a number of numerical benchmarks to show both robustness and accuracy.

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