A novel stress-accurate FE technology for the numerical simulation of the FSW process.

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ABSTRACT

In this work a novel finite element technology based on a three-field mixed formulation is presented. The Variational Multi Scale (VMS) method is used to circumvent the LBB stability condition allowing the use of linear piece-wise interpolations for displacement, stress and pressure fields, respectively. The result is an enhanced stress field approximation which enables for stress-accurate results in non-linear computational mechanics [4-5]. The use of an independent nodal variable for the pressure field allows for an ad-hoc treatment of the incompressibility constraint. This is a mandatory requirement due to the isochoric nature of the plastic strain in metal forming processes.

The highly non-linear stress field typically encountered in the Friction Stir Welding (FSW) process is used as an example to show the performance of this new FE technology. The numerical simulation of the FSW process is tackled by means of an Arbitrary-Lagrangian-Eulerian (ALE) formulation [1-3]. The computational domain is split into three different zones: the work-piece (defined by a rigid visco-plastic behaviour in the Eulerian framework), the pin (within the Lagrangian framework) and finally the stir-zone (ALE formulation).

A fully coupled thermo-mechanical analysis is introduced showing the heat fluxes generated by the plastic dissipation in the stir-zone (Sheppard rigid-visco-plastic constitutive model) as well as the frictional dissipation at the contact interface (Norton frictional contact model).

Finally, tracers have been implemented to show the material flow around the pin allowing a better understanding of the welding mechanism.

Numerical results are compared with experimental evidence.

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