Development of an inverse module and of a semi-analytical sensitivity analysis for thermo-mechanical parameters identification

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Abstract :

Numerical simulations of forming processes require a good knowledge of the constitutive parameters of the material. These parameters are identified using laboratory tests close to the forming process boundary conditions. If mechanical tests involve large strain, the material flow may not be homogeneous and the use of an inverse model may be necessary.

The present paper describes an inverse method coupled with a finite element software. The direct model solves a strongly coupled thermo-mechanical equilibrium problem using an incremental approach. Since the discrete system is non–linear, it is solved using an iterative procedure based on Newton-Raphson algorithm. State variables are updated using a Lagrangian formulation and automatic remeshing algorithm is used to avoid element degeneracy.

The inverse problem is presented as the minimisation of a least square function and is solved using a stabilised Gauss-Newton algorithm. The sensitivity analysis is done using a semi-analytical method, which permits to identify various model parameters without any additional computational effort. Furthermore, this method is compatible with the remeshing algorithm contrary to the classical finite difference scheme.

When the number of parameters to identify is relatively important, the Gauss-Newton method may become unstable due to correlation effects between the parameters. It is shown that for the identification of complex constitutive law parameters, the inverse problem becomes ill-conditioned. A stability analysis is presented in order to understand the reasons of the unstability and a stabilisation method is proposed.