A thermo-elasto-viscoplastic constitutive model for residual stresses in FSW

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ABSTRACT

This work deals with the prediction of the residual stresses in the Friction Stir Welding (FSW) process. The FSW process is a relatively recent welding process. FSW is a solid-state joining process during which materials are not melted. Thus, the heat-affected zone is smaller and the quality of the welding is better with respect to more classical welding processes. In spite of the important number of applications of the FSW, the phenomena happening during the welding are still not well understood. Therefore, the investigations on this process and especially regarding numerical simulations are still very active [1, 2, 3]. A rotating non-consumable tool is inserted between the two work-pieces to be joined and displaced along the welding direction. As the material in the neighbourhood of the tool is submitted to extremely high strains resulting from the mechanical intermixing of the two materials by the tool, advanced numerical simulation techniques have to be extended and developed in order to track the actual material deformation. The 3D numerical model of the FSW process presented uses the Arbitrary Lagrangian Eulerian (ALE) formulation to control the mesh displacement regardless of the real material displacement [4]. In addition, to be able to model the FSW process with a non-cylindrical pin, a remeshing operation is periodically required [5].

The mechanical properties of the weld in service crucially depend on the residual stress field. To accurately predict this residual stress field, a thermo-elasto-viscoplastic constitutive model is used in the simulations for the material plates. This constitutive model is used both during FSW process, as well as during the cooling phase.

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