Crystal Plasticity Finite Element Process Modeling for Hydro-forming Micro-tubular Components

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Abstract: Micro-tubes manufactured by hydro-forming techniques have now been widely used in medical and microelectronics applications. One of the difficulties in forming such parts is the control of localized necking in the initial stages of the deformation/forming process. A lack of microstructural information causes conventional macro-mechanics finite element(FE) tools to break down when used to investi-gate the localized microstructure evolution and necking encountered in micro-forming. An effort has been made to create an integrated crystal plasticity finite element(CPFE) system that enables micro-forming process simulations to be carried out easily, with the important features in forming micro-parts captured by the model. Based on Voronoi tessellation and probability theory, a virtual GRAIN(VGRAIN) system is created for generating grains and grain boundaries for micro-materials. Numerical procedures are developed to link the physical parameters of a material to the control variables in a Gamma distribution. A script interface is developed so that the virtual microstructure can be input to the commercial FE code, ABAQUS, for mesh generation. A simplified plane strain CPFE modeling technique is developed and used to capture localized thinning and failure features for hydro-forming of micro-tubes. Grains within the tube workpiece, their distributions and orientations are generated automatically by using the VGRAIN system. A set of crystal viscoplasticity constitutive equations are implemented in ABAQUS/Explicit by using the user-defined material subroutine, VUMAT. Localized thinning is analyzed for different microstructures and deformation conditions of the material using the CPFE modeling technique. The research results show that locations of thinning in forming micro-tubes can be random, which are related to microstructure and grain orientations of the material. The proposed CPFE technique can be used to predict the locations of thinning in forming micro-tubes.

Key words: micro-mechanics modeling, micro-forming, hydro-forming

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