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Molten Sheet Metal Shaping, A Multi-Scale Friction Scale and Its Formulation

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Editorial

In the finite element (FE) simulation of the sheet metal forming process, an accurate representation of friction is crucial. Friction is frequently oversimplified by using a constant Coulomb friction coefficient. The use of an existing multi-scale friction model to the hot stamping process is explored in this work. During hot stamping, the model takes into account the effects of tool and sheet metal surface topography, as well as the evolution of contact pressure, temperature, and bulk strain. To calibrate the model, normal load flattening and strip drawing experiments are carried out. When the tool surface evolution due to wear is taken into account, the findings show that the model can reasonably forecast friction in strip draw experiments. Finally, the FE simulation of a hot-stamped item was used to demonstrate the use of the defined multistate friction model.

In the automotive sector, hot stamping is utilised to create high-strength structural elements. A sheet metal blank is heated in a furnace, shaped at high temperatures (600–800ºC), and then quenched in a press to produce a high-strength item with acceptable geometrical accuracy. The hot-stamped steel is commonly coated with Al-Si alloy to minimise scaling during austenitization and offer corrosion protection to the end product. In the metal forming business, finite element (FE) simulations are currently employed for feasibility assessments and process parameter optimization. The material and friction behaviours in these FE models should be precisely characterised to accurately anticipate the stresses and strains. The material behaviour of hot-stamped steels has been widely studied in the past. However, the use of a constant Coulomb friction coefficient (COF) in FE simulations of hot stamping operations oversimplifies the description of friction, and the actual conditions are not effectively represented. This research is focused on describing these circumstances. At high temperatures, friction models have been devised and applied to a variety of forming processes. Stupkiewicz and Mróz, for example, created a three-body contact model to explain friction in hot metal forging. Hard third-body particles imbedded in the work piece surface layer represent the oxide scale. The concept is based on a micromechanical model that involves particle contact with a hard tool surface and a soft work piece interface. For aluminium extrusion, Wang created a friction model. The rate of atomic interaction and the strength of adhesive junctions are the two elements that influence the strength of the adhesive junction in this model. Another option is to use a phenomenological model to produce a database of COFs that can be integrated into commercial FE software packages. In the FOSTA P871 project, this method was examined for hot stamping.

The model is a function of temperature, pressure, and velocity; however, the effect of tool and sheet surface topography on the COF is not taken into account. In addition, a database must be built for each unique tool and sheet material combination. The calibration of the friction model was demonstrated in the simulation of a hot-stamped part production. The chosen component was found to be friction-insensitive. As a result, it is suggested that the multi scale friction model be validated on a more friction-sensitive product. Finally, the calibrated friction model developed in this research can be used to better understand the friction mechanism and the impact of various process parameters on hot stamping.

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