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Detailed thermal and material flow analyses of Friction Stir Forming using a three-dimensional particle based model

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Abstract

The Material Point Method is proposed as a framework to model friction stir forming. The flexibility of the method allows for the development of a fully coupled thermo-mechanical model which includes heat transfer processes due to plastic dissipation as well as frictional heating. A procedure is proposed to fully determine all numerical parameters from experimental data, thus eliminating the need for further calibration of the results. The model was used to gain insight into heat transfer mechanisms and material flow in friction stir forming of copper plates. Experimental verification of the results confirmed the predictive capability of the model. The predicted temperatures were in satisfactory agreement with thermocouple data while the material flow in the model compared reasonably well with experiments, thus providing a useful tool for analysing the complex physical mechanisms at play in friction stir forming.

Keywords: Friction Stir Forming, Friction Stir Processing, Material Point Method, material flow, large deformations, modeling