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A fast and accurate two-stage strategy to evaluate the effect of the pin tool profile on metal flow, torque and forces in friction stir welding

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Abstract

Pin geometry is a fundamental consideration in friction stir welding (FSW). It influences the thermal behaviour, material flow and forces during the weld and reflects on the joint quality.

This work studies four pin tools with circular, triflute, trivex, and triangular profiles adopting a validated model of FSW process developed by the authors. The effect of the rotating tool geometry on the flow behaviour and process outcomes is analysed. Additionally, longitudinal and transversal forces and torque are numerically calculated and compared for the different pin shapes. The study is carried out for slip and stick limiting friction cases between pin and workpiece.

The main novelties of the paper are a "speed-up" two-stage simulation methodology and a piecewise linear version of the constitutive model, both of them conceived for the use in real case industrial applications, where the achievement of accuracy with affordable simulation times is of importance.

The Norton-Hoff constitutive model is adopted to characterize the material behaviour during the weld. The piecewise linear version of the model developed by the authors greatly facilitates the convergence of the numerical solution ensuring both computational efficiency and accuracy. A two-stage computational procedure is applied. In the first stage, a forced transient is carried out; in the second one, the magnitudes of interest are computed.

The study shows that the proposed modelling approach can be used to predict and interpret the FSW behaviour for a specific pin geometry. Moreover, the reduction of the simulation time using the two-stage strategy can be up to 90%, compared to a standard single stage strategy.

***Keywords**: Pin profile, FSW, Friction, Force, Torque, Temperature*