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Computational modelling of Inertia Friction Welding

Ross Williams[1], Daniele Barbera[1], Euan Wielewski[1] and Andrew McBride[1]

[1] School of Engineering, University of Glasgow, Glasgow, G12 8QQ, UK, www.gla.ac.uk
r.williams.2@research.gla.ac.uk, Daniele.Barbera@glasgow.ac.uk,
Euan.Wielewski@glasgow.ac.uk, Andrew.McBride@glasgow.ac.uk

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This study details the development and validation of a finite element methodology to robustly simulate the inertia friction welding (IFW) process. IFW allows for the welding of complex alloys and dissimilar materials. This is not possible using conventional fusion processes. IFW is thus attractive to the aerospace sector. The process is driven by the friction due to contact at the weldline. Here, the temperature of the material is raised during the conditioning phase in order to promote plastic flow. Friction welding in general is a difficult process to model. There are the extremely high temperature gradients in the vicinity of the weld interface and the material undergoes large deformations. Further challenges arise from the short and violent process to complete a weld and the inability to halt welding mid-weld on account of the flywheel inertia. These factors make it challenging to obtain experimental data for comparison. As such, a model which is able to better-predict the macroscopic response of a weld is of great use in industry for optimising process parameters. The current objectives of this work are the prediction of welding process parameters and thermomechanical material response. In order to model IFW it is necessary to employ finite strain thermoplasticity theory to capture the large, highly-coupled, plastic deformations observed during the process. In addition to this, a crucial region of focus is on the contact conditions, particularly at the weld interface. This is an area where there is little understanding of this process, yet it can significantly affect the resulting weld. Finally, it is necessary to correctly characterise the thermal boundary conditions throughout the IFW process. Due to the inherent large deformations, broad temperature range and medium-to-high strain rate, a modified Johnson-Cook model is assessed to characterise the von Mises yield stress. The large deformation caused by the welding process, tends to disrupt the Lagrangian mesh quality. For this reason, a robust and automatic remeshing scheme is implemented and typical features such as the flash and weld surfaces are identified.