Title: Small strain finite element modelling of friction stir spot welding of Al and Mg alloys

Authors: P. Jedrasiak, H.R. Shercliff

PII: S0924-0136(18)30327-3
DOI: https://doi.org/10.1016/j.jmatprotec.2018.07.031
Reference: PROTEC 15858

To appear in: *Journal of Materials Processing Technology*

Received date: 21-3-2018
Revised date: 24-7-2018
Accepted date: 25-7-2018

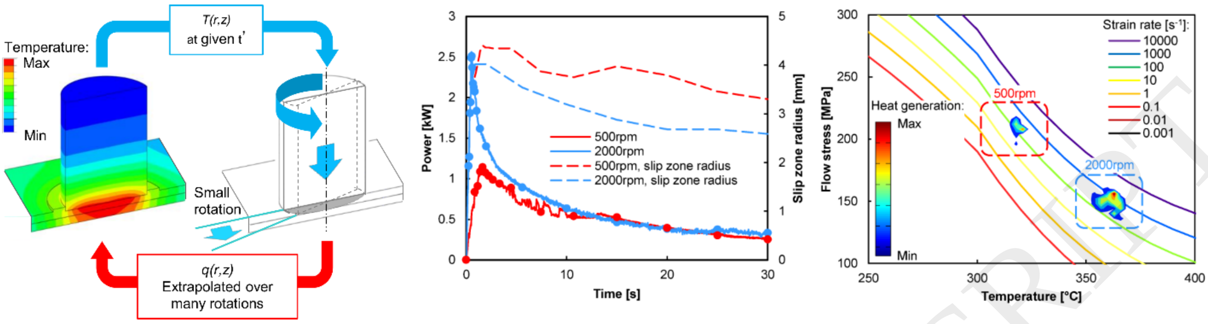
Please cite this article as: Jedrasiak P, Shercliff HR, Small strain finite element modelling of friction stir spot welding of Al and Mg alloys, *Journal of Materials Processing Tech.* (2018), https://doi.org/10.1016/j.jmatprotec.2018.07.031

Small strain finite element modelling of friction stir spot welding of Al and Mg alloys

Jedrasiak P.[1,2] and Shercliff H.R.[1,*]

[1] Department of Engineering, University of Cambridge, Trumpington St, CB2 1PZ, UK.
[2] TWI, Granta Park, Cambridge, CB21 6AL, UK
* Corresponding author: hrs@eng.cam.ac.uk (44-1223-332683)

Graphical Abstract



Abstract

A finite element model was developed to predict the spatial and temporal variation of heat generation and temperature in FSSW of aluminium and magnesium alloys. Heating by friction and bulk plasticity is computed at intervals using small-strain elastic-plastic analysis for a small fraction of one tool rotation. This runs in parallel with a conventional thermal analysis running for the whole weld cycle. The model was tested at two tool rotation speeds with experimental data for three wrought aluminium alloys, and two casting alloys (one aluminium and one magnesium). Heat generation history was found to be remarkably similar for both rotation speeds and across all five alloys. A key aspect of the model is the use of a physically-based kinematic boundary condition at the tool-workpiece interface, with the surface velocity profile having an inner sticking region and an outer slipping region. The method shows the potential for rapid calculation of heat input and temperature fields in large strain frictional processes such as FSSW, without recourse to fully coupled explicit FE analysis.

Keywords: Friction stir spot welding; aluminium alloys; magnesium alloys; process modelling; finite element analysis.

1. Introduction

Friction stir spot welding (FSSW), shown schematically in Figure 1, is a potential sheet joining process for automotive applications. A rotating cylindrical tool made from a hard, wear-resistant material, is plunged into two overlapping plates, and retracted after a dwell time of the order of 1s. This short cycle time and its suitability for thin sheets (~1mm) make the process a viable alternative to resistance spot welding (RSW) and self-piercing rivets (SPR). Conventional FSSW tools leave a hole, associated with low static strength (Badarinarayan et al., 2007) or cracking (Yamamoto et al., 2007). As a consequence, attempts have been made to eliminate the hole using a refill variant of FSSW (Uematsu et al., 2008), or a pinless tool (Bakavos and Prangnell, 2009; Bakavos et al., 2010).