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Numerical Methods in the Simulation of Friction Stir Welding*

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ABSTRACT

Friction stir welding (FSW) was invented by the welding institute (TWI) in UK in 1991 as a new solid joining technique which is advantages for joining some hard-to-weld metals by traditional fusion welding such as aluminium alloys, magnesium alloys, etc. This is the reason why FSW can become more and more interesting to numerous scientists and engineers and is quickly applied to industries of manufacturing in aerospace, automobile, ship, etc.

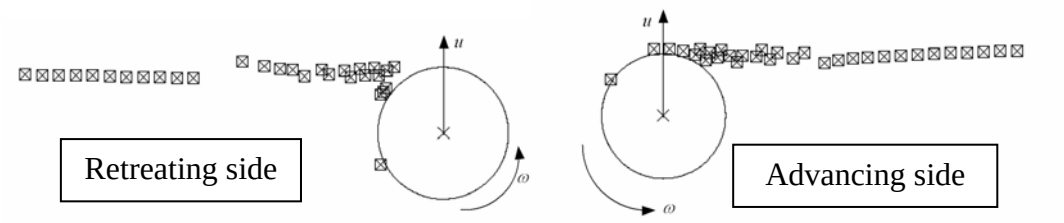

Fig. 1 Prediction of material flow in 2D semi-coupled thermo-mechanical model

Although FSW has been developed for more than seventeen years, many questions remain ambiguous, such as the metal flows, formations of weld defects, evolutions of textures, residual stresses, temperature rises, etc. So, different numerical methods are developed for the investigations of these problems. Semi-coupled thermo-mechanical model of FSW [1, 2] can reduce the computational costs greatly and is available for the studies of material flows, as shown in Fig. 1. Although the fully coupled model of FSW [3, 4] can be time-consuming, the temperature rises on friction stir weld and welding tool can be predicted, as shown in Fig. 2. Based on this model, formation of weld defects can be further studied. In the simulations of FSW based on solid mechanics, contact models should be carefully defined because this is very important for the accurate prediction of temperature rise and material behaviours. When the friction stir welding has been completed in the numerical model, the fixtures can be released and the

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temperature can be reduced to room temperature for the prediction of the residual stresses [5].

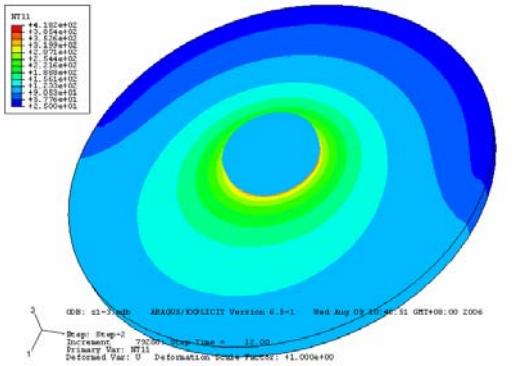

Fig. 2 Temperature rise of friction stir weld and welding tool

Based on the developed models by the authors, recrystallization theory can be directly coupled into these models for the predictions of grain size evolutions in FSW, as shown in Fig. 3. Comparison shows that the predicted grain sizes in a fully coupled thermo-mechanical model can be more accurate to the ones in a real manufacture.

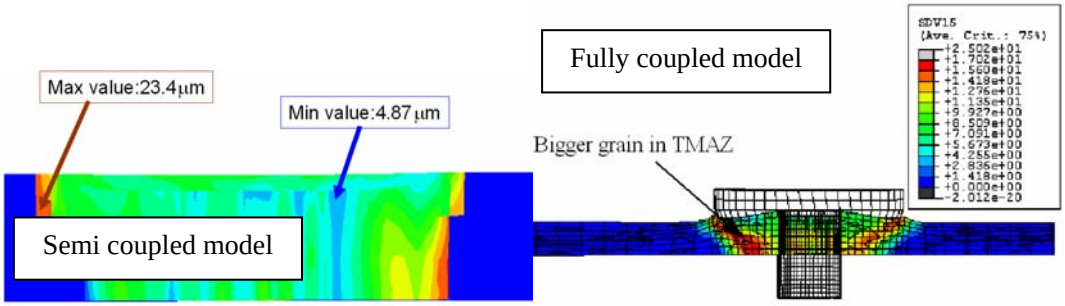

Fig. 3 Prediction of grain sizes in friction stir welds

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