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FLOW RULE BASED SIMULATION OF GRAIN AND SZ SIZES IN FRICTION STIR WELDING

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Compared to the other traditional joining techniques, Friction Stir Welding (FSW) shows its advantages in joining light alloys such as aluminium alloy, magnesium alloy, titanium alloys, etc. Different numerical models have been developed for the investigations on the heat generations, the material flows, the residual distortions and residual stresses, the tool forces and even the microstructural changes. In fact, the changes of the grain sizes in the welding zone are determined by the deformation and the temperature histories in the FSW process. The material flow rules in FSW have been studied in detail [1, 2]. Based on the material flow rule of each traced particle, the histories of the strain rates and the temperatures can be calculated and be further used for the prediction on the grain size evolutions in the welding zone. The movements of the material particles can be useful for the determination of the different welding zones on the cross section of the friction stir weld.

A fully coupled thermo-mechanical model [3] is used for the simulation of the FSW process. ALE method is used for the controlling of the mesh distortions in the local region around the welding tool. The movements of the material points are used for the calculations of the true strain rates. Strain rates and temperatures are used to calculate the Zener-Hollommon parameter and then the grain size are calculated based on the Zener-Hollommon parameters. Results indicate that the different weld regions can be distinguished according to the different material flows of the traced particles. The widths of the Thermo-Mechanical Affected Zone (TMAZ) and the Stirring Zone (SZ) become narrower in smaller shoulder diameter. Smaller shoulder can lead to smaller grain size in SZ due to the lower welding temperature. Smaller pin leads to narrower SZ but wider TMAZ. With the increase of the rotating speed, the width of the SZ can be increased on the top surface but be hardly affected near the bottom surface. The grain size in SZ can be increased with the increase of the temperture and can be decreased with the increase of the strain rates. But the influence of the temperature is much more important in teh prediction of the grain sizes. Monte Carlo method can be used to obain the detaield information of the grain evolutions.

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REFERENCES

[1] Z. Zhang and J. T. Chen, Computational investigations on reliable finite element based thermo-mechanical coupled simulations of friction stir welding, *Int. J. Adv. Manuf. Technol.*, Vol. 60, pp. 959-975 2012.

[2] Z. Zhang and H. W. Zhang, Numerical studies on controlling of process parameters in friction stir welding, *J. Mat. Process. Technol.*, Vol. 209, pp. 241-270, 2009.

[3] Z. Zhang and H. W. Zhang, A fully coupled thermo-mechanical model of friction stir welding, *Int. J. Adv. Manuf. Technol.*, Vol. 37, pp. 279-293, 2008.