

Numerical studies on grain growth in friction stir welding

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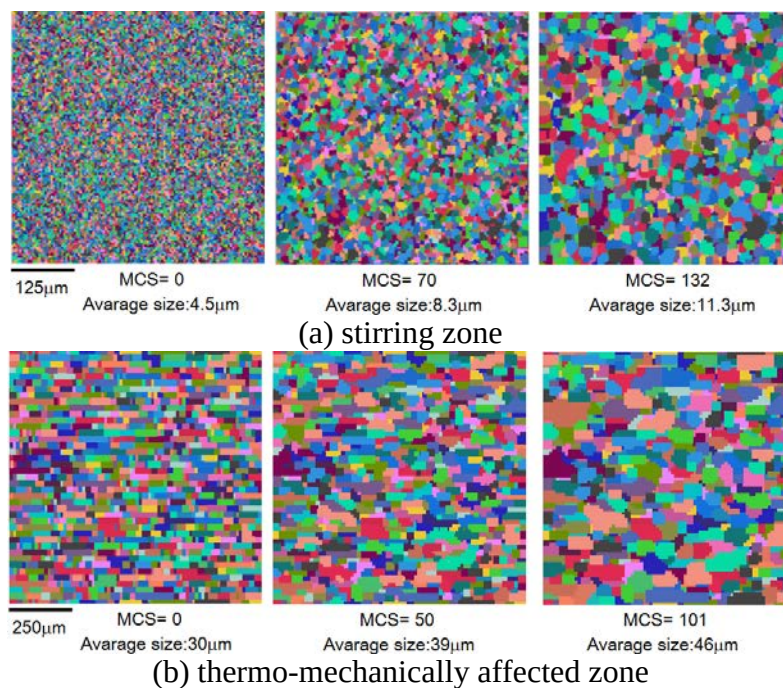
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Abstract

As a solid joining technique, friction stir welding has been quickly applied to many industrial fields including the locomotive, aerospace, ship, etc. With the heat generated from friction and plastic deformation, the material near the welding tool can become softer and easier to be stirred. The frictional heat is much higher than the heat generated from the plastic deformation [Zhang and Zhang (2009)]. A total of about 54.3% energy can be transformed into heat in friction stir welding of Al6061 [Zhang and Chen (2012)]. Both the temperature history and the plastic deformation can affect the grain growth process and then affect the final weld quality. The microstructure in friction stir weld is the key factor in the determination of the mechanical properties of the welded joint. So, an adaptive remeshing model [Zhang and Wan, (2012)] is used to simulate the friction stir welding process. Then, Monte Carlo method is used for the simulation of the grain growth based on the obtained temperature history and material flow. Detailed description on the material flows and heat generations can be found in [Zhang (2008); Zhang and Zhang (2014)].

The width of SZ can be distinguished by movements of the traced material particles. The inner border of the HAZ can be determined by material behaviors and the outer border can be distinguished by the predicted grain size distribution after welding. The computed grain size evolutions in different welding zones are shown in Fig. 1. The average grain size in the stirring zone is 11.3 μm . The grain size is increased to 46 μm in the thermo-mechanically affected zone and 110 μm in the heat affected zone.



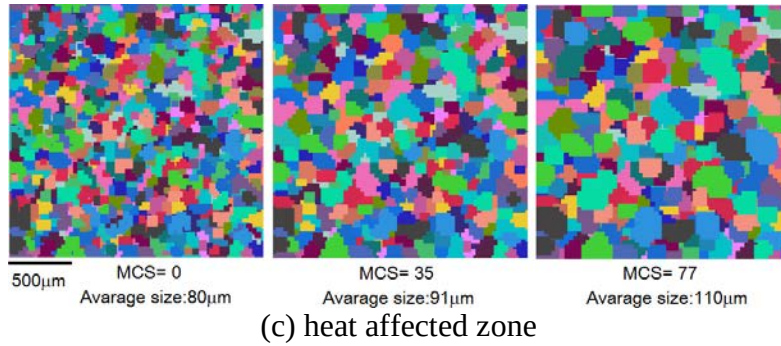


Figure 1. Simulated grain growth of different areas

In stirring zone, base grains are broken and recrystallized into small and fine equiaxed grains. In the heat and mechanical affected zone, grains suffered extension from the tool rotations, the extension ratios which are computed from the traced material particles are then used in the grain growth process. Grains in the heat affected zone are only influenced by the temperature field. The steps of Monte Carlo simulation are calculated from the grain boundary migration model, which is mainly influenced by the temperature cycle. The predicted results are compared with the experimental values from literatures for validation of the current method.

Keywords: Friction stir welding, Monte Carlo method, Grain growth, Recrystallization

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