WORKPIECE SIZE EFFECTS ON RESIDUAL STRESS IN METAL MATRIX COMPOSITES AFTER FSW

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ABSTRACT

The total residual stress (RS) in the metal matrix composites (MMCs) includes both macroscopic and microscopic (originating from elastic mismatch, thermal misfit and plastic misfit) RSes [1]. RS can significantly affect the performance of the MMCs [2-5]. Therefore, it is important to quantitatively measure or modleing RSes in the MMCs [6, 7]. It is known that the ditribution and the magnitude of RSes depend on the sizes of workpieces or structures [8]. For instance, Chobaut et al. [9] reported that in the 7449Al alloys, the peak compressive in-plane RSes on the surface are ~-200 MPa and ~-300 MPa for the 20 mm and 75 mm thickness 7449Al plates, respectively. Nevertheless, the size effects on the macroscopic and microscopic (M-m) RSes in MMCs are seldom addressed.

Accurate determination of M-m RSes in MMCs requires modern techniques such as neutron diffraction or synchrotron X-ray diffraction [1]. For instance, we developed a new method for determining M-m RSes in MMC welds via neutron diffraction [10]. However, for many engineering cases, e.g. large-sized MMC structures, accurate determination of RSes based on these methods still may be impossible. Therefore, modeling method is important to quantitavtively predict the M-m RSes in MMCs.

In this work, a multiscale model is used to study the workpiece size effects on the M-m RSes in SiC/2009Al composite plates. The multiscale model is verified via neutron diffraction measurements firstly. Then the multiscale model is used to assess the effects of the length, the width and the thickness of 17 vol.% SiC/2009Al-T4 composite plate on the M-m RSes after friction stir welding (FSW).

Modeling results reveal that: (I) the length and the width of the composite plate have small effects on the maximum temperature and the local temperature gradient around the FSW tool, as shown in Figure 1(a); (II) increasing the thickness of the plate increases the temperature gradient along the thickness diraction; (III) increasing the length of the plate increases the maximum value of the longitudinal macroscopic RS, and decreases the level of the transversal macroscopic RS; (IV) increasing the width of the plate increases the maximum value of the longitudinal macroscopic RS,

and increases the level of the transversal macroscopic RS; (V) increasing the thickness of the plate decreases the longitudianl macroscopic RS, increases the level of the transversal macroscopic RS; (VI) the length, the width and the thickness of the plate have small effects on the microscopic RSes; (VII) the thermal misfit RS in the MMCs is more sensitive to the temperature rather than the size of the plate; (VIII) the effects of the size of plate on the total RS in MMCs are mainly caused by the variations of the macroscopic RS, as shown in Figure 2.

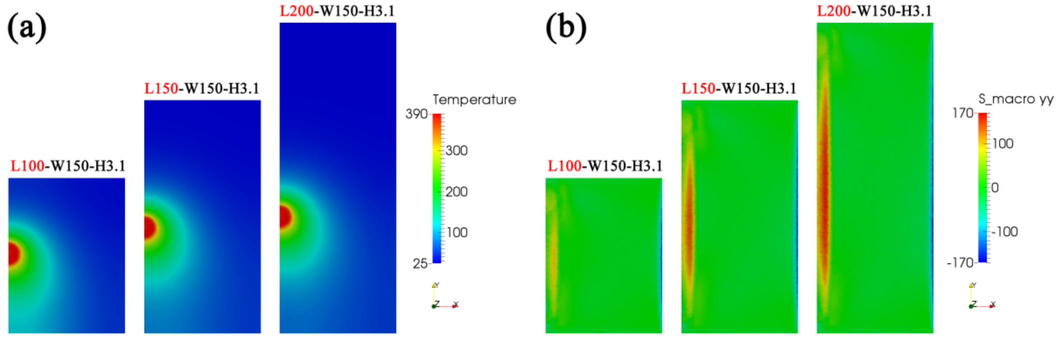

Figure 1: Effects of the length of SiC/2009Al composite plate on the (a) temperature, and (b) longitudinal macroscopic RS.

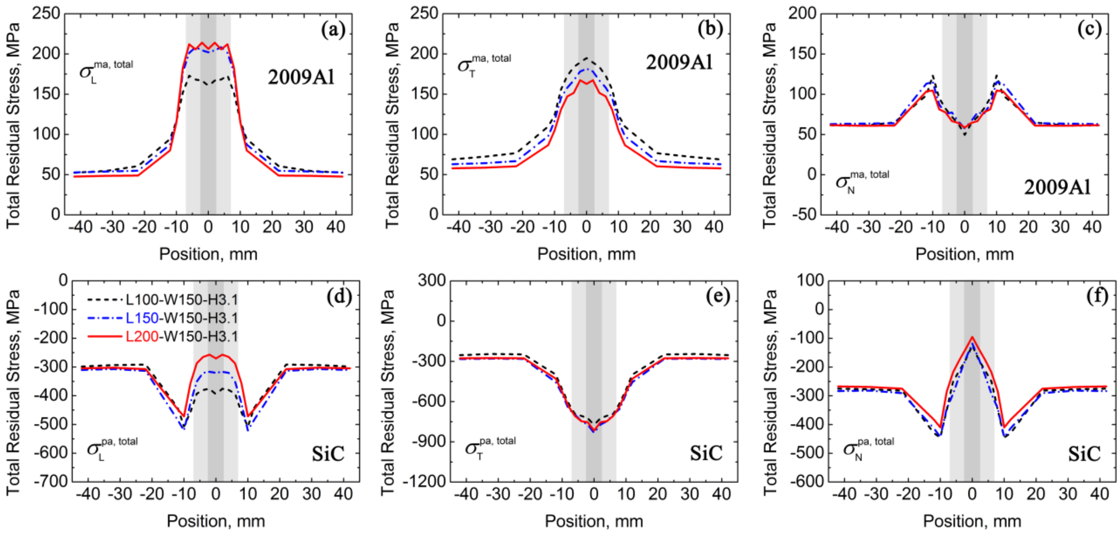

Figure 2: Effects of the length of SiC/2009Al composite plate on the total RS in both phases.

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