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Study on the Friction Stir Welding of Copper and Aluminum

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There have been many works on friction stir welding (FSW) a few decades, proving the superiority of this technique over other welding techniques. Until now, the researchers have focused much attention on friction stir butt welding of copper to aluminum, but little on friction stir lap welding. The rolled plated of aluminum and circular copper were used in the experiment. The tool is a high–speed steel and the tool shoulder diameter is 30mm, pin diameter 10mm and pin length is 5mm. A vertical milling machine was used for the friction stir welding of circular copper plate and aluminum plate. The rotational speed of the tool varied from 1 250~1 400r/min and welding time 20~60s, respectively.

The tensile strength was increased with the rotational speed, but decreased above 1 250r/min. The maximum strength was about 84MPa at the welding time of 40s and then, decreased at longer welding time. Bringing together the results of the mechanical test and the X–ray diffraction analyses, it is concluded that the tensile strength of joint reached maximum by a certain amount (11.3% Al_2Cu) of intermetallic compound (IMC).

This is attributable to the effect of precipitation strengthening of the IMC. The effect of precipitation strengthening is stronger than one of solid–solution strengthening and the yield strength of alloy increases because the precipitate phase enhances a lot the resistance of dislocation move. The results of SEM and XRD analysis revealed that discontinuous copper–rich zone was detected in the aluminum side.

This result confirms that copper atoms should be diffused through the certain zone (diffusion path) of the interface, not through the whole zone of the interface in the friction stir welding. The copper atoms can't be diffused through the zone of the aluminum oxide layer, which acts as the diffusion barrier. The results of XRD analysis revealed that the intermetallic compound, Al_2Cu (θ phase) was formed at the welding time of 40s and also Al_2Cu_3 (δ phase) at 50s.

The SEM photographs confirm that the bonding interface is relatively straight and the amount of copper is small in the bonding zone. Bringing together all information, at the primary step, the copper and aluminum are mixed by the rotation friction, then, the copper is adhered to the plasticized aluminum to stop its rotating. At this time, the copper atoms are diffused into the plasticized aluminum and the aluminum atoms into the solid copper, resulting in the bonding of aluminum and copper. The practical possibility of the Cu–Al friction stir welding was proved by introducing the Cu–Al dissimilar terminal into the power industry.