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Short Communication

Effects of heating process on the microstructures and tensile properties of friction stir spot welded AZ31 magnesium alloy plates

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ABSTRACT

In this paper, the effects of heating process on the microstructures and tensile properties of a friction stir spot welding (FSSW) welded AZ31 magnesium alloy were investigated by microstructural observations and tensile tests. The results shown that compared with the FSSW welded joint, the width of the bonded zone of the heating FSSW welded AZ31 magnesium alloy joint increased remarkably, while the width of the partial metallurgical zone and the number of the voids formed in it reduced. The tensile test results indicated that the increase of the heating temperature improved the tensile shear load (TSL) of the heating FSSW welded joint greatly when the heating temperature was lower than 573 K. However, the TSL of the heating FSSW welded joint decreased when the heating temperature was more than 573 K due to the coarsening of the grains.

1. Introduction

Magnesium alloys have a great potential to replace steel, copper and aluminum alloys structural parts in automotive industry because of their low density in combination with a high strength, an excellent castability, a perfect electromagnetic interference shielding property, a high thermal conductivity and a high damping capability [1,2]. At present, resistance spot welding is the main method to join the body panels in automotive industry. However, the resistance spot welding technique is unsuited for the welding of magnesium alloys due to the strong cracking susceptibility of the resistance spot welded magnesium alloy joints [3], the strong corrosion of magnesium to copper electrode [4] and the high-energy requirements [5]. Recently, Motor Corporation and Kawasaki Heavy Industry [6] have developed a new friction stir spot welding (FSSW) technique with energy and equipment saving advantages. Compared with the conventional resistance spot welding technology, a significant advantage of the FSSW is that the welded joint formed without fusion of the base metal, which avoids the formation of some types of welded defects (such as pores and cracks) in the weld seams. Therefore, this welding technique is very suitable for the welding of magnesium alloys and aluminum alloys. However, the lower plastic deformation ability of magnesium alloys compared with aluminum and steel leads to the decrease of the mechanical properties of the FSSW welded magnesium alloy joints [5]. Compared with a linear friction stir welding, the FSSW welding is a transient process and the heating and cooling rates of the workpieces are relatively high [7]. The short heating time and the low heat input during a FSSW welding process added the difficulty of plastic deformation of the magnesium alloys due to the decrease of bonding time and the reaction period. Hence, more voids, wider no contact zone and partial metallurgical zone formed in the welded joint [6,8,9]. Although the increase of the holding time of pin in the sheets may increase the heat input of the joint at initial stage, the decrease of the friction force between sheets and pin may result in the decrease of the heat input. In addition, an increase of rotational speed improves the heat input remarkably. However, the higher rotational speed may result in a higher residual stress in the weldments. This also reduces the tensile shear load (TSL) of the FSSW joints [10]. Hence, the FSSW technique needs to be developed to avoid the problems presented above.

In this paper, a heating FSSW technology was developed to improve the microstructure and mechanical property of AZ31 magnesium alloy joint. The characterization of the microstructures and the tests of the tensile properties of the FSSW joint and heating FSSW joints were performed. Moreover, the strengthening mechanism of the heating FSSW welded AZ31 magnesium alloy joints was discussed.

2. Experimental process

Hot-extruded AZ61 magnesium alloy sheets (provided by Chongqing Magnesium Company, China) with a size of 80 mm × 30 mm × 2.5 mm were used for the welding tests. The nominated chemical composition, thermal properties and typical room-temperature mechanical properties of AZ31 wrought magnesium alloy [5] are presented in Table 1.

In order to avoid the influence of impurities on the surface of the magnesium alloy sheets on the results of the welding tests,

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