Friction Stir Welding Technology to Apply Flame-resisting Magnesium Alloy to High-Speed Rolling Stock

Hisashi MORI
Senior Researcher, Frictional Materials, Materials Technology Division

1. Introduction

To manufacture lightweight car body structures and parts for high-speed rolling stock, as flame-resisting magnesium alloy is more lightweight than aluminum alloy, it might be a more effective material to use to join different members. For its actual application, however, joining technology for this alloy must be investigated in detail, in addition to studying its material properties and ease/difficulty of processing. Thus we are currently researching basic joining techniques and evaluating metallurgical properties of joint faces. Friction Stir Welding is thought to be the most promising technique to join flame-resisting magnesium alloy.

2. Friction Stir Welding conditions for flame-resisting magnesium alloy members

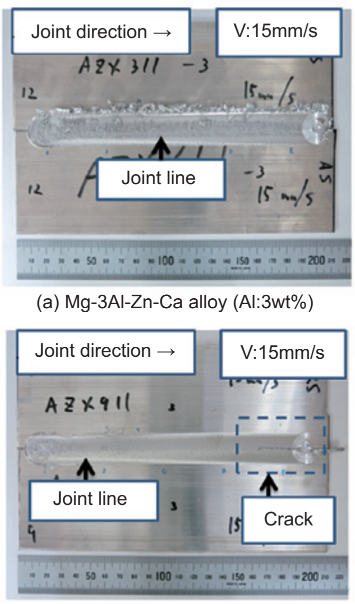
In friction stir welded members of flame-resisting magnesium alloys, calcium added to yield fire resistance reacts with the aluminum in the alloy thereby producing new compounds that affect joint properties. Therefore, we had three flame-resisting magnesium alloys (Mg-Al-Zn-Ca alloy) manufactured for test purposes. These test members had different volumes of aluminum (3, 6 and 9 mass % aluminum) to study the relation between the joining speed and the volume of aluminum. Two members were joined successfully at a joining speed of 1 to 10mm/s. When the joining speed was increased to 15mm/s or over, however, cracks were observed on the joint face of the alloy containing 9% aluminum (Fig. 1).

3. Metallurgical characterization of Friction Stir Welded joint parts

We observed a cross-section of joined alloy by optical microscope to find that a circular plastic metal flow had emerged on the cross-section of joint part, with its area increasing in proportion to joining speed. We also found that there were fine precipitations in the metal flow pattern (Fig. 2). We measured the hardness of the cross-section and examined the relation between hardness and joining speed. As shown in Fig. 3, the hardness of the cross-section was higher for alloys with larger volumes of aluminum, presumably because of the increased precipitations in volume. However, in one case the hardness decreased with volume at the joining speed of 15mm/s. This may be a factor that caused cracking.

4. Conclusion

In discussing the application of friction stir welding of flame-resisting magnesium alloy, extensive basic studies are required on joining conditions, such as joining speed and materials to be joined. We will further study joining conditions in detail, while studying the strength and other characteristics of joint parts in the future.



(a) Mg-3Al-Zn-Ca alloy (Al:3wt%)

(b) Mg-9Al-Zn-Ca alloy (Al:9wt%)

Fig. 1 An appearance of a flame-resisting magnesium alloy for friction stir welding (joining speed: 15mm/s)

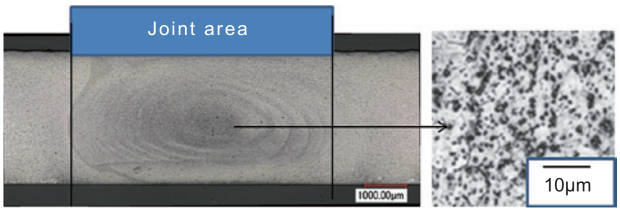


Fig. 2 Cross-section of the joint face of a flame-resisting magnesium alloy (Mg-6Al-Zn-Ca alloy) (joining speed: 5mm/s)

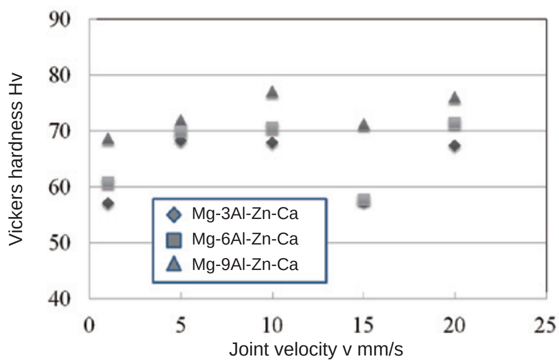


Fig. 3 Relation between joining speed and the maximum hardness of the cross-section of a fire-resistant magnesium alloy