ABSTRACT

Magnesium is a lightest structural alloy, which has been widely used in transportation industries mainly due to their low density and high strength-to-weight ratio. In addition, magnesium alloys have good castability, sound damping capabilities, electromagnetic interfere shielding properties, excellent machinability and recyclability. However, to further expand the application of magnesium alloys, more effective welding and joining techniques are required. Joining of magnesium alloys by conventional welding techniques is very difficult due to the problems such as, cracking, expulsion and void formation in the weld zone. The drawbacks associated with fusion welding include: (a) complex thermal stresses and severe deformation, (b) the presence of porosity and crack in the fusion zone, (c) the excess eutectic formation.

Gas Tungsten Arc Welding (GTAW) of magnesium alloys produced some defects such as porosity and hot crack, which deteriorate their mechanical properties. Friction Stir Welding (FSW) is capable of joining magnesium alloy without melting it and thus can eliminate problems related to the solidification. As an emerging joining technique, friction stir welding (FSW) has great potential for magnesium alloys, since it can significantly reduce weld defects such as oxide inclusions, porosity, cracks and distortions commonly encountered in fusion welded joints. Hence, in this investigation an attempt was made to study the effect of friction stir welding process
parameters on mechanical and metallurgical properties of AZ61A magnesium alloy joints and the results were compared with Pulsed Current Gas Tungsten Arc Welded (PCGTAW) AZ61A magnesium alloys joints.

The extruded plates of AZ61A magnesium alloy were machined to the required dimensions (300 mm x 150 mm x 6 mm). Square butt joint configuration, was prepared to fabricate the FSW and PCGTAW joints. The smooth (unnotched) tensile specimens were prepared to evaluate yield strength, tensile strength, elongation and reduction in cross sectional area. Notched tensile specimens were also prepared to evaluate notch tensile strength and notch strength ratio. Microstructural examination was carried out using an optical microscope (OM). The precipitated phase constitutions of the welded joints were identified using X-ray diffraction (XRD). The fractured surfaces of the tensile specimens were analysed using Scanning Electron Microscope (SEM).

Empirical relationship was developed to predict the tensile strength of FSW joints incorporating process parameters, namely rotational speed, welding speed, axial force and tool profiles. These parameters were optimized using design of experiments concept, analysis of variance method and response surface methodology to attain maximum tensile strength of the joints. Similarly, empirical relationship was developed to predict tensile strength of PCGTAW joints incorporating parameters such as peak current, base current, pulse frequency and pulse on time. The developed relationship can be effectively used to predict the tensile strength of FSW and PCGTAW joints at 95% confidence level.
Of the two welded joints, the joints fabricated by FSW exhibited higher tensile strength values, and the enhancement in strength is approximately 12 % compared to PCGTAW joints. The formation of relatively finer grains (9 μm) in the weld region, higher stir zone hardness (84.7 Hv), the considerably smaller heat affected zone, the presence of uniformly distributed finer intermetallics in the weld region are the main reasons for superior tensile properties of FSW joints compared to PCGTAW joints.