

ABSTRACT

Friction stir welding (FSW) has emerged as an effective solid state joining technique in a short period after its invention by W M Thomas at TWI, Cambridge, England, particularly for aluminium alloys which are difficult to weld using traditional fusion welding techniques. Excellent metallurgical properties, fine microstructure, absence of cracks in weld zone and high penetration depths are some of the key advantages of the process. Artificially aged Al-Mg-Si alloys have been the most widely studied alloys in FSW because of their use in aerospace structures, automotive parts, sports equipment, etc. However, due to the dissolution of precipitates in stir zone after FSW, stir zones in these alloys are significantly softer than the base metal, thereby drastically reducing the post weld formability of these alloys. Interestingly, relatively few works have been done on FSW of naturally aged Al-Mg-Si aluminium alloys, despite the fact that stir zones in these alloys have equal or slightly better strength than that for the base metal and thereby provide better post weld formability.

In this work, studies on friction stir welding were carried out on naturally aged 6063 aluminium alloy which is used in intricate extrusions, hydro formed tubes for chassis, etc. Systematic studies were conducted on four different aspects of FSW of these alloys: (i) Effect of tool pin profile on weld morphology and weld mechanical characteristics for three easy to fabricate tool pin profiles: tapered cylindrical, tapered square, and square, (ii) Weld zone models for accurate prediction of weld mechanical response, (iii) Use of weld zone temperatures as monitoring parameters for evaluating weld strength and quality, and (iv) Effect of backing plate material on weld characteristics in friction stir butt and lap welding. Square tool pin was found to provide best quality welds. While, "simple" weld zone models could accurately predict the joint efficiency of the welds, they tend to overestimate weld ductility. In butt welding, optimal weld mechanical characteristics were obtained for peak mid-section temperatures of around 450°C in stir zone and 360-380°C in heat affected zones. Lastly, backing plate material was found to play an important role, especially in friction stir lap welding.

Keywords: Friction stir welding, naturally aged aluminium alloy, monitoring parameters, backing plate, weld zone model