Chapter 10
Mechanical and Corrosion Behavior of Friction Stir Welded AA 6063 Alloy

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ABSTRACT

Friction stir welding (FSW) is considered to be the most significant development in solid state metal joining processes. This joining technique is energy efficient, environmentally friendly, and versatile. In particular, it can be used to join high-strength aerospace aluminum alloys and other metallic alloys that are hard to weld by conventional fusion welding. The project aims to join Aluminum 6063 alloy plates by FSW and emphasize the (1) mechanisms responsible for the formation of welds without any defects, microstructural refinement, and (2) effects of FSW parameters on resultant microstructure, mechanical, and corrosion properties.

INTRODUCTION

Friction stir welding (FSW) is a solid-state joining process that uses a non-consumable tool to join two facing work pieces without melting the work piece material (Salem, 2003; Sharma et al., 2017; Sivashanmugam et al., 2010). The heat is generated by friction between the rotating tool and the work

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piece, which leads to a softened region near the FSW tool. When the tool is traversed along the joint line, it mechanically helps to bond the two pieces of metal with the application of pressure. A rotating cylindrical tool with a profiled probe is fed into a butt joint between two clamped work pieces, until the shoulder which has a larger diameter than the pin touches the surface of the work pieces (Desai & Kapopara, 2009). The probe is slightly shorter than the weld depth required and the tool shoulder riding on top of the work surface. After a short dwell time, the tool is moved forward along the joint line at the pre-set welding speed. The heat due to friction is generated between the wear-resistant tool and the work pieces. Along with that heat generated by the mechanical mixing process and the adiabatic heat within the material cause the stirred materials to soften without melting (Ating et al., 2010; Lueth & Hale, 1970; Obi-Egbedi et al., 2012). As the tool moves forward, a special profile on the probe forces plasticized material from the leading face to the rear, where the high forces assist in a forged consolidation of the weld. This process of the tool traversing along the weld line in a plasticized tubular shaft of metal results in severe solid-state deformation involving dynamic recrystallization of the base material. Jingming and Yifu (2017) investigated the effects of preheating treatment on temperature distribution and material flow of friction stir welded aluminum alloy and steel (Tang & Shen, 2017). Ning and Yunlong (2017) found that better mechanical properties was attained with the rotating speed of tool as 610 rpm and feed 60mm/min (Guo et al., 2017). The hardness of friction stir welded alumnium 7449 alloy was improved with the speed of 1500 rpm and feed 8mm/min (Martinez et al., 2017). The dissimilar friction stir welds were obtained by reinforcing SiC in AA6082-T6 and AA5083-H111 aluminum alloys and the hardness was observed to be higher in the weld nugget (Pantelis et al., 2016). The optimum tensile strength of Al 1100 and St37 steel lap welds was achieved at minimum welding speeds and maximum speed of the tool (Pourali et al., 2017). Yu Chen et al.(2015) found that the welding heat input has a very significant effect on the hardness of the welds (Yu et al., 2015). The ductile mode fracture was observed in the friction stir welded aluminium alloy (Kumbhar et al., 2011).The microstructures of weld varied depending on length of the probe, rotational speed of the tool and its holding time and it was observed that the tensile strength was improved with increasing in probe length (Tozaki et al., 2007). Elangovan (2007) investigated the properties of friction stir welds by different tool geometries and they found square pin tool yield defect free welds with better mechanical properties (Elangovan & Balasubramanian, 2007). The objective of the present work is to investigate the effect of tool geometry on the mechanical and corrosion properties of friction stir welded A6063-O aluminium alloy. The corrosion properties of welded lap joints of AA6061-T6 aluminum alloy produced by FSW process has been investigated and it was observed that intermetallic particles distributed in the weld region causes galvanic coupling leads to accelerate the corrosion (Gharavi et al., 2015). The resistance to pitting corrosion was observed owing to the grain refinement, heat input, and passivation layer at stir region of friction stir welded joints of aluminum alloy AA5052-H32 using a tool with featured shoulder and threaded pin (Soto-Díaz et al., 2021). The corrosion behaviour of friction stir welded AA6061-T3 alloy joints were investigated and it was observed that the conical pin profile of the tool rotated at 850 rpm exhibited better corrosion resistance than the straight pin profile (Abbas et al., 2021). The corrosion study of the dissimilar (between AA7075-T651 and AA2014-T6) friction stir welds was carried out and it was found that the weld nugget stir zone experienced the inter-granular corrosion, while heat affected zone on advancing side experienced pitting corrosion (Raturi & Bhattacharya, 2021).