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Influence of friction stir welding process and tool parameters on strength properties of AA7075-T_6 aluminium alloy joints

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ABSTRACT

The aircraft aluminium alloys generally present low weldability by traditional fusion welding process. The development of the friction stir welding has provided an alternative improved way of satisfactorily producing aluminium joints, in a faster and reliable manner. In this present work, the influence of process and tool parameters on tensile strength properties of AA7075-T_6 joints produced by friction stir welding was analysed. Square butt joints were fabricated by varying process parameters and tool parameters. Strength properties of the joints were evaluated and correlated with the microstructure, microhardness of weld nugget. From this investigation it is found that the joint fabricated at a tool rotational speed of 1400 rpm, welding speed of 60 mm/min, axial force of 8 kN, using the tool with 15 mm shoulder diameter, 5 mm pin diameter, 45 HRc tool hardness yielded higher strength properties compared to other joints.

1. Introduction

Aluminium alloy AA7075 (Al–Zn–Mg–Cu) is one of the strongest aluminium alloys in industrial use today. Its high strength-to weight ratio, together with its natural aging characteristics, makes it attractive for a number of aircraft structural applications [1]. The alloy derives its strength from precipitation of Mg_2Zn and Al_2CuMg phases. A major problem with this alloy is that it is not fusion weldable. It is extremely sensitive to weld solidification cracking as well as heat-affected zone (HAZ) liquation cracking due to the presence of copper. While it is possible to overcome the problem of weld solidification cracking using a suitable non-heat-treatable aluminium alloy filler (for example, Al–Mg or Al–Si), the resulting joint efficiencies are unacceptably low [2]. Further, oxidation and/or vaporization of zinc present several problems during welding, such as porosity, lack-of-fusion, and hazardous fumes. Therefore, use of alloy AA7075 is currently limited to applications that do not involve welding [3].

During friction stir welding (FSW), a rotating tool moves along joint interface, generates heat and results in recirculating flow of plasticized material near the tool surface. This softened material is subjected to extrusion by the tool pin rotational and traverse movements leading to formation of friction stir processing (FSP) zone [4]. The formation of FSP zone is affected by the material flow behaviour under the action of rotating tool. However, the material flow behaviour is predominantly influenced by the material properties such as yield strength, ductility and hardness of the base metal, tool design, and FSW process parameters. Compared to fusion welding techniques, friction stir welding strongly reduces the presence of distortions and residual stresses [5–7].

Hatamleh and Singh [8] have reported the effect of shot-peened and laser-peened on weld microstructure and mechanical properties of AA7075-T_6 aluminium alloy joints. The metallographic section show a classic weld nugget region and the stirring marks, commonly denoted as "onion rings," typically found in this region of the weld. A more recent investigation by Cai et al. [9] revealed that the grains in the nugget zone are not 3d equiaxial but 2d rod-like. The grain structure in Thermo-Mechanical Affected Zone (TMAZ) region was elongated and distorted due to the mechanical action from the welding tool. The heat-affected zone was unaffected by the mechanical effects from the welding tool, and the grain structure in that region resembles the parent material grain structure.

There have been lot of efforts to understand the effect of process parameters on material flow behaviour, microstructure formation and mechanical properties of friction stir welded joints. Finding the most effective parameters on properties of friction stir welds as well as realizing their influence on the weld properties has been major topics for researchers [10–12]. The influence of some of the

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