MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF AA6061-AA7075 DISSIMILAR FRICTION STIR WELDING

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ABSTRACT

In this paper, mechanical and microstructural characterizations on dissimilar friction stir welding joints of aluminium alloy AA6061 and AA7075 were conducted. Mechanical property analysis of specimens was conducted using tensile test and Vickers hardness test. Meanwhile, microstructure characterization of the optimum sample was conducted using optical microscope, scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). Results show that samples exhibit good quality appearance with minor surface defects. Fractured tensile specimens revealed that the failure occurs at the weaker aluminium side (AA6061). The highest tensile strength of 219.6 MPa was achieved using 1000 rpm rotational speed, 110 mm/min travel speed and 3˚ tilt angle. The results from the micro-hardness analysis show that the highest value of 151 HV was obtained from the thermo-mechanically affected zone (TMAZ) of AA7075 matrix. Microstructure analysis on the other hand shows a single vortex lamellar structure in the weld zone, indicating good material mixing. The fracture surface of the samples indicates ductile fracture behaviour initiating from the AA6061 matrix.

KEYWORDS: Friction stir welding; AA6061; AA7075; dissimilar welding; mechanical properties; microstructural characterization

INTRODUCTION

Friction stir welding (FSW) is a solid state joining process to join metallic alloys together through heat generated from the friction between a rotating tool and the joint line. It was invented and patented in The Welding Institute, United Kingdom in 1991 and has become an increasingly important process in a wide area of research fields such as in ship building, aviation and automotive industry[1][2][3][4].

Compared to common fusion welding, FSW has shown to be a promising technique since the welding is done under solid-state process, thus avoiding common defects such as burn through, slag and undercut [5]. Other defects such as spatter, hot cracking and distortion can be practically eliminated completely. Besides that, the process is simple, i.e. no rigorous welding training required, and toxic fumes as a result of the process is non-existant.

Despite approximately 99% of the present research on FSW focuses on similar aluminium sheets, a growing number of research have been conducted on dissimilar FSW, particularly between aluminium of different grades [6][7][8]. Recent paper reports include aluminium FSW of 2-series to 6-series [9][10], AA2024 to AA7075 [11][12], 5-series to 6-series [13][14][15], and AA6061 to AA7075 [5], with promising results.

A recent study by Guo et al. reported a dissimilar FSW between AA6061 and AA7075 [5]. The paper mainly focused on limited parameters such as materials positioning, downward force and travel speed. It also concluded that the best joint was achieved when the AA6061 base metal is placed at the advancing side and AA7075 at the retreating side, respectively.

In light of this discovery, this study aims to further expand the parametric effect study to include rotational speed and tilt angle variations, and conduct mechanical testing on dissimilar FSW of AA6061-AA7075 to analyse the effect of the welding parameters on the joint quality. Microstructural characterization is then initiated to observe its structural morphology as well as its fracture surface.

MATERIALS AND EXPERIMENTAL METHODS

Material and tool preparation

In this study, AA6061 and AA7075 aluminium alloy sheets were utilized as the base metal. The materials were cut into 2 × 50 × 100 mm dimensions. The chemical compositions of the base metals are shown in Table 1.

The H13 tool dimension used in this study is shown in Table 2. Furthermore, mild steel was used as backing plate and functions as a support during the welding process [6].