Effect of Al2O3 Nano-Particles on AA1060 Joints Fabricated by Friction Stir Welding

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Abstract - *This paper aims to study the effect of adding Al2O3 Nanoparticles on the tensile strength of similar AA1060 weld fabricated by friction stir welding process. Nanoparticles Powder (Al2O3) was placed on the surface of the aluminum plates during FSW, and in the direction of welding process. The mechanical properties of welded joints were investigated with respect to different processing parameters. FSW with Nanoparticles showed, increases in the UTS.*

Key Words: FSW, Nanoparticles, aluminium, UTS.

1. INTRODUCTION

Friction stir welding (FSW) it is considered the most reliable welding technique for the major industrial companies, aluminium alloy and all other alloys which are nearby in their mechanical properties can classified as non-wieldable alloys. Mechanical properties for joint zone by other techniques have significant difference with respect to the base metal. FSW was developed by The Welding Institute (TWI), and it was basically carried out on aluminium alloys [1]. the concept of this process depend on a rigid rotating tool which penetrating two pair of aluminium sheet and moving traverse the joint line. Welding parameters, such as tool geometry, rotation speed, and traverse movement have been investigated by many authors [2-5]. Hence, the ultimate tensile strength of friction stir welding joints was improved by increasing of the tool pin rotation speed until to reach a limited range.

Processing parameters have significant effects on the mechanical properties, hence many investigators were studied those effects on the welded joints properties. The Tensile strength was improved with increase in rotational speed for AA6351 Aluminium alloy, as reported by [6]. The tensile strength of the stirred zone was significantly increased with respect to the base metal, the improvement of stirred zone was inasmuch smaller grain size produced in the stirred zone [7]. Higher traverse speed causes lower strength as reported by [8]. Hence, the specimens were welded at high tool traversing speed (120 mm/min). The ultimate tensile strength was decreased with increasing of rotation speed for tool pin, while the elongation of welded joint was improved more than the base metal by 9.4% reported by [9]. the ultimate tensile strength and yield strength was decreased with respect to base metal while the elongation have been increased as reported by [10], The tensile testing results showed the FSW joint exhibited apparently lower YS and UTS than the base metal but it showed better ductility.

Nanoparticles additives during friction stir welding are affects on the mechanical properties especially on the hardness and wear resistance, but the tensile strength and ductility were decreased because the welded joint became brittle as investigated by [11-16]. In the current study, the mechanical properties and tensile strength of aa1060 alloy fabricated by friction stir welding process will be investigates in presence of Al_2O_3 Nanoparticles.

2. EXPERIMENTAL PROCEDURE

AA 1060 aluminum alloy sheets were prepared with dimensions of 150 mm x 50 mm x 5 mm the alloying element presented in Table 2-1. The plates were fixed using special fixture and mounted on the automatic milling machine to fabricate welding process, Figure 2-1, show the schematic drawing of the welding process. The friction stir welding tool was machined and fabricated from cold worked tool steel (K110 steel), the chemical composition of the tool materials presented in Table 2-2. The tool was designed based on the previous literature as discussed in the introduction section. There are many tool designs and different shape for pin of the tool, for this investigation new pin shape like conical triangle made from carbon steel heat treated to get good friction and mixing of the material. The tool shoulder was cylindrical and flat with diameter 20mm. The pin was triangular with grooving 0.5mm. The pin length 5mm, it made 1mm less than aluminum plates that we want to weld it to avoid touches of the tool with the fixture. The tool geometry was designed in conical triangle shape.as shown in Figure 2-2.The tool was plunged to the milling machine with tilting angle of 2 degree. Three rotation and traverse speed were performed during welding process. The designed processing parameters for tool rotation speed were, 800. 1200and 1000 rpm, furthermore three traverse speed of 12, 32 and 52 mm/ min.

Table2-1: Aluminum alloy 1060 contents.

Alloy	Si	Fe	Cu	Mn	Mg	V	others	Al
1060	0.25	0.40	0.035	0.05	0.045	0.04	0.03	99.6

Table2-2: Chemical composition of FSW tool (K110)

Alloy	C	Cr	Mo	Si	Mn	V	Fe
1060	1.5	11	1.1	0.6	0.5	0.5	Bal.

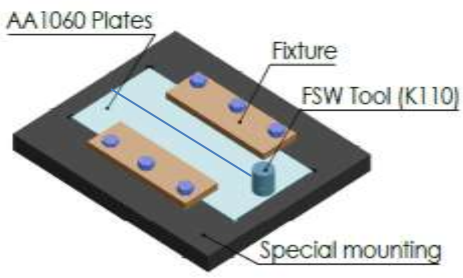

Fig 2-1: Schematic diagram of FSW processing.

Fig 2-2: Typical FSW tool.

2.1 Tensile test

Samples were prepared to tensile test according to ASTM standard (ASTM E8) Tensile Testing of Metals. After performed FSW the surface of the welded joints were machined and prepared well, to avoid any error occurred during tension test. The machine test and specimen are shown in Figure 2-3. In each case of processing parameter there are five samples were tested.

Fig 2-3: Tension test machine, and tested specimen

3. RESULTS AND DISCUSSION

From the results of tensile strength reveals that, the strength of the base metal was higher than the joints which fabricated by FSW, that can be explained, hence the tool geometry play an important role in FSW quality. Therefore, the current study was focused on the effect of processing parameters and Al_2O_3 Nanoparticles on the strength of the welded joint using FSW. The processing parameters such as; tool geometry, rotation speed and welding speed are considered directly affect the magnitude of frictional heat generated and plastic flow of material.

3.1 Effect of rotation speed and traverse speed on tensile strength.

The rotation speed and traverse speed are effects on the tensile strength without additives of nanoparticles, as shown in Figure 3-1. The tensile strength increased at lower rotation speed with corresponding lower traverse speed. In case of using Al_2O_3 nanoparticles, the tensile strength decreased as the rotation speed increased, furthermore the strain rate decreased, as shown in Figure 3-2. The traverse speed has significant influence on the heat generation during FSW process. A heat index relationship, the pseudo heat index (PHI) attempts to correlate the heat input during FSW with weld process parameters as Equation 1. Where, (ω) for spindle speed and (V) for travel speed.

$$PHI = \omega^2/V \quad (1)$$

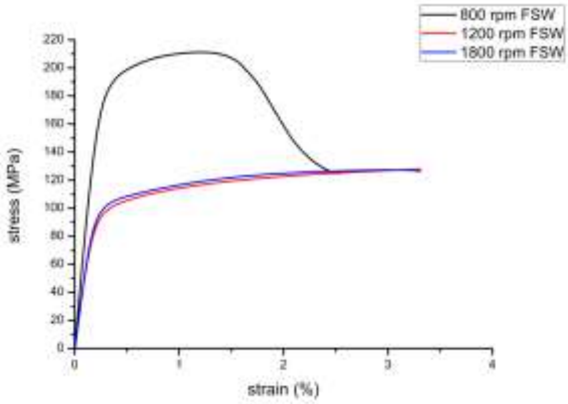

Fig 3-1: Effect of rotation speed on FSW AA1060, at 12 mm/min traverse speed.

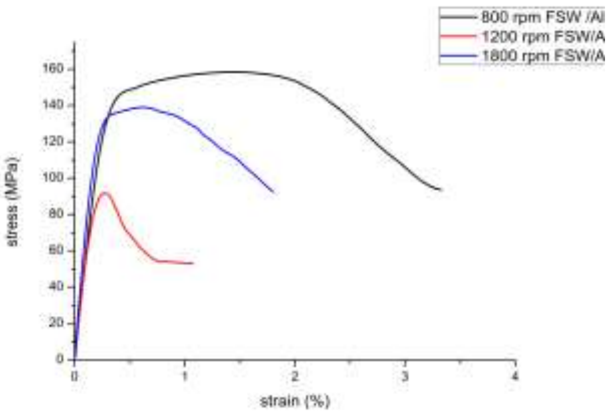

Fig 3-2: Effect of rotation speed on FSW AA1060/ Al2O3, at 52 mm/ min traverse speed.

Traverse speed effect on the ultimate tensile strength as shown in Figure 3-3. Higher tensile strength was located at lower traverse speed. However the combination between traverse speed and rotation speed change the ultimate tensile strength (UTS), as the rotation speed increase the, UTS decreased, while an additional increase in the rotation speed, UTS, return to increases. Figure 3-4, show the relationship between UTS and heat index, the pseudo index explains the drop occurred in the relationship between rotation speed and

UTS. Higher PHI value mean that, extra heat generation during welding process not sufficient to perform plastic deformation of the welded joints.

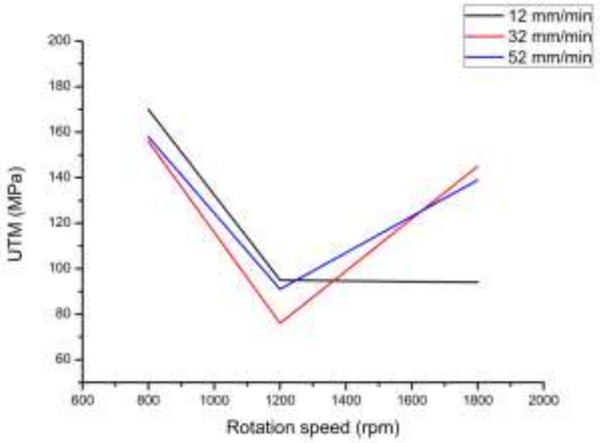

Fig 3-3: Effect of traverse speed on the UTS, for different rotation speed

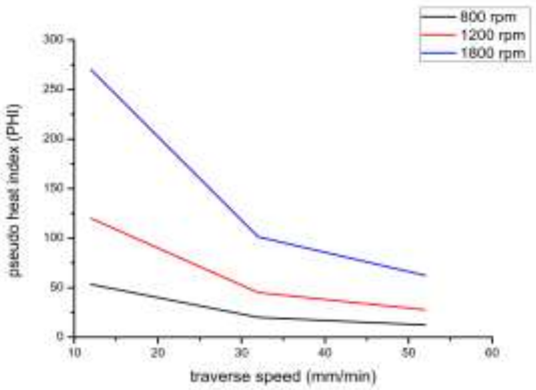

Fig 3-4: Pseudo heat index (PHI)

4. CONCLUSION

From the previous results, the processing parameters have a significant effect on the FSW joint and these conclusions can be summarized as :The geometry effect on the tensile properties of FSW joints. Hence, taper triangle tool pin not sufficient for AA1060 aluminum alloy, the results revealed that, base metal alloy indicates tensile strength higher than FSW joints .Maximum tensile strength was showed with lower rotation speed.Al_2O_3 Nanoparticles addition during FSW, increase the UTS. However, decrease the joint ductility.

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