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Effect of process parameters on friction stir welding of dissimilar Aluminium Alloy

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ABSTRACT : *In this study, dissimilar aluminium AA6061 and AA7075 6mm thickness plate were welded by friction stir butt joint using different rotational speed and transverse feed of 1200,1400,1600 rpm and 20,35,50 mm/min at constant axial force 5kN.The effect of welding parameter was evaluated in different mechanical properties of hardness distribution and tensile properties for axial weld zone. The significant optimal transverse feed is achieved with high weld quality and excellent joint properties with help of square tool. In this transverse feed the excellent result was obtained both tensile strength as well as hardness in order to improve productivity.*
Keywords *- Aluminium Alloy, Friction Stir Welding, Tensile Strength, Hardness,*

I. INTRODUCTION

Modern aerospace concepts demand reductions in both the weight as well as cost of production of materials.Under such conditions, welding processes have proven most attractive, and programs have been set up to study their potential. Car manufacturers and shipyards are also evaluating new production methods. Increasing operating expenses are driving manufacturers to reduce weight in many manufacturing applications, particularly in aerospace sector. The goal is to reduce the costs associated with manufacturing techniques to result in considerable cost and weight savings by reducing riveted/fastened joints and part count. One way of achieving this goal is by utilizing a novel welding technology known as Friction Stir Welding (FSW). Friction stir welding is a solid-state joining process developed and patented by the Welding Institute (TWI) in 1991 by Thomas et al and it is emerged as a welding technique to be used in high strength alloys (2xxx, 6xxx, 7xxx and 8xxx series) for aerospace, automotive and marine applications that were difficult to join with conventional techniques[1,2].In this innovative welding there was eliminated plenty of defects like cracking, porosity, oxidation and other defects. FSW can be used to join types of similar and dissimilar sample with the help of suitable welding tool and different probes the main beauty of this welding are material is not to be melted during welding. In this welding produced excellent joint performance compare to other processes .additionally the energy input used for FSW is relatively low no melting occur the heat affected zone and thermo mechanically affected zones (TMAZ) are relatively small.

Dinakaran et al (2012) have been produced the friction stir welding of AA6061 both cast and wrought alloy. in this paper we see that the tensile strength and hardness are gradually increased at 1200 rpm the joining efficiency reached in the level of 94%.

Mostafa et al [2013] This paper describe the effect of processing parameters on the mechanical and metallurgical properties of dissimilar joints of AA6082–AA6061 produced by friction stir welding was analysed in this study. Different FSW samples were produced by varying the welding speeds of the tool as 50 and 62 mm/min and by varying the alloy positioned on the advancing side of the tool. In all the experiments the rotating speed is fixed at 1600rpm. The downward force was observed to be constant as the welding speed for all the produced joints increases. The tensile strength of the dissimilar joint is lower than that of the parent metal. With the 6082 alloy positioned on the advancing side of the tool, the dissimilar joints exhibited good mechanical properties with respect to AA6061. Micro structural changes induced by the friction stir welding process were clearly identified in this study. Friction stir welding of dissimilar alloys AA6082T6- 6060T6 resulted in a dynamically recrystalized zone, TMAZ and HAZ. A softened region has clearly occurred in the friction stir welded joints, due to dissolution of strengthening precipitates. With AA6082 on the advancing side; the corrosion rate is higher with respect to increasing welding speed of the tool while corrosion rate decreased in case of AA6061 on advancing side. Elatharasan et al [2013] This paper describe FSW processes parameter. The parameter plays a major role in joint characteristic. The experiment were conducted based on three factor namely speed,feed,and axial force. The tensile strength was achieved at 96% and yield strength is 90%.If increase in rotational speeds, welding speeds and tool axial force the ultimate tensile strength of the FSW joint reach upto maximum level. Rajakumar et al [2010] this paper describes the tool parameters on strength properties of AA7075-T6 aluminium alloy joints. The joint fabricated using the FSW process parameters of

1400 rpm (tool rotational speed), 60 mm/min (welding speed), 8 kN (axial force), with the tool parameters of 15 mm (shoulder diameter), 5 mm (pin diameter), 45 HRc (tool hardness) yielded higher strength properties compared to other joints. The maximum strength properties of 315 MPa yield strength, 373 MPa of tensile strength, 397 MPa of notch tensile strength, 203 HV of hardness and 77% of joint efficiency respectively was attained for the joint fabricated using above the process and tool parameters. Defect free fine grained microstructure of weld nugget and uniformly distributed finer MgZn2 particles in the weld nugget are found to be the important factors responsible for the higher tensile strength of the above joint. Welding tool design is critical in FSW.

Optimizing tool geometry to produce more heat or achieve more efficient “stirring” offers two main benefits: improved breaking and mixing of the oxide layer and more efficient heat generation, yielding higher welding speeds and, of course, enhanced quality. The simplest tool can be machined from an M20 bolt with very little effort. It has proved feasible to weld thin aluminium plates, even with tooling as simple as this, although at very slow welding speeds. However, tool materials should feature relatively high hardness at elevated temperatures, and should retain this hardness for an extended period. The combination of tool material and base material is therefore always crucial to the tool’s operational lifetime. With parameter adjustment and tool geometry optimization, the oxide-layer could be broken more effectively. The need to generate more frictional heat and break the oxide-layer more effectively has been a driving force in tool development for light-metals.

II. EXPERIMENTAL PROCEDURE

1.Welding

Aluminium alloys of AA6061 and AA7075 were selected for fabricating dissimilar joints using the FSW process. The thickness of the plates are 6mm each the chemical composition of base metal AA6061 and AA7075 evaluated by spot spectroscopy analysis the test results are shown in table 1

Table 1.chemical composition of base metal AA6061 and AA7075

Element	**WT % 6061**	**WT % 7075**
Al	97.93	97.93
Si	0.485	0.123
Fe	0.227	0.227
Cu	0.162	1.64
Mn	0.376	0.021
Zn	0.013	5.321

Trial runs were carried out by using two major parameters like welding speed and welding feed with constant axial force. The welding processes are carried out by using three different rotational speed of 1200, 1400, 1600rpm and transverse feed of 25, 35,50mm/min. The axial force is kept constant 5kN.The direction of welding was normal to the rolling direction.

The aluminium plates are prepared to the dimensions of (100X 50 mm) using hack saw and grinding machine. The joint was fabricated in the single pass procedure used in CNC vertical milling machine. The aluminium plates are fixed in the milling table and tool is fixed on the spindle. CNC program is prepared as per the input parameter. The friction stir welded dissimilar AA6061 and AA7075 aluminium alloys as shown in fig 1.The traverse force acts parallel to the tool motion and is positive in the traverse direction. Since this force arises as a result of the resistance of the material to the motion of the tool it might be expected that this force will decrease as the temperature of the material around the tool is increased.

Figure 1. FSW of AA6061 and AA7075

In providing proper contact and thereby ensuring a high quality weld, the most important control feature is down force (Z-axis). This guarantees high quality even where tolerance errors in the materials to be joined may arise. It also enables robust control during higher welding speeds, as the down force will ensure the generation of frictional heat to soften the material. When using FSW, the following parameters must be controlled down force, welding speed, the rotation speed of the welding tool and tilting angle. Only four main parameters need to be mastered, making FSW ideal for mechanized welding.

2 Tensile

The tensile specimens were prepared as per ASTM E8M. The schematic diagram of the tensile specimen as shown in fig 2.

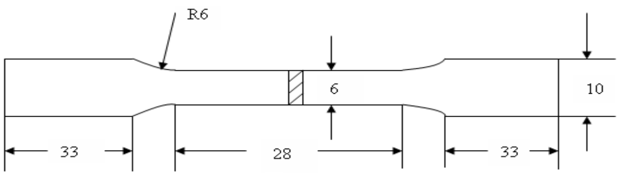

Figure 2. Tensile specimens as per ASTM E8M

III. RESULTS AND DISCUSSION

1.Tensile strength

The three different rotational speeds were influenced in this paper of 1200, 1400, 1600rpm. The higher rotational speed and medium transverse feed produced excellent mixing of friction stir welding and ultimate tensile strength reached up to the maximum level in this higher rotational speed. The welding zone area zinc particle will be evenly distributed in this zinc particle produce substantially increase strength. The lower rotational speed produce insufficient heat input and also affects the tensile properties.

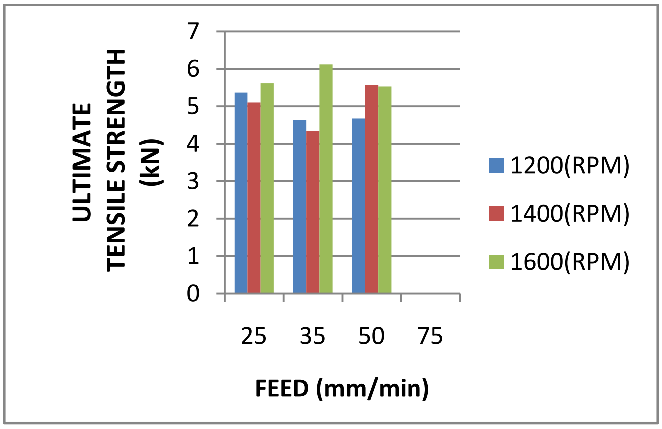

Figure 3. Effect of transverse feed on Ultimate tensile strength

The fig 3 shows that the 1600rpm rotational speed and 35mm/min transverse feed is the very fine result of ultimate tensile strength.

In this parameter achieved that better joining performance. The lower rotational speed is affecting the tensile properties. The optimal transverse feed 35mm/min has to improve the ultimate tensile strength. The rotational speed of 1600rpm and feed of 35mm/min gives the maximum ultimate tensile strength. The feed of 25 and 35 mm/min it will reduce the ultimate tensile strength for all the welding and rotating speeds used in the present study, the specimens welded at 35 mm/min show the best behavior in the low cycle regime. This can significantly reduce the extend of metallurgical transformation taking place during welding. If the transverse feed is increased above 35mm/min tensile strength of the joint decreased.

2.Hardness

The medium rotational speed fig 4 shows that increased the hardness. In the FSW process, three factors contribute to the formation of the joints. The higher rotational speed will be effect the hardness at same time lower rotational speed is also effect the hardness. The medium transverse feed and rotational speed to increase the hardness. As compared to the base material, considerable softening occurs throughout the weld zone due to the elimination of strain-hardening effect by dynamic recrystallization. Hence, the hardness decreases in thermo mechanically affected zone towards the weld nugget as compared to the parent metal.

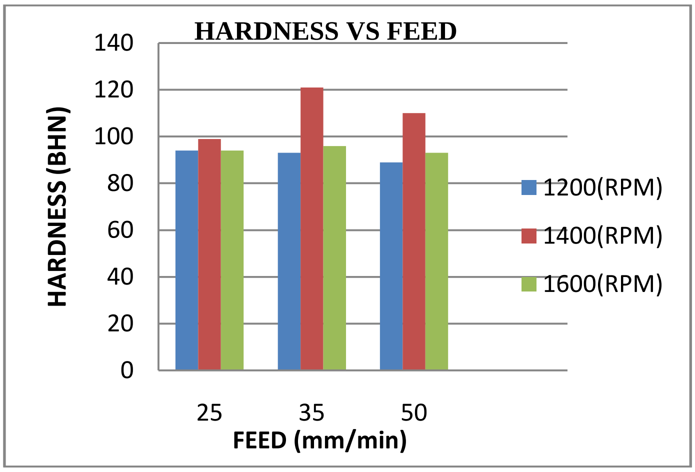

Figure 4. Comparisons of Hardness Vs feed

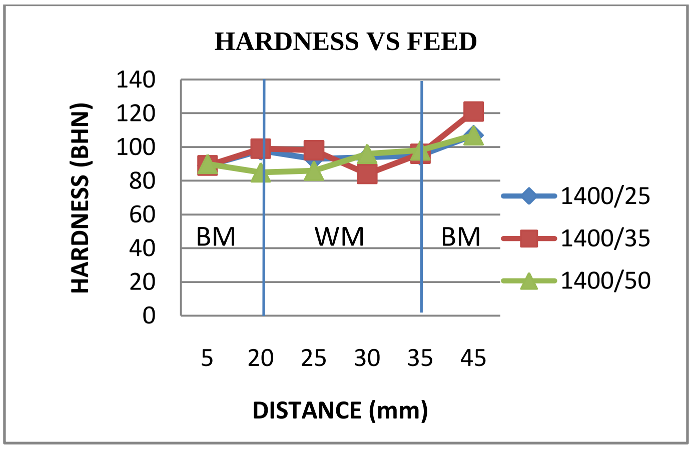

Figure 5. Hardness Vs distance at 1400 rpm

The fig 5 shows that maximum hardness value is 121 BHN in the rotational speed of 1400 rpm. The right hand side is the side of the aluminum alloy 7075 is quite similar. The center is expected to weld the aluminum alloy 7075, which is not as homogeneous with a 6061 aluminum alloy. Will notice that the left hand side of the AA 6061 is a value that is higher than the center is expected of them as a tool to bring material AA 7075 was merged with the AA 6061, making the show the hardness is high over the center line.

IV. CONCLUSION

FSW of AA6061 and AA7075 dissimilar joints were successfully accomplished for the different parameters. The various parameters involved in FSW such as tool rotational speed and transverse feed to decide the weld quality were studied. When the tool rotational speed is increase the heat input also increased. From that experimental found that the 35mm/min transverse feed gives excellent mechanical property both tensile as well as hardness.

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