Effects of tool rotation speed and tilt angle on friction stir welding of Al- 6075

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Abstract:- Friction stir welding (FSW) is a new technology of welding the aluminium alloy profile plate. In conventionally welding technique toxic and hazardous gases emits. But FSW we didn't get such toxic gases and it is energy efficient. There are few parameter which effects FSW like tool tilt angle, tool rotational speed, tool shape design, and feed rate. In this paper impact of tool tilt angle and tool rotational speed on tensile strength and hardness is discussed.

Keywords:- *Friction Stir welding, 6075 aluminum alloy, tilt angle,tool rotational speed tensile strength.*

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I. Introduction

Aluminium alloys are used in wide application in automobile industries, aerospace, high speed ships, bridges due to its light weight and higher strength to weight ratio. In industries welding is very important and widely applicable metal joining process.Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool). It was invented by the Welding Institute (TWI) in 1991. There are three zone in FSW (a) the stir zone, (b) thermo mechanically affected zone (TMAZ), (c) heat affected zone.

Kumar et al.,(2011) studied the effect of geometry of tool pin, tool rotation speed and welding speed on the mechanical properties of friction stir welded joints made for samples of commercial grade aluminium alloys. The results obtained showed that tools with tapered pins created superior mechanical properties for the FS welded joints. It was also found that overall mechanical response depends on the ratio of the tool rotation speed to the tool transverse speed. Sidana et al.,(2012) described effect of tool rotation speed on microstructure properties of Friction stir welding Al6061 -T6 alloys. It has been revealed that increase in tool rotation speed gives better joint strength. Mushsin et al.,(2012) described effect of process parameters (rotation and transverse speed) on the transient temperature distribution in FSW of AA 7020- T53. Conclusion have been made that axial load measured from experimental work decrease with increase in rotational speed because that decrease in strength due to temperature increases in penetration position. The experimental data showed that the maximum temperature measured during FSW at mid position 629K and numerically value from the simulation is 642K, which is significantly less than the melting point of 7020-T53. Prakash et al.,(2013) described a study of process parameters of friction stir welding of AA 6061 aluminium alloy. Conclusion have been made that tool rotation speed, tilt angle, weld speed & axial force are the main factor which effect welding. It has been found that on tool rotation speed 1120 rpm, welding speed 20 mm/min and pin length of 5.2mm tensile strength was 142 MPa. Silva et al.,(2013) described study of welding fsw (friction stir welding) of aluminium alloy 2024-t3 and electrolytic copper. Conclusion have been made that The efficiency of the welded joints is of the order of 0.45 compared to the base metal aluminum and 1.6 for copper,with significant loss of ductility. It is also important to note that the good electrical conductivity of these materials is linked to the absence of discontinuities in the junction. Eramah et al.,(2014) described influence of friction stir welding parameters on properties of 2024 t3 aluminium alloy joints. Conclusion have been made that the tool manufactured from the tool steel 56NiCrMoV7 has great durability in the friction stir welding process, i.e. it has great wear resistance. Even in the more severe welding regimes, fracture or excessive deformation of the pin did not occur.

II. Experimental procedure

The friction stir welding set up was prepared on vertical milling machine installed in mechanical workshop, a fixture for clamping the samples was prepared. FSW tools of high carbon steel material with 5 mm diameter (as welding parameter) were prepared on lathe machine. Firstly some trials were performed to finalize the working ranges of welding parameters. A clamping fixture of cast iron material was specially fabricated to fix the two aluminium plates. As the process consists of main two forces, first due to rotation of tool and secondly due to linear movement of bed, so to restrict the pieces from any side movement the fixture was fabricated. There may be many nuts on the fixture according

to the requirement to hold the work piece. But in the experiment we used four nuts to hold the job in the fixture. The tool was prepared from High carbon steel material, as it was desirable that the tool is hard wear, tough and strong. The tools were made with pin diameters 5mm was taken as a process parameter in Fig Shoulder Diameter 17mm, Shoulder Height 20mm Pin length for single sided 5.5, 3mm Pin diameter 5 mm.

Figure 1.Welding Tool

Aluminium with commercial series is mostly used in industrial applications due to its moderately high strength and very good resistance to corrosion makes it highly suitable in various structural, building, marine, machinery, process-equipment applications. The plates were prepared with 150*50*6.

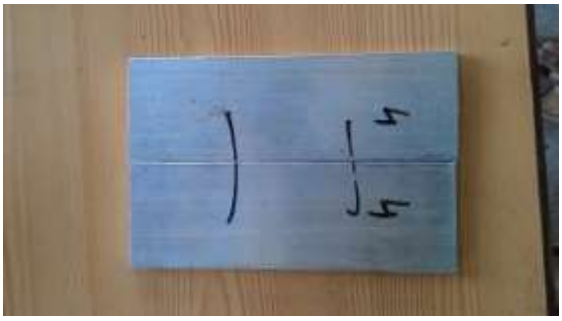

Figure 2.Work piece before welding

The friction stir welding process was performed on a vertical milling machine. The specially designed fixture was clamped on bed of vertical milling machine. The tool was mounted on the vertical spindle. Then two prepared aluminium pieces were clamped into the fixture.

Figure 3.Work piece and Fixture Setup

Then the rotating tool was made to embed into the butt joint. Then after some time, when there was sufficient heating was achieved due to friction between tool and plates, the bed was given automatic feed, along the joint direction. Thus the welding was achieved. Then visual inspection done to check external defects like voids surface open tunnel defects and lack of penetration defects.

The FSW is performed at aluminium alloy at rotation speed of 1950, 2300, and 3050. FSW is also performed on tool tilt angle of 0^0, 1.5^0, 3^0 to evaluate tensile strength and hardness variation of FSW.

Figure 4. Specimen after welding

Tensile test is one of the most frequently performed mechanical tests.

This type of test generally involves gripping a specimen at both ends and subjecting it to increasing axial load until it breaks. Recording of load and elongation data during the test allows the investigator to determine several characteristics about the mechanical behaviour of the material.

After the test Measure the final gage length and calculate Elongation. The length has

Figure 5.Specimen after Tensile Fracture

been measured according to the gage marking and mechanical properties such as ultimate tensile strength and percentage of elongation tested.

III. Result & Conclusion

By conventionally welding technique welding of aluminium is very difficult because it melts at TIG/MIG welding temperature. So FSW solve the heating problem of welding aluminium. It gives high tensile strength, hardness, high

impact strength. We have obtained all the welded specimen at desired parameters by FSW.

Effect of Tilt angle

Sr. No	Nomenclature of sample	Tilt angl-e 0	Tilt angl-e 1.5	Tilt angl-e 3	AV-G (HV)
1	1950 RPM SINGLE 'V'	24	25	26	25
2	2300 RPM SINGLE 'V'	26	28	27	27
3	3050 RPM SINGLE 'V'	28	29	30	29

Table 1

From the above table we can conclude that as the tool tilted angle increase tensile strength of welded specimen increases. The tensile strength of welded joint with 3^0 tilted tool is more than 1.5^0 tilted tool and tensile strength of welded joint with 1.5^0 tilted tool is more than 0^0.This increase of tensile strength due to more downward force applied by tool shoulder that generate additional heat. This increase in downward force remove external defect like void.

Tensile Characteristics

Effect of tool rotation speed

Sr.no	Tilt angle(degree)	Rotational speed (rpm)	UTS(N/mm^2)	% elongation
1	0	1950	90	9.23
2	0	2300	82	8.89
3	0	3080	76	8.39
4	1.5	1950	107	10.53
5	1.5	2300	99	9.56
6	1.5	3080	92	8.95
7	3	1950	120	12.47
8	3	2300	112	11.79
9	3	3080	101	10.68

Table 2

It can be observed that the tensile strength decreases from 90 to 76 MPA with 0° tilted tool welding and 107 to 92 MPA with 1.5^o tilted tool and 120 to 101 with 3° tilted tool. Increase in rotational speed from 1250 to 3080 rpm and keeping low welding speed and by increasing the tool rotational speed, there is sharp decrease in tensile strength.

At high welding speed, and increasing the tool rotational speed, there is a decrease in tensile strength.

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