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EXPERIMENTAL STUDY OF FRICTION STIR WELDING SPEED EFFECT ON STRENGTH OF MATERIAL AA-6082 AND AA-6061 ALUMINIUM ALLOYS

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ABSTRACT

Aluminium alloy has gathered wide acceptance in the fabrication of light weight structures requiring a high strength to weight ratio. Compared to the fusion welding processes that are routinely used for joining aluminium alloys, Friction Stir Welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast. In present study an attempt has been made to develop a model to predict tensile strength of the friction stir welded Two Different AA6082-AA6061 aluminium alloys by incorporating FSW process parameters. The FSW process parameters such as rotational speed, welding speed, axial force and attack angle play vital roles in the analysis of weld quality. The aim of this research study is to investigate the effects of different welding speeds on the weld quality of Two Grads AA6082-AA6061 aluminium. The obtained results explain the variation of stress as a function of strain and the effect of different welding speed on ultimate tensile strength and hardness. The friction stir welded plates of AA6082-AA6061 by using the taper pin profile reaches the ultimate tensile strength of 115Mpa which is (62.16% - 60.52%) of the base metal ultimate strength.

Keywords: Practical on Friction stir welding, AA6082-AA6061 aluminium alloys, welding speed, mechanical properties.

INTRODUCTION

The welding of aluminium and its alloys has always represented a great challenge for designers and technologists. As a matter of fact, lots of difficulties are associated to this kind of joining process. Friction Stir Welding (FSW) is an emerging solid state joining process in which the material that is being welded does not melt and recast. Friction stir welds will not encounter problems like porosity, alloy segregation and hot cracking, and welds are produced with good surface finish and thus no post weld cleaning is required. The effect of process parameters such as rotational speed, traverse speed, tool geometry and axial force on weld properties is major topics for researchers. Most of the papers published on FSW are focusing on the effect of FSW parameters and tool profiles on tensile properties and microstructure formation. Hence, here an attempt has been made to develop a model to predict tensile strength of the friction stir welded aluminium alloys. In this investigation, an attempt has been made to understand the effect of different welding speed on the weld quality of Two Different Grads AA6082-AA6061 aluminium using FSW process. Taper pin are used as tool pin profiles in this research. The pin travelled longitudinally at different welding speed (mm/min) and the tool rotation speed was held constant at 1400 rpm in all of the experiments.

FRICTION STIR WELDING

The principle of Friction Stir Welding FSW, a cylindrical shouldered tool with a profiled pin is rotated and plunged into the joint area between two pieces of sheet or plate material. The FSW process is divided in two famous processes defined as lap joints and butt joints. In this research, the process of butt joints is investigated. The two plates are clamped on a rigid back plate. The fixturing prevents the plates from spreading apart or lifting during welding. The welding tool, consisting of a shoulder and pin, is then rotated to a prescribed speed. The tool is slowly plunged into the work piece material at the butt line, until the shoulder of the tool forcibly contacts the upper surface of the material and the pin is a short distance from the back plate. A downward force is applied to maintain the contact and a short dwell time is observed to allow for the development of the thermal fields for preheating and softening the material along the joint line. At this point, a lateral force is applied in the direction of welding (travel direction) and the tool is forcibly traversed along the butt line until it reaches the end of the weld. Alternately, the plates could be moved while the rotating tool remains stationary. Upon reaching the end of the weld, the tool is withdrawn while it is still being rotated. As the pin is withdrawn, it leaves a keyhole at the end of the weld. The FSW process of butt joints is shown in Figure 1.

Figure-1 *Experimental work*

Figure-2

The friction stir welds have been carried out by using a properly designed clamping fixture that allows the user to fix the two sheets (150mm × 150mm) with the Square plate of 3mm thickness to be butt welded on a vertical milling machine. Figure 2 shows the vertical milling machine used for experimental work.

Table-1 *Specification of milling machine*

Make	BFW	
Model	HF1	
Table Size	1175mm x 230mm	
Movement	Longitudinal	590
	Transverse	270
Speeds	45-2000rpm	
No. of Feeds	18	
Feed Range	16-800 mm/min	

Table-2 *Mechanical properties of AA6082-AA6061*

Material	Ultimate Strength (MPa)	Yield Stress (MPa)	% Elongation
AA6082	185	60	14
AA6061	190	65	16

Table-3 *Chemical compositions (wt. %) of the base metal*

Base Material	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr
6082	0.1	0.4	0.6	0.6	0.4	0.1	0.2	0.25
6061	0.15	0.7	0.4	0.7	0.8	0.2	0.2	0.15

CONFIGURATION OF WELDING TOOL GEOMETRY

Figure 3 shows the image of tool pin profiles used in this research work in order to fabricate the joint in which is the taper shape pin and geometrical configuration is shown in figure. The big diameter of the pin and small diameter of the Taper pin 5.54mm 4.30mm.The material of tool is AISI H13 the properties are shown in table 4, 5.

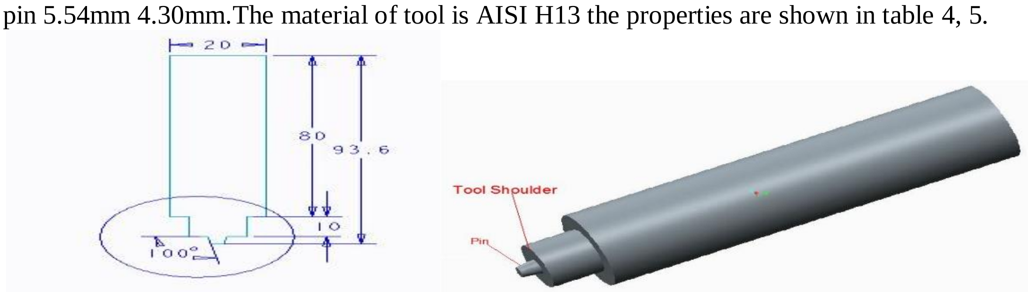

Figure-3 *Tool Dimension*

Table-4 *Properties of AISI H13*

Density Kg/M^3	Thermal conductivity W/m-k	Thermal Expansion $60^{-6}/^{o}C$	HRB
7.76	28.6	10.4	95

Table-5 *Chemical composition (wt. %) of tool*

Element % Present	Si 0.3 to 0.4%	C 1.8 to 2.1%	Mn 0.3 to 0.4%	Cr 11.8 to 12.2%

Heat treatment of tool as per ASTM A-681 for good mechanical properties under the practical performance shown in table 6

Table-6 *Heat treatment*

Temperature	$1010^{0}C$
Time	30 min
Cooling	Air cooled
Hardness	50 HRC

WELDING PARAMETER

The welding parameters used to fabricate the joints are presented in Table 7.

Table-7 *Welding parameter*

Rotating speeds(rpm)	1400
Welding speeds (mm/min)	80,100,125
Pin length (mm)	3.6
Tool shoulder diameter (mm)	12

All the view of fixture with clam, Aluminium Plate, nut, bolt is shown in Figure 4.

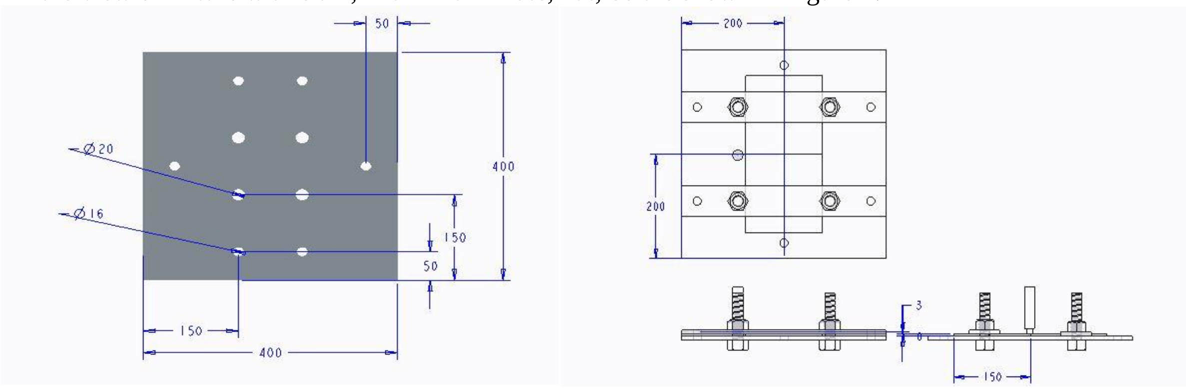

Figure-4 *Fixture Dimension and Diagram*

ALL PART USE IN THE PRACTICAL

Table-8

Part List			
1	Base Plate	M.S	1
2	Workpice	Aluminium	2
3	Insulation Plate	Asbestos	2
4	Clamp	M.S	2
5	Nut & Bolt	C-30	4

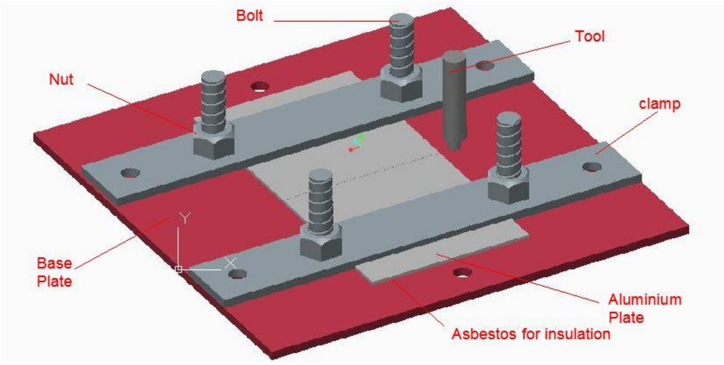

Figure-5 *Image of practical arrangement.*

SPECIMEN PREPARATION FOR TENSILE TESTING

The welded joints are sliced using power hacksaw and then machined to the required dimensions to prepare tensile specimens as shown in Figure 6. These specimens are taken in the normal direction of the weld. The specimen is loaded and tensile specimen undergoes deformation.

Figure-6 *tensile specimen for test*

Dimensions of tensile specimen are 30mm x 200mm.Which is used in the test for finding Mechanical Properties. Tensile tests were performed to determine the mechanical properties of the material such as yield strength, tensile strength and percentage of elongation have been evaluated. Three specimens are tested at each condition and average of the results of three specimens is measured as a final result.

RESULT AND DISCUSSION

The predicted results are plotted as graphs and they are displayed in Figure 7 to 9. The plotted graphs can be effectively used to understand the effect of FSW process parameters such as welding speed tool profiles on tensile strength of friction stir welded AA6082-AA6061 aluminium alloy joints.

EFFECT OF WELDING SPEED ON THE TENSILE PROPERTIES

Tensile properties such as tensile strength have been evaluated. At each condition specimens are tested and average of the results of specimens is presented as the outcome of this research work. Figures show the engineering stress-strain relationship of the welded products and Results are shown in tables from 9 to 11.

Table-9 *Test Result on Welding Speed 80 mm/min*

S.No	TEST PARAMETER	UNIT	RESULE	TEST METHOD
1	Ultimate Tensile Strength	Mpa	62.0	IS:1608-2005
2	0.2 Proof Stress/Yield Stress	Mpa	27.0	
3	Elongation Percent	%	9.5	

Stress-Strain Curves for speed of 80 mm/min

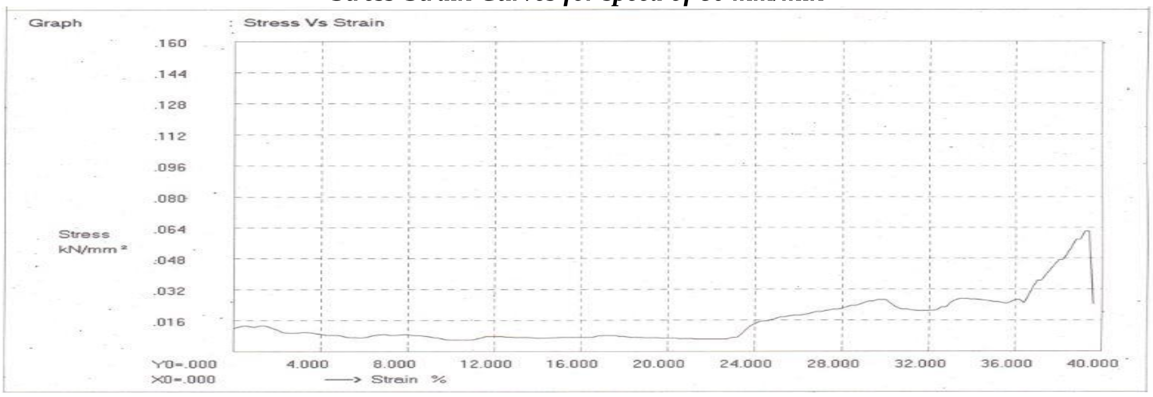

Figure-7

Table-10 Test Result on Welding Speed 100 mm/min

S.No	TEST PARAMETER	UNIT	RESULE	TEST METHOD
1	Ultimate Tensile Strength	Mpa	115.0	IS:1608-2005
2	0.2 Proof Stress/Yield Stress	Mpa	27.0	
3	Elongation Percent	%	7.95	

Stress-Strain Curves for speed of 100 mm/s

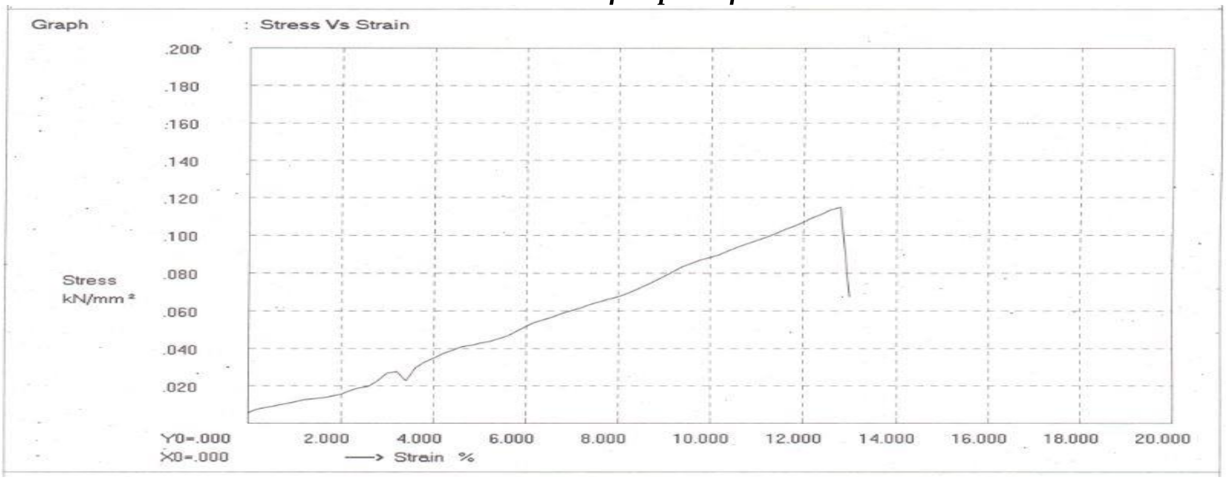

Figure-8

Table- 11 Test Result on Welding Speed of 125 mm/min

S.No	TEST PARAMETER	UNIT	RESULE	TEST METHOD
1	Ultimate Tensile Strength	Mpa	77.0	IS:1608-2005
2	0.2 Proof Stress/Yield Stress	Mpa	33.0	
3	Elongation Percent	%	9.4	

Stress-Strain Curve for Speed of 125 mm/min

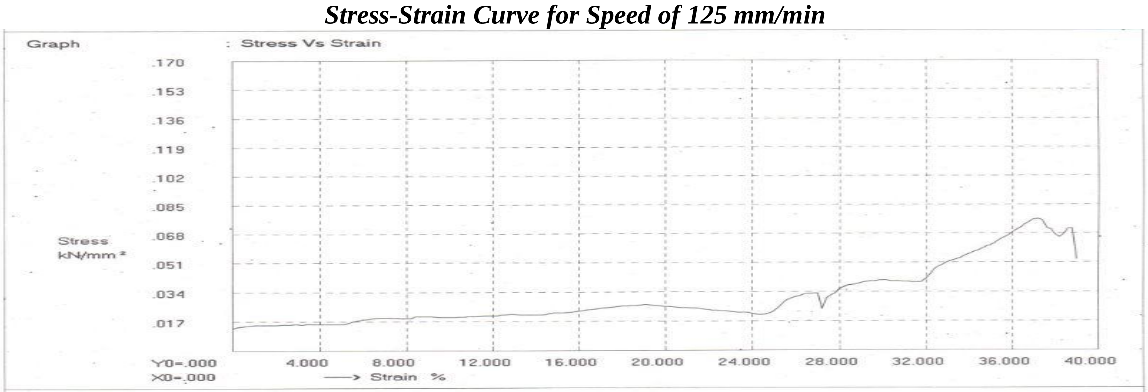

Figure-9

CONCLUSION

In this paper, AA6082-AA6061 alloys welded by using FSW process. Taper shape tool pin profile used and study the mechanical properties of joint. Also the effect of different welding speed is investigated in this research. From this research, the following conclusions are derived:

The results indicate that welding speed has a significant effect on the joint and on the mechanical properties. When we increasing the welding speed after some certain limit the strength of the joint start goes down. It is found that the joint fabricated using taper pin exhibits superior tensile properties at the 100 mm/min of speed. The joints fabricated at a welding speed of 100 mm/min show superior tensile properties compared to 80,125 mm/min which is 115 Mpa (62.16% - 60.52%) of the base metal ultimate tensile strength. At welding Speed of 80 mm/min ultimate tensile strength of the taper pin profile goes up to the 62 Mpa which is (33.51% - 32.63%) of the base metal ultimate tensile strength. at welding Speed of 125 mm/min ultimate tensile strength of the taper pin profile reaches to the 77 Mpa which is (41.62% – 40.52%) of the base metal ultimate tensile strength. Finally we conclude that the friction stir welded plates of AA6082-AA6061 by using the taper pin profile at a welding speed of 100 mm/min reaches the ultimate tensile strength of 115Mpa (62.16% - 60.52%) of the base metal ultimate strength. When we increasing the welding speed after some certain limit the strength of the joint goes down like at speed of 100mm/min it is 115Mpa and at speed of 125mm/min it goes down 77Mpa.

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