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OPTIMIZING THE PARAMETERS FOR FRICTION STIR WELDING OF DISSIMILAR ALUMINIUM ALLOYS AA 5383/AA 7075

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ABSTRACT

Aluminium alloys which exhibits very attractive mechanical, physical and chemical properties have intensive demand in various areas especially marine structure. In order to join aluminium alloys various welding methods are employed but the recent innovative and environmental friendly techniques is friction stir welding. In this study dissimilar aluminium alloys AA 5383 and AA7075 have been joined using friction stir welding. The factors which influencing the welding parameter are tool rotation speed, transverse feed which are varied to 700, 800, 900 rpm and 40, 60, 80 mm/min. The 6mm plates are joined by keeping the axial force constant at 10kN. The weldment is achieved using a square tool of pin diameter 8mm. The effect of welding parameters chosen are evaluated using hardness testing to know the resistance to wear of the weld metal and tensile testing to know the properties and ductility of a weldment. The maximum tensile strength obtained is for the parameter of 700 rpm and 40 mm/min transverse feed produced a high tensile strength of 211MPa.

Keywords: friction stir welding, transverse feed, axial force.

1. INTRODUCTION

In shipbuilding industry the use of aluminum alloys is increasing due to its light weight compared to steel. Aluminum alloys are helpful in reducing weight, excellent corrosion resistance and very good strength to weight ratio.

Friction stir welding (FSW) a solid state welding process produces coalescence at temperature below melting point of base materials being joined is invented by Welding institute (TWI), United Kingdom in the year 1991 [1].Without the use of filler metals welding can be achieved using FSW. The FSW process is an ideal metal joining technique which is a green technology due to its environmental friendliness, energy consumption, and its versatility. Dissimilar aluminum alloys and similar aluminum alloys are joined efficiently using FSW without concern for the compatibility of composition which is an issue in fusion welding [2-4]. A non-consumable rotating tool serves the purpose of connecting two plates by means of frictional heating. The tool pin and shoulder are helpful in generating heat, and stirring to produce the joint. FSW process results in intense plastic deformation in materials which results in fine equiaxed recrystallized grains. Material flow mechanism is explained with the dominant parameters involving tool rotational speed, welding speed, and axial force [5]. Various joint configurations are possible in FSW but the most preferable configuration is butt and lap joints. No special preparation is needed for FSW of butt and lap joints.

AA 7075 is one of the most used aluminum alloy which is extensively used in automotive industries. The welding of AA 7075 by fusion welding results in cracking [6, 7]. Due to oxidation and vaporization of zinc during welding results in many defects. AA 5383 is an aluminum magnesium alloy and the most important feature is high resistance to oxidation and corrosion, which is extensively used in marine industries, pressure vessels and trucks.

Jeom Kee Paik [8] have been produced the joint of AA 5383 and AA 5083 by means of fusion welding and FSW. It is observed that tensile strength performance of friction stir welded aluminum alloys is superior to that of fusion welded aluminum alloys. Wichai Pumchan [9] studied the FSW of AA 6063 and AA 7075 for constant rotational speed of 2000 rpm, welding speed of 500-200 mm/min and tilt angle of 2^0. The maximum tensile strength of 105 MPa for welding speed 100 mm/min and maximum hardness of 152HV at weld center was welding speed of 50mm/min. Ravikumar et al [10] reports on FSW of AA 7075 and AA6061 with three rotational speeds of 800, 900,1000 rpm and welding speeds of 80,90,100 mm/min. the axial force is kept at 12 kN constant and tilt angle of 0^0.Three different pin profiles (Taper cylindrical threaded, taper square threaded and square) tools are used for welding. The parameters of 900 rpm and 90 mm/min for cylindrical threaded and 800rpm and 90 mm/min yielded substantial values in terms of tensile strengths.

The literature review reveals that tool geometry and parameters have greater influence on joint efficiency. For joining of AA 5383 and AA 7075 parameters and tool geometry are choosen carefully for FSW. The effect of tool rotational speed, welding speed are analyzed, and mechanical behavior of weldment for the dissimilar aluminum alloys using FSW. In this study the transverse tensile testing is performed to study the properties of weldment such as tensile strength, yield stress and elongation. The hardness testing is performed to give an idea of the resistance to wear of the weld metal. Hardness values can give information about the metallurgical changes caused by welding.

2. EXPERIMENTAL SETUP

Aluminum alloys of AA 7075 and AA 5383 were selected for fabrication of dissimilar joints using the FSW process. The FSW joints were produced at Annamalai

University, Chidambaram, Tamil nadu using CNC controlled FSW machine
The chemical composition of base metals AA7075 and AA5383 are evaluated by Spot spectroscopy analysis the test results are shown in Table-1.

Table-1. Chemical composition of base metals AA7075 and AA5383.

Composition (Wt %)								
Elements	Al	Zn	Mg	Mn	Fe	Cu	Cr	Si
AA 7075	90.05	5.496	2.374	0.028	0.139	1.564	0.251	0.023
AA 5383	94.78	0.021	4.237	0.579	0.214	0.012	0.064	0.057

The thickness of the plates are 6mm each and the plate is 150 mm long and 50 mm wide. The base metal properties are tested and the values are shown in Table-2.

Table-2. Base metal properties.

Base metals	Ultimate Tensile Strength (MPa)	Yield stress (MPa)	% of Elongation	Brinell Hardness value	Impact strength (Joules)
AA 7075	578.997	521.997	9.20	186	23
AA 5383	112.99	75.55	3.75	105	19

Table-3. Welding parameters.

Tool rotational speeds	700,800,900 rpm
Transverse feeds	40,60,80 mm/min
Axial force	10kN constant
Tilt angle	0^0

The square tool was prepared for the welding with a pin diameter 8 mm, tool shoulder of 24 mm and pin length of 5.7 mm, as shown in Figure-1. The joints were fabricated using CNC controlled FSW machine by single pass procedure. The feed, tool rotational speed, and axial load are given as input parameter using automatic CNC controller machine. The friction stir welded dissimilar AA7075 and AA5383 aluminum alloys shown in Figure-2. The AA7075 is placed on the advancing side and AA5383 is placed on the retreating side since its hardness is less than the other.

Figure-1. Square tool.

Figure-2. FSW of AA7075 & AA5383.

3. RSEULTS AND DISCUSSIONS

a) Tensile test

The tensile test sample is prepared as per ASTM standard E 8M. The three rotaional speeds influenced in this paper are 700, 800, 900 rpm. The lower tool rotational speed with lower feed produced maximum tensile strength. The higher rotational speed with 40mm/min feed rate gives more tensile strength than other feed rates. The Figure-3 shows tool totational speed of 700rpm gives maximum UTS of about 211.333 N/mm^2. The Figure-4 shows the tool rotational speed can be of anything but the feed rate should be lower. The lower the feed rate higher the UTS. The lower tensile strength is achieved in the TRS of 900 rpm with feed rate of 80mm/min due to improper mixing of zinc from AA7075 side to AA5383 side of magnesium.

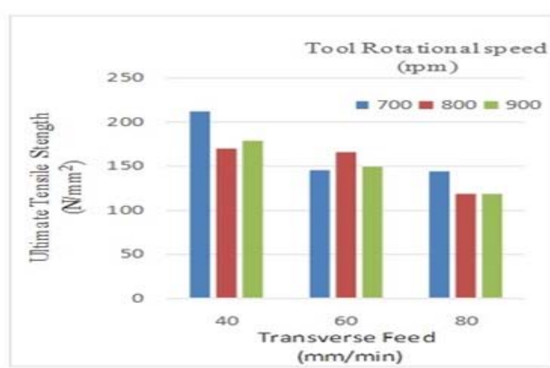

Figure-3. Transverse feed vs. UTS.

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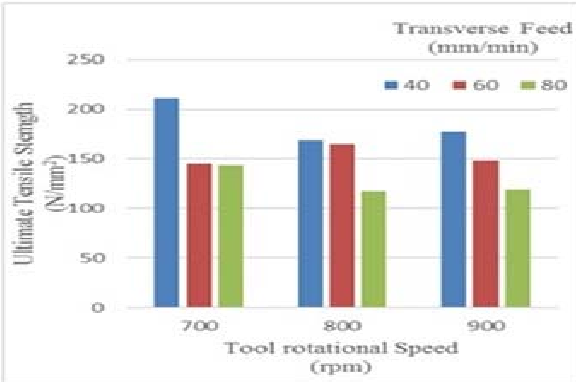

Figure-4. Tool rotational speed Vs UTS.

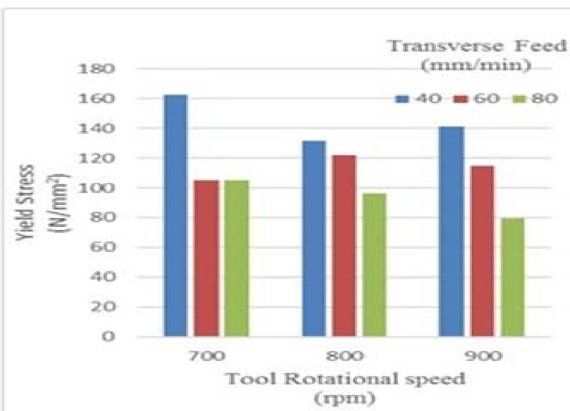

Figure-5. Tool rotational speed vs. yield stress.

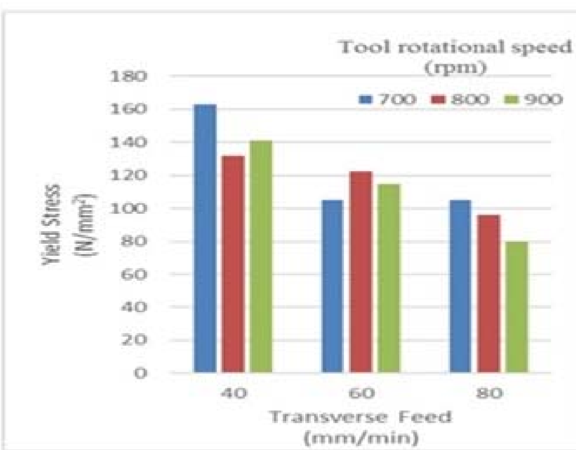

Figure-6. Transverse feed vs. yield stress.

The Figure-5 shows the yield stress for TRS with varying transverse feed. The varying transverse feed has an impact on yield stress. The lower feed rates have given maximum yield stress. Figure-6 shows the higher feed rate affects the yield strength, lower the feed greater the yield stress.

b) Hardness test

The hardness test is performed for the specimen by means of Rockwell hardness. The 1/16 ball indentor is choosen for aluminum alloys. The Figure-7 shows hardness for 700 rpm with varied transverse feed, the hardness for 700rpm, with 40mm/min produced high hardness in the weldment. The higher feed rate affects the hardness of the material. As compared to base metal the hardness increases in the HAZ zone in AA5383 side, as it progress towards weld zone and AA7075 side it gradually increases. The Figure-8 shows TRS of 800 rpm with feed rate of 40mm/min have high hardness compared to other feed rates. The hardness value in the weldment is comparatively higher due to the very good mixing of zinc in AA7075 and magnesium in AA5383.

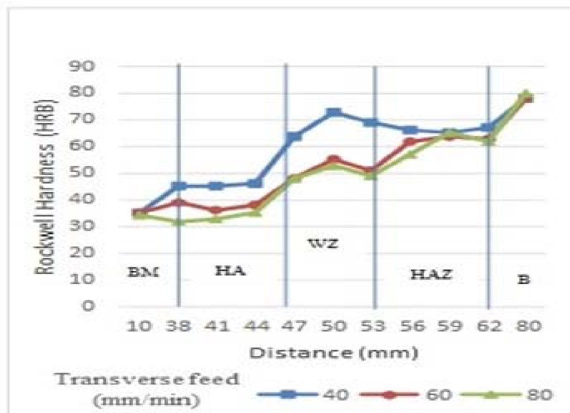

Figure-7. At 700 rpm TRS with various transverse feed.

Figure-8. At 800 rpm TRS with various transverse feed.

The Figure-9 shows the hardness value for constant tool rotational speed of 900 rpm with varying transverse feed rates. Both 40mm/min and 60mm/min give a similar hardness in the weldment. The lower rates give enough heat input to join these hard aluminum alloys. The hardness of base metal AA5383 is 35 RHB, it increases in the weldment and it increase when it move towards AA7075 base metal side.

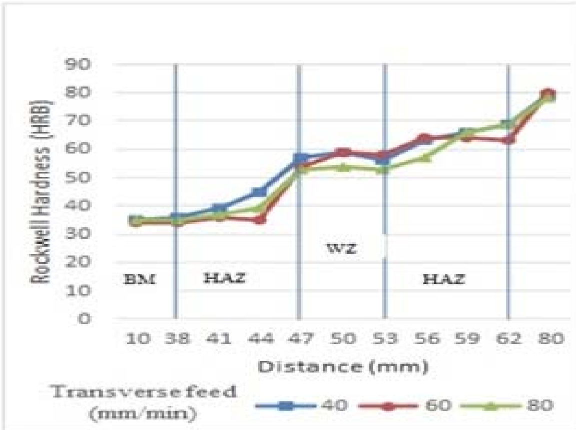

Figure-9. At 900 rpm TRS with various transverse feed.

4. CONCLUSIONS

FSW of AA7075 and AA5383 dissimilar joints were successfully accomplished for the different parameters. The Weld quality for various tool rotational speed and transverse feed has been studied. When the transverse feed increases lack of heat input affects the joints and its tensile properties gets affected. From the experiment conducted the tool rotational speed of 700 rpm with 40mm/min transverse feed gives excellent mechanical property both tensile as well as hardness.

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