Effect of tool on tensile strength in single and double sided friction stir welding.

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Abstract - *In this experimental work, an extensive investigation had been carried out on AL 19000-H12 grade aluminum alloy plates. Plates of aluminum alloy (AL19000H12) size 200x50x6 mm were used for experiment. Material of weld tool used high carbon steel Diameter of tool head used 17 mm and length 50mm. Four different tool pin profiles (Straight cylindrical, Square, Threaded and Triangular) be used to fabricate joints in a single and sequential double sided. In this investigation, tool rotation and traverse speeds be kept constant i.e. 3000 rpm and 25 mm/min. The variables are shape of the tool and having passes one sided and both sided. Tensile test specimens are prepared according to the guidelines of American Society for Testing of Materials (ASTM) to be tested on UTM (Ultimate tensile strength). Ultimate tensile strength, percentage elongation and joint efficiency are noted. Various mechanical properties of the joints are evaluated.*

Keywords: - AL19000H12, Join efficiency, Percentage elongation, Tensile strength, UTM.

1 INTRODUCTION

In this investigation, an attempt has been made to establish relationship between the base material properties and FSW process parameters. FSW is a solid state welding process for joining aluminum alloys and has been employed in aerospace, rail, automotive and marine industries for joining aluminum, magnesium, zinc and copper alloys. In FSW, the base metal properties such as yield strength, ductility and hardness control the plastic flow of the material under the action of rotating non-consumable tool.

Several previous studies reported the effects of the tool threads and probe profile on different aluminum alloys. In spite of these achievements, the effect of tool shape on mechanical properties in single and sequential double sided friction stir welds of aluminum alloy AL19000 has not yet been systematically classified. Additionally, in order to design effective tools of high carbon steel to precede FSW on aluminum alloys, new concept is necessary. The tool requires the following characteristics:

1. As simple a shape as possible to reduce cost

2. Sufficient stirring effect to produce sound welds.

Hence an attempt has been made to study the effect of influence of tool shape on the mechanical properties (tensile strength) of AL19000 in single and double sided friction stir welds in this project.

2 EXPERIMENTAL METHODOLOGY

2.1 Friction Stir Welding:-

Friction stir welding also produces a plasticized region of material, but in a different manner. The plates to be welded are butted together and clamped to a rigid backing plate. A non consumable rotating tool is pushed into the material to be welded. Then the central pin, or probe followed by the shoulder is brought in to contact with the two parts to be joined. The rotation of the tool heats up and plasticizes the material which is in contact with it. As the tool moves along the joint line, material from the front of the tool is swept around this plasticized annulus to the rear so eliminating the interface.

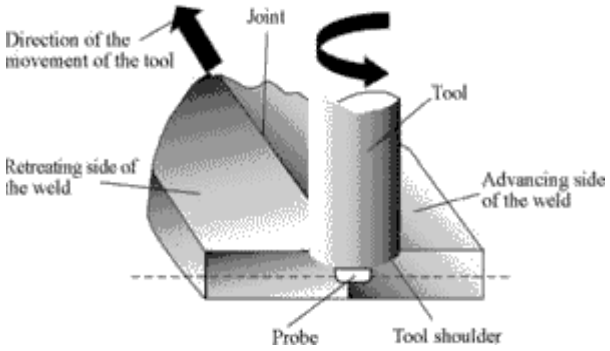


Fig.1 Friction Stir Welding

In general, the process is robust and a wide range of processing parameters and tool designs can be used to make metallurgical sound welds in a given alloys and plates thickness while using a wide range of processing parameters, the chosen process parameters may significantly affect the mechanical properties of weld through direct modification of weld microstructure.

3 EXPERIMENTAL SETUP AND PROCESS PARAMETERS SELECTED

3.1 Work piece material and composition

The base material (BM) used in this investigation is aluminum alloy AL19000. AL19000 having mechanical properties like Tensile strength (110Mpa), Yield strength (105MPa) and Elongation up to 12 %.Plates of aluminum alloy (AL19000H12) size 200x50x6 mm were used for experiment. The chemical composition of AL 19000 Cu(0-0.1), Mn(0-0.1), Si(0-0.5), Fe(0-0.6) and Min.99% Al.

3.2 Selection of Tool for experiment

High carbon steels used for welding. Diameter of tool head used 17 mm. Different shapes of tools being used for single side FSW dimensions are given below

1. Straight Cylindrical (SC) – pin diameter-5mm and pin length – 5.5 mm
2. Square (SQ)- pin dimensions – (5x5)mm , diagonal 7 mm and pin length – 5.5 mm
3. Cylindrical Threaded (TH) – pin diameter 6mm , pitch of thread- 0.7 mm, pin length- 5.5 mm
4. Triangular (TR) – diagonal – 5mm , pin length- 5.5 mm

Fig2. Different shapes of tools being used for FSW

Similarly four shapes of tools being used for double sided FSW dimensions are given below

1. Straight Cylindrical (SC) - pin diameter-5mm and pin length -3 mm
2. Square (SQ) - pin dimensions – (5x5)mm, diagonal 7 mm and pin length-3 mm
3. Cylindrical Threaded (TH)- pin diameter 6mm, pitch of thread- 0.7 mm, pin length-3 mm
4. Triangular (TR) – diagonal – 5mm , pin length- 3 mm

3.3 Experimental work

Machine tool used for FSW operation is vertical milling machine of following specifications.

Specifications	Values
Make	PACMILL
Range	100-4650 rpm on 50Hz
Type	Vertical
Longitudinal bed range	900mm
Cross bed range	600mm
Traverse feed range	12-900 mm/min.
Motor	3H.P, 1450 rpm
Tool holder diameter	50 mm

Before testing welded specimen (single and double sided) were assigned number as single sided welded specimen assigned odd number and double sided welded specimen assigned even numbers.

Figure 3 Vertical milling machine used for FSW operation

Sr. No.	Specimen name	Type of weld pass	Tool shape
1	S1	Single	Straight cylindrical
2	S2	Double	Straight cylindrical
3	S3	Single	Square
4	S4	Double	Square
5	S5	Single	Cylindrical threaded
6	S6	Double	Cylindrical threaded
7	S7	Single	Triangular
8	S8	Double	Triangular
9	S9	Base metal	-

1. TENSILE TEST RESULTS OF BASE METAL (Notch Tensile Strength)

Specimen No.	Dimension	Ultimate Tensile Strength		Percentage Elongation	
	Area (mm^2)	Load (kgf)	Stress (N/mm^2)	Elongated Length (mm)	% Elongation
S-9	14.48x6	1280	144	52.48	4.96

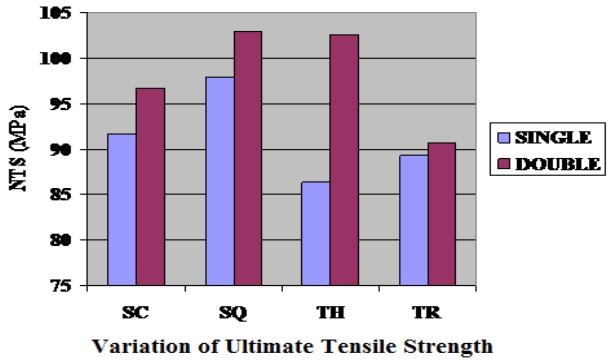
2. TENSILE TEST OF WELDED SPECIMENS IN SINGLE PASS (Notch Tensile Strength)

Specimen No.		Ultimate Tensile Strength		Percentage Elongation		Joint Efficiency
	Area (mm^2)	Load (kgf)	Stress (N/mm^2)	Elongated Length (mm)	% Elongation	
S-1	14.75x6	828	91.75	52.21	4.42	63.71
S-3	15.35 x6	920	97.96	56.73	13.46	68.00
S-5	15.60 x6	824	86.33	53.27	6.54	59.95
S-7	15.20 x6	830	89.25	53.64	7.28	61.97

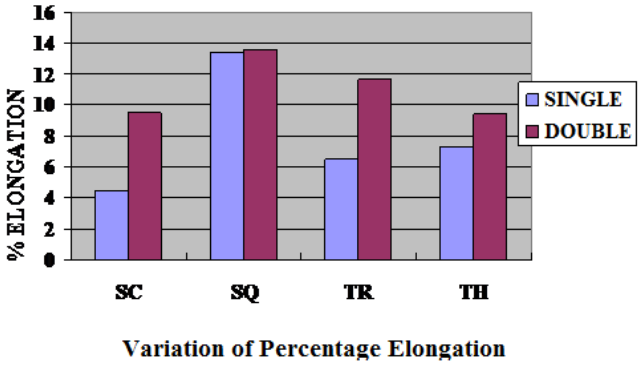
3. TENSILE TEST RESULTS OF WELDED SPECIMENS IN DOUBLE PASS (Notch Tensile Strength)

Specimen No.		Ultimate Tensile Strength		Percentage Elongation		Joint Efficiency
	Area (mm^2)	Load (kgf)	Stress (N/mm^2)	Elongated Length (mm)	% Elongation	
S-2	14.88x6	880	96.66	54.73	9.46	67.13
S-4	15.30 x6	964	102.98	56.82	13.64	71.51
S-6	14.85x6	932	102.57	55.82	11.64	71.23
S-8	14.70 x6	816	90.73	54.70	9.4	63

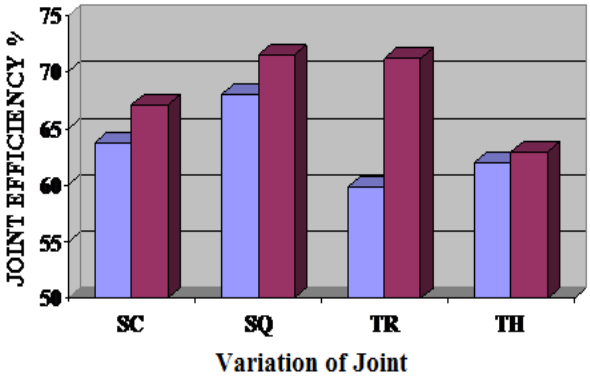
4 RESULT AND DISCUSSION:-



Variation of Ultimate Tensile Strength



Variation of Percentage Elongation



Variation of Joint

In this investigation an attempt has been made to study the effect of tool pin profile (straight cylindrical, threaded, triangular and square) on the formation of friction stir processing zone in a single and sequential double sided friction stir weld in AL19000. From this investigation, the following important conclusions are derived:

i. The joints fabricated by double passes have shown higher ultimate tensile strength and also percentage of elongation as compared to the joints fabricated by single pass and this trend is common for all the tool profiles.

ii. For the straight cylindrical pin profile tool, crack like defects are found in both single and double pass joints.

iii. Square pin tool having inferior tensile strength in both single sided and double sided FSW.

5 CONCLUSIONS

From this investigation, the following important conclusions are derived:

(i) The joints fabricated by double passes have shown higher ultimate tensile strength and also percentage of elongation as compared to the joints fabricated by single pass and this trend is common for all the tool profiles.

(ii) Square pin tool having inferior tensile strength in both single sided and double sided FSW.

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