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STUDY THE EFFECT OF TENSILE STRENGTH IN SINGLE SIDED FRICTION STIR WELDING ON AA6063 ALUMINIUM ALLOY

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ABSTRACT

Friction stir welding is a technique in which the work pieces are joined by profits of frictional heating and plastic deformation indeed a temperature below the melting point of the material to be joint. AA6063 is an aluminium alloy with magnesium and silicon as the alloying element. It has generally good mechanical properties and is heat mendable and weld able. It is similar to aluminium alloy HE9. Experiments are showed by varying rotational speed, transverse speed and altered shoulder diameter. The Taguchi Method is used to find the combination of the three welding parameters. In this work three parameters are taken and L9 orthogonal array are selected to progress parameters for strength of the welded joint. The Tensile strength is mainly posh by Tool speed and beside it shoulder diameter & feed rate also affect to some extent.

KEYWORDS: Friction stir welding (FSW) Tool, simple milling machine, Aluminium alloy 6063, Minitab15, Tensile strength, cylindrical tool.

INTRODUCTION

Friction stir welding (FSW) developed by The Welding Institute (TWI), in 1991is one of the judiciously current solid state welding technique. [1] The ASM explanation for a welding process is "a materials joining process which produces amalgamation of materials by heating them to seemly suitable temperatures with or without the application of pressure or by the application of pressure alone and with or without the usage of filler material."[2].

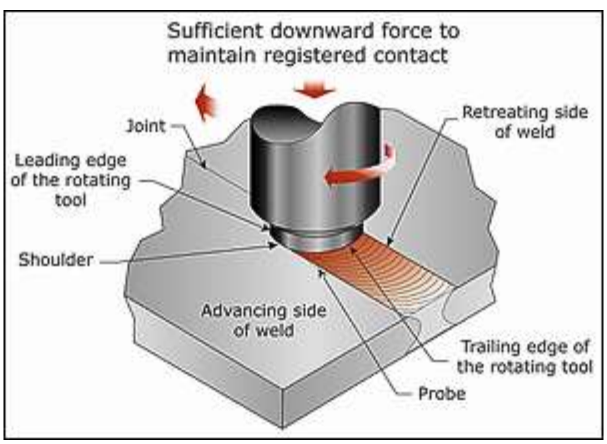

Fig 1. Friction stir welding.

A rotating cylindrical tool generally consisting of shoulder and pin is injected into and stirred laterally the butt joint of the joining partners. Since heating and plastic flow of the welded material produced by the rotating FSW tool attain bonding of the joining partners well below the melting point [4]. Forceful design by Taguchi is one of the best procedure for inward at a conclusion while selecting most advantageous welding parameters within a short duration of time at less materials cost and labor effort.[7]**.**W. M. Thomas et al in this paper will focus on the relatively new joining technology friction stir welding (FSW)[13]. Hidetoshi Fujiietal. seeking the optimal tool design for welding steels, the effect of the tool shape on the mechanical properties and microstructures of 5-mm thick welded aluminum plates [5]. P. Cavaliere et al.the goal of the this work was to examine on the mechanical and micro structural properties of different 2024 and 7075 aluminium[9] .A. Heidarzadeh et.al attempted used to evolution a mathematical model expecting the tensile properties of friction stir welded AA 6061-T4 aluminum alloy joints at 95% buoyancy level[3]. K. Elangovan et al In this study, five different tool pin profiles (straight cylindrical, tapered cylindrical, Threaded cylindrical, triangular and square) have been used to construct the joints at three different welding speeds [7]. V. Balasubramanian et al. studied that the FSW joints have been made using five different grades of aluminium alloys (AA1050, AA6063, AA2024, AA7039 and AA7075) using different combinations of process parameters [8]. Properties and tool rotational speed and welding speed, respectively. YAN Yong et al [15] in this research work different friction stir welding between 5052 Al alloy and AZ31 Mg alloy with the plate thickness of 6 mm was examined. Sound weld was obtained at rotation speed of 600 r/min and welding speed of 40 mm/min. Yong-Jai KWON et al [14] in his work, Friction stir welding between 5052 aluminum alloy plates with a thickness of 2 mm was achieved. The tool for welding was rotated at speeds ranging from 500 to 3000 r/min under a constant traverse speed of 100 mm/min. Puneet Rohilla et al. [10] directed the experiment, tool rotation and traverse speeds are kept constant i.e. 2000 rpm and 20 mm/min. The variables are shape of the tool and having licenses one sided and both sided Aluminum alloys are widely used as high precise strength material in automotive, avionics and ship-building industries. [6].

EXPERIMENTATION

Friction stir welding with vertical milling machine.

To express out the FSW experiment a vertical milling machine is used. The tool is straddling in the vertical arbor using a appropriate collates. The plates to be concomitant are clamped to the horizontal bed with nil root gaps. The clamping of the test pieces are done such that the drive of the plates are totally restricted under both plunging and translational forces of the FSW tool.

Table 1.The specification of the milling machine

Manufacturer	(PACMILL) Simple milling machine
Spindle Position	Vertical
Max. rpm	4700
Diameter of Tool Holder	17 mm
Motor	4 hp, 1420 rpm
Longitudinal Transverse speed Range	12-800 /min.

Welding tool

The tool geometry plays an important key role in material stream and in turn agrees the traverse rate at which FSW can be carried out. A FSW tool has two basic functions: (i) localized heating, and (ii) material flow. The initial FSW tool premeditated is a simple cylindrical tool with 16 mm shoulder diameter & two more diameters (18 & 20mm) are used to assemble the joints. The chosen tool geometries and the fabricated tool for FSW of 5mm thick aluminum alloy. All through the welding, the Straight Cylindrical shape tool is used and the material of the tool is High Carbon Steel.

Table 2. The dimensions of tool

Specifications	Values
Length of Tool	60 mm
Tool Shoulder Diameter	16 mm
Pin Diameter	6 mm
Pin Length For Single Pass	5.6 mm

Work Piece Material

Aluminum 6063 is used as the work piece material for stentorian out the experimentation to improve the Tensile strength. The plates used are of thickness 6mm and length & breadth of 2745mm and305mm (9ft. x 1ft.). Before the welding the sheet cutting into 9 pieces of length 305mm x 305mm (1ft.x 1ft.)& again cuts the single piece into two pieces of 153mm x 305mm (0.5ft.x1ft.).

Table 3. Composition of material AA6063

Material	Cu	Mg	Mn	Si	Fe	Al
AA 6063	0.10 max.	0.45-0.9	0.10 max.	0.2-0.6	0.35 max.	Remainder

Working Level Of Process Parameters

Experiments are attained to find the working levels of parameters. The levels are distinguished in experiments in table 4.

Table 4. Process parameters levels

Level	Tool Speed(rpm)	Feed Rate(mm/min)	Shoulder dia(mm)
1	1540	20	16
2	1725	25	18
3	1920	30	20

Design Of Experiment

Taguchi's designs directed to permit greater understanding of differentiate than many of the traditional designs. Taguchi resisted that conventional sampling is lacking here as there is no way of obtaining a casual sample of forth coming conditions. Taguchi proposed scattering each experiment with an "exterior array" or orthogonal array should fictitious the random environment in which the experiment would function. The design of experiment is shown in Table.5

Table 5. Design of Experiments

Sr. No.	Tool Speed(rpm)	Feed Rate(mm/min)	Shoulder dia(mm)
1	1540	20	16
2	1540	25	18
3	1540	30	20
4	1725	20	18
5	1725	25	20
6	1725	30	16
7	1920	20	20
8	1920	25	16
9	1920	30	18

RESULTS AND DISCUSSIONS

Ultimate Tensile Strength

Tensile strength of the FSW joints are foreseeable by conducting tests in universal testing machine(UTM). Tensile strength is the maximum load that a material can providing without fracture when being stretched. After machining, the prepared tensile specimens are inspected. As per the ASTM guidelines in the electro mechanical run universal testing machine (UTM) with a maximum 100KN capacity and the tensile force is given.

Table 6. Result for the ultimate tensile strength

Speed (rpm)	Feed rate (mm/min.)	Shoulder diameter (mm)	Area (mm^2)	Load (KN)	Tensile strength
1725	25	20	90	23.9	0.265

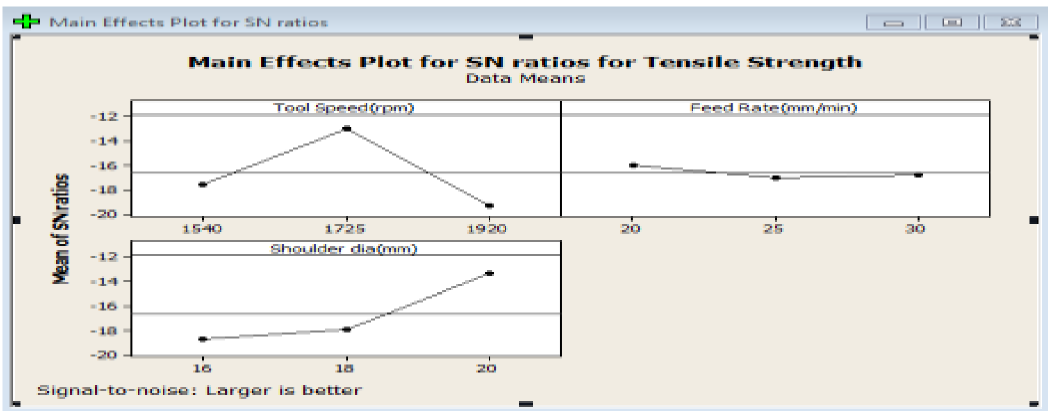

Fig. 2. Main Effects Plot for SN ratios for Tensile Strength

Effect of tool speed in tensile strength

The effect of tool speed on the Tensile strength values is shown in Fig.2 for S/N ratio. The effect of tool rotational speed on tensile strength in friction stir welded Al 6063 alloy joints. At lesser rotational speed (1540 rpm), the tensile strength of FSW joints is lower.

When the rotational speed is increased from 1540 rpm, melodiously the tensile strength reaches to a maximum at 1725. If the rotational speed is increased above 1725 rpm, the tensile strength of the joint decreased. Higher tool rotational speed (1920 rpm) resulting in higher heat input per unit length and slower cooling rate in the FSW zone causes excessive grain growth, which subsequently leads to lower tensile properties of the joints. Its effect is increasing with increase in tool speed up to1725 RPM. So the optimum tool speed is level 2 i.e. 1725 RPM.

Effect of feed rate in tensile strength

Of the three welding speeds used to fabricate AA 6063 alloy joints, the joint fabricated at a welding speed of 25 mm/min yield good tensile strength. The joint fabricated at a welding speed of 25 mm/min exhibited higher tensile strength and this may be due to adequate heat generation that is exactly sufficient to cause the material to flow plastically with appropriate under condition.

When the feed rate increases above the limit, then the tensile strength decreases because the avoidable grain evolution produces in welded region. The effect of feed rate on the tensile strength values are shown in Fig.2 for S/N ratio. Its effect is decreasing with increase in feed rate. So the optimum feed rate is level 1 i.e. 25mm/min.

Effect of Shoulder diameter in tensile strength

The shoulder of tool is designed to produce heat (due to friction and material deformation) on the surface of work piece. Due to large surface area friction increases which in turn increase the amount of heat generated. The temperature distribution under the shoulder diameter become more uniform with increase of shoulder size, the higher temperature is increased because the material flows at advancing side and the retreating side were different . It might be estimated that the temperature distributed is symmetric. The outcome of parameter shoulder diameter on the tensile strength values is shown in Fig. 2 for S/N ratio. Its effect is increasing with increase in shoulder diameter. So the optimum shoulder dia. is level 3 i.e. 20 mm.

Discussions
Optimization of headway parameter is the key in the Taguchi method to succeeding high quality without increasing cost. Optimization of headway parameters can improve quality and the ultimate process parameters obtained from the Taguchi method and other noise factors. Taguchi method is experimental design easy to apply for many engineering applications. Taguchi method can be used to quickly trivial the scope of a research project or to recognize problems in a manufacturing process. The Tensile strength is considered as the quality characteristic with the concept of "the larger-the-better".
The S/N ratio for the larger-the-better is:

$$S/N = -10\log_{10}\{1/n\sum 1/y^2\}$$

CONCLUSION
Taguchi method is used in this work. The present study is carried out to study the effect of input parameters on the tensile strength. The following conclusions have been drawn from the study:

- The Tensile strength is mainly affected by Tool speed and alongside it shoulder diameter & feed rate also little contribute to some extent.
- The Parameters considered in the experiments are optimized to conquer maximum Tensile Strength. The best decor of input process parameters for maximum Tensile Strength is Tool speed-1725 rpm, federate 25 mm/min, and Shoulder diameter-20 mm.

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