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

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ABSTRACT

In this paper, the effects of tool speed, feed rate, shoulder dia. On various mechanical properties of Aluminium alloy 6063 produced by friction stir welding have been analyzed. Friction stir welding is a technique in which the work pieces are merged by profits of frictional heating and plastic deformation certainly 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 moral mechanical properties and is heat mendable and weld able. It is similar like to aluminium alloy HE9. Experiments are exposed by varying rotational speed, transverse speed and altered shoulder diameter. The Taguchi Method is used to treasure the combination of the three welding parameters. In this work three parameters are taken and L9 orthogonal array are selected to development parameters for strength of the welded joint. An optimal result has been obtained using main effects plot using S/N ratio values. The elongation is mainly posh by temperature distribution and near it shoulder diameter & feed rate also affect to some extent.

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

INTRODUCTION

Aluminium alloys in the present modern world are suitable for wide applications including automobile industries, aerospace, railway fabrication, high speed ships and construction of heavy structures due to its light in weight and higher strength to weight ratio properties. Friction stir welding (FSW) developed by The Welding Institute (TWI), in 1991 is one of the sensibly current solid state welding technique. [1] The ASM description for a welding process is "a materials joining process which creates amalgamation of materials by heating them to decent 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].

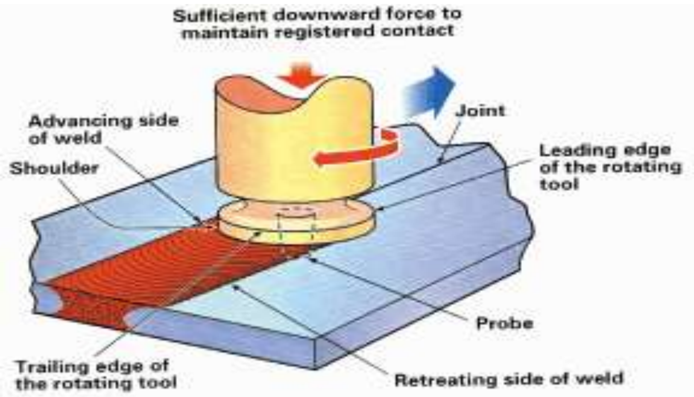

Fig 1. Friction stir welding.

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A rotating cylindrical tool normally consisting of shoulder and pin is vaccinated into and stimulated laterally the butt joint of the joining partners. Since heating and malleable flow of the welded material produced by the rotating FSW tool achieve bonding of the joining partners well below the melting point [4]. Dynamic design by Taguchi is one of the best procedure for inner at a conclusion while selecting most advantageous welding parameters within a dumpy duration of time at less materials cost and labor effort.[7]**.**W. M. Thomas et al in this paper will focus on the moderately new joining technology friction stir welding (FSW)[13]. Hidetoshi Fujiietal. looking for the optimal tool design for welding steels, the effect of the tool shape on the mechanical things and microstructures of 5-mm dense welded aluminum plates [5]. P. Cavaliere et al.the goalmouth of the this work was to observe on the mechanical and micro structural properties of different 2024 and 7075 aluminium[9] .A. Heidarzadeh et.al tried used to evolution a mathematical model imagining 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 concept the joints at three different welding speeds [7]. V. Balasubramanian et al. studied that the FSW joints have been made using five different marks 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 breadth 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 fluctuating 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 adjustable are shape of the tool and having licenses one sided and both sided Aluminum alloys are widely used as high detailed strength material in automotive, avionics and ship-building industries. [6].

EXPERIMENTATION

***Friction stir welding with vertical milling machine*.**

To prompt out the FSW experiment a vertical milling machine is used. The tool is bestriding in the vertical arbor using an appropriate collates. The plates to be connected are clamped to the horizontal bed with nil root gaps. The clamping of the test pieces are done such that the energy 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 position
Max. rpm	4700
Diameter of Tool Holder	17 mm
Motor	4 Horse Power(hp), 1420 rpm
Longitudinal Transverse speed Range	12-800 mm/min.

Welding tool

The tool geometry plays an vital key role in material tributary 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 deliberate is a simple cylindrical tool with 16 mm shoulder diameter & two more diameters (18 & 20mm) are used to accumulate the joints. The elected 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.

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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 thunderous out the experimentation to progress the elongation percentage. The plates used are of thickness 6mm and length & breadth of 2745mm and305mm (9ft. x 1ft.). Before the welding the sheet spiteful into 9 pieces of length 305mm x 305mm (1ft.x 1ft.)& again portions 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 achieved to find the working stages 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 focused to permit greater understanding of differentiate than many of the traditional designs. Taguchi battled that conventional sampling is lacking here as there is no way of obtaining a unplanned sample of forth coming conditions. Taguchi proposed scattering each experiment with an "exterior array" or orthogonal array should pretend the random environment in which the experiment would function. The design of experiment is shown in Table.5

Table 5. Design of Experiments(DOE)

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

Percent elongation quantifies the ability of an element or compound to stretch up to its breaking point. It is measured by dividing the change in length (up to the breaking point) by the original length, then multiplying by 100. Materials with a higher percentage elongation can stretch more before breaking. Brittle materials, such as glass or ceramics, have low elongation while very ductile materials, such as rubber of some plastics, have very high elongation. Metals tend to have low to moderate elongation capabilities.

Elongation percentage = change in length/ original length * 100

Table 6. Result for the elongation percentage

Speed (rpm)	Feed rate (mm/min.)	Shoulder diameter (mm)	Area (mm^2)	Holding Length(mm)	Change in length(mm)	Elongation (%ge)
1725	25	20	90	50	8.7	17.4

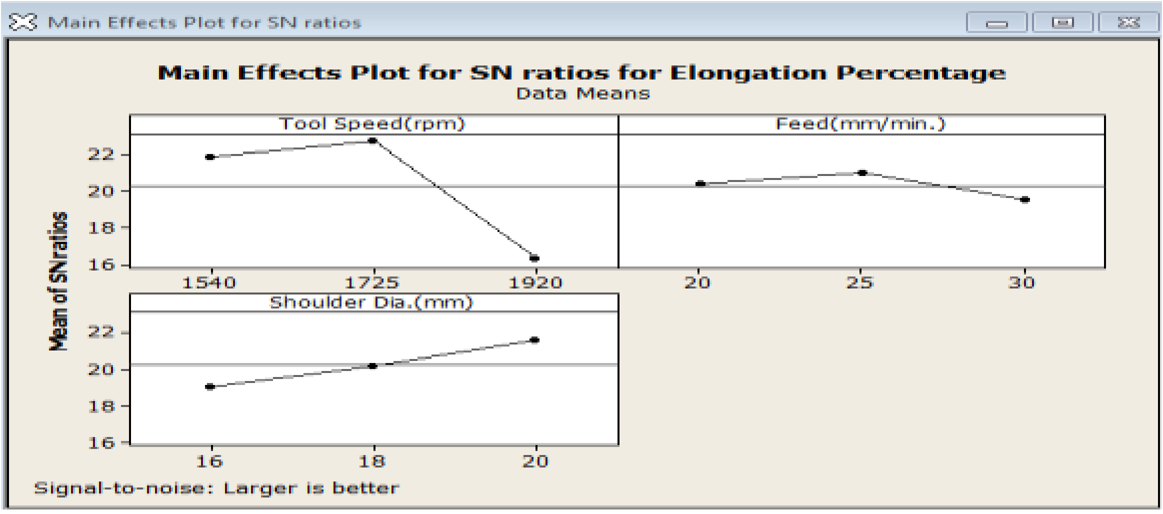

Fig. 2. Main Effects Plot for SN ratios for Elongation Percentage

Effect of tool speed in elongation percentage

The effect of tool speed on the Elongation values is shown in Fig.2 for S/N ratio. The effect of tool rotational speed on elongation in friction stir welded Al 6063 alloy joints. At lesser rotational speed (1540 rpm), the elongation of FSW joints is minor. It is understood that the heat input has strongly influenced the percentage of elongation. It is also found that the heat input plays an important key role in elongation.

When the rotational speed is increased from 1540 rpm, melodically the tensile strength reaches to a supreme at 1725 then the elongation percentage is also higher. If the rotational speed is increased above 1725 rpm, the tensile strength of the joint reduced. Higher tool rotational speed (1920 rpm) resulting in advanced heat input per unit length and slower cooling rate in the FSW zone causes unnecessary grain growth, which subsequently leads to lower elongation 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 elongation percentage

Out of the three welding speeds used to fabricate AA 6063 alloy joints, the joint invented at a welding speed of 25 mm/min yield good elongation**.** The joint fabricated at a welding speed of 25 mm/min displayed higher elongation and this may be due to satisfactory heat generation that is exactly proper to cause the material to flow plastically with appropriate under condition.

When the feed rate increases overhead the limit, then the elongation percentage decreases because the avoidable grain evolution produces in welded region. The effect of feed rate on the Elongation 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 elongation percentage

The shoulder of tool is calculated to produce heat (due to friction and material deformation) on the surface of work piece. It was initiate that when the shoulder diameter is added, more shoulder area touches to the work piece as a result more heat will be created on the work piece so that the weld joint will be improved. As the shoulder diameter increases the shoulder contact area also increases as a result more friction heat is generated. The temperature supply under the shoulder diameter become more even with increase of shoulder size, the higher temperature is increased because the material flows at advancing side and the retreating side were dissimilar. It might be estimated that the temperature spread is symmetric. The outcome of parameter shoulder diameter on the elongation 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 progression parameter is the key in the Taguchi method to ensuing high quality without increasing cost. Optimization of headway parameters can increase quality and the ultimate process parameters got from the Taguchi method and other noise factors. Taguchi method is experimental design relaxed to apply for many engineering applications. Taguchi method can be used to rapidly trivial the scope of a research project or to recognize problems in a manufacturing process. The Elongation is considered as the quality characteristic with the concept of "the larger-the-better".

The S/N ratio for the larger-the-better is:

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

TAGUCHI ANALYSIS: SIGNAL TO NOISE RATIO RESULTS

Response Table for Signal to Noise Ratios
Larger is better

Level	Tool Speed(rpm)	Feed(mm/min.)	Shoulder Dia.(mm)
1	21.83	20.37	19.07
2	22.70	20.98	20.19
3	16.32	19.50	21.58
Delta	6.38	1.48	2.51

CONCLUSION

Taguchi method is charity in this work. The present study is approved out to study the effect of input parameters on the Elongation percentage. The following conclusions have been strained from the study:

- The Elongation is mainly exaggerated by Tool speed, temperature and alongside it shoulder diameter & feed rate also tiny contribute to some extent.
- The Parameters considered in the experiments are improved to conquer maximum Elongation. The best design of input process parameters for extreme Elongation Percentage is Tool speed-1725 rpm, federate 25 mm/min, and Shoulder diameter-20 mm.

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