International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 02, February-2015

Optimization of Process Parameters of Friction Stir Welded Joint for Aluminium Alloys (H30-H30)

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***Abstract-* In this project I was used taper cylindrical with three flutes all made of High speed steel for the friction stir welding (FSW) aluminium alloy H30 –H30 and the tensile test of the welded joint were tested by universal testing method. The detailed mathematical model is simulated by Minitab17. In this investigation, an effective approach based on Taguchi method, has been developed to determine the optimum conditions leading to higher tensile strength. Experiments were conducted by varying rotational speed, transverse speed, and constant welding depth using L9 orthogonal array of Taguchi method. The present work aims at optimizing process parameters to achieve high tensile strength.**

Key words: Friction stir welding (FSW) Tool, CNC milling machine, Aluminium alloy H30-H30, Minitab17, Tensile test, taper cylindrical tool.

I. INTRODUCTION

Friction stir welding is a dynamically version of pressure welding processes. It was recently developed in England by welding institute (TWI) in 1991.friction stir welding can be created high quality weld by using milling machine because using same movement conditions but tool is different. Friction stir welding is extensively used for Al, Mg .Cu, Ti, for work pieces that could not welded by conventional types of welding and different applications because of economical and quality consideration [1]. This technique has been extended to similar as well as dissimilar welding of the above mentioned alloys and also to the welding of steels [2]. FSW can done on CNC milling machine for small work pieces to professional single purpose robotic machine in orbital FSW in steel pipes welding in oil industries [3]. The schematic of friction stir process shown in Figure 1.

Friction Stir Welding has been widely used in the aerospace, shipbuilding, automobile industries and in many applications because of many of its advantages over the conventional welding techniques some of which include very low distortion, no fumes, porosity or spatter, no consumables (no filler wire), no special surface treatment and no shielding gas requirements.

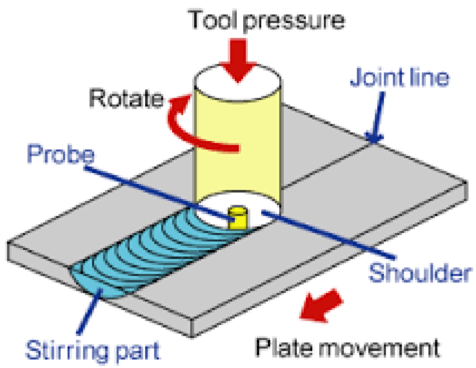


Fig. 1: Schematic of Friction Stir Welding.

In FSW, there have been lots of efforts to understand the effect of process parameter on flow behavior, microstructure formation and hence mechanical properties of FSW joints. To study the effect of FWS process parameters, most workers follow the traditional experimental techniques, i.e. varying one parameter at a time and keeping others constant.

Taguchi method is a power full method which can improve the performance of the product is that the optimization of process parameters of similar alloy H30-H30 using Taguchi method has not repeated yet. Taguchi method is used to analyze the effect of process parameter (i.e. rotational speed, transverse speed, and welding depth) for optimizing tensile strength of FS Welds of similar aluminium alloys H30-H30.

II. TAGUCHI METHOD

Optimization of process parameter is the key in the Taguchi method to achieving high quality without increasing cost. Optimization of process parameters can improve quality and the optimal 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 narrow the scope of a research project or to identify problems in a manufacturing process.

When the number of the process parameters increases, a large number of experiments have to be carried out. To solve, the Taguchi method uses a special design of orthogonal array to study the entire process parameter with only a small number of experiments.

A. FSW process parameters:

Process parameters plays important role in deciding the weld quality. The process parameter was selected shown in table.

Table1. Process Parameters with corresponding levels

Sr. No	Process Parameters	Range	Level 1	Level 2	Level 3
1	Rotational speed	800-1600 rpm	800	1200	1600
2	Travel speed	30-50 mm/min	30	40	50
3	Welding depth	5mm	5	5	5

III. MATERIALS AND METHODOLOGY

A Aluminium alloy H30-H30:
The base materials selected for this investigation were AA6082-T6 and 6082-T6 aluminium alloys sheets of 6.5 mm thickness having chemical composition and shown in the Table 1. In the present study, sheets of size 100mm x 70mm of AA6082-T6 and AA6082-T6 were cut for welding by FSW.

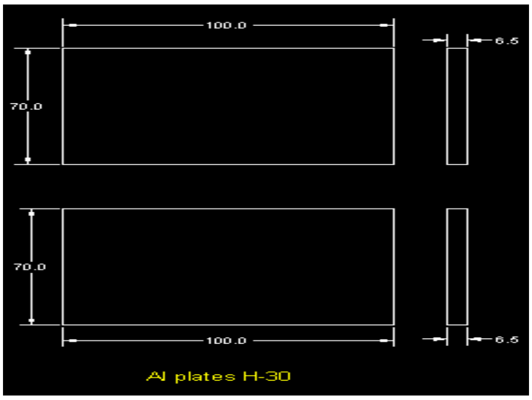


Fig.2Work piece Dimensions


Fig.3 aluminium alloy H30-H30

Table 2 .Chemical Composition of H30:

Element	Mg	Si	Fe	Cu	Cr	Zn	Ti	Mn	Al
%	0.69	0.60	0.30	0.10	Nil	0.06	Nil	0.38	Balance

1. Alloy Designations:
Aluminium alloy 6082 also corresponds to the following standard designations and specifications but may not be a direct equivalent:
AA6082
HE30
DIN 3.2315
EN AW-6082
ISO: Al Si1MgMn
A96082

B. Selection of Tool:
The friction stirring tool consists of a pin, or probe, and a shoulder. Contact of the pin with the workpiece creates frictional and heating and softens the workpiece material contacting the shoulder to the workpiece increases the workpiece heating, expands the zone of softened material.

1 Material:
Friction stirring is a thermo mechanical deformation process where material of base plate deforms due to the temperature created by shoulder. Friction stir weld requires the proper tool material selection for the desired application. Thus, it is undesirable to have a tool that loses dimensional stability, the designed features, or worse, fractures.

2. HSS:
Tool is used in this study which was made of high-speed tool steel. This is most commonly used material, easy availability and machinability, thermal fatigue resistance, wear resistance, especially for aluminium and copper. Taper Cylindrical tool with three flutes is used in this study which was made of high-speed tool steel.

3. Design of tools**:**
Tool was made in two different parts due to the length of pin, one is shoulder for holding purpose and another is tip or pin which is penetrated in base mater

Step 1: after selecting material for tool facing and turning was done for shoulder or shank on lathe machine.


Fig.5 tool on lathe machine

Step 2: Pin or tip is also made from hss and the fluets were provided on tool making machine as shown.

Fig.6 pin profile made on tool machine

Differents type of tools are made as follows:

a) cylindrical with four flutes: The length of the pin is short. These tool was failed due to its edges and taper angle. The pin was removed or cut the material insteaded of stir.

Fig 7 (a) cylindrical with four flutes

b) Threaded cylindrical tool with three flutes: The design was right, but its edges were sharp due to that edges cuts the material and this tool was also failed.

Fig.7 (b) Threaded cylindrical tool with three flutes

C) taper cylindrical tool with three flutes: This tool was also failed due to its taper ratio.

Fig.7 (c) taper cylindrical tool with three flutes

d) taper cylindrical with threads : The design was rigtht but, the length of the pin was large compared to thickness of base material. So trial was not conducted for this tool

Fig.7(d) taper cylindrical with threads

e) Taper cylindrical with flutes: this tool was given done the welding but the result was not satisfied as shown below.

Fig. 7(e) Taper cylindrical with flutes and welded Al plates

f) Taper cylindrical tool with three flutes**:** this tool was same like (e), there were small modification. We increased the length of pin, taper ratio and also provided the circular shape on the shoulder as shown below.

Fig. 7(f) Friction stir welding taper cylindrical tool with three flutes

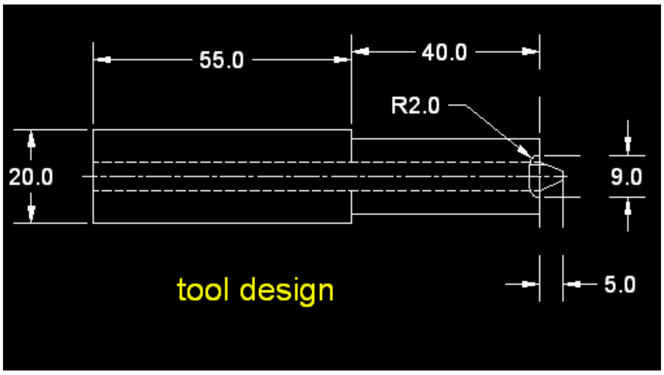


Fig.8 Taper cylindrical tool with dimensions**:**

C .Friction stir welding procedure:

Three experiments in each set of process parameters have been performed on Al-6082 plates by L9 orthogonal array. The three factors used in this experiment are the rotating speed, welding depth and travel speed. The factors and the levels of the process parameters are presented in Table.3 and these parameters are taken based on the previous trials to weld the FSW of aluminium's. The experiments are performed on a vertical milling machine.

Table.3 Experimental layout of L9 Orthogonal array

Experiment	Rotational speed	Travel speed	Welding depth
1	1200	10	5
2	1200	20	5
3	1200	30	5
4	1400	10	5
5	1400	20	5
6	1400	30	5
7	1600	10	5
8	1600	20	5
9	1600	30	5

Fig.9 shows Tool on VMC

Fig.10 Work piece after friction stir welding

IV. WELD TESTING PROCEDURE

After friction stir welding tensile test performed on universal testing machine. Testing performed in temperature between 10 to 30°C if A is the cross sectional area and F is the maximum force and tensile strength calculated by:

Tensile strength=F/A

Fig.9 Process Setup for Tensile Test

Fig.11 Tensile specimen before failure

Fig.12 Tensile specimen after failure

ISSN: 2278-0181
Vol. 4 Issue 02, February-2015

Table.4 The input parameter of orthogonal array and the output characteristics

Sr. No.	**Rotational Speed (RS) RPM**	**Travel Speed (TS) mm/Min**	**Welding depth (AF) N**	**Tensile strength (Mpa)**
1	1200	10	5	69
2	1200	20	5	55
3	1200	30	5	66
4	1400	10	5	32
5	1400	20	5	80
6	1400	30	5	32
7	1600	10	5	77
8	1600	20	5	69
9	1600	30	5	59

V. RESULT DISCUSSION

A. Friction Stir Welded Joint Results:

We weld the mention dimension aluminium alloy H30-H30 with the mentioned process parameter was successfully done on CNC milling machine with taper cylindrical tool (with three flutes) & then perform tensile strength test to the welded joints compare the results and make conclusion.

Fig 13.Al alloy H-30 before and after welding

B. S/N Ratio Analysis:

'Signal' represents the desirable value (mean) for the output characteristics and the term 'noise' represents the undesirable value for the output characteristic. The S/N ratio are uses to measure the quality characteristic deviating from the desired value in Taguchi method. The S/N ratios available depending on type of characteristic: lower is better (LB), nominal is best (NB), larger is better (LB). Larger is better S/N ratio used here.
Larger the better characteristic

$$S/N = -10 \log10 (MSD)$$
$$MSD = (1/Y1^2 + 1/Y2^2 + 1/Y3^2 + ...)/n$$

Where Y1, Y2, Y3 are the responses and n is the number of trial and m is the target value of result. The highest S/N ratio was the optimum level for responses measured.

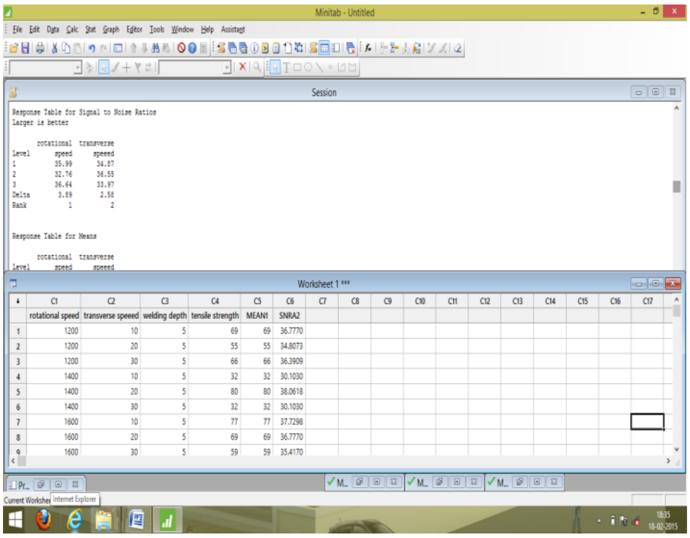

Fig.14 Tool after welding


F.15 work piece after welding

Table 5: S/N ratio of tensile strength of FS Welds

Sr. No.	Rotational Speed (RS) RPM	Travel Speed (TS) mm/Min	Welding Depth (WD) mm	Tensile Strength(UTS) Mpa	S/N Ratio
1	1200	10	5	69	36.7770
2	1200	20	5	55	34.8073
3	1200	30	5	66	36.3909
4	1400	10	5	32	30.1030
5	1400	20	5	80	38.0618
6	1400	30	5	32	30.1030
7	1600	10	5	77	37.7298
8	1600	20	5	69	36.7770
9	1600	30	5	59	35.4170

Table 6: Mean and S/N ratio of tensile strength of FS Welds on MINITAB



Higher value of S/N ratio was selected for the input parameters. The optimum input parameter for friction stir welding joints are rotational speed 1400 (level 2), transverse speed 20mm/min and constant welding depth 5mm. the S/N ratio was directly found on MINITAB 17.

C. Taguchi Design

Taguchi Orthogonal Array Design

L9 (3^2)

Factors: 2
Runs: 9

Columns of L9 (3^4) Array

1 2

Taguchi Analysis: tensile strength versus rotational speed, transverse speed

1. Taguchi Analysis: Mean UTS versus RS, TS,
Larger is better

Table 7 Response Table for Signal to Noise Ratios

Level	RS	TS
1	35.99	34.87
2	32.76	36.55
3	36.64	33.97
Delta	3.89	15.67
Rank	1	2

Table 8 Response Table for Means

Level	RS	TS
1	63.33	59.33
2	48.00	68.00
3	68.33	53.33
Delta	20.33	15.67
Rank	1	2

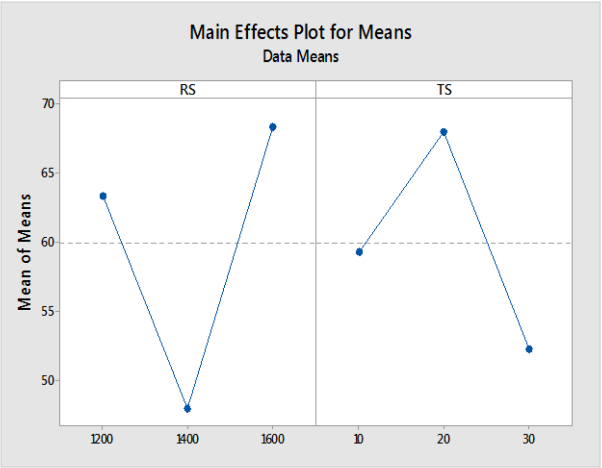


Fig.16Main Effect Plot For SN Ratio

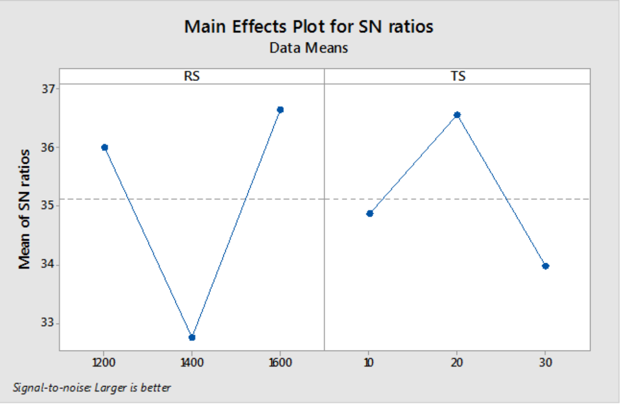


Fig.17 Main Effect Plot For Mean

VI. CONCLUSIONS

1. Friction stir welding is apply successfully for aluminum alloy H30-H30 by CNC milling machine.

2. The optimum value of process parameters such as rotational speed, traverse speed and welding depth are found to be 1400rpm (level 2), 20 mm/min (level 2) and 5mm (constant) respectively.

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