EFFECT OF TOOL PARAMETERS ON FSW JOINT OF 6082 AL ALLOY BY TAGUCHI METHOD

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Abstract

Friction stir Welding is the type of welding used as a solid state joining process (below melting point) for materials that is different alloys of aluminum, magnesium etc. and also for hard materials like steels. The effects of various parameters of FSW welding process like rotational speed, depth of cut, feed rate, probe diameter, shoulder diameter, welding speed have been investigated to reveal their Impact on welding joint using Taguchi Methodology. Experimental plan is performed by a Standard Orthogonal Array. The results of analysis of variance (ANOVA) indicate that the proposed mathematical model can be adequately describing the performance within the limit of factors being studied. The optimal set of process parameters has also been predicted to maximize the MRR.This paper deals with wear characteristics during FSW at different tool materials at different process parameter of Aluminum alloy 6082. Different Welded samples are Prepared with different rotational speed, welding speed and shoulder diameter. Taguchi is applied to optimization.

Keywords- FSW, rotational speed, shoulder diameter, welding speed, Taguchi, Anova

1. Introduction

Friction stir welding (FSW) is developed and patent by Mr. Thomas at the welding institute (UK) in the year of 1991 [1]. Friction stir Welding is the type of welding used as a solid state joining process(below melting point) for materials that is different alloys of aluminum, magnesium etc. and also for hard materials like steels because it avoids the common problems obtained in conventional welding process [2]. It is very efficient and environment friendly. Aluminium alloy especially 2xxx and 7xxx series are different to weld by conventional fusion welding process because of poor solidification and porosity in fusion zone. Hence Aluminium alloys are easily welded by FSW.[2]Difficulties in conventional welding processes is porosity formation, solidification cracking, and chemical reaction may arise during welding of dissimilar materials although sound welds may be obtained in some limited cases with special attentions to the joint design and preparation, process parameters and filler metals.[3]The fact that joining of alloys could be usually faced problems in many sectors that includes automotive, aerospace, ship building industries, electronics etc.[5]where fusion welding is not possible due to large difference in physical and chemical properties of the components to be joined.

Table 1. Chemical composition of Al6082

Element	% Present
Si	0.7-1.3
Fe	0.0-0.5
Cu	0.0-0.1
Mn	0.4-1.0
Mg	0.6-1.2
Zn	0.0-0.2
Ti	0.0-0.1
Cr	0.0-0.25
Al	Balance

Figure 1.1 shows the schematic diagram of FSW process. In this process material that is going to be joined is fixed on bed with the help of fixtures and a non-consumable rotational tool plunges through the material. Due to stirring action and consolidated pressure by the tool the semi-solid material gets joined [3]. There is generation of friction heat due to contact between tool and work piece. Which brings the material in semi-solid state [5].

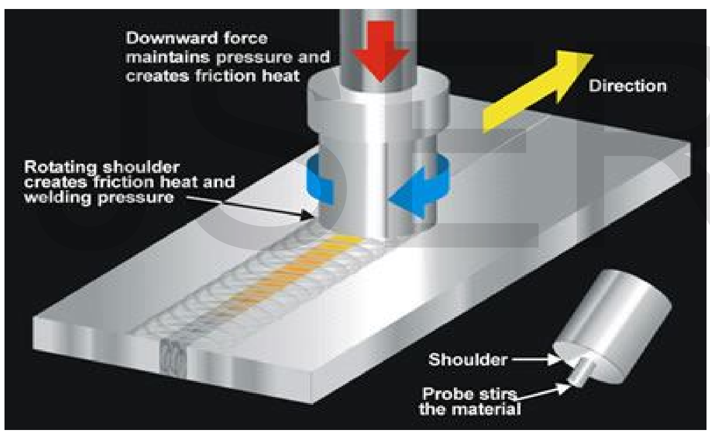

Figure 1.1 Schematic diagram of FSW

Won-Bae Lee et al. studied the microstructures and wear property of Friction stir welded AZ91 Mg Alloy/ Sic particles reinforced composite. They found an improvement in the wear property of the weld zone as compared to base metal. They concluded the wear resistance within the weld zone, as elevated by the specific wear loss, was superior as compared to the base metal [6]. Dinaharanl et al. developed an empirical relationship to predict the effect of process parameter on sliding wear behavior of Butt joints of friction stir weld AA6061/0-10 wt.% ZrB2 composites. They concluded that wear rate decreases as tool rotational speed, welding speed and axial forces increases. After that further increase in these process parameter increases the wear rate[7]. Prakash et al. studied the tribological behavior i.e. dry sliding wear charchetristics using a computer aided pin on disc wear testing machine of friction stir process Al 6061 sheet with metal reinforced. They concluded that wear rate decreased as weight percentage of Al2O2 increased[8]. R.Palanivel et al. developed an empirical relationship between FSW process parameter and wear resistance of friction stir welded joints of dissimilar Aluminium alloys AA5083-AA6351.It was found that wear resistance increases as tool rotational speed, welding speed and axial force increases up to certain level then it starts decreasing [9].Fernandez and Murr et al. studied the FSW of cast Al 359/20%SiC composite. They focused on the effect of FSW tool rotational speed and weld speed for reducing the tool wear rate. The result indicated that minimum wear obtained with the lowest tool rotational speed [10]. Prater et.al. Characterized the tool wear in FSW of A359/20%SiC MMC by varying process parameters. It was also observed that with increase in the welding speed the ultimate tensile strength of the joint decrease [11]. Mishra et.al. address that tool wear and shape optimization are associated with the tool material and further research is needed for selection of tool material [12].As It has been noted that, a production of quality need a selection of the appropriate tool material with a correctparameters for a specific applications. Thus, it is unusable to have v a tool that has less dimensional stability [6]. There are lots of researchers who consider different criteria for the selection of tool materials. Although different researchers have selected the tool materials based on literature, experience but this not precise the optimum tool materials selection.

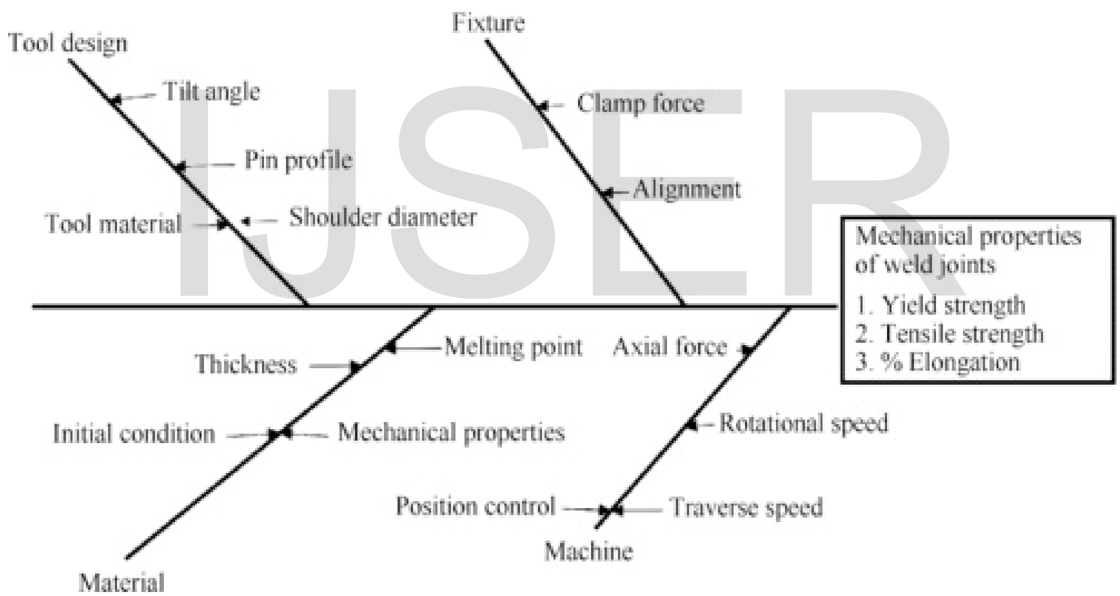

Figure 1.2 various process parameters of FSW

It has been reported a production of a quality FSW needs a selection of the appropriate tool material for a specific application. Thus it is unsuitable to have a tool that loses dimensional stability.It can be summarized that wear of any welded components causes defect. And defects in any welded part can arise due to improper selection of process parameters or due to wear of the welded part.From all the above conclusion there is need of proper selection of tool material and process parameters to maintenance wear or to prevent this wear for defect free welding.

2. Experiment Detail

In present study, Al 6082 plate of 30mm thickness, 70mm width and 280mm long is used as a work material. The Friction stir welding tool was of HSS with different rotational speed, different welding speed and different shoulder diameters. The welds were done using a FSW process. Fsw process was carried out at different parameters respectively. The work piece specimen was tested under different welding speed and shoulder diameter with different rotational speed.

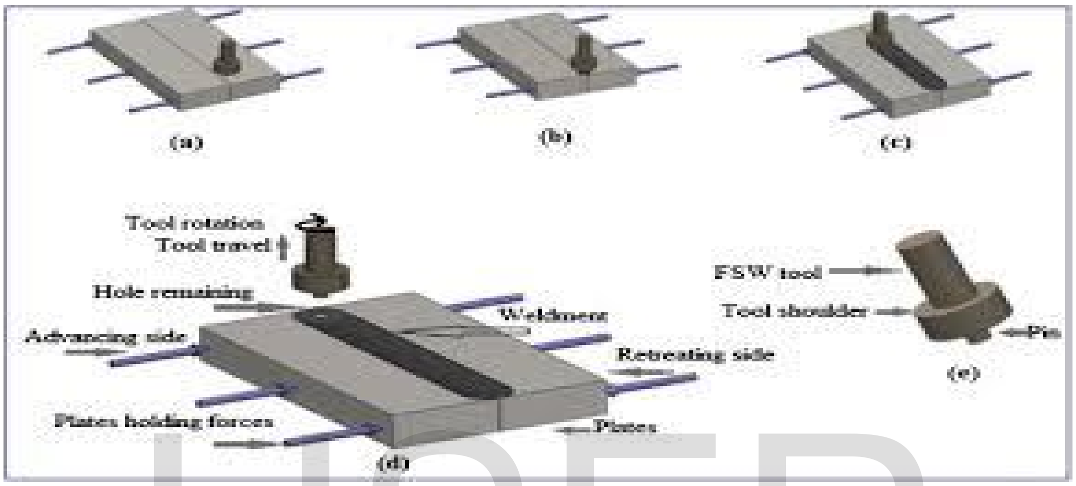

Figure 2.1 Experimental setup of FSW

Experiments are designed with the help of using taguchiorthogonal array. The software used for DOE (Design of experiment) is Minitab15.

Table 2.1 Table of standard orthogonal array

welding speed(rpm)	rotational speed(mm/min)	shoulder diameter(mm)	Wear*10^{-5}(mm^3/min)	SNRA3	MEAN3	COEF1	FITS1
800	25	14	34	30.62958	34	29.44444	31.44444
800	35	16	35	30.88136	35	1.888889	37.11111
800	45	18	25	27.9588	25	-0.44444	25.44444
900	25	16	29	29.24796	29	-0.77778	29.44444
900	35	18	34	30.62958	34	4.555556	31.44444
900	45	14	24	27.60422	24	0.888889	26.11111
1000	25	18	23	27.23456	23	1.222222	25.11111
1000	35	14	33	30.37028	33		33.44444
1000	45	16	28	28.94316	28		25.44444

3. Result and Calculation

Table 01Response Table for Signal to Noise Ratios

Level	Welding Speed (A)	Rotational Speed (B)	Shoulder Dia (C)
1	-29.82	-29.04	-29.53
2	-29.16	-30.63	-29.69
3	-28.85	-28.17	-28.61
Delta	0.97	2.46	1.08
Rank	3	1	2

From Table 01, Optimal Parameters for Tuning Operation were **A_2, B_3, and C_3**

The difference of SNR between level 1, 2 and 3 indicates that Rotational Speed contributes highest effect (Δ_{max} - Δ_{min} = 2.46) followed by Shoulder Diameter (Δ_{max} - Δ_{min} = 1.08 and Welding Speed (Δ_{max} - Δ_{min} = 0.97).

Therefore, the predicted value of S/N Ratio for turning operation

η_p (Wear)=-29.28+ [(-29.16-(-29.28]+[-29.16-(-29.28)]+[-28.61-(-29.28)] =-28.37

Response Table for Means

Level	Welding Speed	Rotational Speed	Shoulder Dia
1	31.33	28.67	30.33
2	29.00	34.00	30.67
3	28.85	25.67	27.33
Delta	3.33	8.33	3.33
Rank	3	1	2

Analysis of Variance for wear, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Welding Speed	2	17.56	17.56	8.78	0.52	0.657
Rotational Speed (rpm)	2	106.89	106.89	53.44	3.19	0.0239
Shoulder Diameter	2	20.22	20.22	10.11	0.60	0.624
Error	2	33.56	33.56	16.78		
Total	8	178.22				

TABLE NO. Result and Experiment

welding speed(rpm)	rotational speed(mm/min)	shoulder diameter(mm)	Wear*10^{-5}(mm^3/min)	SNRA3	MEAN3	COEF1	FITS1
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1000	35	14	33	30.37028	33		33.44444
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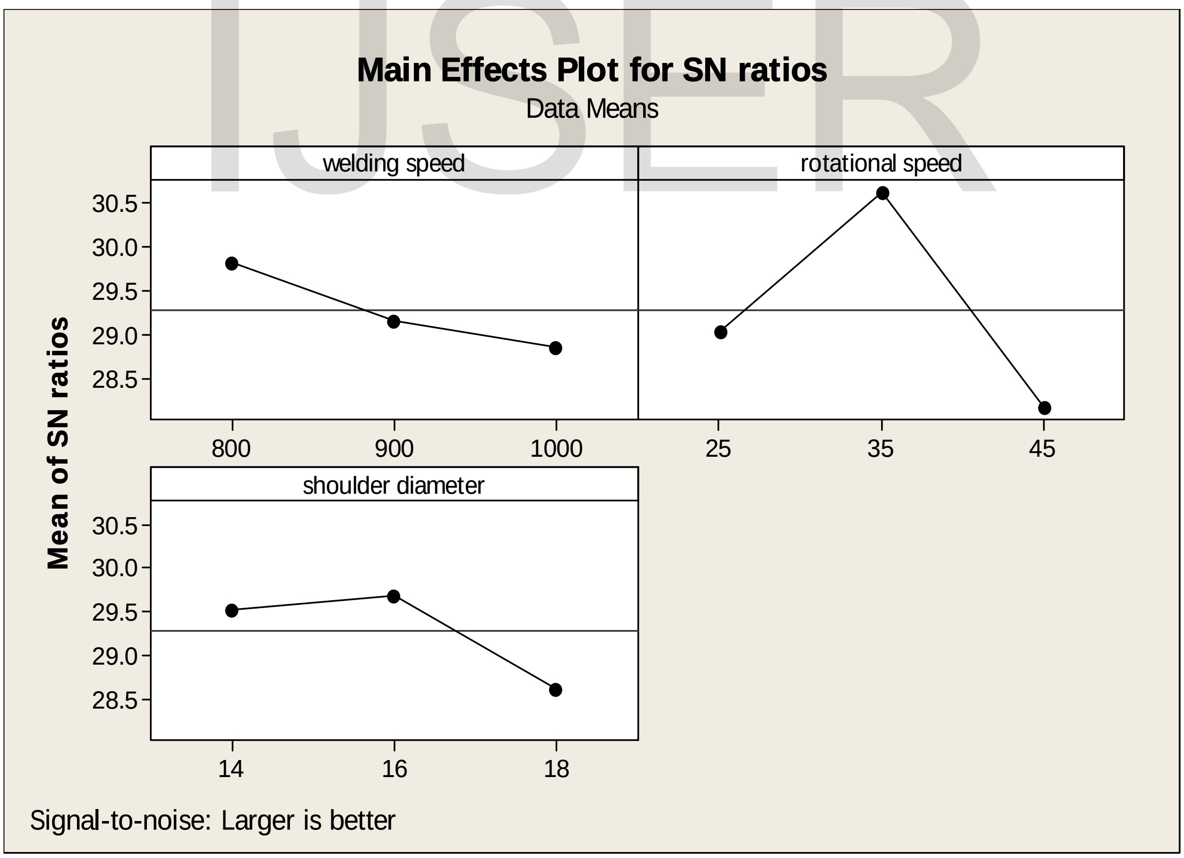
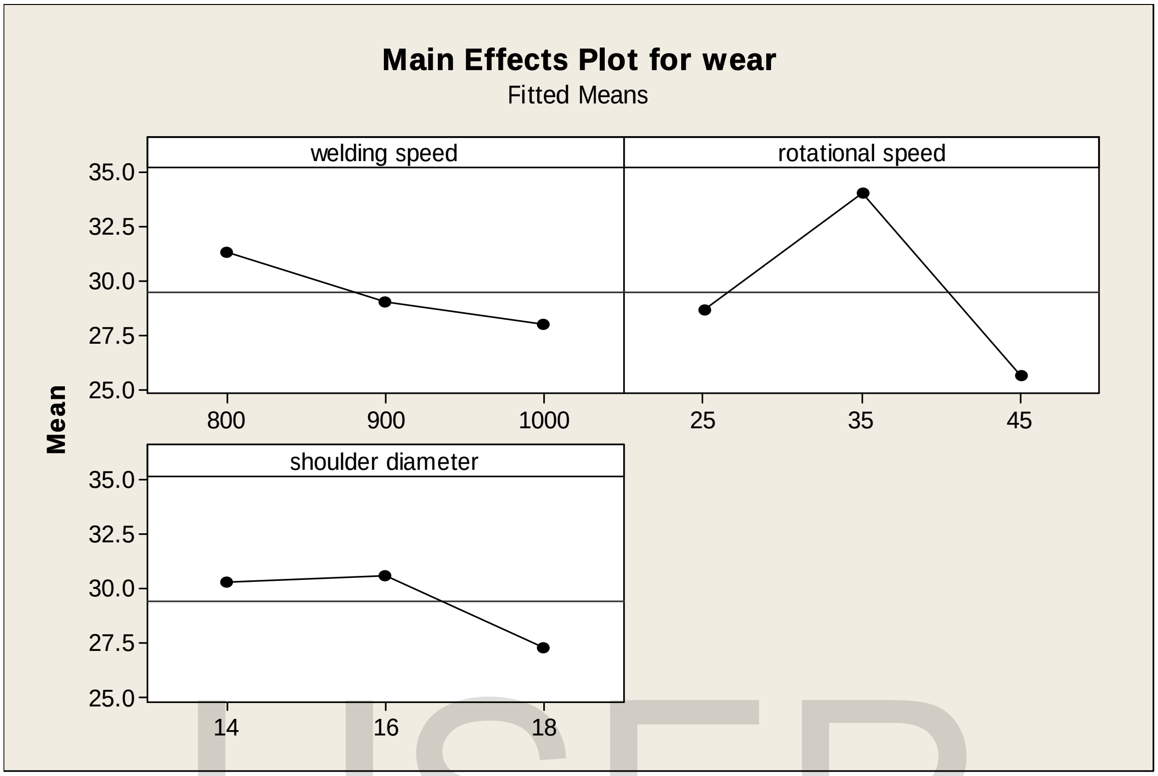
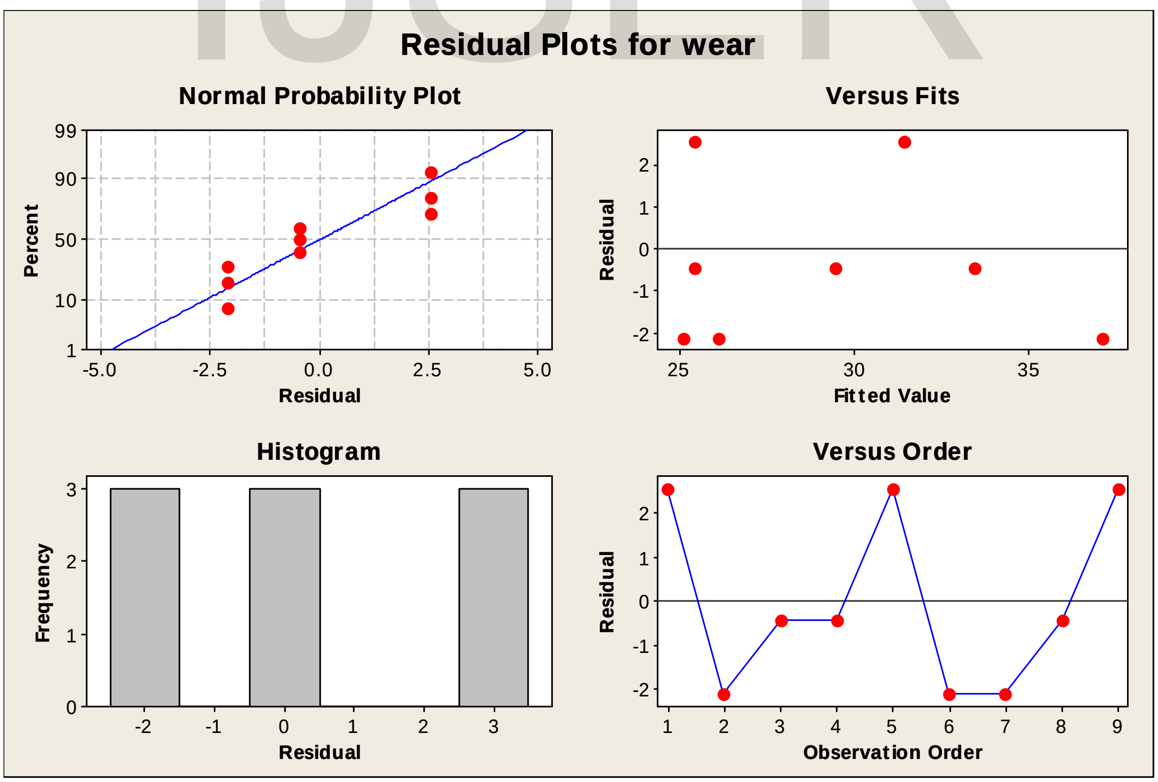
Fig.1 Main Effects Plot for SN Ratio




Main Effects Plot for wear
Fitted Means
welding speed
rotational speed
shoulder diameter
Mean
35.0
32.5
30.0
27.5
25.0
800
900
1000
25
35
45
14
16
18


Residual Plots for wear
Normal Probability Plot
Versus Fits
Histogram
Versus Order
Percent
Residual
Fitted Value
Frequency
Observation Order

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