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Process Optimization of Friction Stir Welded Silicon Carbide Composites by Taguchi Methodology

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***Abstract*:** *Friction stir welding process is a modern emerging solid state joining process used to join high strength aluminum metal matrix composite. Friction stir welding produce sound welds in metal matrix composite without any deleterious reaction between matrix and reinforcement. This present work focused to evaluate the effect of process parameters such as welding speed; tool rotational speed and tool geometry on tensile strength of friction stir welded. SiC composite joints. Process parameters were determined by the Taguchi parametric design approach. Result indicated that tool rotation speed, welding speed and tool geometry influence on tensile strength of welded joints.*

***Keywords*:** *Friction stir welding, tensile strength, joint efficiency, metal matrix composite and Taguchi method.*

I. Introduction

In order to produce stronger joints, the Friction Stir Welding process (FSW) can be used. Many applications such as aerospace, automotive and ship building industries, [1] Friction stir welding is a solid state welding process. The work pieces that are to be joined are clamped together on a backing plate. A rotating non consumable tool with a profiled pin and large concentric shoulder slowly plunged into the joint line between two plates which are clamped together. Here coalescence is created by the combined action of frictional heating between tool and work pieces and the plastic deformation of base metal due to the rotation of the tool. 95% of heat generated in the process is transferred to the work piece and only 5% flows into the tool [2]. Taguchi methods developed by Genichi Taguchi to improve the quality of manufacturing goods are recently applied to the field of engineering, manufacturing and marketing. The Taguchi method is a very powerful tool for carrying out experimental design. The main aim of the Taguchi method is to produce an optimum result by analyzing the statistical data which have been given as an input function. This method allows limited number of experimental runs by utilizing a well balanced experimental design called orthogonal array design and signal to noise (S/N) ratio. Taguchi methods have been successfully utilized by Lakshminarayananet.al. [3]. In order to study the effect of FSW process parameters, most workers follow the traditional experimental techniques, i.e. varying one parameter at a time while keeping others constant. This conventional parametric design of experiment approach is time consuming and calls for enormous resources. Taguchi statistical design is a powerful tool to identify significant factor from many by conducting relatively less number of experiments. However, this design fundamentally does not account for the interaction.

II. Experimental Procedure

In this work AA7075 with (SiC) is used by the stir casting process to produce composite of dimension 100mm×50mm×6mm plates. The chemical composition of the AA7075 is shown in TABLE1. Silicon carbide powder having a diameter of 200μm was chosen as reinforcement particles because they have high wear resistance. The average Tensile strength value using UTM is given in TABLE.2.

Table1. Chemical composition of AA7075-T6

Element	Mg	Mn	Zn	Fe	Cu	Si	Cu	Al
Wt%	2.05	0.11	5.12	0.36	1.15	0.55	1.25	Bal

Table2. Tensile strength of Fabricated composite

S.NO	Sic (wt %)	Average %Elongation	Tensile Strength (M Pa)
	10.5	5.45	327

2.1. Identification of Process Parameters and Finding their Limits

The predominant FSW process parameters which influence the tensile strength of friction stir welded joints are tool rotational speed, welding speed and tool geometry [7]. The tools made of high carbon high chromium steel oil hardened to 62HRC with Hexagonal pin profile was used in the present work. The geometry of the tools are shown in Fig.1

Hexagonal

Fig. 1 Friction stir welding tools

A large number of welds were carried out to fix the working ranges of all selected factors the limits of each factor were decided. The upper limit of a factor was coded as +1 and the lower limit was coded as –1 for the convenience of recording and processing experimental data. The coded values for intermediate values were calculated using the following relationship [8].

Xi = 2[2X–(X max + X min)] / (X max – X min), Where Xi is the required coded value of a variable X; X is any value of the variable from X min to X max; X min is the lowest level of the variable; X max is the highest level of the variable. The Minitab software was used to study the statistical analysis for the obtained results. Welding process parameters and their levels are shown in TABLE 3.

Table3. Welding process parameters and their levels

Process Parameters	Level 1	Level 2	Level 3
Tool Rotational Speed (rpm)	900	1200	1400
Welding Speed (mm/sec)	.9	1.6	1.9
Tool Geometry	Square	Hexagonal	Octagonal

2.2. Developing and Conducting the experiments as per the Design Matrix

According to the design matrix 27 sets of weld were performed and extracted three tensile specimens from each welded plate to evaluate ultimate tensile strength in terms of the ASTME8M-04 standard. The dimensions of each specimen are shown in Fig.2. The shaded portion represents the weld bead. The ultimate tensile strength was estimated using a computerized universal testing machine at room temperature. Joint efficiency was calculated by comparing ultimate tensile strength of welded plates with that of the parent composite. In order to assess influence of factors on response, means and signal-to noise ratio (S/N) for each control factor are to be calculated In this work, S/N ratio was chosen according to criterion, larger – the better, in order to maximize response.

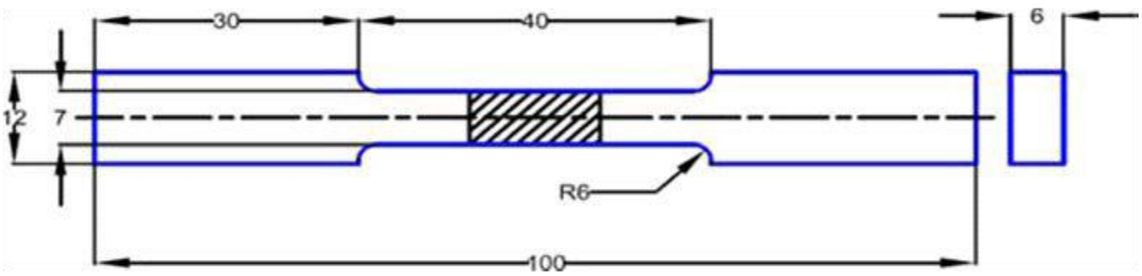

Fig.2. Dimensions of tensile specimen

III. Results and Discussions

3.1 Signals to Noise Ratio

The better, in order to maximize the response, in Taguchi method the signal to noise ratio is used to determine the deviation of the quality characteristics from the desired value. The S/N ratio (larger-the better) can be expressed as In this work tensile strength is one of the main characteristics.

S/N = -10 log10 {1/n“^{n} (1/y^{2})}

where n is the number of test Considered in describing the quality of FSW joints. Each control conducted, y i is the average observed data of each test. In the factor can be calculated in order to assess the influence of parameters on the response, the means and signal – to – noise (S/N) ratios.

The signals are indicators of the effect on average responses and the noises are measures of the influence on the deviations from the sensitiveness of the experiment. In this work, the S/N ratio was chosen according to the criterion of the larger present study, the tensile strength data were analyzed to determine the effect of FSW process parameters. Tensile strength, joint efficiency and SN ratio of FSW composite joints are shown in TABLE 4.

Table 4. Tensile strength, joint efficiency and SN ratio of FSW composite joints

Trial Run	Rotational Speed	Welding Speed	Tool Geometry	Tensile Strength (M Pa)	Joint Efficiency	SN Ratio
1	-1	-1	-1	251	77.89	47.11
2	-1	-1	-1	262	80.25	48.22
3	-1	-1	-1	266	80.82	48.56
4	-1	0	0	265	82.56	48.48
5	-1	0	0	278	85.54	48.75
6	-1	0	0	279	84.85	48.65
7	-1	+1	+1	244	74.21	47.32
8	-1	+1	+1	245	75.23	47.45
9	-1	+1	+1	246	75.56	47.85
10	0	-1	0	278	83.54	48.96
11	0	-1	0	282	87.58	49.54
12	0	-1	0	286	89.57	49.24
13	0	0	+1	295	90.54	49.56
14	0	0	+1	298	91.59	49.23
15	0	0	+1	295	89.56	49.25
16	0	+1	-1	282	88.36	49.45

IV. Data Analysis

4.1 Analysis of Variance

Analysis of variance (ANOVA) test was performed to identify the process parameters that are statistically significant. The purpose of the ANOVA test is to investigate the significance of the process parameters which affect the tensile strength of FSW joints. The ANOVA results for tensile strength of means and S/N ratio are given in TABLE 5 and 6.

In The results of ANOVA indicate that the considered process parameters are highly significant factors affecting the tensile strength of FSW composite joints in the order of rotational speed, welding speed and tool profile. Effects of interaction between process parameters are not significant.

Table 5 Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Rotational Speed	2	2402.99	2402.89	1201.99	237.55	.002
Welding Speed	2	724.83	724.67	362.63	71.64	.006
Tool Geometry	2	347.92	347.45	173.58	34.15	.018
Residual Error	2	10.89	10.20	5.65	-	-
Total	8	3485.45	-	-	-	-

DF-Degrees of freedom, Seq SS - Sequential sum of squares, Adj SS-Adjusted sum of square, Adj MS-Adjusted mean square, F – Fisher ratio, P - probability that exceeds the 95% confidence level.

Table 6 Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Rotational Speed	2	2.5341	2.5341	1.2679	246.56	0.002
Welding Speed	2	0.8107	0.8107	0.4049	79.21	0.004
Tool Geometry	2	0.4336	0.4336	0.2618	42.19	0.016
Residual Error	2	0.0126	0.0126	0.0053		
Total	8	3.7838				

DF – Degrees of freedom, Seq SS - Sequencial sum of squares, Adj SS-Adjusted sum of square, Adj MS – Adjusted mean square, F – Fisher ratio, P – probability that exceeds the 95% confidence level.

4.2. Optimizing the Tensile Strength Properties

Analyzing means and S/N ratio of various process parameters, it is observed that a larger S/N ratio corresponds to better quality characteristics. Therefore, optimal level of process parameter is the level of highest S/N ratio (10). Mean and S/N ratio for ultimate TS was at maximum when rotational speed 1200 rpm, welding speed 1.3mm / sand tool geometry is square, which are shown in Fig 3.

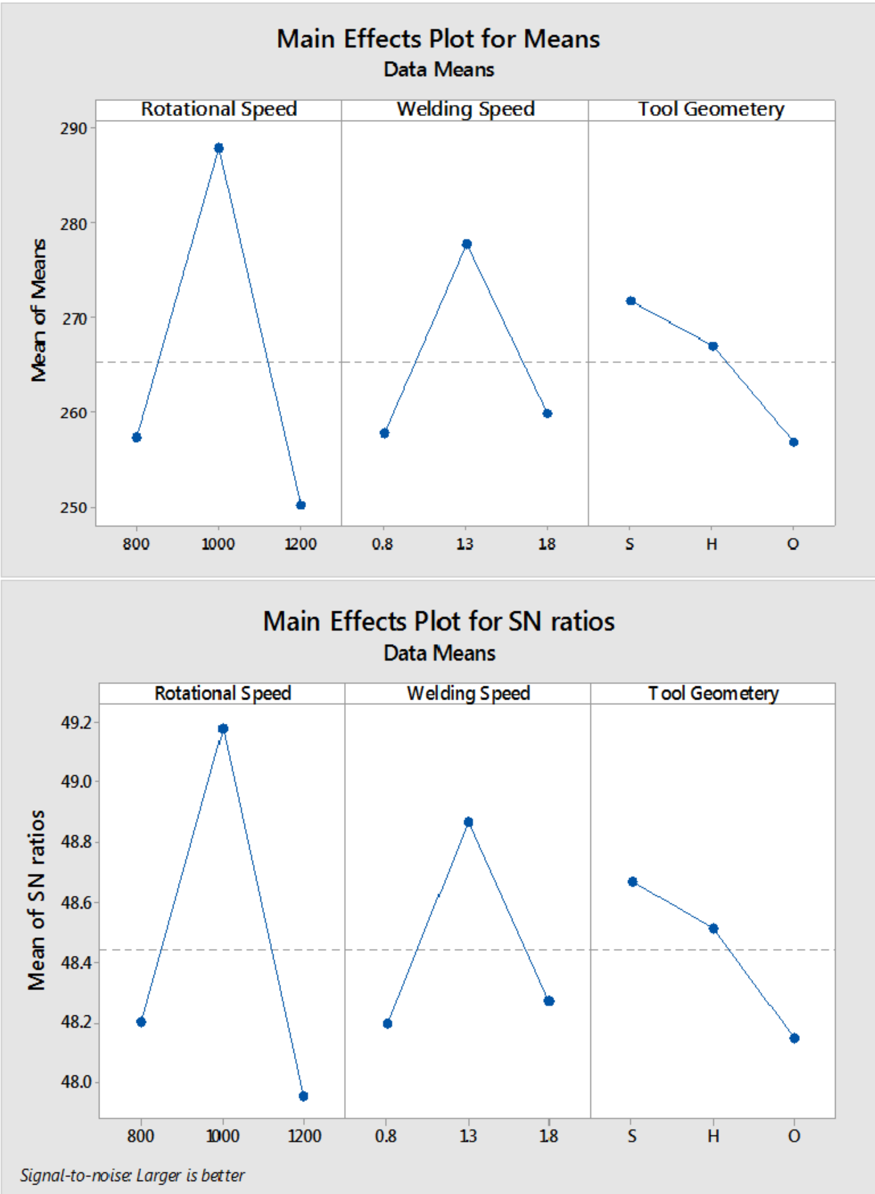

Fig. 3. Response graphs of means and SN ratio for tensile strength

V. Conclusion

1. Friction stir welding has been successfully extended to join AA7075 SiC composite.
2. The optimum parameters were evaluated and the percentage of contribution of FSW process parameters was evaluated. It was found that the tool rotational speed had 83% contribution, welding speed had 15% and tool geometry had very less 2% contributions of weld joints.
3. The joints welded by the square pin profile tool have better mechanical properties followed by hexagonal pin profile tool and octagonal pin profile tool respectively.
4. Non-linear regression analysis model may employ successfully for designing process parameters of friction stir welded composite.
5. With increased capital speed S/N ratio first increases and then decrease.
6. Welding speed also responds like rotation speed and decrease with decrease in S/N ratio.
7. Tool Geometry decreases with increase in S/N ratio.

References

[1]. Dayong Kim, Wonoh Leeand Juneheyung Kim, 2010. Chongmin Kimand Formability of evaluation of friction stir welded 6111-T4 sheet with respect joining material direction. *International Journal of Mechanical Science, DOI: 10.1016* / j.ijmecsci.2010.Maharashtra Institute of Technology, India, 009.01.00.

[2]. Chao.Y.J., Qi.X, and Tang, W.2003. Heat transfers in friction stir welding-Experimental and numerical studies, Transaction of *the ASME, pp.125*.138-145

[3]. A. K. Lakshminarayanan, V. Balasubrahmanyan. Process parameters optimization for friction stir welding of RDE – 40 aluminum alloy using Taguchi technique; Trans. *Non ferrous Met.Soc China2008.18*.548-554

[4]. Casalino G. Curcio E, Memola F, Minutolo C. Investigation on Ti6A14 Vlaser welding using statistical and Taguchi approaches [J].*Journal of Material Processing Technology, 2005, 167*:422"428.

[5]. Guharaja S., Nooral Haq. A, Qkaruppannan KM. Optimization of greens and casting process parameters by using Taguchi’s method [J*].International Journal of Advanced Manufacturing Technology, 2006, 30: 1040*"1048.

[6]. Vijan P, Arunchalam V.P. Optimization of squeeze casting process parameters using Taguchi analysis [J*]. International Journal of Advanced Manufacturing Technology, 2006, 30:1122*"1127.

[7]. Kumar S, Kumar P, Shan HS. Parametric optimization of surface roughness castings produced by evaporative pattern casting process [J], *Materials Letters, 2006, 60:3048*"3053.

[8]. M. Thambidurai, N. Muthukumarasamy, N.Murugan, S. Agilan, S. Vasantha, and R. Bala sundaraprabhu, *Metall. Mater. Trans - B**41**, 1338(2010)*

[9]. V.Bala subramanianetal, (2010). “An assessment of microstructure, hardness, tensile and impact strength of friction stir welded ferrite stainless steel joints” *Materials and Design.3:*4592–4600.

[10]. R.S.Mishra, Z.Y.Ma, (2005). “Friction stir welding and processing”. *Materials Science and Engineering.R50*:1–78.