Performance Evaluation of Inputs on Machining Characteristics of 6082 AL Alloy: ANN Approach

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A FSW is solid-state joining process that combines two angled pieces of metal without melting the metal. The process generates heat by friction among angled metal pieces and rotating tool, producing heat that is then used to fuse the pieces together. This leads to a softened area around the FSW tool. In the present work the effects of several factors of the FSW welding process i.e. rotation speed, welding speed and Shoulder Diameter, have been investigated to analyse the output characteristic. The output parameters were forecasted using multi-layer feed forward ANN (MLFF-ANN) and analyzed using analysis of variance. Confirmation experimental runs were also conducted in order to validate the results.

Keywords: ANN Modelling, Wear, DOE, Friction Stir Welding.

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1 Introduction

A friction Stir welding is a found very suitable joining method perticulary in case of aluminium alloys. This welding technique with high performance of its joints enable its use to join complicated loaded parts such as used in aero plane and marine industries because of its ability to weld thick materials. Optimising the alloy location according to their properties could consequently improve the aerospace structures. Although FSW technology has attracted significant interest from the aerospace and transportation industries, and extensive literature exists on FSW, there are few reported systematic studies on process parameter The only principle globally accepted is that, for each set of welding conditions (joint type, base material and plate thickness), a specific set of welding parameters must be used to ensure acceptable process behaviour. According to these prior findings, the mechanical properties of the AA 6xxx friction stir welds was based on on size, volume fraction and distribution of precipitates in the welding line structure and heat affected zone (HAZ). Friction stir welding of the non heat treatable aluminium alloys, such as the AA 5xxx series, is very less studied than for the AA 6xxx alloys. However, it has already been established that the mechanical properties of the welds produced from the AA 5xxx alloys depend perticularly on the grain size and density of the dislocations. And therefore a methodology is needed to develop to weld a particular area accordimg to load and geometry of the structure. This study will enable to join the structure with optimize using of the resources according to the strain required by the due to load.

1.1 Literature Review

In the nineteenth century, Mr Thomas from USA made a device on FSW and got patent on it [1]. The joining process is characterised with joining of work piece by keeping their temperature below their melting point. Alloys of aluminium, magnesium etc can be joined by this method. The method is also suitable to join hard materials for their application in aerospace, chemical and nuclear industry which is difficult by conventional joining processes [2]. From microstructural view point weld has very fine equiaxed structure which produces high strength and ductility [3–5]. This technology can even weld difficult to fusion weld Aluminium alloys of 2XXX & 7XXX series which are extensively used in aerospace applications [6–9]. Relationship to forecast the impact of process variables upon wear due to sliding in Butt joints during FSW of AA6061/0-10 wt.% ZrB_2 composites and found decreased wear rate with increase in welding speed, rotational speed and axial forces. [10]. Tribological analysis of friction stirred Al 6061 metal reinforced sheet revealed decrease in wear rate with increase in weight (%) of Al_2O_2 [11]. As welding speed increases during FSW of A359/20%SiC MMC the weld's ultimate tensile strength reduces [12].

In current research work the investigation were made to analyze the effects of Welding Speed (SW in rpm), Rotational Speed (SR in mm/min), Shoulder Diameter (d in mm) on wear, by developing ANN models. The prediction was first made through ANN model and input factors are taken as follows: Welding Speed (rpm) of 800, 900 and 1100; Rotational Speed (rev/min)of 27, 30, and 35, and Shoulder Diameter (mm) of 11, 13 and 15 were chosen as input parameters. Experiments were designed using Taguchi-L9 orthogonal array.

2. Methodology

In the current experimentation three levels of each factor has chosen i.e. welding speed (rpm), Rotational Speed (rev/min) and shoulder diameter (mm). A MLFF-ANN; is trained through error back propagation (EBP) technique for predicting the tool wear. The EBP is supervised learning technique based on generalized delta rule [13] which requires input and output sets referred as training patterns.

Appropriate weights to predict the desired output is done by MLFF-ANN. ANN model is produced through input–output database generated by conducting experiments set up based on Taguchi orthogonal array.

Table 1.1 Element Composition

Element Present	Silicon	Ferrous	Copper	Mn	Mg	Zinc	Titanium	Chromium	Aluminium
%	0.7-1.3	0.0-0.5	0.0-0.1	0.4-1.0	0.6-1.2	0.0-0.2	0.0-0.1	0.0-0.25	Balance

Three levels of each factor are identified for each factor in current research work and illustrated in

Table 1.2 Factors with Levels

Factors	Level 01	Level 02	Level 03
Welding Speed (rpm)	800	900	1100
Rotational Speed (rev/min)	27	30	35
Shoulder Diameter (mm)	11	13	15

2.1 ANN Modelling

The modelling for input and output was done through ANN toolbox through MATLAB software. The simulated MLFF-ANN architecture consisting 3 neurons in input layer one for each considered process inputs and the output layer comprising of 2 neurons.

Table 2. Main Experimental Table with ANN Modelling

SW in rpm	SR in mm/min	d in mm	Experimental Wear (w)	ANN Predicted Wear	SNRA1	MEAN1
800	27	11	31	30	-29.8272	31
800	30	13	32	35	-30.103	32
800	35	15	33	27	-30.3703	33
900	27	13	31	29	-29.8272	31
900	30	15	34	33	-30.6296	34
900	35	11	35	34	-30.8814	35
1100	27	15	25	23	-27.9588	25
1100	30	11	29	29	-29.248	29
1100	35	13	32	31	-30.103	32

Table 3. Response of S/N Ratios

Level	SW	SR	d
1	-30.10	-29.20	-29.99
2	-30.45	-29.99	-30.01
3	-29.10	-30.45	-29.65
Delta	1.34	1.25	0.36
Rank	1	2	3

The table 3 indicated that Welding Speed is the most significant factor and is ranked first, trailed by Rotational Speed and subsequently by Shoulder Diameter.

Table 4. Response of Means

Level	SW	SR	d
1	32.00	29.00	31.67
2	33.33	31.67	31.67
3	28.67	33.33	30.67
Delta	4.67	4.33	1.00
Rank	1	2	3

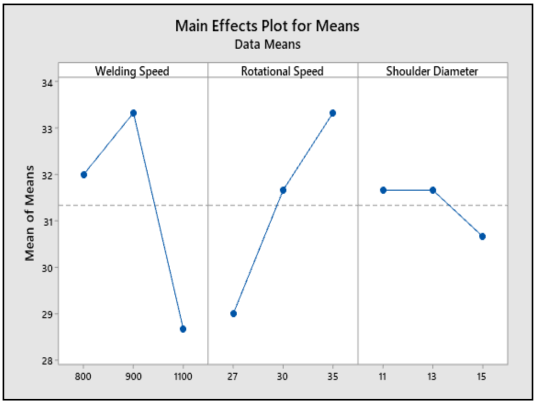

Fig.1(a) Plot of Main Effects - Mean

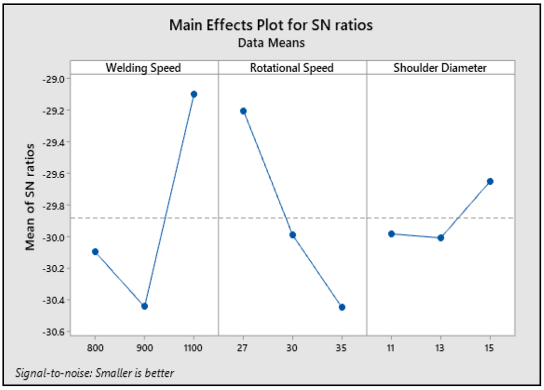

Fig.1(b) Plot of Main Effects - S/N ratios**.**

Table 03 and Figure 1 (b) depicts the largest S/N ratio found for tool wear are as follows; third level of welding speed followed by first level of rotational speed and third level of shoulder diameter.

Table 5. ANOVA for wear

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Welding Speed (rpm)	2	34.667	17.333	3.29	0.03
Rotational Speed (rev/min)	2	28.667	14.333	7.43	0.119
Shoulder Diameter (mm)	2	2.000	1.000	0.43	0.700
Error	2	4.667	2.333		
Total	8	70.000			

From the table 05 it is also found that the factor welding speed is found significant with the P value of 0.03. The evaluation of F value of table 05 with P value of the input parameters for 95% confidence level shows that that the factor welding speed was found to be significant. Figure1 shows the effect of the each level of the three factors on wear for the mean value of measured wear at each level for all the 09 runs.

2.3. Regression Equation

Wear = 31.333 + 0.667 Welding Speed_800 + 2.000 Welding Speed_900 2.667 Welding Speed_1100 - 2.333 Rotational Speed_27 + 0.333 Rotational Speed_30 + 2.000 Rotational Speed_35 + 0.333 Shoulder Diameter_11 + 0.333 Shoulder Diameter_13 - 0.667 Shoulder Diameter_15

3. Result and Discussion

In the existing experiment work the forecasted and the test result were accomplished through various combinations of input variables. The test trials were designed using L9 orthogonal array which wasable to produce satisfactory results to yield minimum wear of the tool which is more suitable to use in aerospace, chemical and marine application. MLFF-ANN predicted values in close proximity to experimental results. The trial 3 of the experimental designed was found to be optimally suitable for attaining the objectives of the experiment and the Tool wear was mostly dependent on welding speed with % contribution of 49.524, and Rotational Speed % contribution of 40.95.

Optimization of the input parameters was done using Taguchi method of input and the optimal value was predicted using a predictive equation. The results attained after conducting the experimental work can be used in future to get minimum wear. This research work is done using all possible chosen interactions among the three levels of the parameters in order to expand the study and for future use.

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