Proses Optimization of Friction Stir Welding Process for AA5052 Alloy using Taguchi Method.

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ABSTRACT- Process optimization is important in manufacturing field for best utilization of resources. In this work, AA5052 with thickness of 2 mm is butt weld using friction stir welding (FSW) process. The optimization is using Taguchi method. Spindle speed and weld rate are varied between 800 rpm – 1000 rpm and 5 mm/s- 20 mm/s respectively. The weld is tested using tensile test as the response of signal to noise ratio 'larger is better'. From the parameter optimization work 100 Mpa of tensile strength is produced. The significant factor that impact the weld quality is the weld rate.

1. INTRODUCTION

Recently, Aluminium Alloys, AA 5XXX are widely used in many emerging fields of aerospace industry and marine industry in the construction of frames, pipelines and automotive. The discovery of FSW in 1991 by The Welding Institute (TWI) is one of the attractive technologies for welding Especially for metallic material [2] and offers an efficient solution to weld difficult material to be welded using traditional methods such as metal inert gas (MIG).

The reasons are because less distortion, lower residual stresses and fewer defects [1-2]. These advantages is because of the joining takes place much below the melting temperatures, hence known as a solid state welding process.Although FSW process has been widely used, but there is lack of work in process optimisation for the specific materials. Additionally, it is found that tensile strength is a major issues whereby the strength is lower than the parent material.

Previous studies have shown processed parameters such as tool rotation speed, tool traverse speed and plunge depth have the most significant factors that affected the mechanical strength for aluminum welded components under friction stir welding process joining [3]. Driven by the necessity to continue enhancing the tensile strength of Aluminum alloy 5052 material in marine industry application these controllable factors setting names rotational speed and traverse speed should be further studied using a structure experimentation approach and expectation result of optimum process setting shall be developed and recommended for marine industry application process references.

Various experimental design methods are available to predict the response under a given set of operating parameters accurately and efficiently. Taguchi method is such a method, which uses an orthogonal array to cut down the number of experiments. Result from earlier studies have reported that the Taguchi parameter design will also give accurate results with lesser number of experiments to be performed compared to full factorial analysis [5]. Therefore, in this work, friction stir welding parameter will be optimize to maximize the tensile strength of AA5052 rectangular tension test specimens dimension joints using the mechanical testing of tensile test following ASTM-E8 standard.

2. METHODOLOGY

This experiment was carried out on the FSW Machine model FSW2-100. AA 5052 was selected with the dimension of 120mm length X 50mm width X 2mm thickness. The plates were butt welded in a single pass, using cyclindrical tapered tool pin profiles. The machining parameters was set based on the L_9 ortagonal array as shown in Table 1.

Table 1 Factors and their levels

Serial	Factor	Levels		
		1	2	3
A	Spindle Speed (rpm)	800	900	1000
B	Weld Rate (mm/s)	5	10	20

The tests were carried out using universal testing machine (UTM) from INSTRON, model 5960 Dual Column Testing Systems with the capacity of 50kN.

Minitab 18 software has been used in this analysis to analyze the data. The values of signal to noise ratio (S/N ratio) using 'larger is better' is adopted. Equation (1) show the formula of the s/n ratio.

$$S/N = -10*\log (\Sigma (1/Y^2)/n) \quad (1)$$

Y is responses for the given factor level combination and n is number of responses in the factor level combination.

3. RESULTS AND DISCUSSION

Figure 1 illustrate the example of one of the welded plate. Minimum weld was produced with good quality weld finished. There is no visible defects accept the tool entry marking and exit.

Table 2 shows the values of the design of experiment L_9 and the tensile test response value. Figure 2 and 3 show the main effect plot for mean and SN ratios. In the SN ratio graph, the optimum parameter is observed by the highest level plotted. It is because the signal-to-noise ratio (S/N) identifies the control factor setting that minimizes the effects of the noise factors. The highest main effects plot for mean of the spindle speed is at 800 rpm and weld rate is at 5mm/s.

Figure 1 Welded joint specimen

Mitra *et al* [4] reports the main effect is a value which shows the extent influence of a factor on the response. Hence, the combination for optimum parameter condition is A1B1 (800 RPM, 5mm/s) that will give the optimum tensile test.

Table 2 Experiment L_9 and Tensile test result

Run	Spindle Speed (rpm)	Weld Rate (mm/s)	Tensile value (Mpa)
1	800	5	101.75
2	800	10	39.4362
3	800	20	82.3782
4	900	5	88.5864
5	900	10	55.5852
6	900	20	34.1724
7	1000	5	82.9034
8	1000	10	97.2992
9	1000	20	9.3072

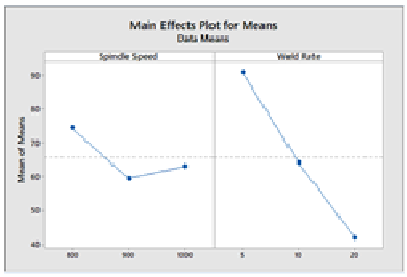

Figure 2 Main Effects Plot Means Alloy.

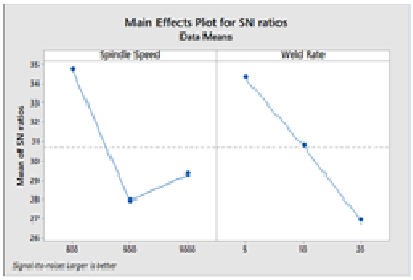

Figure3 Main Effects Plot S/N Ratio

Table 3 show the responses table for signal to noise ratio. From the result, it show that weld rate is the most significant factor for the high tensile strength.

Table 3 Response Table for Signal-to-Noise Ratios

Level	Spindle speed	Weld rate
1	34.73	34.30
2	27.92	30.77
3	29.31	26.90
Delta	6.80	7.40
Rank	2	1

Table 4 shows the predicted and confirmation test value. Since the percentage of error between actual and the predicted value is very small which is 0.27%, thus the validation test can be considered as a successful and the recommended optimum setting B1A1 can be accepted.

Table 4 Predicted and Confirmation Test Value

	Tensile Strength (mean)
Predicted value	99.888
Confirmation value	100.157
% of error	0.27% (less 1%)

4. CONCLUSION

In Conclusion, the optimum combination levels of welding parameter for friction stir welding (FSW) process on AA 5052 alloy tensile strength is at 800 rpm spindle speed (level 1) and at 5 mm/s weld rate (level 1) or A1B1. According the confirmation test, it shows that the result can be effectively used with 0.27% confidence level. Proper selection of the weld parameter is extremely important factor that need to be focused.

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