Process Parameter Optimization of Friction Stir Welding for Joining AA6105 Using Taguchi Method

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Abstract— Aluminium alloy 6105 are used in engineering design like automotive connector stock, structural members due to their light weight, better machinability, strength properties and braze ability. Friction stir welding is a solid state joining process in which material is welded without melt and recast. This research presents the effects of parameters on TS (KN/mm2) and hardness during friction stir welding of aluminium alloy 6105. The friction stir welding parameters such as tool rotational speed (950-1550 rpm), welding speed (25-45 mm/min) and tilt angle (0-1 degree) has been used. Using TAGUCHI method, appropriate L9 orthogonal array has been used. It was noted that for the friction stir welding of aluminium alloy 6105, maximum TS is 0.0912 KN/mm2, which is obtained at 1250 rpm tool rotation speed, 25 mm/min welding speed and zero degree tilt angle.

Keywords: FSW, AA6105, TAGUCHI, ANOVA, TS

I. INTRODUCTION

Welding is a permanently joining process. Welding uses temperature, pressure and metallurgical condition to mixed two materials together.

There are two types of welding i.e. solid state welding and fusion welding. In fusion welding, there is no pressure applied but a filler material is always used. In solid state welding, pressure is applied along with heat. No filler materials are used. Friction welding is a form of solid state welding process, which depends on the flow of metal, and deformation and on the formation of molten bridge. The basic principle of friction welding involves the simultaneous application of pressure, relative motion, generally in a rotational mode, between the components to be joined. The friction welding which require pressure, relative motion and time, is an efficient thermal energy source for the welding of material.

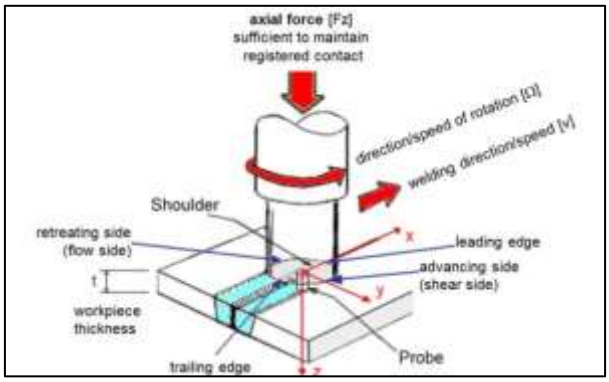

Fig. 1.1: Friction Stir Welding

II. TAGUCHI METHOD

The Taguchi method involves reduction of the variation in the process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation.

Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies. Instead of having to test all possible combinations like the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources.

The Steps for Design of experiment:-

1) Define the process objective
2) Determine the design parameters
   – affecting the process
3) Create orthogonal arrays for the parameter design indicating the number of and conditions for each experiment.
4) Conduct the experiments indicated in the completed array to collect data on the effect on the performance measure.
5) Complete data analysis to determine

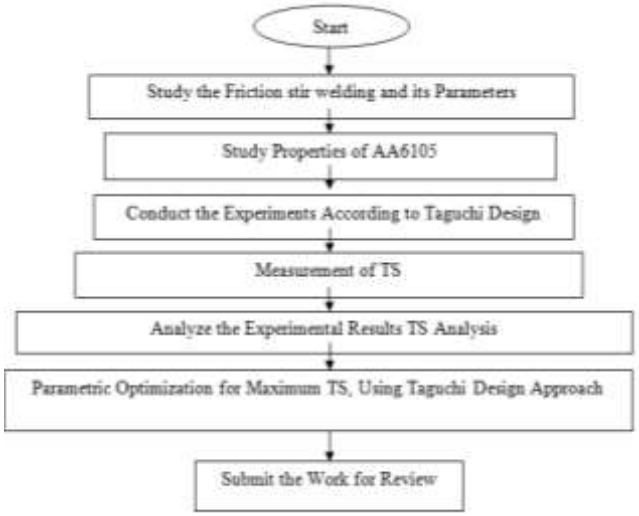

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Figure: 2.2(a) front view Figure: 2.2(b) during Welding

Fig. 2.2: Work Area

III. RESULT

S.No	N	S	T	TS
1	950	25	0	0.085
2	950	35	0.5	0.078
3	950	45	1	0.067
4	1250	25	0.5	0.082
5	1250	35	1	0.084
6	1250	45	0	0.087
7	1550	25	1	0.079
8	1550	35	0	0.076
9	1550	45	0.5	0.072

Table 3.1: Testing result of Tensile Strength

N= Rotational Speed (rpm)
S= Welding Speed (mm/min)
T= Tilt angle (degree)
TS= Tensile Strength (KN/mm^2)
VHN= Vickers Hardness number

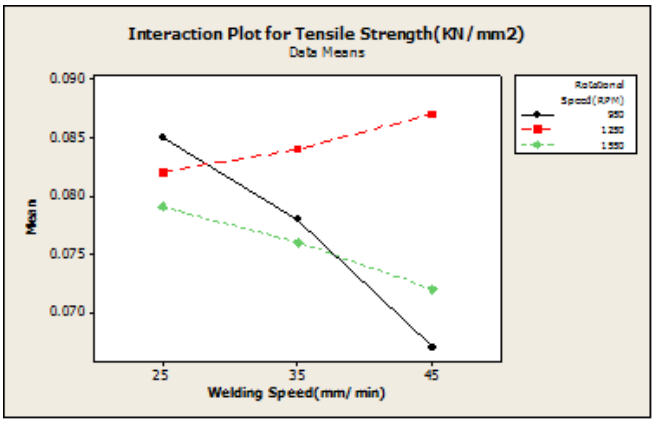

Fig. 2.3: Interaction plot for Tensile Strength

For calculate the maximum value of tensile strength, firstly select the maximum value of tool rotational speed. Secondly select the maximum values of welding speed and then select the maximum value of tilt angle.

Tensile Strength (TS) Formula:

$$TS = N_2 + S_1 + A_1 - 2T$$

Where,

T = overall mean of tensile strength

N_2 = average tensile strength at second level of tool rotational speed i.e. 1250 rpm.

S_1 = average tensile strength at first level of welding speed i.e. 25 mm/min.

A_1 = average tensile strength at first level of tilt angle of tool i.e. zero degree.

$$TS = 0.08433 + 0.082 + 0.082666 - 2\times0.07888$$

$$TS = 0.0912 \text{ KN/mm}^2$$

The experimental result shows that the tool rotational speed has a significant effect on tensile strength of the joint. As the tool rotational speed is increase tensile strength of the joint is also increase but after achieve a highest tensile strength of the welded joint then they start decreasing.

The experiment result also show that the welding speed is the next important parameter for tensile strength of the joint. The plot result shows that tensile strength is decrease by increasing the welding speed.

The tool tilt angle has the smallest effect on tensile strength of the joint. As the tool tilt angle is increase tensile strength of the joint is also decrease

IV. FUTURE SCOPE

Though a systematic experimental study has been carried for the tensile strength of aluminium alloy 6301 using FSWM, ample scope is there for carrying out further research in the area.

1) In this investigation only three parameters (rotational speed, welding speed and tilt angle) were included as input factors. Study of other parameters such as axial force, shoulder diameter and pin diameter can be included.
2) The study can be extended to other Taguchi of aluminium alloy and harder materials.
3) In present research response tensile strength and hardness are selected. Further investigations can be done to find out other response like Yield Strength, Impact Strength and % Elongation etc.
4) The tool made of other material can also be used for further investigation.

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