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Optimization of the Parameters on the Friction Stir Welding to Improve impact Strength of Welding Joint of two Dissimilar Alloys of Aluminium

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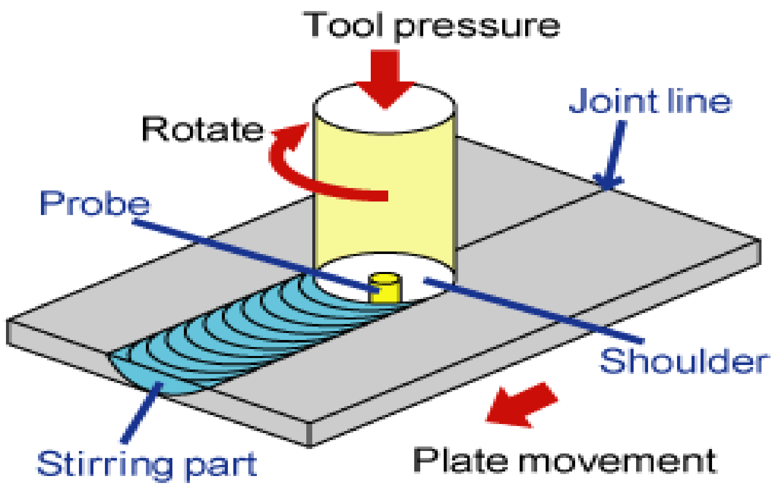
ABSTRACT

The process of Friction stir welding is a solid-state joining process i.e. used for joining similar as well as dissimilar metals like Mg, Al, Cu, Ti, and alloys made from them. Here in the present experimentation, two aluminium alloys i.e. Aluminium 5052 and Aluminium 5086 was used to carry out the friction stir welding with different combinations of process parameters. Tool speed of rotation, traverse speeds and tilt angle of tool are important parameters used in the present work. For the evaluation of the impact strength for weld joint Izod Charpy method was used. It was evaluated from the present work that at the joint interface region, welded material exhibit a similar texture with the materials non-rigorous mixing at joint the nugget. After the evaluation of impact strength of the entire specimen it is observed that joint has good mechanical properties. The inter diffusion of welded metals and similar orientation of texture is there on the joint. It is found that the impact strength of the joint with friction stir welding is highly influenced by traveling speed of tool than rational speed of tool than tilting angle of tool.

Keywords: Friction Stir Welding; Charpy test; Taguchi Method Impact Strength;; Friction Welding; Aluminium Dissimilar metals welding;

INTRODUCTION

It is very difficult to join the two dissimilar metals using the conventional welding approach, as combination desirable properties are required for parent materials. The process of friction stir welding proved very affective in joining the same. In Friction Stir Welding process rotating, non-consumable tool, having a shoulder and specific probe profile or pin, is pushed downward on the joint where the heating due to friction is much to increase the material temperature to a point of plastic deformation of material Friction welding is also known as a forge welding because in this process joining is obtained by pressure application. The heat required to join the two surfaces in the friction stir welding is basically obtained by means of friction only. The pressure applied increases the friction. By this process the temperature of two mating parts is raised up to a level where they can be welded easily. The raised temperature remains below the recrystallization temperature. Lots of material combination of different material can be joined using this process and lots of other operations can be made using the frictional heat. The process was firstly invented in 1991; FSW process was developed and is first patent was made by The Institute of Welding (TWI) The type of welding is also known as solid state welding that needs a third tool for joining the two surfaces. A soft surface is developed neat the tool due to the heat generated between work piece material and tool. A mechanical intermixing of two work-pieces take place at the joint, this softened material melted due to its elevated temperature can be made joined external mechanical pressure which is applied with tool. Conventional milling machine can be used as the equipment for welding where we can use the welding tool instead of the milling tool. 1.5-30 mm thickness of the aluminium material can be welded. In the welding surface basically three distinct structural zones are generated: as nugget, the thermally mechanical affected zone also known as TMAZ and a Heat Affected Zone also known as HAZ.



Friction Stir Welding

W M Thomas et al. (1999) [1] makes welding of unlike aluminium alloys and metals of non-ferrous type, this has a little change in FSW which increase the temperature, During the welding of steel a color change is observed. After a few seconds of contact with the plate the color of the tool changes to orange, A temperature approximate 1000°C is observed by the color detection. In travelling of the tool on seam line of joint, the track leaves behind the tool trailing edge that appeared bright red color with temperature approximately 900-1000°C. This color of the tool changed cherry red represents temperature range of about 600°C. The temperature of toll majorly depends upon the tool rotational speed, and it increases with increasing speed.

H.J. Liu et al. (2003) [2] has concluded that during the friction-stir-welding of the 2017-T351 a softened region is observed in the joint, which has weld and two Heat Affected Zones, in aluminum alloy, as a result the tensile properties of joints will be low as compare to the base material. The parameters of welding have great impact on the various properties like tensile strength and locations of fracture in the joints. In case the pitch of revolution is more than a definite value causes void defects in the joint, in case the tensile properties are low, and a fractured is observed at the weld center.

Paul A. Colegrove Hugh et al. (2007) [3] made various observations through various experimentation for prediction of the generation of heat and the temperature field with the flow properties of the metal to be welded, conditions of process and tool and workpiece dimensions. To determine the effect of welding parameters of heat generation trials weld were done on the aluminum alloys. It is observed that at lower rotation speed deformation of shoulder is more. Micro sections of weld show the flow of material. More localized deformation of material take place at speed of rotation with harder materials near the tool surface.

Experimental Setup

In the present work of friction stir welding process, a conventional PACKMILL manufactured vertical milling machine was used which applicable for high duty. Aluminum alloy 5052 and 5086 are the two dissimilar metals to be joined, Table 1 shows the chemical compositions of the work piece materials to be joined, and Table 2 shows the mechanical properties of material in use. Specimens of 127 mm (length) × 72 mm (width) × 5 mm (thick) size were used as work piece material.

Table 1: Nominal Chemical Composition of the Aluminium 5052 and Aluminium5086

Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others Total
AA5052	**0.25**	**0.40**	**0.10**	**0.10**	**2.2-2.8**	**0.15-0.35**	**0.10**	**–**	**0.15**
AA5086	**0.4**	**0.5**	**0.1**	**0.2-0.7**	**3.5-4.5**	**0.05-0.25**	**0.25**	**0.15**	**0.15**

Table 2: Mechanical Properties of the Aluminium 5052 and Aluminium5086

Material	UTS (MPa)	YS (Mpa)	Elongation %	Hardness (VHN)
AA5052	214	214	10	80
AA5086	310	276	12	107

Table 3: Specifications of Milling Machine

Specifications	Values
Manufacturer	PACMILL (Semi- Automatic)
Spindle Position	Vertical
RPM range	4650 R.P.M
Diameter of Tool Holder	17 mm
Motor	3 HP, 1430 rpm

First pilot experiments were done on the workpiece using random values and then from those pilot experiments the suitable values of these parameters were selected. Based on observations from the pilot experiments these levels were found suitable for the experimentation.

Table 4: DOE Factors and Levels

S.N	Factors	Level-1	Level-2	Level-3
1	Tool Rotational Speed	1200	2300	3080
2	Tool Travelling Speed (mm/min)	45	55	65
3	Tool Tilt Angle (^{o})	1.5	2.5	3.5

Based on these observed levels of process parameters welding is done on work material using Taguchi L9 orthogonal array and nine were done using four levels of three parameters.

After a successful welding of the samples at vertical milling machine the sample were analyzed for removal of any defect present. The samples having defects were welded again on the same configuration same as that of defected one. To find the impact strength, the small samples suitable for Izod Charpy test were cut from the weld bead. An Izod Charpy method was used to calculate the impact strength of the welded joint.

Table 5: Observation table for Impact Strength and Tensile Strength

Exp No.	TOOL ROTATIONAL SPEED(RPM)	TOOL TRAVELING SPEED MM/MIN	TOOL TILTING ANGLE in Degree	Impact Strength in Joule
1	1200	45	1.5	16
2	1200	55	2.5	9
3	1200	65	3.5	15
4	2300	45	2.5	14
5	2300	55	3.5	6
6	2300	65	1.5	8
7	3080	45	3.5	14
8	3080	55	1.5	12
9	3080	65	2.5	4

After all the observations done, then all these observations are used for doing analysis and finding the results with the help of Minitab software. The calculations and graph plots for different element are discussed in detail in the next chapter.

RESULT AND DISCUSSION FOR IMPACT STRENGTH (IZOD CHARPY TEST)

The value of impact strength decreases with increase in the rotating speed of the tool. The rate of decrease of impact strength is high as the speed increases from 1200 rpm to 2300 rpm. But the impact strength does not change as the speed increases from 2300 rpm to 3080 rpm. It is observed that the impact strength is decreasing as the tool rotational speed increases. The trend is observed same in both SN Ratio and Mean Plot.

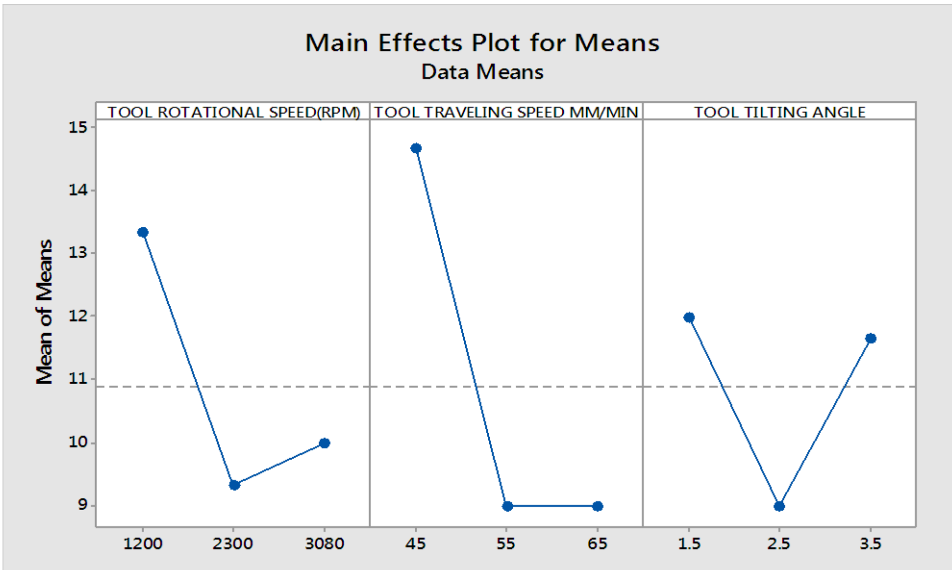


Fig. 1 Main Effects Plot of Means for Impact Strength

Table 6 Response Table for Means for Impact Strength

Level	TOOL ROTATIONAL SPEED (RPM)	TOOL TRAVELING SPEED MM/MIN	TOOL TILT ANGLE
1	13.333	14.667	12.000
2	9.333	9.000	9.000
3	10.000	9.000	11.667
DELTA	4.000	5.667	3.000
RANK	2	1	3

CONCLSION

- It is concluded that the impact strength highly influenced by tool traveling speed than tool rational speed than tool tilting angle.
- Impact strength is decreasing with decreasing tool rotational speed.
- Impact strength is decreasing with decreasing tool travel speed.
- Impact strength is seeming to be decrease with increase tool tilt angle.

Table 7 Optimal combination for Impact Strength

Physical	Optimal Combination		
Requirements	Speed(RPM)	Feed Rate (mm/S)	Tool Tilt Angle (^{o})
Maximum Impact Strength	1200	45	1.5
	Level-1	Level-1	Level-1

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