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EXPERIMENT INVESTIGATION OF FRICTION STIR WELDING OF AA7075 USING BOX BEHNKEN DESIGN

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ABSTRACT: Friction stir welding is referring to new solid state welding technique for metallic material, such as aluminium alloy. Friction stir welding (FSW) uses a non-consumable tool to produce frictional heat in the adjoining surfaces. The welding process is to be conducted on varying the welding process parameters such as tool rotation speed (rpm), welding speed (mm/min) and tool pin profile. It has also been observed that, contour plot states that FSW performed well with highest UTS of 218.849 N/mm2 at rotational speeds of 1400 rpm and welding speed of 25 mm/min with cylindrical tapered pin profile tool to gives good strength of AA7075.

I. INTRODUCTION

Friction stir welding is referring to new solid state welding technique for metallic material, such as aluminium alloy. The FSW was first invented at the welding institute (TWI) of the United Kingdom in 1991.[1] A non-consumable rotating tool are specially defined of pin length and shoulder diameter are inserted into two plate to be joint and travel along the welding line of joint to two work piece material. The rotational mainly two primary functions heating between work piece and during moment of material to produce the joint. During high temperature of performed by friction between the tool and work piece and produce plastic deformation of work piece.[2] Advantages of FSW over conventional fusion-welding processes of Low distortion and shrinkage, even in long welds, excellent mechanical properties in fatigue, tensile and it is not produce arc and frame.[3]

II. REVIEW OF PUBLISHED STUDY

The welding process parameter was control the quality of welding rotation speed 1600 and 1200 rpm, transverse speed 120 mm/min and tool till angle 20 and process parameter to obtain detect free weld joint. The dimensions of aluminium alloys plate were used such as 100 mm length, 50mm width and 6mm thickness. [4] Tool pin profile and welding parameter on the formation of friction stir weld and tensile strength. The triangular pin tool profile was produce max. Tensile strength produced which achieve by rotation speed 1400 rpm and traveling speed 16 mm/min.[5] Effect of tool pin profile microstructure and tensile properties of FSW dissimilar stir welding process using three different tool pin profile like cylindrical, tapered cylindrical and thread cylindrical. In this process parameter rotation speed 1600 rpm, 1200 rpm and welding speed 10 mm/min, 40 mm/min was used. Form the trail experiment, the specimen's size of aluminium plates were 150mmX150mmX6mm joint configuration was used for the fabrication of friction stir welding joint.[6] The specimen cut into rectangular piece of 50mmx50mmx10mm. Friction stir welding was carried out on the specified alloy in CNC vertical milling machine. The rotation speed 1200 rpm, 1400 rpm, 1600 rpm and welding speed is 40 mm/min, 60 mm/min and 80 mm/min respectively. The friction stir welding the resultant at 1400 rpm tool rotation speed, welded surface were good without any defects. The optimum tool feed which displayed good tensile strength during FWS was 60 mm/min and tool rotation speed was 1400 rpm.[7] The friction stir welding work piece sample at weld condition of rotation speed 12000 rpm, welding speed 0.7 mm/min and load 7000 N.[8] Friction Stir Welding focuses on the tensile behaviour of dissimilar joint of AA5083 H111 alloy to AA6351-T6 alloy produced by friction stir welding. There five types tool were used such as straight square tool (SS), Tapered Square tool (TS), Straight Hexagon tool (SH), Straight Octagon tool (SO), and Tapered Octagon tool (TO). It was found that the joint fabrication at a tool rotation speed 950 RPM with travelling speed 50 mm/min, 63 mm/min, 75 mm/min had been used to weld joint. [9]

III. METHODOLOGY

In the friction stir welding process, a cylindrical tool pin, thread tool pin, and tapered tool pin (probe) is rotated at speed 1400 rpm, 1600 rpm, 1800 rpm and feed transverse ratio 15 mm, 20 mm and 25 mm into the joint to be weld between two plates. The plates which are to be welded have to be clamped in a proper manner that abutting joint face from being forces apart during welding. In experiment has consisted of conventional milling machine and friction stir welding tool.

IV. TOOL MATERIAL

In this work we have used aluminium alloys joint by FSW with the help of Hot Work Tool Steel (H13). This alloy is one of the hot works, Chromium type tool steels. It also contains molybdenum and vanadium as strengthening agents. This alloy is wieldable. H13 finds applications for hot die work, die casting and extrusion dies. Machinability of the H13 is medium to good.

Table:1-Chemical Composition of H13

Carbon	0.32-0.45
Chromium	4.75-5.5
Manganese	0.2-0.5
Molybdenum	1.1-1.75
Phosphorus	0.03 max
Silicon	0.8-1.2
Sulphur	0.03 max

V. MATERIAL USED IN EXPERIMENT

In this experiment used of Aluminium alloy 7075 T6. It has main contains of zinc as the primary alloying element. Aluminium alloys 7075 T6 has high strength, good fatigue strength, and average machinability. The main alloying element in the 7000 series is zinc (Zn) and magnesium (Mg). A magnesium content of around 0.8 – 1.2% provides good strength with good formability and high corrosion resistance in sea water, which results in a hard enable alloy. It is lowest toughness and resistance to stress corrosion cracking. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.

Table:2-Chemical Composition of AA7075 T6

Element	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn	Al
% Present	0.18-0.28	1.2-2.0	0.0-0.5	2.1-2.9	0.0-0.5	0.0-0.4	0.0-0.2	5.1-6.1	Balance

Table:3-Mechanical Properties of AA7075 T6

International alloy designation	% Machinability	% Elongation	Ultimate tensile Strength (MPa)	Vikar Hardness (kgf/mm^2)	Shear Strength (MPa)
AA7075	70	11	572	175	331

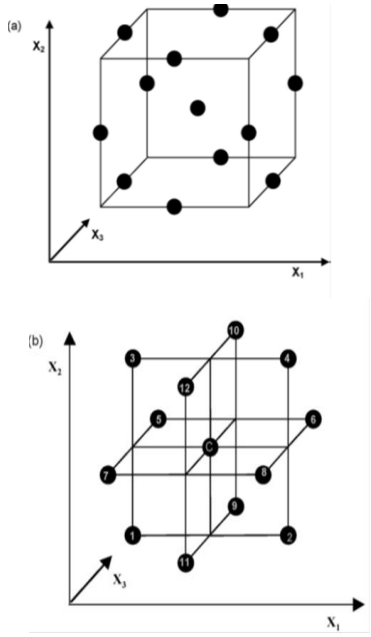
VI. BOX–BEHNKEN DESIGN

In the friction stir welding are total 9 experiments for Tool-1(straight cylindrical pin tool), 9 experiment for Tool-2 (tapered pin profile tool) and 9 experiments for tool-3 (thread cylindrical tool pin profile) have been conducted with 3 levels using BBD (Box–Behnken design) in order to study the influence of the parameters. Three levels of rotational speed have been considered at 1400 (low), 1600 (med), 1800 (high) rpm respectively. Three factors (variables) are tool rotational speed and tool travel speed and tool pin profile so the number trial experiments come to 3^3=27.

Box-Behnken Designs (BBD) is use to find out the relationship between response surface function and variable. It is based on the second order. BBDs represent of three level designs that are highly efficient for estimating second-order response surfaces. Box Behnken Design is represent of graphical can two ways,

A) Cube that consists of the central point and the middle points of the edges,

B) Three interlocking 22 factorial designs and a central point.



VII. RESULT END DISCUSSION

A contour plot consists of two-dimensional view. In contour plot all points that have the same response are connected to produce contour lines of constant response. Surface plots show how the fitted response relates to two continuous variables. A surface plot displays the three-dimensional relationship in two dimensions, with the variables on the rotation speed (rpm) and welding speed (mm/min) and the response (UTS) variable represented by a smooth surface. Here contour plot states that FSW performed well with highest UTS of 218.849 N/mm^2 at rotational speeds of 1400 rpm and welding speed of 25 mm/min with cylindrical tapered pin profile tool.

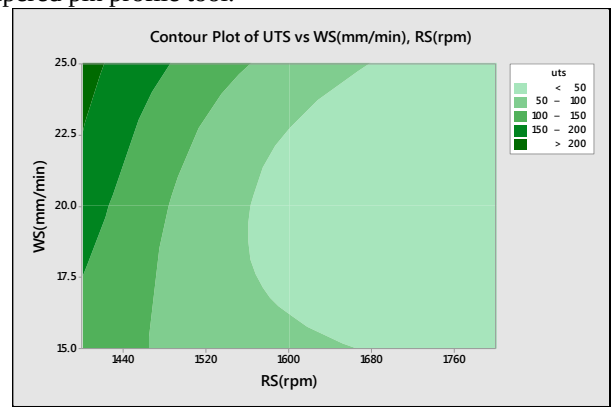


Fig.: 1 Contour Plot of UTS v/s WS (mm/min) and RS (rpm)

Surface plot of fig. 2 denotes the continuous change in UTS with respect to tool profile and Rotation speed (rpm). As the graph is moving toward the lower rotating speed of 1400 rpm and higher welding speed of 25 mm/min and the higher performance of 218.849 has been observed.

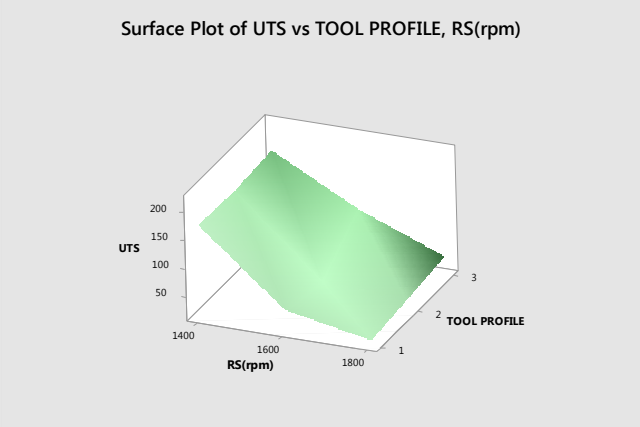


Fig.: 2 Surface plot of UTS vs Tool Profile and RS(rpm)

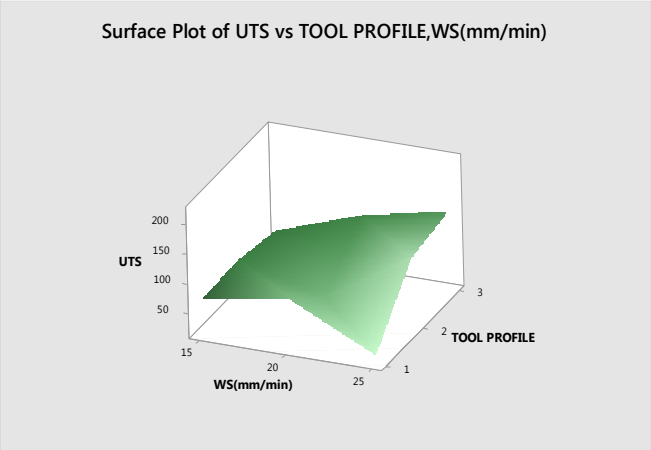


Fig.: 3 surface plots of UTS v/s tool profile and WS(mm/min)

Surface plot of fig. 3 denotes the continuous change in UTS with respect to tool profile and welding speed (mm/min). As the graph is moving toward the lower rotating speed of 1400 rpm and higher welding speed of 25 mm/min and the higher performance of 218.849 has been observed.

VIII. CONCLUSION

In this paper presents experimental investigation of friction stir welding of Al alloy 7075 T6. The correlation of mechanical properties and microstructure with the process parameters for the optimization of process is a unique approach which has been the main motivation behind this project. The conclusions can be extracted Contour plot states that FSW performed well with highest UTS of 218.849 N/mm2 at rotational speeds of 1400 rpm and welding speed of 25 mm/min with cylindrical tapered pin profile tool.

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