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PERFORMANCE ANALYSIS OF FRICTION STIR WELDING ON ALUMINIUM AA7075 AND AA2024 ALLOY MATERIAL

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ABSTRACT

Friction stir welding was invented at Welding institute, United Kingdom in the year 1991 and has ever since been proved to be one of the best solid state joining methods for materials such as aluminium and magnesium. Some of the aluminium alloys which are not weld able (Al-Cu, Al-Zn-Mg alloy) by fusion welding techniques, which produce defects and reduce the mechanical properties on the weld nugget could be welded using friction stir welding (FSW) successfully with excellent joint efficiencies. However effect of the process parameters on the properties of weld have not been investigated fully. In this study friction stir welding of aluminium alloys is selected for investigation. The welding process are to be conducted on varying the welding process parameters such as Tool rotation speed (RPM), Welding speed (mm/min), Downward force (KN) and Tool pin profile. The properties such as defects, microstructure, hardness, tensile and bend behaviour on welded plates are to be studied and compared with the base metal. Based on the results the process parameters are to be optimized.

Key Words: *Aluminium, Friction stir welding, Fusion welding technique, Magnesium.*

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1. INTRODUCTION

Friction stir welding has a wide application potential in ship building, aerospace, automobile and other manufacturing industries. The process proves predominance for welding non-heat treatable or powder metallurgy aluminium alloys, to which the fusion welding cannot be applied. Thus fundamental studies both on the weld mechanism and on the relation between microstructure with mechanical properties and process parameters have recently been started. A great advantage is, in particular the possibility of joining dissimilar materials, which are not, or only with great difficulties weld able by classic fusion welding techniques. One of the possible applications is for example the welding of high performance materials, such as particle reinforced aluminium alloy, to larger structures made from a lower performance, but less expensive alloy. In 'fusion welding' the two surfaces of metals melt either directly or along with the filler and the inter-mixed molten metal solidifies to form a welded joint. A metallurgical bond is formed giving adequate strength to the joint. Pressure welding consists of processes where the bond is obtained by applying only ‘pressure ‘, or ‘heat and pressure’ or ‘melting and solidification under pressure’. There are a set of pressure welding processes where there is no melting of the surfaces of the metals to be joined. These pressure welding processes are called “SOLID PHASE WELDING” processes.

Table 1.1. Micro structural Zones In Friction Stir Welding

S.No	Region	Material Flow	Temperature
1.	Weld Nugget (SZ) Stirred Zone	High	High
2.	TMAZ (Thermo mechanically affected zone)	Low	Medium
3.	HAZ (Heat affected zone)	None	Medium

2. TOOL GEOMETRY

Tool geometry is the most influential aspect of the process development. It plays a critical role in material flow and in turn governs the traverse rate at which friction stir welding can be conducted. The tool consists of a shoulder and pin. In the initial stage of tool plunge, the heating results primarily from the friction between pin and work piece. The tool is plunged till the shoulder touches the work piece. The friction between shoulder and work piece results in the biggest component of heating. From the heating aspect, the relative size of the pin and shoulder is important. The shoulder also provides confinement for the heated volume of material. The second function of tool is to stir and move the material. Threaded tool pin profiles produce defect less weld joints and improves the microstructure with mechanical properties on the welded plates.

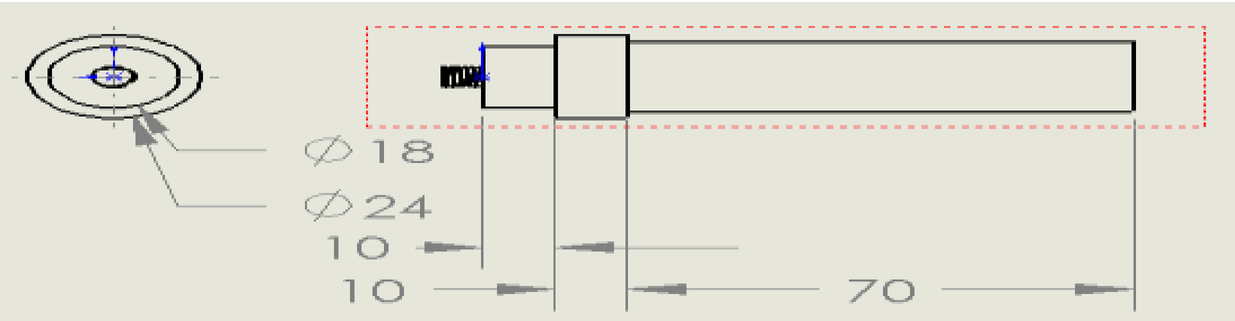

Figure 2.1. Straight Cylindrical Threaded Tool Pin

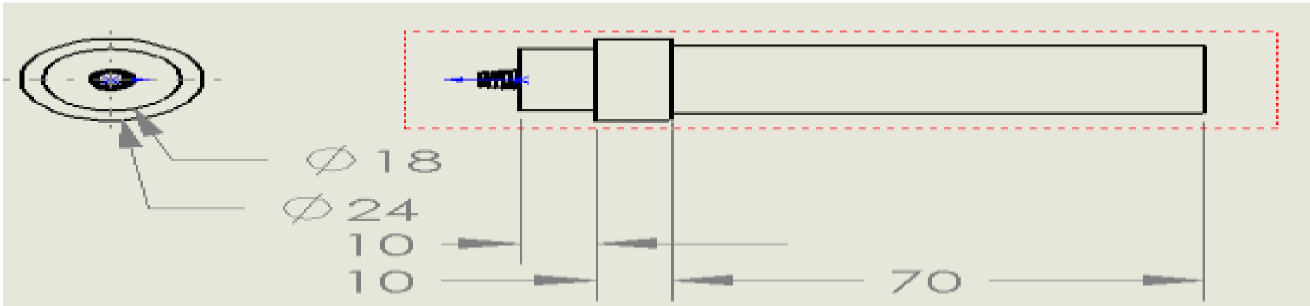

Figure 2.2. Tapered Cylindrical Threaded Tool Pin

3. METHODOLOGY

The experiments were conducted using Friction Stir Welding (FSW) on commercial AA7075 and AA2024.

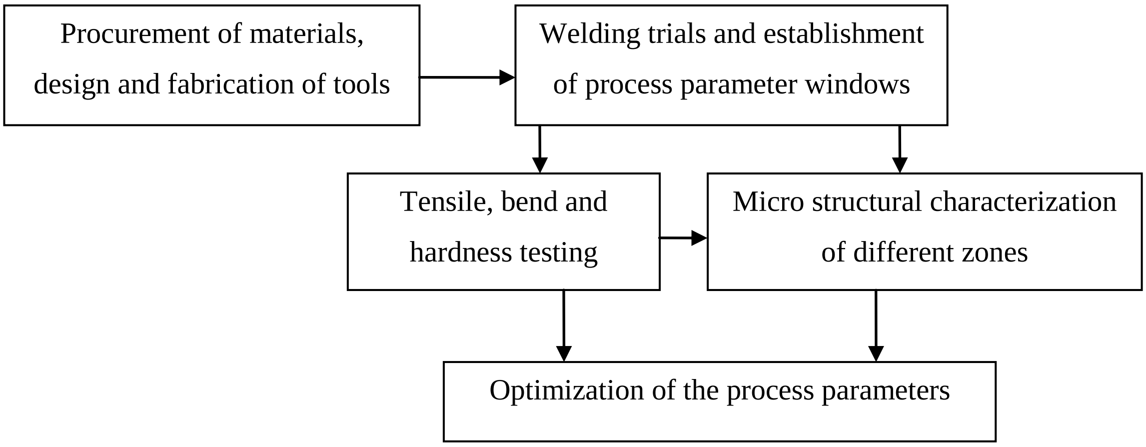

Figure 3.1 Flow Chart of Experimental Activities

4. MATERIAL USED IN EXPERIMENT

Experiment were conducted on AA 7075 and AA2024 base material, which is a pure aluminium grade contains 99.1 percentage of aluminium and tensile strength of 110 MPa. The base material composition is given in Table 3.1. 4.4%Cu, 0.6%Mn, 1.5%Mg.

Table 4.1. Base Material Composition

Material	Si	Fe	Cu	Mn	Mg	Zn	Al
AA2024	0.103	0.136	4.416	0.535	1.646	0.011	Remainder

Material	Si	Fe	Cu	Mn	Mg	Zn	Cr	Al
AA7075	0.062	0.186	1.445	0.019	2.55	5.602	0.195	Remainder

The materials are cut according to this size for effective clamping so that deflection of the base material is arrested and defect free weld could be obtained without any adverse reduction in mechanical behaviour.

Table 4.2. Specimen Size of AA 7075 and AA2024

Length	250 mm
Breadth	100 mm
Thickness	5 mm

4.1 Tool design

Shank length	=	100 mm
Shank diameter	=	22 mm
Shoulder length	=	15 mm
Shoulder diameter	=	18mm
Pin length	=	5.5 mm
Pin diameter	=	6mm
Pitch	=	1mm

4.2 Tapered cylindrical threaded tool pin

Shank length	=	100 mm
Shank diameter	=	22 mm
Shoulder length	=	15 mm
Shoulder diameter	=	18mm
Pin length	=	5.5 mm
Pin diameter	=	4. 6mm
Pitch	=	1mm

4.3 Tool used and Specimen size

Length	=	250 mm
Breadth	=	100 mm
Thickness	=	5mm

Straight cylindrical tool is used.

Made up of M2 high speed steel hardened and tempered to 50 HRC.

5. RESULTS AND DISCUSSION

5.1 Visual Inspection

S600 and S800 welds are shown in Figure. The tool rotation speed in S600 is 600 RPM and tool rotation speed in S800 is 800 RPM. The weld indicated no visible defects. The weld surface is even and uniform.

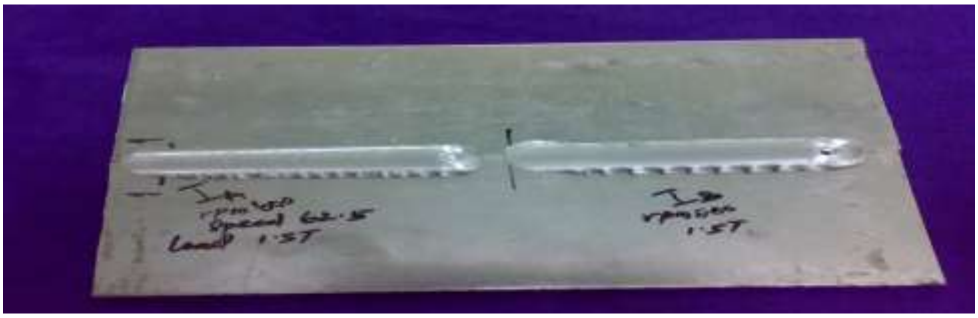

Figure 5.1.1 S600 and S800 Experiment Butt Welded Plates

S1000 and S1200 welds are shown in Figure 4.2. The tool rotation speed in S1000 is 1000 RPM and tool rotation speed in S1200 is 1200 RPM. Similar to S600 and S800 welds, there are no visible defects in the S1000 and S1200 welds. Weld surface indicated a smooth surface finish produced at 1000 and 1200 RPM. This confirms that as the tool rotation speed increases smooth surface is produced at the weld.

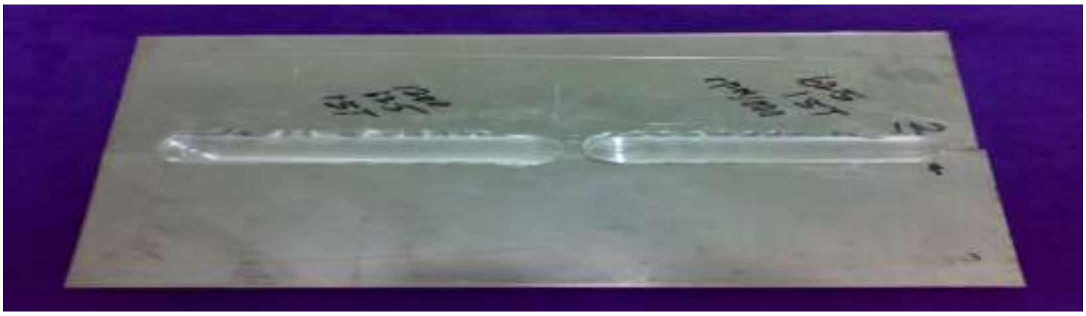

Figure 5.1.2 S1000 and S1200 Experiment Butt Welded Plates

A bead-on welding was made on the base plate at 1200 RPM tool rotation speed. The weld surface is found to be defect less and smooth.

Figure 5.1.3 S1200 Experiment Bead-On Welded Plate

5.2 Radiography Inspection

X-Ray radiographic inspection was carried out using Radiographic unit and the radiographs indicated a good quality weld without any pores and discontinuities at weldment. This conforms the presence of no defects at weld nugget irrespective to tool rotation speed.

5.3 Tensile Properties

Figure 5.3.1 Tensile Tested Weld Specimen

Table 5.3.1.Tensile Test Results

SI. NO.	Specimen Code	Breaking load N	Tensile strength (MPa)	Elongation %	Fracture position
1	S600	8850	101	21	Weld nugget
2	S800	9250	106	25.2	Weld nugget
3	Base Metal(ASM Hand Book,2000,vol.9)	--	110	42	--

5.4 Bend Test Result

Both face bend and root bend tests were performed on the welded specimens and the photographs of tested specimens are shown in Figure 4.5. Most of the welds presented good ductility, allowing for very high bend angles and no cracks were observed. Such ductility is a well known characteristic of the AA7075 and AA2024. In case of weld samples that broke during the bend tests, the reason behind it is an incorrect mixing of the material and insufficient downward force.

Figure 5.4.1 Bend Tested Weld Specimen

Table 5.4.1.Tensile Test Results

SI. NO.	SPECIMEN CODE	ROOT BEND	FACE BEND
1	S600	No cracks observed	No cracks observed
2	S800	Cracks observed after 90 degree bend	No cracks observed

6. CONCLUSION

From the Friction Stir Welding study on AA 7075 and AA2024 alloy weld plates it was found that Quality of welding could be produced with the tool rotation speeds of 600-1200 RPM. No defect occurs in weld nugget region irrespective to tool rotation speed. Tensile test shows the tensile strength is reduced by only about 10% and the percentage elongation reduced almost half compared to the base metal. As tool rotation speed increased the tensile properties marginally increased. The welded specimens passed both root and face bend test allowing for very high bend angles and no cracks were observed in weld nugget. Quality welds could be produced with the tool rotation speeds of 600-1200 RPM. No defect occurs in weld nugget region irrespective to tool rotation speed. The welded specimens passed both root and face bend test allowing for very high bend angles and no cracks were observed in weld nugget.

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