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Experimental Analysis of Friction Stir Welding using Aluminium 6063

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Abstract:- **Friction stir welding (FSW) is a solid state material joining process in which the material which is being welded does not melt or recast. A non-consumable tool used in this process to generate frictional heat in the abutting surfaces. Fusion welding processes FSW is routinely used for joining structural aluminium alloys. Since aluminium alloy is deposited in the fabrication of light weight structures which requires a high strength to weight ratio. In FSW welding parameters such as rotating speed, axial load, and welding speed and tool pin profile play important roles in deciding welding quality. In this paper, authors tried to understand the effect of tool pin profile on FSP zone formation in Aluminium 6063 pipe. The joints are fabricated using two different tool pin profiles such as hexagon and square. Also, the effect of tool pin geometry on mechanical properties is investigated.**

Keywords: Friction stir welding; Tool pin profile; tensile properties, hexgon.

1. INTRODUCTION

Friction stir welding is a solid state joining process that uses heat and pressure energy to join the materials. In this a cylindrical shouldered tool with a profiled pin is rotated and plunged into the joint area between two pieces of sheet or plate material. Frictional heat between the wear resistant welding tool and the work pieces causes the latter to soften without reaching melting point. It always made a fine grain microstructure due to recrystallization arising during the process. Many experimental studies on the mechanical and micro structural properties of friction stir welding of aluminium plates have been published, but there are only few papers about aluminium pipe welding.

Qasim et al., (2012). Investigate the friction characteristics of AA6061-T6 pipes welded by friction stir welding method. In this, the effect of welding speed, rotational speeds on FSP zone are investigated.

Kourshid et al., (2013). Investigate the effect of rotational speed on the outer surface of friction stir welding of AA6063 aluminium pipe. They resulted if stirrer's speed is increased, plastic deformation of pipes also increased.

This paper will focus on the tool pin effects on the mechanical properties of the welded joints of friction stir welded AA 6063 pipe.

2. EXPERIMENTAL SETUP

Table 1: Chemical Composition (wt %) of 6063 Al

Weight %	Ai	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Other each	Each total
6063	Bal	0.20-0.6	0.35	0.10	0.10	0.45-0.90	0.10	0.10	0.10	0.05	0.15

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The material used in this study (AA6063) was received from kovai metal mart. Table 1 and 2 shows the chemical composition and mechanical properties of AA6063 pipe. A conventional vertical milling machine was used for this welding process. FSW tool is fixed on the rotating spindle head in the milling machine which moves in an up & down (linear) motion. So for circular feed a rotating clamping fixture is used to clamp the two pieces of pipe together for joining.

Figure 1: FSW setup

A special type of mandrel is used in this process. It will hold the pipe in both ends and also at the centre it supports the pipe to prevent from pouring down of the material during the process.

Figure 2: Internal mandrel

An external mandrel is used to support the pipes from bending, due to axial load applied during the process.

Figure 2: External mandrel

Table 2: Mechanical Properties of AA6063 alloy

Proof stress Mpa	Tensile strength Mpa	Shear strength Mpa	Elongation %	Hardness Vickers HV
50 min	131	70	27	25

3. TOOL CONSIDERATIONS

In FSW, the tool consists of two main parts (shoulder and pin) to create heat and pressure on the weld. Because contact of the pin with the work piece generates frictional, deformational heating and crucial role on material flow, contact of the shoulder with the outer surface of the work piece creates additional heating, expand the welding area and holding the deformed material. So that tool is an important part in the friction stir welding. Therefore, tool should have the following characteristics,

- Good wear resistance,
- High temperature strength,
- Coefficient of thermal expansion,

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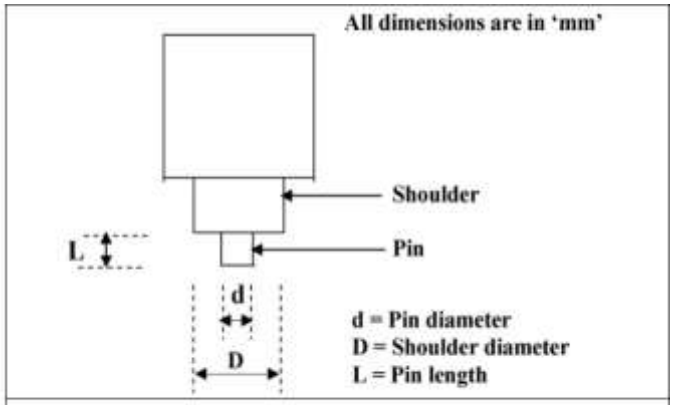

Figure 3: FSW tool

Figure 4: Weld flash

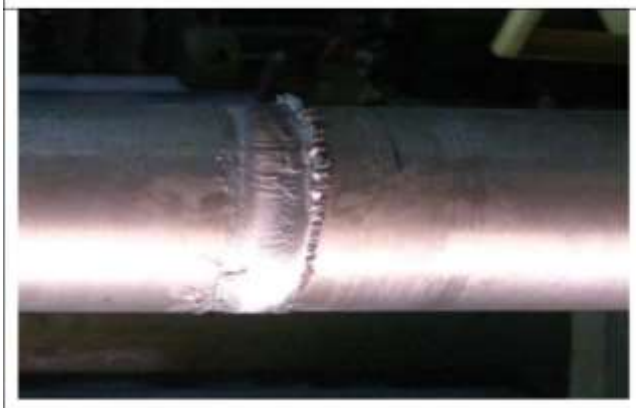

Table 3: Welding Parameters	
Pin profile	Square, hexagon
Pin length	4.7 mm
Shoulder diameter	15 mm
Rotational speed	1600 rpm
Welding speed	0.75 mm/sec

For welding tool high carbon steel is used for friction stir welding.

Tensile tests were performed according to ASTM E8M-04. Tensile samples were prepared for each weld and tests were conducted by using universal testing machine. Macro tests were prepared based on ASTM E340. The optical micro scope was used during the micro structural analysis.

4. RESULTS AND DISCUSSION

Visual inspection

During the welding process welds were visually inspected. Initially at the start of the weld root gap between the pipe should be minimum, because the bond cannot taken place well. The outer surface of the weld depends on the welding parameters selected.

Tensile tests were conducted for all three joints produced by friction stir welding. The test results were compared based on the ultimate tensile strength of the weld produced by each pin profile.

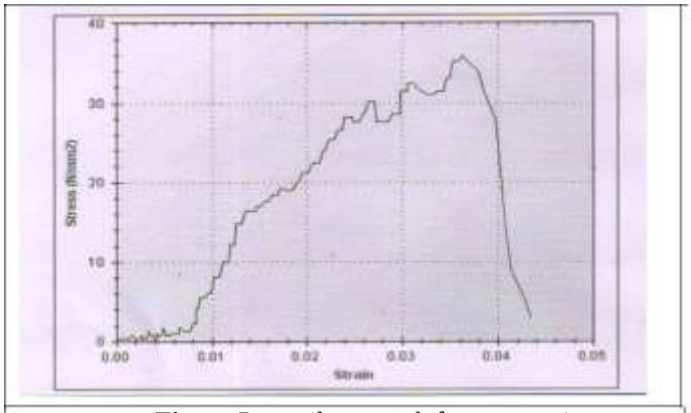

Figure 5: tensile strength for square pin

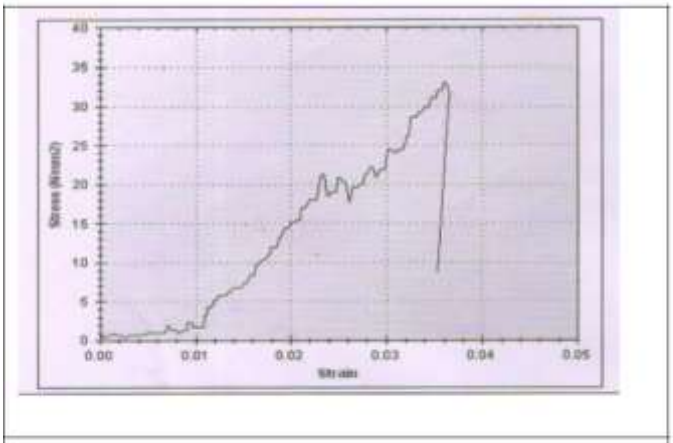

Figure 6: Tensile strength for hexagon pin

The test shows that in FSW, the property of the weld joint depends on the working parameters. The important parameter is tool pin profile because it plays a crucial role on material flow and heat generation.

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5. DISCUSSIONS

The visual inspection and tensile tests are shows that welded workpiece having blow holes. So that mechanical strength in all three welded pieces having lower value than the base material. Reasons behind is, here we using a flat shoulder tool for rounded work pieces so it doesn't contact fully with work piece surface. So stirred materials are moving away from the welded zone and also because of the less contact heat produce by the tool is less.

Comparing the results produced by these two pins, in which square pin gives better strength. Reason behind is, square pin having lower circumferential area so area of the HAZ is less. In welding components HAZ is the weakest part in a material. so that the square pin gives better mechanical strength comparing with hexagon pin.

6. CONCLUSIONS

From the results several conclusions are made, Rotational speed of 1600 rpm and welding speed of 0.75 mm/sec gives better weld surface.

The comparative evaluation of the results produced by the friction stir welding of 6063 aluminium alloy the square and hexagon tools reveal that the square pin gives better mechanical strength.

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