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RESEARCH ARTICLE

# COMPRASSION OF TOOLS FOR FRICTION STIR WELDING USING SOFTWARE

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**ABSTRACT**

The upgoing trend of research on joining of dissimilar alloys grown the interest on the study and analysis of Friction Stir welding. Joining of different steel groups and Aluminium has been on the research interest on the previous decade. Recent innovative research and development areas is on with Magnesium alloy groups. The Aluminium alloys and Magnesium alloys are investigated for the weld strength with respect to the change of welding parameters including tool geometry, the tool transverse speed, and the tool angular velocity. In this paper, the tools were compared for friction stir stir welding of butt joint using AA6061 and AZ61.

## INTRODUCTION

FSW is a technique that allows aluminium alloys, lead, magnesium, titanium, steel, copper & other metals to be continuously welded without the use of any filter material (Thomas, ?).The tool rotates about its axis and also along the welding direction. This forms the joint. The characteristic like tool geometry i.e., shoulder diameter, tool shape, rotational speed, feed rate, shown in the Figure (1)vertical pressure caused by the tool pin & shoulder and eternal cooling affect the heat generated in the material (Cam, 2011). Tool pressure, rotational speed of tool, welding speed, geometries of tool pin & tool shoulder are very important key factors that control welding temperature & material flow (Cavaliere *et al*., 2006).Poor alignment of the welding tool, a short pin and an inadequate plunge depth result in lack of penetration or disbanded surfaces which are major players in initiation of failure. The material being welded is partially deformed by the FSW tool (Mishra and Mahoney, 2007). In FSW, the rotating tool causes a local plastic deformation (Li *et al*., 2011). Functions of two main parts of the tool i.e., the shoulder& pin are to generate heat for material softening and flow control of material for a defect free weld .The profile of tool pin strongly influences the change of microstructure of the welded region and hence plays significant role in corrosion behavior. Previously studies were made on control geometry for choosing the tool pin profile with respect to microstructure and mechanical properties (Threadgill *et al*., 2009). Studies on tool profile on the microstructure and corrosion behavior of welds are scarce (Mishra and Mahoney, 2007).

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The current investigation is aimed at studying the micro structural changes in various zones and the pitting corrosion behavior of our alloys. Friction Stir Welds made using four tool profiles (i) straight cylindrical (ii) straight threaded cylinder (iii) tapered (iv) threaded tapered. Pin geometry affects the weld nugget microstructure. The weld made using straight threaded cylinder tool profile shows very fine grain distribution when compared to the weld made using straight cylinder, tapered tool, and tapered threaded tool profiles. Very fine grains are formed by straight threaded cylinder profile due to dynamic recrystallyzation compared to weld nuggets made using the other three tool profiles.

The shape of the weld nugget and the TMAZ zone is only dependent on the shape & the geometry of welding tool and not on the welding parameters .It is observed in a threaded cylinder tool that there was a relatively higher rate of dissolution of precipitates was observed in the heat affected zone of weld made. The reason behind this phenomena is higher amount of heat generation in the precipitation of FS welds using threaded cylinder tool profile. Earlier tool designs by "Mishra and Mahoney (2007)" revealed that they used simple tool geometries comprising a cylindrical, threaded and fixed pin with a concave shoulder machined from tool steel.

As the tool advances, the newly deformed metal is pushed into the shoulder cavity where it is then directed back towards the pin. Shoulder with convex surface is ineffective as it pushes the material away. Friction stir welding uses a non-consumable tool which allows to weld alloys of aluminium, magnesium, steel, titanium and copper (Thomas *et al*., 2002). Friction stir welding is a solid state welding process which comprises of a rotating which has a shoulder and a pin. The pin is plunged into the metal that has to be welded.

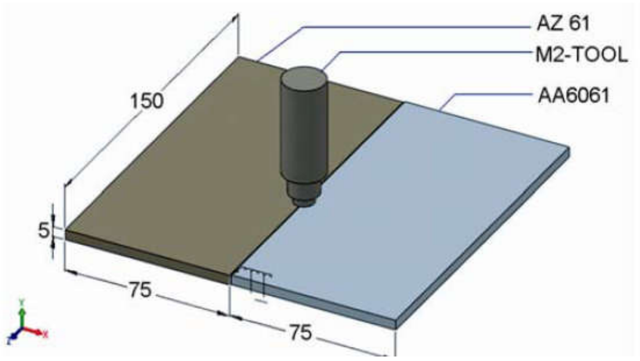


**Figure 1. Schematic illustration of Friction Stir Welding of dissimilar alloys AA6061-AZ61**

A pre-determinedload or predetermined amount of force is applied on the weld metal or the plunges into the upper surface of the metal through a specific distance. Then the rotating tool is moved along a line at which the joint or weld has to be formed. During the rotation of the tool, frictional heat is supplied to the metal which plasticizes it allowing to flow under the influence of the shoulder and the pin. The heat produced due to friction and deformation of the metal and also the force applied by the shoulder of the tool helps in the plasticized bonding of the metal (Friggard *et al*., 1999).

**Table 1. Composition of AA 6061 –and AZ 61**

| Element (%) | Al | Mg | Si | Fe | Cu | Mn | Ni | Cr | Others |
|---|---|---|---|---|---|---|---|---|---|
| AA6061 | 96.2 | 1.0 | 0.6 | 0.5 | 0.3 | 0.1 | 0.04 | 0.3 | 0.96 |
| AZ61 | 6.2 | 92.29 | 0.1 | 0.005 | 0.05 | 0.15 | 0.005 | - | 1.2 |

**Table 2. Mechanical properties of AA 6061 – T6 and AZ 61**

| Material | Yield Strength (MPa) | Ultimate Tensile Strength (MPa) | Elongation (%) | Vicker's Hardness (0.5 kg) |
|---|---|---|---|---|
| AA6061 | 276 | 310 | 17 | 107 |
| AZ61 | 230 | 306 | 16 | 68 |

Thus the weld is completed behind the pin. The properties after the weld are affected by the process parameters which include the rotational speed of the tool, welding speed, plunging force, tilt angle of the tool and the geometry of the tool (Mishra and Ma, 2003; Clark Lakshminarayanan *et al*., 2009). Most of the characteristics of the parent metals are retained after the welding. Friction stir welding is highly advantageous over other welding process in that it forms less pores, low distortion and less shrinkage and it also avoids cracking of the welded metal at the welded zone. Because of the absence of any fillers or filler materials the weld produced is less contaminated. The joints produced by the Friction stir welding show superior mechanical properties because of the recrystallized fine grains.Friction stir welding is environmental friendly, versatile and energy-efficient and also it is rapid and can be automated easily (Cook *et al*., 2004). During the Friction stir welding process the maximum temperature which is produced at the welding zone is 0.6 to 0.9 times the melting point temperature of the metal that has to be welded. And hence,the use of larger temperature-gradient is avoided (Mishra and Ma, 2005). There is a smooth surface finish of the welded joints and the residual stresses are very low, the fatigue strength is also increased considerably due to its fine grained microstructure (Lomolino *et al*., 2005; Middling *et al*., 1999). Friction stir welding is widely used in Defence and Aero-Space application (Thomas *et al*., 1995), Railways (Kawasaki, 2004), Ship building (Pepe, 2006), bridge structures (Vigh and Okura, 2013), and in automotive components (Smith, 2001).

**Experimental work**

In this experimental work, Friction stir welding (FSW) is carried out for thirty specimens with constant axial load and transverse speed. For three different Plunge Down Time(PDT), ten different Rotational speeds are selected as Variable parameters.

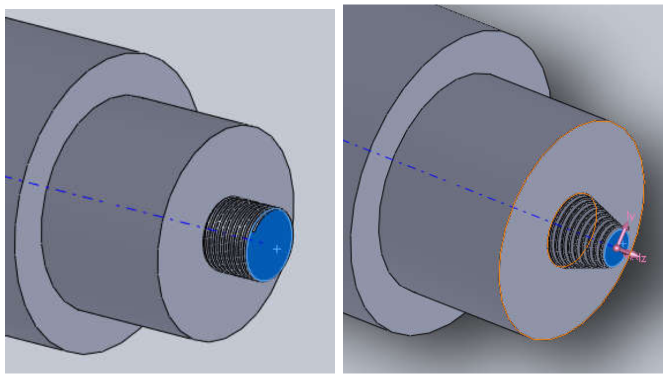

**Figure 2. Tool used for the friction stir welding**

The three different combinations are selected due to the research interest on investigation of stronger side for Aluminium alloy and Magnesium alloy for advancing side and retreating side. Tool tilt is set for 0° and the AA 6061 - AZ 61, base metal of 150 mm weld length with 6 mm thick is Friction Stir Welded with Butt configuration. The sample welded specimens are shown in Figure 2. The AA 6061 and AZ 61 plates for the current work is identified with the composition shown in Table 1. A common mechnical properties of AA6061 T6 and AZ 61 is shown in Table 2.

## RESULTS AND DISCUSSION

From the investigation in Friction Stir Weld on AA6061 – AZ 61 alloys, In the software fig 3. Indicating the stress are good in the three different zones, therefore it was concluded that the taper threaded tool is best for the weld strength. The material flow mechanism determines the tensile strength based on the material kept at advancing side. The AA 6061 on advancing side reveals comparatively better weld strength. Apart from normal welding parameters such as rotational speed, transverse speed and axial load the Plunge Down time also is equally important.

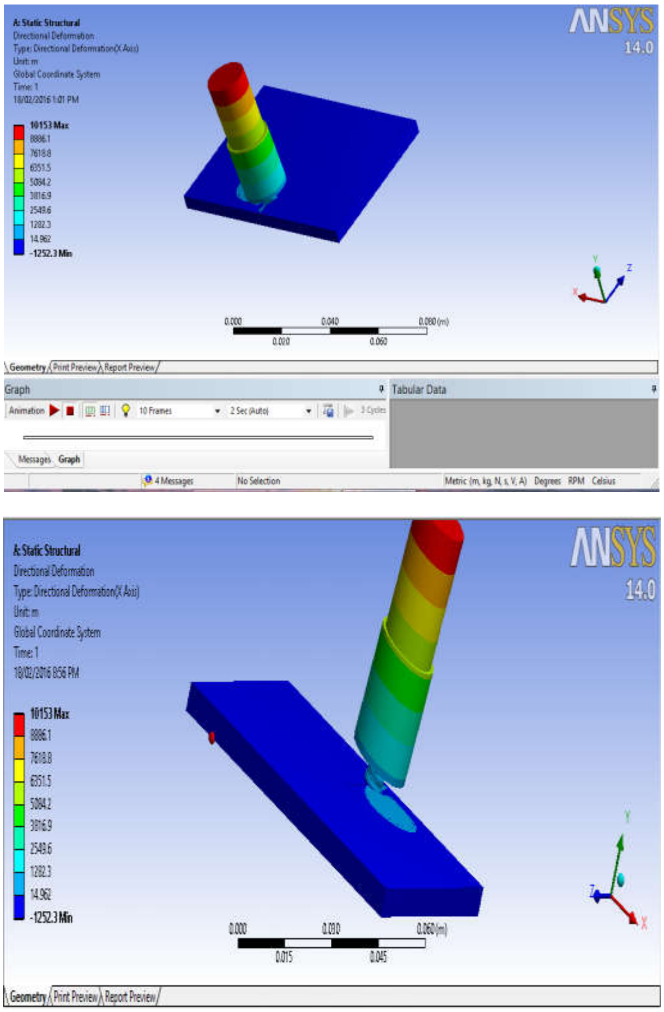


**Figure 3. Anysis analysis of the two different tools**

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