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# Investigation of the microstructure and mechanical properties of AA6063 and AA7075 dissimilar aluminium alloys by friction stir welding process

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ABSTRACT

Friction stir welding (FSW) is one of the advanced welding processes to join both similar and dissimilar alloys and materials. The FSW process is most widely used in automotive, aerospace, and nautical industries to join similar and dissimilar aluminum alloys. In this research work, two dissimilar aluminum alloys of AA6063 and AA7075 were joined using the friction stir welding process and characteristics of the welded joint were studied. Friction stir welded joints of dissimilar alloys were studied by varying the input process parameters of tool rotating speed of 800, 1000 to 1200 rpm with varied the welding speed of 30 to 60 mm/min. The influence of varying the input parameters was studied by the mechanical properties of the friction stir welded (FSW) specimen and the microstructure were analyzed using SEM images.


## 1. Introduction

Friction stir welding (FSW) serves to joining aluminum combinations, magnesium, copper, titanium, and stainless steel without preheating the material. The welding technique is done by pivoting an FSW on non-consumable device into parent meta here mechanical energy is changing over into nuclear power, then plastic nuclear dissemination will happen. The device works around the zones, heat impacted zone (HAZ) trailed by parent material [1]. The solid state joining process (FSW), is done at Welding Institute (TWI) the metals are fortified lesser the liquefying point temperatures of the parent metal. While blend happens the mechanical way of behaving of the materials.

Nowadays FSW has been made in an arising pattern in an assembling area chiefly its suits on various input combinations, the improvement happens with different methodology and procedures of cycle boundaries, and it is relative with other traditional welding strategies [2]. The intensity age from the instrument to the workpiece by FSW process can safeguard the mechanical way of behaving of the parent metal and will decrease the shrinkage decrement and remaining stresses in the weldments.

## 2. Literature review

In this process device is mixed into the parent metal with a turned with the descendant pushed along the surfaces of the base metal is held in a frightful situation by fixing to a base plate. The device profile is produced with indistinguishable features with a greater width segment known as shoulder, and a more modest measurement segment named a pin. The pin profile has various shapes as cylindrical, conical, triangular, threaded, square, and hexagonal shapes friction happens between the device pin profile and the shoulder of the instrument will create the intensity and will plasticize the parent metal and it will cause the weld joint [3,4].

A schematic portrayal of FSW interaction and gear setup is displayed in Fig. 1. significant piece of the material is pushed from the propelling side to the withdrawing side [5] the Main achievability of rubbing mix welding (FSW) in aluminum composites is contrasted with traditional combination welding process. This is because of the strong state joining process [6,7].In this work, 70 mm × 75 mm and 6 mm thickness of comparable aluminum

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**Fig. 1.** FSW Equipment setup.

combinations AA6082 are welded utilizing FSW. The Tensile properties and hardness were researched. In this study, a thermal model of the grating mix-welding process was repeated for the AA6082 plates and the intensity created during the cycle is determined by the numerical articulation [8]. The Heat worth of 880 W was determined for the welding speed 1000 rpm, 2.5 mm/*sec* and 8 KN by utilizing numerical articulation [9,10]. The Friction stir welding tool is shown in the Fig. 2 and the friction stir welded composite specimens are shown in Fig. 3.

The Mechanical Behaviour of Aluminium AA6063-T6 compound is explored utilizing friction stir welding (FSW) Process, aluminium AA7075-T6 composite is a light medium-strength amalgam with great consumption opposition and mostly utilized in a wide assortment of high-pressure applications like fuel liners, radiators and marine fittings [11,12]. The extent of cycle boundaries considered in this work are apparatus rotational speed as 800–1200 rpm, the rotational speed was picked 100–200 mm/min and axial force was picked 8 KN. Pin profile was picked as straight Cylindrical Tool. The following are the description of the FSW Equipment; in X-axis range of 1 m to 100 m or more and to 5000 mm/min velocity, servo controlled, the Y-axis is 1-meter standard and 600 mm stroke, Z-axis is force or position controlled with 50 kN axial force with 5 degrees of tilting is permitted by both the direction.

## 3. Friction stir welding condition and process parameters

The spindle rotational speed range between 800 rpm – 1200 rpm and the Traverse speed is 1.66 mm/*sec* and 2.5 mm/*sec*, Axial power of 8x103 N the two sides welding was carried. Aluminum AA6063-T6 and AA 7075- T5 compounds are joined adequately by strong state joining strategies utilizing different Tool

**Fig. 2.** FSWTool.

**Fig. 3.** FSW Welded Specimens.

turn speeds. The enhancements in the mechanical way of behaving to be identified, ultimate extension assessment/rigidity of the weldments and hardenability of weldments assessed at work testing will be one-sided by the device revolution speed, feed & axial force. The response of the instrument rotational rates and feed towards a definitive rigidity and solidify capacity of the welded joints were established obviously.

The pin height is 5.7 mm and axial force is 8.5 KN is used for double side welded by FSW technique. Sturdiness ranges are expanded from a hardness range of 40–55 HRC based upon the carbon content and the lesser alloying component. The presence of is well reasonable for hot working bites the dust uniquely in expulsion cycle of Magnesium and aluminium. The fundamental benefit of the picked equipment device material over customary up to 550 °C high-strength prepares is capacity. The straight cylindrical-shaped pin profile of hardware can plunge into the plates with high rotational speed and mix the material to frame plastic nuclear dispersion The level round and hollow shoulder width is multiple times the pin breadth which goes about as producing medium during the welding system. The tool dimensions are maintained as pin length (L) is 5.7 mm, pin diameter (d) is 6 mm, and Tool shoulder diameter (D) is 18 mm.

Aluminum compound AA6063-T6 vs AA 7075- T5 is recognized as the Base material because of its expansive accessibility and high-pressure applications generally utilized in the designing project. The combination of Chemical substances of the Aluminum metal AA6063-T6 vs AA 7075- T5 is given in the following table. The different levels of the Aluminium plate are picked in light of by dissecting the cycle of the ASTM Standards of Metals. The particulars are 70 × 75 mm and the thickness of the metal plate was 6 mm. Presently 6 mm thickness was picked in a large portion of 6 mm plates are utilized in this research.

## 4. Results and discussions

### 4.1. Tensile strength Test

Tensile strength for comparable aluminum alloys of FSW weldments and the output were addressed against the rotational velocities are (800 rpm, 1000 rpm, and 1200 rpm, and spindle feed of 1.66 mm/*sec* and 2.5 mm/*sec*. It is seen that better elasticity is accomplished at the Tool Rotational Speed of 1000 rpm navigate feed of 2.5 mm/*sec* and pivotal power at 8KN. Table 1 consists of Tensile strength values of FSW plates and Fig. 4 shows the tensile strength tested specimen. Fig. 5 shows the tensile test results by graphical representation.

**Table 1**
Tensile strength of FSW plates.

| Experiment No | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Tool rotation (rpm) | 800 | 1000 | 1200 | 800 | 1000 | 1200 |
| Welding speed (mm/*sec*) | 1.66 | 1.66 | 1.66 | 2 | 2 | 2 |
| Tensile Strength (MPa) | 108.68 | 107.12 | 88.68 | 114.73 | 114.85 | 109.42 |

**Fig. 4.** Tensile strength tested specimen.

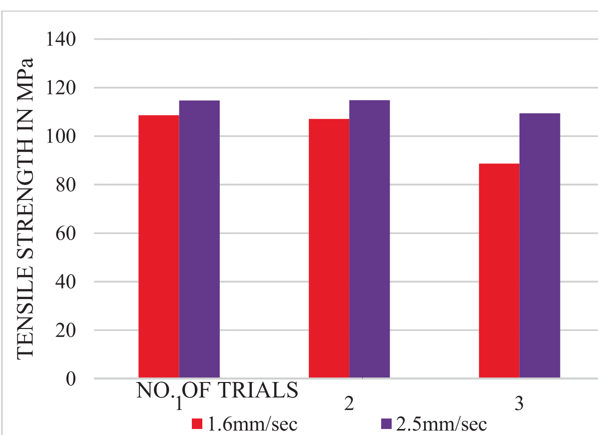



**Fig. 5.** Tensile Test Results.

### 4.2. Hardness Test

Vickers Hardness Test (VHN) for dissimilar aluminum combinations FSW welded in a sample form. An effort is made given the better rigidity boundary examination the outcomes were addressed against the rotational speed of 1000 rpm Welding Speed of 2.5 mm/*sec* and power of 8.5 KN. Hardness indenter put in three zones of the welded zone and observed that a better hardness of VHN 94.36 in 1000 rpm of tool rotation is observed. Table 2 shows the Vickers Hardness value of the FSW plates.

### 4.3. Microstructure analysis

The microstructure shows a combination among weld and base metals. The microstructure of AA6082 base metal shows lengthened particles of Al-Si and MgSi in a lattice of aluminum strong arrangement. The base metal has coarse grain while the weld has fine grains and it uncovers that no imperfections were tracked down in the welded zone. The example is taken from the weldment made at 1000 rpm, 2.5 mm/*sec* and 8.5 KN, which gave the best outcome of different weldments as shown in Fig. 6.

Fig. 6 shows the SEM micrographs of the various tool speed such as 800, 1000 and 1200 rpm. The microhardness distribution is an important factor in the grain size and the precipitate distribution. The main reason for hardening the stir zone is the secondary phase beta precipitates are brooked. It is due to the higher dynamic recrystallization of fine grain structure. In the FSW process, generally, the softened regions are created around the stir zone. So near the stir zone, they have a lower hardness. In the FSW process, near the stir zone, the hardness is lower, due to the over aging of copper present in the aluminium alloy as a second phase.

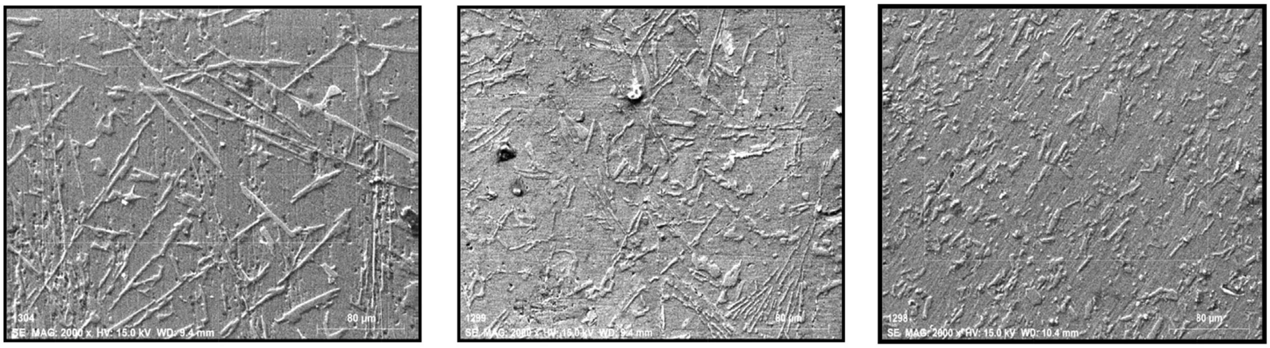
## 5. Conclusion

The friction stir welding process has been was carried out on the AA6063-T6with AA 7075- T5 and the dissimilar aluminium alloy weldments were made and the following conclusions were made.

- The Aluminum alloy AA6063-T6 and AA 7075- T5 Friction Stir Welded weldment was made at 1000 rpm, 2.5 mm/*sec* and 8.5 KN, which gave the best outcome than the other weldments.
- The microstructure of AA6063-T6 with AA 7075- T5 shows stretched particles in a grid of aluminum strong arrangement and it has coarse grain while the weld has fine grains and it uncovers that no imperfections were found when the speed 1200 rpm in the weld.
- The Vickers hardness at the welded zone is higher than the other hardness value, the maximum hardness value is observed at 94.36 VHN in 1000 rpm of tool rotation with 2.5 mm/*sec* and 8.5 KN.

**Table 2**
Vickers Hardness of FSW plates.

| Experiment | Tool Rotation Speed-TRS (rpm) | Welding Speed-WS (mm/*sec*) | Axial Force (KN) | Weld zones | Vickers Hardness No (VHN) |
|---|---|---|---|---|---|
| 1 | 800 | 2.5 | 8.5 | Nugget Zone | 82.54 |
| 2 | 1000 | 2.5 | 8.5 | Nugget Zone | 94.36 |
| 3 | 1200 | 2.5 | 8.5 | Nugget Zone | 86.47 |



800 rpm 1000 rpm 1200 rpm

**Fig. 6.** SEM micrograph of the various tool speed.

## Data availability

Data will be made available on request.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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