EFFECT OF TOOL PIN GEOMETRY ON FRICTION STIR WELDED DISSIMILAR ALUMINIUM ALLOYS - (AA5083 & AA6061)

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ABSTRACT

The present investigation aims in assessment of process parameters on microstructure and mechanical properties of Friction stir welded (FSW) dissimilar Aluminum alloys because of their scope of use in naval and marine applications. Dissimilar FSWed joints were fabricated by varying the rotation speeds, transverse speed and keeping tool geometry as cylindrical with threaded. The welding parameters and tool pin geometry amusement significant roles in deciding the weld quality. During FSW process Al 5083 is placed in advancing side and Al 6061 on the retreating side. The investigational results are exposed that the sound defect free joints acquired by varying the process parameters. From the results, it is observed that higher mechanical properties are acquired at a pivot speed of 900 rpm, and welding velocity of 31.5mm/min due to refinement of microstructure. The perceived outcomes were linked with the microstructure and crack highlights.

Keywords: Friction Stir Welding, Dissimilar Al Alloys, Pin Geometry, Microstructure, Mechanical Properties.

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1. INTRODUCTION

Friction stir Welding is the sort of welding utilized as a solid state joining process for materials that is distinctive composites of aluminum, magnesium etc. and as well for hard materials similar to steels as it deflects the common problems obtained in conventional welding processes. A Friction stir welding tool is a critical component to the success of the process. Friction stir welding (FSW) is a joining process that with a non-consumable device to join two standing up to workpieces without softening the workpiece material. [1-2] Heat is generated because of rubbing between the rotating tool and the workpiece material, which
prompts to a softened region close to the FSW tool. The tool is traversed along the joint; it mechanically intermixes the two metal pieces and forges the hot and diminished metal by utilizing the mechanical pressure, which is applied by the tool. It is basically utilized on wrought or extruded aluminium alloys and especially for structures which require very high weld quality \[3-4\]. The impact of the process parameters such as rotational speed (V) and welding speed (ν), tool pin profile on weld properties and microstructure has been explored in this present examination. \[5-6\]The objective of this paper is to distinguish the significant process and FSW parameters on mechanical properties of AA6061 and AA5083 dissimilar aluminium alloys in FSW process.

H. Jamshidi Aval et al \[8\] examined that instrument geometry has assumes a crucial part on elasticity, prolongation, yield quality and hardness of the welded joint manufactured utilizing two dissimilar aluminum alloys 5086– 6061. They found that concave shoulder instrument comprising of cone shaped test engraved with three grooves created better outcomes when compared with other tools.

Zhao et al. \[9\] was considered the impact of pin geometry on bonding and mechanical properties of friction stir welded 2014 aluminum compound. It is inferred that the pin profile influences the stream of the plastic material and the best quality weld was obtained utilizing the taper tool with screw thread.

M. Ilangovan et al \[10\] In this examination, an endeavor has been made to join the heat treatable (AA 6061) and non-heat treatable (AA 5086) aluminum combinations by friction stir welding (FSW) process utilizing three different tool pin profiles like straight cylinder, taper cylindrical and threaded cylindrical. The elastic properties and microhardness were assessed for the welded joint. From this examination it is established that the utilization of threaded pin profile adds to better stream of materials between two composites and the generation of defect free stir zone.

A. Devaraju et al \[11\] In this present research work, the impact of fine Post-weld Rapid cooling on Grain estimate and Mechanical properties of Friction Stir Welded AA 2014 was examined. The welding parameters and tool pin profile play significant jobs in choosing the weld quality.

P Satish Kumar et al \[12\] was analyzed the Influence of Tool Revolving on Mechanical Properties of Friction Stir Welded 5083Aluminum composite. It is seen that at revolution speed of 710 rpm, 40 mm/min welding speed with decrease with threaded profile brought about great mechanical properties.

A. Devaraju et al \[13\] in this examination the joining of unique AA2024 and AA7075 aluminum plates of 6 mm thickness was completed by friction stir welding (FSW) procedure. In the present examination, the high quality AA2024 T3 and 7075-T6 were welded by the FSW procedure. To certain the ideal mechanical properties by changing the rotational speed from 900 to 1400 rpm and welding speed between 30 to 60 mm/min. Better mechanical properties are gotten with square pin profile tool at a pivot speed of 1400rpm and welding pace of 60mm/min.

M. Shiva Chander et al \[14\] in this paper, the impact of cryogenic (fluid nitrogen) cooling on grain size and impact of microstructure on mechanical properties of Friction mix welded (FSW) unique Aluminum 5083 and 6061 composites were contemplated because of their scope of utilization in maritime and marine applications. It was seen that better mechanical properties are gotten at rotational speed of 900rpm and welding velocity of 31.5mm/min the fine microstructure is acquired.
2. EXPERIMENTAL WORK
At initial a base metal of 5 mm thickness of AA5083-AA 6061 aluminum composites was welded as butt-joint. These are welded under vertical processing machine having 1 HP engine and 3000 rpm. We have picked H13 instrument steel as it has Non-distorting qualities and having high hot hardness. Specifications of tool shoulder and pin used are 24mm, 8mm, and length of stick 4.7 mm. [7] The FSW process parameters has shown in table 1. A consistent pivotal power of 5 KN has been connected with three rotational and welding speeds at tool pin profile (cylindrical with thread) for staying all FSW joints. After the fulfillment of FSW examples were cut for various tests (tensile test, impact test (charpy), micro hardness, and micro structure) as indicated by ASTM principles. After weld examples made they were go for test machines.

![Fig.1. FSW of aluminum 5083 and 6061 plates](image1)

![Fig. 2. Tensile test specimen](image2)

A steady axial force of 5KN has been applied with three rotational and welding speeds with tool profile (cylindrical with threaded) for remaining all FSW joints. Experiments were coordinated with cylindrical with threaded pin profile on 5083-6061 Aluminum alloy combination with different tool rotational speeds of 710 rpm, 900 rpm and 1400 rpm and also welding speed of 31.5 mm/min correspondingly. The examinations were passed on out on a Vertical milling machine (Make HMT FM-2, 10 hp, 3000 rpm) shown in Fig 1.

After FSW, microstructural observations were done at the cross section of Nugget Zone of weldments. This surface could be mechanically polished and etched with Keller’s reagent (2 ml HF, 3 ml HCl, 20 ml HNO3, 175 ml H2O) by employing optical microscope (OM). [8-9]The tensile tests were conducted by utilizing a computer controlled universal testing machine. Micro-hardness tests were completed at the cross section of nugget zone (NZ) by utilizing Vickers digital micro-hardness analyzer.

**Table.1. FSW process parameters**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Tool Pin profile</th>
<th>Rotational speed (rpm)</th>
<th>Welding speed (mm/min )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cylindrical with thread</td>
<td>710</td>
<td>31.5</td>
</tr>
<tr>
<td>2</td>
<td>Cylindrical with thread</td>
<td>900</td>
<td>31.5</td>
</tr>
<tr>
<td>3</td>
<td>Cylindrical with thread</td>
<td>1400</td>
<td>31.5</td>
</tr>
</tbody>
</table>
3. RESULTS AND DISCUSSIONS

MECHANICAL PROPERTIES

The tensile samples were extricated from each joint. These samples were tested utilizing universal testing machine (UTM) as per the ASTME 8-04 guidelines shown in figure 2.

The tensile properties such as yield strength, ultimate tensile strength and level of elongation, of friction stir welded AA6061 and AA5083 alloy joints were assessed with cylindrical with threaded tool profile. The outcomes demonstrate that the tensile properties of the welded joints are essentially changed as to different pin profiles. A higher tensile strength of 173.79 MPa was attained in the joint made by cylindrical with threaded pin profiled tool at 900 rpm and welding speed of 31.5 mm/min. A lower tensile strength of 126.16 MPa was accomplished in the joint made by cylindrical with threaded pin profiled tool at 710 rpm and welding speed of 31.5 mm/min. This might be because of the impact of fine grain structure during the welding process. [10-11]

The % elongation of cylindrical with thread tool is 6.1 % and this is correlated with the yield stress at the tool rotational speed of 900 rpm and welding speed of 31.5 mm/min. There is an increase of deformation which is expected to the microstructure changes in the mix zone and the ideal proof stress was obtained as 127.12 MPa with cylindrical with threaded tool Profile compared to other joints. The results obtained and have shown in table 2.

Table 2. Mechanical properties of friction stir welded 5083 & 6061 aluminium plates

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Tool Rotation speed(rpm)</th>
<th>Hardness (HV)</th>
<th>Ultimate Tensile strength (MPa)</th>
<th>Yield strength (MPa)</th>
<th>% of Elongation</th>
<th>Impact (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>710</td>
<td>60.7</td>
<td>126.16</td>
<td>85.13</td>
<td>0.9</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>900</td>
<td>76.3</td>
<td>173.79</td>
<td>127.12</td>
<td>6.1</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>1400</td>
<td>82.8</td>
<td>144.808</td>
<td>95.63</td>
<td>3.58</td>
<td>20</td>
</tr>
</tbody>
</table>
4. MICROSTRUCTURAL OBSERVATION

Based on microstructural characterization of grains and precipitates, three unique zones have that are Nugget (stirred) zone, thermo-mechanically influenced zone (TMAZ) and heat affected zone (HAZ). It was seen that the joints made at 900 rpm and welding speed 31.5mm/min resulted in extremely smaller equi-axed grains compared to a base material. [12] The images of these microstructures projected at a magnification of 100X. The micro structure specimen was brought from every sample from its NG. The specimen’s NG was super wrapped by utilizing various emery papers and lastly brought it into mirror image. At that point after we go for etching we utilize keller’s reagent (2 ml HF, 3 ml HCL, 20 ml HNO3 and 175 ml H2O).
5. CONCLUSIONS

From the above discussion the impact of different tool profiles and various process parameters on mechanical properties and microstructure influences incredibly and has shown below:

- It is to be seen that ultimate mechanical properties were obtained at 900 rpm with welding speed of 31.5 mm/min i.e., 173.79 MPa (UTS) by using cylindrical with threaded tool pin profile. And the microstructure is also correlated with the acquired mechanical properties.

- Poor mechanical properties like UTS, % elongation and impact strength were acquired at 710 rpm with a welding speed of 31.5 mm/min.

- A fine and equiaxed grain microstructure acquired at 900 rpm and 31.5 mm/min welding speed.

- The highest hardness value is 82.8 Hv at a rotational speed of 1400 rpm by using cylindrical threaded tool profile resulted, due to the surplus frictional heat is generated at this circumstance. [13-14]

- The impact strength is 28 J at a rotational speed of 900 rpm and welding speed of 31.5 mm/min, and is correlated with the ultimate tensile strength value 173.79 Mpa.

- From the results the optimum process parameters at 900 rpm and welding speed 31.5 mm/min with cylindrical with threaded tool profile were better for FSW of 5083 and 6061 dissimilar joints.

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