Experimental and Analytical Analysis on Friction Stir Welding Of Dissimilar Materials: Aluminium and Copper

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ABSTRACT: In this project, FEA analysis is performed for friction stir welding of aluminum alloy 5083 and copper using pin profile round and taper. The analysis is done using different rotational speeds 700rpm, 1150rpm and 1350rpm. The plate sizes are 130mmX45mmX3mm. The tool material is HCHCR steel. The tool shoulder dia is 22mm, tool pin dia is 5mm, pin length is 1.7mm. Modeling is done in Pro/Engineer and analysis is done in Ansys. Experimental investigation is done to verify the mechanical properties of friction stir butt welded aluminum alloys 5083 and copper using pin profile round. The properties investigated are tensile strength and hardness, compared before and after welding. The experiments are conducted with speeds of 700rpm, 1150rpm and 1350rpm and feeds 30, 45 and 60mm/min. Experimental work is conducted on 3 axis vertical milling machine.

KEYWORDS: - aluminum alloy 5083, copper, HCHCR steel, Pro/Engineer, Ansys, friction stir butt welding

I. INTRODUCTION

Friction Stir Welding is the most recent upgrade to the Space Shuttle’s gigantic External Tank, the largest element of the Space Shuttle and the only element not reusable. The new welding technique—being marketed to industry—utilizes frictional heating combined with forging pressure to produce high-strength bonds virtually free of defects. Friction Stir Welding transforms the metals from a solid state into a "plastic-like" state, and then mechanically stirs the materials together under pressure to form a welded joint. Invented and patented by The Welding Institute, a British research and technology organization, the process is applicable to aerospace, shipbuilding, aircraft and automotive industries. One of the key benefits of this new technology is that it allows welds to be made on aluminum alloys that cannot be readily fusion are welded, the traditional method of welding.
II. TOOL DESIGN

Tools consist of a shoulder and a probe which can be integral with the shoulder or as a separate insert possibly of a different material. The design of the shoulder and of the probe is very important for the quality of the weld. The probe of the tool generates the heat and stirs the material being welded but the shoulder also plays an important part by providing additional frictional treatment as well as preventing the plasticised material from escaping from the weld region. The plasticised material is extruded from the leading to the trailing side of the tool but is trapped by the shoulder which moves along the weld to produce a smooth surface finish. Clearly, different materials and different thicknesses will require different profile probes and welds can be produced from just one side or by welding half the thickness then turning over to complete the other side.

MODELS OF CUTTING TOOLS: ROUND TOOL

PLATE1

PLATE2
ROUND TOOL

ROUND TOOL ASSM

COUPLED FIELD ANALYSIS OF ALUMINUM ALLOY 5083 AND CAST COPPER

700 RPM- ROUND TOOL
Select Preference select thermal
Select element type as a solid brick 20 node 90
Enter material properties
Work piece-Aluminum Alloy 5083
Thermal Conductivity – 0.177 W/mmK
Specific Heat – 900 J/Kg K
Density – 0.00000266 Kg/mm³
Copper
Thermal Conductivity – 0.483 W/mmK
Specific Heat – 385 J/Kg K
Density – 0.000007764 Kg/mm³
Cutter-HCHCR Tool Steel
Thermal Conductivity – 0.020 W/mmK
Specific Heat – 460 J/Kg K
Density – 0.00000767 Kg/mm³
Import IGES model
Enter material properties

**Work piece-Aluminum Alloy 5083**
- Young’s Modulus – 70300 MPa
- Poisson’s Ratio – 0.33
- Density – 0.00000266 Kg/mm³

**Copper**
- Young’s Modulus – 110000 MPa
- Poisson’s Ratio – 0.343
- Density – 0.000007764 Kg/mm³

**Cutter-HCHCR Steel**
- Young’s Modulus – 209900 MPa
- Poisson’s Ratio – 0.3
- Density – 0.00000767 Kg/mm³

### III. RESULTS TABLE

<table>
<thead>
<tr>
<th>ROUND TOOL</th>
<th>700rpm</th>
<th>1150 rpm</th>
<th>1350 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodal Temperature (K)</td>
<td>673</td>
<td>673</td>
<td>673</td>
</tr>
<tr>
<td>Thermal Gradient (K/mm)</td>
<td>323.413</td>
<td>575.392</td>
<td>758.425</td>
</tr>
<tr>
<td>Thermal Flux (W/mm²)</td>
<td>66.237</td>
<td>126.416</td>
<td>136.518</td>
</tr>
<tr>
<td>Displacement (mm)</td>
<td>0.030632</td>
<td>0.011474</td>
<td>0.011541</td>
</tr>
<tr>
<td>Stress (N/mm²)</td>
<td>143.246</td>
<td>143.464</td>
<td>144.21</td>
</tr>
<tr>
<td>Strain</td>
<td>0.006231</td>
<td>0.003058</td>
<td>0.003078</td>
</tr>
</tbody>
</table>
IV. EXPERIMENTAL INVESTIGATION

Experimental investigation is done to verify the mechanical properties of friction stir welding of aluminum alloy 5083 and copper. The properties investigated are tensile strength and hardness compared before and after welding. The welding is done on Conventional Vertical milling machine.

<table>
<thead>
<tr>
<th>TOOL</th>
<th>SPEED (rpm)</th>
<th>FEED (mm/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>700</td>
<td>30</td>
</tr>
<tr>
<td>Round</td>
<td>1150</td>
<td>45</td>
</tr>
<tr>
<td>Round</td>
<td>1350</td>
<td>60</td>
</tr>
</tbody>
</table>

ROUND PROFILE TOOL

WORKPIECES BEFORE WELDING

AFTER WELDING:
TENSILE TEST
Type of test – Mechanical Tensile
Equipment used – UTM 250KN
Specimen Width – 28mm
Specimen Thickness – 3mm

<table>
<thead>
<tr>
<th></th>
<th>UTS (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>30.14</td>
</tr>
<tr>
<td>Sample 2</td>
<td>35.74</td>
</tr>
<tr>
<td>Sample 3</td>
<td>27.02</td>
</tr>
</tbody>
</table>

VICKERS HARDNESS TEST
MACHINE DETAILS
Name – VICKERS HARDNESS
Srl No: VM – 50 MCS

TEST DETAILS
Test Procedure – IS 1501:2002
Type of Hardness – HV
Indentor – Diamond
Load Applied – 5Kgs

<table>
<thead>
<tr>
<th></th>
<th>Impression 1</th>
<th>Impression 2</th>
<th>Impression 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>210</td>
<td>206</td>
<td>206</td>
<td>207.33</td>
</tr>
<tr>
<td>Sample 2</td>
<td>180</td>
<td>178</td>
<td>180</td>
<td>179.33</td>
</tr>
<tr>
<td>Sample 3</td>
<td>210</td>
<td>212</td>
<td>210</td>
<td>210.67</td>
</tr>
</tbody>
</table>

RESULTS

Temperature distribution
Thermal flux

Displacement

Von mises stress

V. CONCLUSION

By observing the tensile test results, ultimate tensile strength is more for the sample welded at speed of 700 rpm. By observing the hardness Test results, the hardness is more done at speed of 1350rpm. So it can be concluded that by increasing the speeds the strength decreases whereas by increasing the speeds the hardness increases.

REFERENCES