Analysis Of Friction Stir Welding Between Dissimilar Materials Using Bobin Tool

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Abstract: Friction stir welding is a solid-state joining process where the original metal characteristics remain unchanged as a whole lot as viable since joining takes place in a plastic state without melting. FSW tool intermixes the metals at the place of the joint, then softens them and fused using mechanical strain. It is used most often applied on large pieces of aluminum alloy materials that are impossible and not suitable for further heat treatment to recover its characteristics. Finite Element Analysis was performed for the Friction Stir Welding process for the joining of dissimilar materials AA6061 and pure copper by varying the process parameters. For this purpose, a simple model was created for Friction stir Butt-welding Tool and work pieces to be joined using CREO software and stress analysis is did on them by ANSYS Software.

keywords: Friction Stir Welding; Aluminum; Copper; Butt joint; Finite Element Analysis

1 INTRODUCTION

Friction Stir Welding (FSW) is a solid-state welding process that is used to produce defect-free and clean welds between similar and dissimilar materials. Friction stir welding (FSW) is a solid-state joining method particularly suited for aluminum alloys, which are difficult to be fusion welded without hot cracking, porosity or distortion. By this welding, the placed job is made to be heated at high-temperature frictionally, therefore it resembles to be more plastic. Significant microstructure alterations and changes will be performed, and in result make several local variations and differences in properties of a weld (i.e. namely mechanical properties). The basic concept of FSW is remarkably simple. A rotating tool with a mainly designed pin and shoulder is slot into the adjoining edges of sheets or plates to be fixed and consequently passes through along the joint line-moving front and backside orientations require knowledge of the tool rotation and travel directions. In FSW tool revolves in the anti-clockwise direction and the advancing side is on the right, where the tool travel direction is opposite the direction of metal flow, and the retreating side is on the left, where the tool travel direction is parallel to the direction of metal flow. [1-5] The FSW contains a welded zone that has a stirred zone also called a nugget. Generally, a (HAZ) Heat- Affected Zone and (TMAZ) A Thermo-Mechanically Affected Zone. The stir zone refers to the zone formerly occupied by the tool pin used in friction stir processing, where large volumes of material are processed. This FSW is also said to be the most efficient welding method to join metals. It is also considered to be a green technology, economically friendly, high energy-efficient and versatile. [6-9] A genetic algorithm is used to evaluate the thermal parameters.

The tool shoulder has tool torque, heat generation, temperature distribution, surface angle and the ratio of the shoulder radius to pin radius on tool reaction force, and the size of the weld zone was investigated. The studies were carried out numerically using the finite-element method. The welding process used AA2024 aluminum alloy plates with a thickness of 3 mm. It was also found that the shoulder angle has very little effect on energy dissipation or on temperature distribution [10] Double-sided friction stir welding tool has the support of giving a development zone in the workpiece to form rectangular in cross-section, as opposed the triangular zone is more usually found when conventional friction stir welding tool designs are utilized. A 3D-Model is being applied here for FE experimentation to assume and predict heat dissipation and based on this, the history of thermal variations, residual stress dissipation at the stir zone and the base metal (Al6061-T6) were predicted [11-13]. The origins of tool shoulder and geometries on friction stirred aluminum welds by esteem to weld strength, weld cross-section area, the grain size of weld and thermo-mechanically affected zone via RSM [14-18]. FSW process varying pin geometries and speeds is numerically modeled, and a thermo-mechanically coupled, rigid-viscoplastic, fully 3-dimensional FEM experiment is being performed to identify the process variables, the material flow pattern and observed grain size at the FSW welded joints. The obtained results finding, optimal tool geometry and speed for progress nugget integrity of aluminum alloys. [19-21] It was also observed that variations in tool path significantly influence the mechanical and micro structural properties of similar and dissimilar FSW weld joints and also Tool pin eccentricity played a considerable role in material mixing and joint qualities of dissimilar FSW joints which was performed successfully by Jayabalakrishnan and Balasubramanian. [22-24]

2.0 Experimental

2.1 Modeling of Friction Stir Welding Parts

Although the Friction Stir Welding Process has many benefits, it has some drawbacks. One of the drawbacks is a risk of occurrence of root flaws especially in single-sided welds. To avoid these, a double-sided or bobbin tool is used to remove the root region (fig-1). Modeling of Bobin tool and aluminum and copper plates were done (fig 1-3). The design of the assembly view and bobbin tool using...
CREO software is shown in (fig 4 & 5). The material selected for the bobbin tool is a high-speed steel and threaded tool pin. Profile diameter of 4 mm, Shoulder Diameter is 12 mm was selected in this experiment.

Dimensions of Al Plate: Length: 75 mm Width: 50 mm Height: 4 mm Material: Al 6061 Designed in CREO Bobbin tool used in this experiment Eliminates weld roots, and root defects. There is a less Z direction forces on fixture and machine. The other benefits are no backing plate’s required, low distortion, simple control and more tolerance in thickness variation.

2.2 Initial Settings:
There are six analyses done with the followed basic settings. Analysis done in ANSYS Workbench, Analysis Method used was Explicit Dynamics Model, which was imported from CREO software. The shape and size of the Materials were selected as per geometry. There are two tool speeds to be considered in friction-stir welding with bobbin tool; how fast the tool rotates and how quickly it traverses the interface. The discussed two parameters have major roles and contributions. Therefore, care should be given to ensure a good efficient welding cycle with a perfect finish.

- Rotating Speed (Angular Velocity of Tool)
- Transverse Speed (Velocity of Tool)

2.3 Parameters of Analysis
Analysis of this experiment was carried out with Ansys workbench using the method of Explicit dynamics 44 and the geometry of the model is imported using CREO software. Analysis was carried out for 3 sets of same rotational speed with varying transverse speed and three sets of constant transverse speed with varying rotational speed. Selected parameters for the experiment is shown in Table 1.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Rotational Speed (Angular Velocity)</th>
<th>Transverse Speed (Velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis 1</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>Analysis 2</td>
<td>1000</td>
<td>15</td>
</tr>
<tr>
<td>Analysis 3</td>
<td>1000</td>
<td>20</td>
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<td>Analysis 5</td>
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<td>15</td>
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<tr>
<td>Analysis 6</td>
<td>1500</td>
<td>15</td>
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</tbody>
</table>

3 Results and Discussion
Maximum Stress-induced and strain deformation are studied in the analysis of Aluminum work piece, Copper work piece and also for bobbin tool in six different conditions and results are tabulated. Maximum Stress in Al6061 plate on Analysis 2 is 0.054 MPa, Maximum Strain in Al6061 plate on Analysis 2 is 7.93E-7(fig6 a & b). Maximum Stress in Cu plate on Analysis 2 is 0.097 MPa, Maximum Strain in Cu plate on Analysis 2 is 9.46E-7(fig7 a
b). Maximum Stress in Bobbin Tool on Analysis 2 is 53.83 MPa, Maximum Strain in Bobbin Tool on Analysis 2 is 3.46E-4 (fig 8 a & b)

**FIG 6 A & B ANALYSIS RESULTS OF ANGULAR VELOCITY: 1000RPM & VELOCITY: 15 MM/S : AL 6061 PLATE**

**FIG 7 A & B ANALYSIS RESULTS OF ANGULAR VELOCITY: 1000RPM & VELOCITY: 15 MM/S : CU PLATE**

**TABLE 2: TABULATION OF ANALYSIS RESULTS**

<table>
<thead>
<tr>
<th>Angular Velocity</th>
<th>Angle 0</th>
<th>Angle 1</th>
<th>Angle 2</th>
<th>Angle 3</th>
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<tbody>
<tr>
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<td>mm/ s</td>
<td>Max S</td>
<td>Max S</td>
<td>Max S</td>
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<td>0.056</td>
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<td>1.00</td>
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<td>0</td>
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<td>7.93E-07</td>
<td>0.097</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
<td>0.054</td>
<td>8.16E-07</td>
<td>0.097</td>
</tr>
<tr>
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<td>0.054</td>
<td>7.93E-07</td>
<td>0.097</td>
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<td>0.102</td>
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<tr>
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<td>8.81E-07</td>
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<td>0.066</td>
<td>9.21E-07</td>
<td>0.113</td>
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</table>

4. Conclusions

- Considering the above results, the welding, this has the parameters Rotational speed of 1000RPM and Transverse speed of 15mm/s, results relatively good max. Stress and max. Strain for Bobbin tool as 53.83MPa and 3.46E-04
- In this condition, the max. Stress and max. Strain of the CU and Al 6061 Plates are a comparatively good one.
- The parameters of the above-mentioned condition are better one for friction stir welding with the threaded pin profiled Bobbin tool.
- With the above-resulted condition, the bobbin tool may have more life, due to the comparatively low max. Stress and strain on the bobbin tool. The expected tool life is 1E6 cycles, which is found by fatigue analysis.

References