Experimental Investigation of Temperature Dependent Impact Property of Friction Stir Welded Al-Alloy

Manikandan.C1, Dr. T. Paramashwaran Pillai2
ME Student1, Assistant Professor2
Department of Manufacturing Engineering
University College of Engineering, BIT Campus, Anna University, Trichy, Tamil Nadu, India

Abstract:
In this present work Al-Alloy is taken for evaluation, the range of the welding thickness is selected with accordance to the limit of the FSW machine and the same is taken for temperature dependent impact testing. The range is of temperature is -15°C to 50°C. The impact property is evaluated in the interval of 10°C. This research experiment provides property tendency over temperature in the form of empirical model, which is formed using scientific computing tool like MATLAB. This model can be used for further prediction of impact property in the experimented range.

1. INTRODUCTION
Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond between the materials. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position.

LITERATURE REVIEW


2. EXPERIMENTAL DETAILS

2.1 Development of Manual FSW welding system
For proper welding and control on welding parameter mainly on welding current a manual welding setup has been developed at De-Humidifier (DH) controlled room. The automated welding setup with its main components. The welding setup consists mainly following parts: TIG Welding torch- Torch is fixed with the movable tractor unit. A tungsten electrode is fixed in the torch and Argon gas is flow through this. TIG welding machine- This is the main part of TIG welding setup by which controlled amount of current and voltage is supplied during welding. A Rectifier (made by FRONIUS) with current range 05-200 A and voltage up to 230 V, depending on the current setting has been used. Gas cylinder- For TIG welding Ar gas is supplied to the welding torch with a particular flow rate so that an inert atmosphere formed and stable arc created for welding. Flow is control by regulator and valve. Work holding table- a surface plate (made of grey cast iron) is used for holding the work piece so that during welding gap between the tungsten electrode and work piece is maintained. Proper clamping has been used to hold the work piece. The torch was maintained at an angle approximate 90° to the work piece.

2.2 Experimental planning and procedure:
For the present work, experimentation be done in two phase. In first phase, Traditional FSW welding on butt joint of Al-alloy 2 sheet (0.8 mm thickness) done with different welding pulsed current setting at DH controlled room.

2.2.1 Experimental procedure:
Thickness 0.8 mm of Al Grade 2 sheet was selected as work piece material for the present experiment. The table No. 2 & 3 is given below the chemical composition and mechanical parameter of Ti Grade 2 Sheet as per ASTM B265. Tisheet was cut with dimension of 75 mm x 25 mm x 0.8 mm with the help of hand saw and grinding done at the edge to smooth the surface to be joined. After that surfaces are polished with emery paper to remove any kind of external material. The Chemical and Mechanical test have been done at M/s Mill Lab and Micro lab accredited by NABL in Chennai. After sample preparation, Titanium sheet are fixed in the welding setup with flexible clamp side by side and welding done so that a butt join can be formed. TIG welding with Alternate Current (AC) was used in experiments as it concentrates the heat in the welding area. 2% Thoriated tungsten electrodes of diameter 0.8 mm was taken as electrode for this experiment. The end of the electrode was prepared by reducing the tip diameter 1 /4 and taper length 2/3 X Dia of the
original diameter by grinding and then striking an arc on a scrap material piece. This creates a sharp taper on the end of the electrode. For the first phase of experiment welding parameters selected are shown in table 1. Before performing the actual experiment a number of trial experiments have been performed to get the appropriate parameter range where welding could be possible and no observable defects like under cutting and porosity occurred.

Table 1. Welding parameters of experiments

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding current</td>
<td>(5-200) A</td>
</tr>
<tr>
<td>Voltage</td>
<td>50 v</td>
</tr>
<tr>
<td>Distance of tip from weld centre</td>
<td>3 mm</td>
</tr>
<tr>
<td>Gas flow rate</td>
<td>(8-10) l/min.</td>
</tr>
<tr>
<td>Current type</td>
<td>DC</td>
</tr>
<tr>
<td>Dimension</td>
<td>75mm*30 mm *0.8mm (5 sample)</td>
</tr>
</tbody>
</table>

2.3 Specimen of Welded joint

Fig.2 shows the welded butt joint specimen where welding performed with different

3. Results and discussion

3.1 IZOD TEST

Izod impact testing is an ASTM standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample. The specimen either breaks or the weight rests on the specimen. From the energy absorbed by the sample, its impact energy is determined. A notched sample is generally used to determine impact energy and notch sensitivity.

The Charpy impact

The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of material. The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after the fracture (energy absorbed by the fracture event). The size of the sample can also affect results, since the dimensions determine whether or not the material is in plane strain. This difference can greatly affect conclusions made. The "Standard methods for Notched Bar Impact Testing of Metallic Materials" can be found in ASTM E23, ISO 148-1 or EN 10045-1, where all the aspects of the test and equipment used are in detail.

Sample Sizes

According to ASTM A370, the standard specimen size for Charpy impact testing is 10 mm × 10 mm × 55 mm. Details of specimens as per ASTM A370 (Standard Test Method and Definitions for Mechanical Testing of Steel Products).

According to EN 10045-1, standard specimen sizes are 10 mm × 10 mm × 55 mm. Sub size specimens are:

10 mm × 7.5 mm × 55 mm
10 mm × 5 mm × 55 mm.

According to ISO 148, standard specimen sizes are

10 mm × 10 mm × 55 mm.
Sub size specimens are:

10 mm × 7.5 mm × 55 mm,
10 mm × 5 mm × 55 mm and 10 mm × 2.5 mm × 55 mm.

7.1 Experimental Results

In this research work the impact strength of friction stir welded Al 6063 at different temperature was measured to formulate the temperature dependent impact property of FS welded Al 6063. The experiment was conducted at -15, -10, -5, 10, 20, 30 and 50°C, the results are presented in the following table

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Impact Strength (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15.00</td>
<td>22.00</td>
</tr>
<tr>
<td>-10.00</td>
<td>15.00</td>
</tr>
<tr>
<td>-5.00</td>
<td>11.00</td>
</tr>
<tr>
<td>10.00</td>
<td>17.00</td>
</tr>
<tr>
<td>20.00</td>
<td>28.00</td>
</tr>
<tr>
<td>30.00</td>
<td>36.00</td>
</tr>
<tr>
<td>50.00</td>
<td>34.00</td>
</tr>
</tbody>
</table>

It is found that the impact strength decreasing towards the negative temperature range and indicated the quickness of the ductility transitions of the friction stir welded Al alloy. Using MATLAB, a scientific computing tool, the experimental results were cure fitted to create a empirical relation, which then tested for accuracy level for further practical use in its application domain.

Curve Fitting

Cftool" is a curve fitting function used in the MATLAB tool which can be used to fit the experimental values to get an accurate curve as well as the empirical relation in the form of polynomial equation, even though different types of curve fitting is available in the tool, polynomial is the easy and have the most detailed model for to make an equation. Goodness of fit:

\[ f(x) = 3.747e-7X^5 - 2.309e-5X^4 - 0.0008184X^3 + 0.05765X^2 + 0.1792X + 10.42 \]

The equation delivered is the empirical relation between temperature and impact strength in the temperature range of -15°C to +50°C, using this equation an user can find out any
temperature dependent impact strength value without further experiments with AL alloy which is friction stir welded.

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Impact Strength (J)</th>
<th>%Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>Empirical</td>
</tr>
<tr>
<td>-11.00</td>
<td>15.00</td>
<td>16.115</td>
</tr>
<tr>
<td>-2.00</td>
<td>10.00</td>
<td>10.298</td>
</tr>
<tr>
<td>26.00</td>
<td>34.00</td>
<td>33.566</td>
</tr>
</tbody>
</table>

A verification test is conducted at three temperatures and its results are compared against the empirical relation to test its accuracy and they are presented below in the form of table and graphs. The comparison shows a very minimal deviation between the experimental and empirical and the empirical is very much in control and accurate and can be used for any application involves the impact strength of aluminium alloy in the temperature range of -15°C to 50°C.

4. CONCLUSION

From the experiment of FSW welding of Titanium sheet following conclusion can be made

- With the manual welding system uniform welding of Titanium Sheet can be possible.
- Welding strength or tensile strength of the weld joint depends on the welding parameters like welding current.
- HV average value of the welded joint is higher than the HV average of Base Material.
- With the increase in current, tensile strength of the weld joint increases.

5. REFERENCES