To Study the Effect of the Tool Rotational Speed on Mechanical Properties of AZ61 Magnesium Alloy

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ABSTRACT

The paper summaries results of experiments aimed at the effect of the tool rotational speed on mechanical properties of AZ 61 Magnesium alloys. The fusion welding of Mg alloys often produces Hot Crack, Porosity which deteriorates its mechanical properties. To overcome from this problem a FSW can be applied for joining of Mg alloys. Five Joints were welded using 900-1700 rpm at Constant axial force & travel Speed. Tensile properties of welded joints were evaluated & macro hardness was also analyzed. Tensile test shows that joint with the rotational speed of 1,500 rpm, welding speed of 41 mm/m, and axial force of 3 KN showed superior tensile properties, compared to their counterparts.

Keywords— Magnesium alloy, Friction stir Welding, Tool Rotational Speed, Welding speed, Axial Force, Tensile Properties.

I. INTRODUCTION

Industry is in continuous search of improved technology to produce products that suit the service requirements, while staying competitive in the market. The industry is also conscious of the environmental degradation due to application of such technologies. This has led to the development of new processes that satisfy the industrial as well as environmental requirements. Welding can be considered as a defect in otherwise good material that is being joined since the material condition is altered by the application of heat. Hence the decision to carry out welding must be carefully made. There is a wide range of welding processes ranging from low input processes like gas welding to high input welding processes such as arc welding. Conventional arc welding finds wide usage in many applications while others are used as special for selected applications. Arc welding contributes in 60 to 80% of metal joining applications. Other welding processes like solid state welding constitute the remaining

In the arc welding process the material is brought to melting stage and molten pool is further superheated since substantially high heat input is given by arc. Because of high temperature of molten pool, the issues such as micro structural changes and chemical reactions take place influencing the properties of the weld. The weld metal is also prone to problem associated with melting and solidification of metal during welding. In solid phase welding, the temperature reaches up to 80% of melting point of material, and the problems associated with melting of metal are not there. In solid phase welding like forge welding requires the application of pressure and heat. In case of friction welding lot of advantages are there, but it requires one component to be rotated and the other has to be kept stationary. This can be mostly applied for jobs that are relatively smaller.

Conventional friction welding can be applied only for rotating components. Numbers of developments are being done in friction welding to widen its range of application. One such process is the friction stir welding which makes use of the heat generated by the friction between the job to be welded and a rotating tool the process is highly environmental friendly. Recognizing this, Government of India through Ministry of Environment and Forests has taken the efforts to develop a low cost computer numerical controlled environmentally cleaner Friction Stir Welding (FSW) technology to weld almost all structural application materials. The effect of pollution at the work place and surrounding environment due to welding will be reduced by application of this technology.

Table 1 Chemical composition of base metal (mass fraction, %)

<table>
<thead>
<tr>
<th></th>
<th>Al</th>
<th>Mn</th>
<th>Zn</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.96</td>
<td>0.17</td>
<td>1.28</td>
<td>Bal.</td>
</tr>
</tbody>
</table>


II. EXPERIMENTAL WORK

The rolled plates of 6 mm thick AZ61 A grade magnesium alloy were used in this Experimentation all methodologies used with paper. The rolled plates of 6-mm-thick AZ61 magnesium alloy were cut into the required size by machining process. The friction stir welding have been carried by using a properly clamping fixture that allows to fix the two AZ61A plates (200 mm × 75 mm × 6 mm) to be square butt welded. In this experimentation FSW were carried out with rotational speed variation of 1700 rpm, 1500 rpm, 1300 rpm, 1100 rpm, and 900 rpm. Welding speed is kept constant, i.e., 41 mm/min. The direction of welding was normal to the rolling direction. Single-pass welding procedure was used to fabricate the joints. No consumable tool made of high steel with threaded pin profile was used to fabricate the joints. An FSW machine (15 hp; 3,000 rpm; 25 KN) was used to fabricate the joints. In total, 5 joints were fabricated using different process parameters.

III. RESULT & DISCUSSION

MICROHARDNESS

The hardness of base metal (unweld parent metal) is 70 Hv. Vickers micro hardness is measured along the mid thickness line of cross section of joint. The FSW recorded high hardness 78Hv in the stir zone.

A graph is plotted with distance from weld centre along x-axis and micro hardness along y-axis from Vickers micro hardness test after weld as shown in figure.

The graph denotes high hardness value in stir zone compared to other zones. There are two main reasons for the improved hardness of stir zone. Firstly, since the grain size of stir zone is much finer than that of the base metal, grain refinement plays an important role in material strengthening. Secondly the small particles of intermetallic compounds are also beneficial to hardness improvement.

TENSILE TEST

The transverse tensile properties such as yield strength, tensile strength, and joint efficiency of friction stir rotational speed of 1,500 rpm, welding speed of 41 mm/min, and axial force of 3 kN exhibited higher yield strength (212 MPa), tensile strength (262 MPa). Joint efficiency is a ratio between tensile strength of welded joint and tensile strength of unwelded parent metal. The joint fabricated with a rotational speed of 1,500 rpm, welding speed of 41 mm/m, and axial force of 3 kN exhibited a maximum joint efficiency of 97.7%.
Table 5 Tensile properties of joints fabricated under different Rotational Speed

<table>
<thead>
<tr>
<th>Tool Rotational Speed (RPM)</th>
<th>Yield strength/MPa</th>
<th>Ultimate tensile strength/MPa</th>
<th>Joint efficiency/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>189</td>
<td>236</td>
<td>87.1</td>
</tr>
<tr>
<td>1100</td>
<td>194</td>
<td>241</td>
<td>89.4</td>
</tr>
<tr>
<td>1300</td>
<td>205</td>
<td>255</td>
<td>94.7</td>
</tr>
<tr>
<td>1500</td>
<td>212</td>
<td>262</td>
<td>97.7</td>
</tr>
<tr>
<td>1700</td>
<td>210</td>
<td>258</td>
<td>96.9</td>
</tr>
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</table>

IV. CONCLUSION

In this investigation, an attempt was made to the effect of FSW process parameters on mechanical properties of friction stir welded AZ61 magnesium alloy. From this investigation, the following important conclusions are derived:

- AZ61 magnesium alloy was successfully joined by friction stir welding process under the following range of process parameters: tool rotational speed of 9,00—17,00 rpm, welding speed of 41 mm/m, and axial force of 3 KN. Joints surfaces shows without any defects.
- Specimen after friction stir welding process, shows improved hardness properties.
- Tensile test shows that joint with the rotational speed of 1,500 rpm, welding speed of 41 mm/m, and axial force of 3 KN showed superior tensile properties, compared to their

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