INVESTIGATION OF THE TEMPERATURE DISTRIBUTION CHARACTER OF TIG PROCESS

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ABSTRACT:
Tungsten inert gas welding (TIG) is one of the most important material joining processes widely used in industry. An attempt has been made in paper to develop an appropriate models for predicting & the Investigation into the Temperature Distribution character of TIG welding. The temperature distribution that occurs during single/multi pass welding affects the material microstructure, hardness, mechanical properties, and the residual stresses that will be present in the welded material. Very limited experimental data regarding temperature distribution during welding of plates is available in the literature. Experimental work will be carried out to find out the temperature distribution during single/multi pass welding of stainless steel plates.

KEYWORDS: TIG Welding, Temperature distribution, Infrared Thermometers, Infra red Images

1. INTRODUCTION:
Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten metal (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. Basically welding is one of the most important material-joining processes widely used in industry. Plates of different thicknesses are used for the fabrication of components, depending upon the applications.

1.2 GAS TUNGSTEN ARC WELDING
Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas (usually an inert gas such as argon), and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. A constant-current welding power supply produces energy which is conducted across the arc through a column of highly ionized gas and metal vapours known as plasma. GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing procedures such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques. Both manual and automatic operations are possible. A related process, plasma arc welding, uses a slightly different welding torch to create a more focused welding arc and as a result is often automated. Manual gas tungsten arc welding is often considered the most difficult of all the welding processes commonly used in industry. Because the welder must maintain a short arc length, great care and skill are required to prevent contact between the electrode and the work piece. Similar to torch welding, GTAW normally requires two hands, since most applications require that the welder manually feed a filler metal into the weld area with one hand while manipulating the welding torch in the other. However, some welds combining thin materials (known as autogenous or fusion welds) can be accomplished without filler metal; mostly notably edge, corner, and butt joints.

2. CONDUCTING THE EXPERIMENTS:
In Tungsten Arc Welding process the output/ quality of weld is highly affected by the input parameters. If any relationship can be established between the input and output parameters, then the desired level or quality can be obtained by varying input parameters. The temperatures distributions have been observed in weld & non-weld region and will try to find analytical solution for transient temperature distribution in the same region.

2.1 WORKPIECE
AISI Type 304 Stainless Steel
The material of plates selected for the experiments is AISI type 304L stainless steel. Two plates of size 150x50x4.8 mm which would form a single butt joint between them were used during the experiments to make a finished weld pad.

3. INFRARED THERMOMETERS

The Thermometer used for measurement of temperature during these experiments was Lutron(LT) 3 in 1, IR, Type K/J/R/E/T, Pt 100 ohm thermometer model : TM-2000. The Detailed Specifications of this thermometer are given below:
4. OBSERVATIONS:

This experimental study was conducted at ISM workshop. The welding parameters were noted during the actual welding to determine the fluctuation if any. The value of temperature distribution was taken using Infrared Thermometers.

Table 4.3

<table>
<thead>
<tr>
<th>Location</th>
<th>Plate 1</th>
<th>Plate 2</th>
<th>Plate 3</th>
<th>Plate 4</th>
<th>Plate 5</th>
<th>Plate 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t(sec)</td>
<td>T(C)</td>
<td>t(sec)</td>
<td>T(C)</td>
<td>t(sec)</td>
<td>T(C)</td>
</tr>
<tr>
<td>A1</td>
<td>10.73</td>
<td>125</td>
<td>7.78</td>
<td>155</td>
<td>7.11</td>
<td>140</td>
</tr>
<tr>
<td>A2</td>
<td>17.63</td>
<td>120</td>
<td>14.12</td>
<td>151</td>
<td>11.21</td>
<td>137</td>
</tr>
<tr>
<td>A3</td>
<td>20.05</td>
<td>111</td>
<td>20.18</td>
<td>139</td>
<td>13.69</td>
<td>131</td>
</tr>
<tr>
<td>B1</td>
<td>25.93</td>
<td>140</td>
<td>26.30</td>
<td>182</td>
<td>47.11</td>
<td>176</td>
</tr>
<tr>
<td>B2</td>
<td>29.47</td>
<td>120</td>
<td>32.09</td>
<td>170</td>
<td>50.86</td>
<td>174</td>
</tr>
<tr>
<td>B3</td>
<td>36.03</td>
<td>103</td>
<td>38.50</td>
<td>143</td>
<td>75.50</td>
<td>152</td>
</tr>
<tr>
<td>C1</td>
<td>40.33</td>
<td>145</td>
<td>46.82</td>
<td>178</td>
<td>83.25</td>
<td>150</td>
</tr>
<tr>
<td>C2</td>
<td>46.03</td>
<td>121</td>
<td>53.32</td>
<td>174</td>
<td>87.52</td>
<td>137</td>
</tr>
<tr>
<td>C3</td>
<td>51.09</td>
<td>103</td>
<td>57.75</td>
<td>159</td>
<td>91.56</td>
<td>130</td>
</tr>
<tr>
<td>D1</td>
<td>56.80</td>
<td>185</td>
<td>62.88</td>
<td>226</td>
<td>100.7</td>
<td>170</td>
</tr>
<tr>
<td>D2</td>
<td>60.39</td>
<td>183</td>
<td>68.17</td>
<td>216</td>
<td>102.1</td>
<td>141</td>
</tr>
<tr>
<td>D3</td>
<td>65.41</td>
<td>157</td>
<td>74.27</td>
<td>215</td>
<td>106.3</td>
<td>131</td>
</tr>
</tbody>
</table>

Along with the weld parameters, we also noted down the temperatures at 12 discrete points (six on each plate and symmetrically placed with respect to weld zone) and the time on which those reading have been taken. For this purpose Infrared thermometer and stop watch of mobile were used.

The temperature readings with time are as follows:

Table 4.2

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Current (ampere)</th>
<th>Travel Speed (mm/sec.)</th>
<th>Reinforcement Height (mm)</th>
<th>Bead Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>115</td>
<td>0.483</td>
<td>1.58</td>
<td>6.49</td>
</tr>
<tr>
<td>2</td>
<td>175</td>
<td>0.949</td>
<td>2.32</td>
<td>6.83</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>0.697</td>
<td>2.81</td>
<td>6.15</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>0.609</td>
<td>2.54</td>
<td>6.37</td>
</tr>
<tr>
<td>5</td>
<td>196</td>
<td>0.645</td>
<td>2.95</td>
<td>7.30</td>
</tr>
<tr>
<td>6</td>
<td>213</td>
<td>0.857</td>
<td>2.72</td>
<td>7.97</td>
</tr>
<tr>
<td>7</td>
<td>264</td>
<td>1.190</td>
<td>2.79</td>
<td>7.92</td>
</tr>
<tr>
<td>8</td>
<td>265</td>
<td>1.195</td>
<td>2.83</td>
<td>8.16</td>
</tr>
</tbody>
</table>

FIG.4.1: Digital pictorial view of TIG welded stainless steel.

Finally the readings obtained are tabulated as below: Table4.2
5. Investigation of Temperature

RAY CAM SOFTWARE: Many of the problems occurred while measuring temperature manually with infrared thermometer. The Ray cam software is the one which shows how advance our technology has become. In this software infrared images are analyzed to study the welding process and change in different process parameters. Infra red images are taken at the time of welding and after the welding. As an input variable, when these images are inserted maximum temperature, minimum temperature, continuous temperature distribution, temperature distribution along a line, in an area etc. can be obtained easily. Along with this histogram can be drawn over a particular area which shows the percentage of points in an area having specific temperature.

5.1 Continuous Temperature Distribution on Welded Specimen

Maximum Temperature (128.04 degree Celsius)
Minimum Temperature (28.08 degree Celsius)

5.2 Curves for Temperature Distribution on a Line

6. Histogram for number of points in a particular area at a specific temperature

7. Temperature of Welded Specimen during Various Stages
8. LIMITATION

- However the when infrared images taken during welding one can see from fig 7,1,7,2,7,3,7,4 that RAY CAM SOFTWARE is not able to show variation of temperature with changing co-ordinates.
- Rather it shows only maximum and minimum temperatures.
- Due to this we cannot obtain either line distribution curve or histogram to depict temperature distribution during the actual welding.
- We could only do this after welding has taken place.

9. CONCLUSIONS:

Comparison between temperature distribution obtained by infrared thermometer and ray cam software:

- Discreet Temperature distribution using infrared thermometer and continuous temperature distribution using ray cam software.
- Working on a welding process has become easier and interesting stuff using Ray cam software which was previously considered to be hectic.
- There is some limit of maximum temperature read by infrared thermometer. Highly advanced technology of Ray cam software enables one to analyze the welding process with various aspects of temperature (max. temp., min. temp., temp. along a curve, histogram etc.)
- Due to the limitation of human operator there surely will be errors in temperature at all the points (except the first) because of time lag to move the thermometer manually from one point to another. In Ray cam software infra red image is captured at a particular instant hence temperature at all the point within the range of image can be obtained easily.

Conclusions regarding Temperature distribution:

- The average value of maximum temperatures for a particular pass, located at the same distance from the weld centre line (on the left or right side plate) will give representative values of maximum temperatures at the referred distance during that pass.
- However, in some cases (in industry) and some of our experimental readings, the weld pass may be laid closer to the left or right side. Due to this the max temperature during each pass of left side of plate may differ with that on the right side of plate
- With the increase in current during different passes for a plate the corresponding temperature also rises and with increase in the travel speed during welding corresponding temp also decreases.

9. FUTURE WORK SCOPE:

Attempt has been made to get continuous temperature distribution. But one could get so only in the images which are captured after the welding. If continuous temperature distribution in the images which are captured during the welding would accessible then HAZ (heat affected zone) width would have easily been calculated. Heat affected zone is the region of the base metal generated in the vicinity of the welded zone and where the microstructure is significantly different from microstructure of the base metal. Heat affected zone is the region heated from recrystallization temp. to the temp. just below the melting point. HAZ width is generally calculated from transient temp distribution (ref.1) which is a roundabout process. Hence future scope of the project is to get continuous temp distribution during the welding to calculate HAZ width.

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