Study of Various Performance Parameter of MIG Welding For Mild Steel 1020 Using Taguchi L9 Array

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ABSTRACT

The aim of the present study is to show the influence of different input parameters such as welding current, arc voltage root gap on the mechanical properties during the Metal Inert Gas Welding (MIG) of mild steel 1020 grade. The hardness and tensile strength of weld specimen are investigated in this study. The selected three input parameters were varied at three levels. On the analogy, nine experiments were performed based on L9 orthogonal array of Taguchi’s methodology, which consist three input parameters. Analysis of variance (ANOVA) was employed to find the levels of significance of input parameters. Arc current has greatest effect on tensile strength followed by root gap and gas flow rate. Root gap has greatest effect on hardness followed by arc current and gas flow rate.

Keywords--- GMAW, MIG, Mild Steel, Welding, Taguchi, ANOVA

I. INTRODUCTION

Metal Inert Gas Welding which is also known as Gas Metal Arc Welding (GMAW) uses a consumable metal electrode and an inert gas or an active gas. It is the process in which source of heat is an arc formed between a consumable metal electrode and the work piece. The arc and molten puddle are protected from contamination by the atmosphere with an externally supplied gaseous shield of inert gas or active gas [1-2]. In this process carbon is used as shielding gas and plate of 12 mm is welded using MIG welding. Hardness testing of metals, ceramics, and composite is useful for a variety of applications for which hardness measurements are unsuitable. Hardness testing gives an allowable range of loads for testing with diamond indenter. The resulting indentation is measured and converted to a hardness value. Taguchi method [3-4] is a systematic application of design and analysis of experiment for designing purpose and product quality improvements. In this research work tensile strength, hardness and microstructure of specimen 1018 mild steel welded by MIG welding are evaluated. In this paper Taguchi method is used to determine the optimum welding parameter. Taguchi method [5] become a powerful tool for improving the productivity in recent year in order to produce high quality products quickly with low cost.
welding speed on penetration depth of mild steel during welding by using Taguchi design method. Result shows the welding voltage has large effect on penetration [8]. A consumable electrode of mild steel with 2mm diameter shielded by carbon dioxide (CO2) gas is used to produce an electric arc with the base metal as shown in figure 1. The heat generated by electric arc is used to melt the filler electrode and base metal. As discussed earlier, Taguchi Approach is applied in this process for the analysis. It help to determine the best level of parameter used to analyzed the best performance of the result.

II. METHODOLOGY

In this experimental work, the specimen is welded at three different levels of welding parameter i.e. current, Gas flow rate and root gap as shown in Table I.

Table 1 Welding parameter and their levels

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Welding Current (A)</th>
<th>Root gap (B)</th>
<th>Gas flow rate (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>Amp</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>160</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Level 2</td>
<td>170</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Level 3</td>
<td>180</td>
<td>4</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 2 Chemical Composition of Base Metal Mild Steel 1020

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.17 to 0.23</td>
</tr>
<tr>
<td>Si</td>
<td>0.09</td>
</tr>
<tr>
<td>Mn</td>
<td>0.37</td>
</tr>
<tr>
<td>P</td>
<td>0.040</td>
</tr>
<tr>
<td>S</td>
<td>0.050</td>
</tr>
<tr>
<td>Fe</td>
<td>99.08</td>
</tr>
</tbody>
</table>

Samples of size 2500×100×12mm were cut with the help of Power Hacksaw. A groove of 60 degree was also made on each sample with the help of Power Grinder. The chemical composition of mild steel sheet using for present study is shown in Table 2.

Figure 2 Cutting of Sample from Strip

The nine experiments were performed based on the L9 array. The effect of different parameters such as welding current, arc voltage and root gap of mild steel
1018 is analyzed. The tensile strength and hardness of all nine weld specimen were checked carefully and the observed value of tensile strength and hardness with their S/N ratios are shown in table 5 and in table 6. Figure 4 shows photograph of welded sample.

Table 5 Result for Tensile Strength

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Welding Current (Amp)</th>
<th>Root gap (mm)</th>
<th>Gas flow rate</th>
<th>Tensile Strength</th>
<th>S/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>160</td>
<td>0</td>
<td>20</td>
<td>320.61</td>
<td>50.1195</td>
</tr>
<tr>
<td>2</td>
<td>160</td>
<td>2</td>
<td>22</td>
<td>353.07</td>
<td>50.9572</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
<td>4</td>
<td>23</td>
<td>283.51</td>
<td>49.0514</td>
</tr>
<tr>
<td>4</td>
<td>170</td>
<td>0</td>
<td>22</td>
<td>339.56</td>
<td>50.6183</td>
</tr>
<tr>
<td>5</td>
<td>170</td>
<td>2</td>
<td>23</td>
<td>405.40</td>
<td>52.5277</td>
</tr>
<tr>
<td>6</td>
<td>170</td>
<td>4</td>
<td>20</td>
<td>477.72</td>
<td>53.5835</td>
</tr>
<tr>
<td>7</td>
<td>180</td>
<td>0</td>
<td>23</td>
<td>412.03</td>
<td>52.2986</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
<td>2</td>
<td>20</td>
<td>415.35</td>
<td>52.3683</td>
</tr>
<tr>
<td>9</td>
<td>180</td>
<td>4</td>
<td>22</td>
<td>338.11</td>
<td>50.5812</td>
</tr>
</tbody>
</table>

Table 6 Result for Hardness

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Hardness WZ (Hv 10)</th>
<th>Hardness PM (Hv 10)</th>
<th>Hardness HAZ (Hv 10)</th>
<th>S/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>232</td>
<td>171</td>
<td>362</td>
<td>8.3458</td>
</tr>
<tr>
<td>2</td>
<td>199</td>
<td>180</td>
<td>232</td>
<td>17.7752</td>
</tr>
<tr>
<td>3</td>
<td>195</td>
<td>182</td>
<td>232</td>
<td>17.8698</td>
</tr>
<tr>
<td>4</td>
<td>232</td>
<td>172</td>
<td>401</td>
<td>7.0812</td>
</tr>
<tr>
<td>5</td>
<td>175</td>
<td>172</td>
<td>217</td>
<td>17.4691</td>
</tr>
<tr>
<td>6</td>
<td>199</td>
<td>180</td>
<td>223</td>
<td>19.3812</td>
</tr>
<tr>
<td>7</td>
<td>172</td>
<td>172</td>
<td>219</td>
<td>16.7970</td>
</tr>
</tbody>
</table>

III. RESULTS AND DISCUSSIONS

Figure 5 shows the steps involved in the Taguchi analysis. Analysis of variance (ANOVA) is a statistical tool used to analyze the S/N ratios. In ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. Analysis of variance technique is used in order to check the adequacy of the model. The term “signal” represents the desirable mean value, and the “noise” represents the undesirable value. Hence, the S/N ratio represents the amount of variation, which presents in the performance characteristics.

![Figure 5 Steps for Taguchi's analysis](image)

In the present study tensile strength and Hardness of the weld specimens were identified as the responses, therefore, “higher the better” characteristic chosen for analysis purpose.

\[
HB : S / N ratio = -10 \log_{10}\left[\frac{1}{n} \sum_{i=1}^{n} y_i^2\right]
\]

Where \( y_i \) represents the experimentally observed value of the with experiment, \( n \) is the repeated number of each experiment, is the mean of samples and \( s \) is the sample standard deviation of \( n \) observations in each run.

**Tensile Strength**

Tensile strength is calculated experimentally and Taguchi method is applied for analysis with the help of ANOVA. On basis of data analyzed, plots for signal-to-noise (S/N) ratio are shown in Figure 6. The calculated S/N ratio has been tabulated in Table 5.
The optimal process parameters have been established by analyzing response curves of S/N ratio. From Figure 6 it is concluded that third level of current (180 amp), second level of voltage (35 volt) and third level of root gap (4 mm) gives the higher tensile strength. Hence the optimum condition of input parameters is A3B2C3.

**Hardness**

The samples used for measuring Hardness are first rubbed with emery paper of size no. 400, 600, 1000 & 2000 and then cleaned with acetone solution. The diagonals of the indents formed by pyramid-shaped diamond indenter on the samples.

The optimal process parameters have been established by analyzing response curves of S/N ratio. From Figure 7 it is concluded that third level of welding current (180 amp), second level of arc voltage (40 volt) and second level of root gap (3 mm) gives the optimal hardness. Hence the optimum condition of input parameters is A3B2C2.

**IV. CONCLUSION**

The mild steel 1020 was used for the present study to explore the different input process parameters on the tensile strength and hardness of the weld samples. The L9 orthogonal has been used to assign the identified parameters. The highest tensile strength obtained in the research is 477.72 at current (170 amp), gas flow rate (20) and root gap (4 mm). The maximum hardness is obtained at a welding current (170 amp), gas flow rate (22) and root gap (0 mm). So according our results we can conclude that our weldments have lower hardness because both pearlite are soft constituents & there is no sign of formation of Martensite.

**REFERENCES**