Optimization of Welding Parameters to Reduce Distortion in Welding of SA 203 GRADE-E by ANOVA

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Abstract

Tungsten Inert Gas (TIG) welding is widely used in fabrication industries. Distortion is major problem due to which reworks and time, cost gets affected. So it has to be controlled. The main objective of this research is to optimize the TIG welding parameters to reduce distortion in plate to plate butt weld joint of material SA203 GRADE –E. An experiment is conducted to study the effect of three TIG welding control parameters as welding current, WEP angle, preheat temperature on welding distortion. Here root gap is taken constant and welding position is same through the experiment. The Experiments were planned using the strategy of DOE. The levels of input parameters were selected and experiments were carried out. The results obtained under the combination of these parameter were analyzed by using ANOVA (analysis if variance), statistical method to investigator the critical parameter affecting the distortion in welding and their contribution.

Keywords: ANOVA, Distortion, DOE, TIG Welding, SA203 Grade-E

I. INTRODUCTION

Welding is major joining technique in fabrication industries for the welding of steels for manufacturing of different structures, pressure vessels, aerospace, shipping, and heat exchangers applications. TIG is arc welding used for smaller fillet and butt welds. In this process the arc is formed between a pointed on consumable tungsten electrode and the work piece, in an inert atmosphere of argon or helium for shielding & electrode replace by filler material. The major design and industry constraints are weld strength and cost competitive.

In optimization of TIG welding processes, parameters play an important role for the final product quality in terms of weld distortions, welding defects, joint efficiency and mechanical properties. As welding process involves the heating and cooling process in non-uniform, uneven manner, the distortions are unavoidable. The weld process contributes to the development of several kinds of distortions like longitudinal, transverse or angular distortions and defects like porosity, cracks, lack of penetration, lack of fusion, undercut, and spatter. Various factors affecting the quality of weld are weld current, consumable size, gas flow rate and the weld speed, preheat temperature weld edge preparation angle, inter pass temperature and transfer speed of consumable. Optimization of these parameters can avoid the major rework and saves production time and cost.

II. EXPERIMENT SET UP AND DETAILS

A. Factorial Design:

Design of experiment is technique of defining and investigating all possible combinations in an experiment involving multiple factors and to identify the best combination. Here the different factors and their level are identified. We have used factorial design, and used full factorial design. The three parameters are varied at three different levels so the no of iteration goes to 27

B. Welding Arrangement:

Here the sample of material selected is taken for welding , with proper welding arrangement including , TIG welding machine , heating cylinder with burner, temperature measuring chalk, spirit level grinding machine etc , here we have carried out welding with proper welding position 3G welding position
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Fig. 1: Welding Equipment

Fig. 2: Experiment Set-Up

Fig. 3: Sample of Plate To Plate Set Up

Fig. 4: Distorted Samples
C. Material Selection:

Here we have selected material as, SA 203 GRADE E with plate of 10mm thick. We have chosen this material as it normally used in fabrication of pressure vessel, heat exchangers, also having good corrosive persistence, resistance to oxidation ease of cleaning and easily available with low cost. The chemical composition is as shown

<table>
<thead>
<tr>
<th>Chemical Composition</th>
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<tbody>
<tr>
<td><strong>Elements</strong></td>
</tr>
<tr>
<td>C</td>
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<tr>
<td>Mn</td>
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<tr>
<td>P</td>
</tr>
<tr>
<td>S</td>
</tr>
<tr>
<td>Si</td>
</tr>
<tr>
<td>Ni</td>
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<tr>
<td>Fe</td>
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</table>

D. Process Parameter:

In this study there are three parameters as welding current, weld edge preparation angle and preheat temperature. Each process parameter has here level of values as mentioned in below table

Constant parameter: welding position and work piece thickness, root gap (4mm)

<table>
<thead>
<tr>
<th>Table - 2 Input Parameters at Different Levels</th>
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<tbody>
<tr>
<td><strong>Parameter</strong></td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>Current</td>
</tr>
<tr>
<td>WEP angle</td>
</tr>
<tr>
<td>Preheat temp</td>
</tr>
</tbody>
</table>

E. Response Parameter:

Here all experiments were conducted; distortion was measured, as shown below

<table>
<thead>
<tr>
<th>Table - 3 Experimental Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sr no</strong></td>
</tr>
<tr>
<td>1</td>
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<td>22</td>
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</tbody>
</table>
III. RESULTS AND DISCUSSION

ANOVA is carried out to analyze the effect of control parameter on response with the aid of trial version of MINITAB 16 software

A. ANOVA Results:

![ANCOVA Results](image)

B. Main Effects Plot:

Main effects plot shows that welding current is the main significant parameter then WEP and preheat temperature. Here as welding current and WEP angle increases the distortion also gets increases but as preheat temp increases, the distortion gets decreases.

![Main Effects Plot](image)

C. Interaction Plot:

Interaction plot shows there is no significant interaction among the parameters. Each parameter contribute individually towards output. Here we have seen that there is interaction between WEP and welding current but has no more significance.
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Fig. 7: Interaction Plot (Data Means) For Distortion

Table - 4
Manual ANOVA Results of Parameters and Their Interaction

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>DOF</th>
<th>Sum of sq.</th>
<th>Mean sq.</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Current</td>
<td>2</td>
<td>25.80667</td>
<td>12.90335</td>
<td>85.60</td>
</tr>
<tr>
<td>A</td>
<td>WEP angle</td>
<td>2</td>
<td>2.723889</td>
<td>1.361945</td>
<td>9.03</td>
</tr>
<tr>
<td>T</td>
<td>Preheat temp</td>
<td>2</td>
<td>0.455</td>
<td>0.2275</td>
<td>1.50</td>
</tr>
<tr>
<td>C*A</td>
<td>Current*WEP</td>
<td>4</td>
<td>0.82112</td>
<td>0.20528</td>
<td>2.72</td>
</tr>
<tr>
<td>A*T</td>
<td>WEP*Preheat temp</td>
<td>4</td>
<td>0.09942</td>
<td>0.02486</td>
<td>0.0824</td>
</tr>
<tr>
<td>C*T</td>
<td>Current*preheat temp</td>
<td>4</td>
<td>0.04</td>
<td>0.01</td>
<td>0.132</td>
</tr>
<tr>
<td>Error</td>
<td></td>
<td>-</td>
<td>0.199</td>
<td>0.0249</td>
<td>0.660</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>26</td>
<td>30.146667</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

ACKNOWLEDGEMENT

I would like to acknowledge with much appreciation the crucial role of Mr. AJIT PANDITRAO, Production Manager of PC4, LARSEN & TOUBRO LIMITED MUMBAI, and Mr. UDAY PADVAL WELDING INCHAGE, at PC4, LARSEN & TUOBRO MUMBAI, for their valuable comments, sharing their time and knowledge on the research carried out during this project. They have contributed a lot towards my understanding and thoughts.

IV. CONCLUSION

Distortion in welding is very important in fabrication industries, welding current is mostly affecting parameter for distortion. From the experiments on work piece plate by TIG welding and analysis by statistical tool ANOVA, welding current is the most influencing parameter to the distortion on weld joints than WEP angle and preheat temperature. Here distortion is directly proportional with the welding current and WEP angle, it means as welding current or WEP angle increases the distortion gets also increases, but the preheat temperature having inversely with distortion.

The percentage contributions for welding current, WEP angle and Preheat temperature are 85.60%, 9.03% and 1.50%, respectively.

REFERENCES