Effect of Gas Metal Arc Welding Process Parameters on Penetration of the Weld

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Abstract— In this paper the effect of various process parameters of gas metal arc welding on the penetration of the weld are studied and the mathematical model are developed in order to study the relation between the parameters and penetration. Mathematical equation is formed with the help of factorial design technique.

Key words: Gas Metal Arc Welding, Penetration of the Weld

I. INTRODUCTION

Good quality of weld is always essential in any field of manufacturing. So in order to have desired quality of weld it is essential to have control over the relevant process parameters of the welding. In Gas Metal arc (GMA) welding there are different parameters like welding voltage, welding speed, wire feed rate, nozzle distance, welding direction, flow rate of gas etc. so to have better quality of weld we must know the proper values of these parameters.

N. Murugan and R.S. Parmar has stated that The voltage has a more predominant effect on the width than that of other parameters, as at 31 and 34 V the width remains constant, irrespective of the value of the speed and of the wire feed rate [1]. I.S. Kim, J.S. Sona, I.G. Kim, J.Y. Kim, O.S. Kim has proved that Empirical models developed from the observed data in the course of this work can be used to control the process variables in order to achieve desired weld bead geometry outcomes and indeed weld quality [2]. As per I.S. Kim, K. J. Son, Y.S. Yang, P.K.D.V. Yaragada the optimal bead geometry is based on bead width, bead height and penetration. The process parameters such as welding speed, arc current and welding voltage influence the bead width, bead height and penetration in GMA welding processes [3]. Erdal Karadeniz, Ugur Ozsarac, Ceyhan Yildiz has experimentally proved that the effect of welding current approximately greater than that of arc voltage and welding speed on penetration [4]

II. EXPERIMENTAL WORK

In this work HSLA steel (IS – 5986) is used as a base metal. Voltage, wire feed rate and wire thickness are selected as the process variable. 2³ factorial design technique is used for the experimentation. Bead penetration is taken as the response of the experiment. Two level values of the selected variables are given in the table 1. Steel wire (IS – 6419 EN) of thickness 0.8 and 1.2 mm of chemical composition C (0.06–0.15%), Mn (1.40–1.85%), Si (0.80–1.15%), S (0.035% maximum), P (0.025% maximum) and Cu (0.5% maximum) were used.

This process was repeated until 8 experimental runs were completed. To measure the bead penetration, the transverse sections of each weld were cut using a power hacksaw from the mid-length position of welds, and the end faces were machined. A profile projector with the image magnification of 10X and 20X was used to accurately measure the bead penetration. The results of the experiment were analyzed on the basis of relationship between input variables and output variable of the CO2 arc welding process.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Limits</th>
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<tbody>
<tr>
<td>V (Volt)</td>
<td>Low: 18 High: 22</td>
</tr>
<tr>
<td>F (m/min)</td>
<td>Low: 7 High: 9</td>
</tr>
<tr>
<td>T (mm)</td>
<td>Low: 0.8 High: 1.2</td>
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</tbody>
</table>

Table 1: Welding variables and limits employed

III. MATHEMATICAL MODEL

In order to quantitatively evaluate the effect of process variables on the penetration of the weld the mathematical model for relationship between process variables and bead penetration have been developed. In general, the response function can be represented as follows:

\[ Y = f(V, F, T) \]  (1)

Where \( Y \) is the measured response (mm), \( V \) is welding voltage, \( F \) is the wire feed rate, \( T \) is the thickness of wire. The linear equation could be expressed as follows:

\[ Y = d_1 + d_2 V + d_3 F + d_4 VT + d_5 VFT + d_6 VFT^2 \]  (2)

Where \( d_1, \ d_2, \ d_3, \ d_4, \ d_5, \ \text{and} \ d_6 \) are the constants and depend on the gas flow rate, wire stick out and material type.

Based on Regression analysis we have obtained the following equations for penetration.

\[ \text{Penetration} = 3.672 - 0.2725 V + 0.1600 F + 0.6925 T - 0.3300 V^2 - 0.8475 VT + 0.01500 FT - 0.6100 VFT \]

Response surface plot and contour plots are generated for the same data using Minitab software.
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From the figure (1, 2 and 3) we can see that interaction between thickness and voltage has more significant effect on the width of the bead as it has more twist and bend than other graph. Feed rate and thickness interaction and voltage and feed rate interaction plays less significant role in affecting the bead penetration. From the figure (4, 5, and 6) we can see that interaction between thickness and voltage has more significant effect on the penetration of the bead as it has more line bend and curves than other graph. Feed rate and thickness interaction and voltage and feed rate interaction plays less significant role in affecting the bead penetration.

IV. RESULTS AND CONCLUSION

After performing 8 different experimental runs, response for bead penetration is calculated. The mathematical equation for the same has been formed. From the results obtained we can conclude that the voltage has more predominant effect on the bead penetration than wire feed rate and wire thickness.

REFERENCES


