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Study of Effects of Gas Metal Arc Welding Process Parameters on the Weld Strength of Automotive Chassis

[#1]Mayuresh S. Likhite, [#2] O. A. More

[1]likhitemaya@gmail.com

[2]oamore@aissmscoe.com

[#1] P.G. student, All India Shri Shivaji Memorial Society's College Of Engineering, Pune, India

[#2] Assistant Professor, All India Shri Shivaji Memorial Society's College Of Engineering, Pune, India

ABSTRACT

This paper focuses on the development of mathematical models for the selection of process parameters and the prediction of bead geometry (bead width, bead height and penetration). The various welding parameters such as welding voltage, wire feed rate and wire thickness were varied on HSLA steel (IS-5986) and the effects of these parameters on weld bead geometry such as penetration, width & height have been studied. Mathematical equations have been developed using factorial design technique. The results obtained show that developed mathematical models can be applied to estimate the effectiveness of process parameters for a given bead geometry. From the results obtained specimen is selected for the weld strength test.

Keywords— **Gas metal arc welding, Automotive chassis, HSLA steel**

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I. INTRODUCTION

Recently automated welding systems have received a great deal of attention because they are highly suitable not only to increased production rate and quality, but also to decrease cost and time to manufacture for a given product. To get the desired quality welds, it is essential to have complete control over the relevant process parameters in order to obtain the required bead geometry and which is also based on weldability. However, mathematical models need to be developed to make effective use of automated arc welding.

In order to achieve the high quality welds, it is essential to have complete control over the relevant process parameters. 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 the quality of the weld form changes by the change in these parameters. So in order to have better quality of weld we must know the right values of the 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].

In this project work HSLA steel (IS-5986) has been selected for processing. This metal is used for the automobile chassis construction. Welding voltage, wire feed rate and wire thickness has been selected as process parameters. 2^k factorial design method is used for experimentation. Responses of bead geometry have been recorded such as bead height, bead width and bead penetration. Mathematical model has been developed and its adequacy is checked on Minitab software.

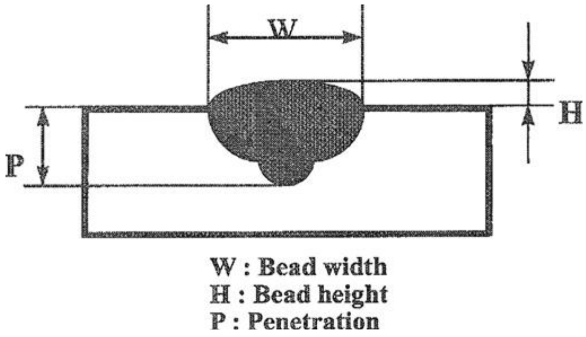

Fig.1 Bead Geometry

II .EXPERIMENTAL WORK

Statistically designed experiments that are based upon factorial techniques, reduce costs and provide the required information about the main and interaction effects on the response factor. In the present study, three two-level process variables such as arc voltage, wire feed rate and wire thickness are considered. All other parameters except these were fixed. The welding variables and limits employed are given in Table 1. The factorial design required 8 weld runs for fitting each equation. The selection of the electrode wire was principally based upon matching the mechanical properties and physical characteristics of the base metal, weld size. 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 steel wire is used for mainly automobile construction purpose. Welding was carried out on experimental plates of 80mm X 30mm X 7mm.

Table.1 Welding variables and limits employed

Variables	Limits	
	Low	High
V (Volt)	18	22
F (m/min)	7	9
T (mm)	0.8	1.2

Table.2 Design matrix and the observed values of the bead dimensions

Specimen No.	Design matrix			Height	Width	Penetrat-ion
	V	F	T			
1	-1	-1	-1	1.83	5.96	2.54
2	1	-1	-1	1.16	7.73	3.13
3	-1	1	-1	3.99	5.96	2.27
4	1	1	-1	1.15	8.53	3.98
5	-1	-1	1	4.37	5.10	4.37
6	1	-1	1	1.89	10.08	4.01
7	-1	1	1	2.77	6.08	6.60
8	1	1	1	1.70	9.71	2.48

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.

III .MATHEMATICAL MODEL

In order to quantitatively evaluate the effect of process variables on the bead geometry, the mathematical model for relationship between process variables and bead height, width and 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:

$Y = d_1 + d_2 V + d_3 T + d_4 VF + d_5 VT + d_6 FT + d_7 VFT$------------- (2)

Where d_1, d_2, d_3, d_4, d_5, d_6 and d_7 are the constants and depend on the gas flow rate, wire stickout and material type.

Based on Regression analysis we have obtained the following equations for height, width and penetration.

$Height = 2.357 - 0.8825 V + 0.04500 F + 0.3250 T - 0.09500 VF - 0.005000 VT - 0.4925 FT + 0.4475 VFT$

$Width = 7.394 + 1.619 V + 0.1762 F + 0.3488 T - 0.06875 VF + 0.5337 VT - 0.02375 FT - 0.2687 VFT$

Penetration = 3.672 - 0.2725 V + 0.1600 F + 0.6925 T- 0.3300 V - 0.8475 VT
+ 0.01500 FT - 0.6100 VFT

To ensure the accuracy of the developed equations and survey the spread of the values, results were plotted using the Pareto Plot in Minitab Software.

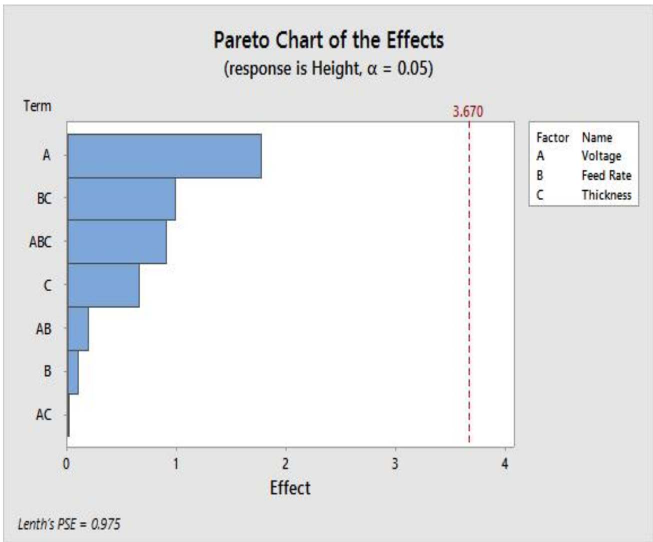

Fig.2 Pareto plot for height

Fig. 2 is of Pareto plot showing the effect of welding parameters on the height of the bead. Fig. 3 is of Pareto plot showing the effect of welding parameters on the width of the bead. Fig. 4 is of Pareto plot showing the effect of welding parameters on the penetration of the bead.

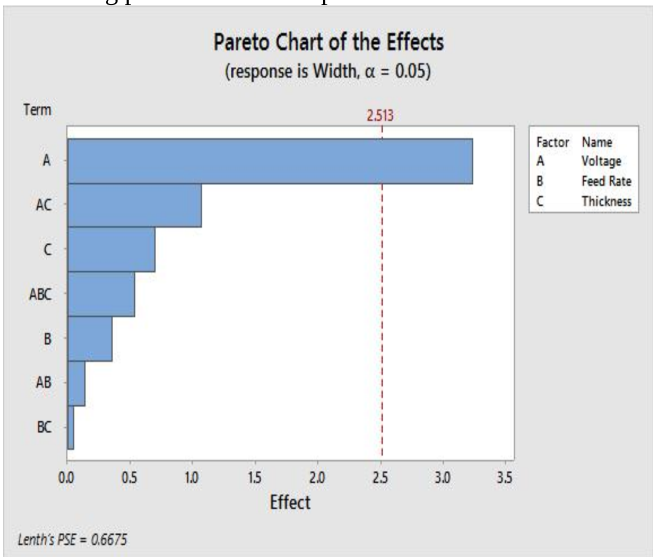

Fig.3 Pareto plot for width

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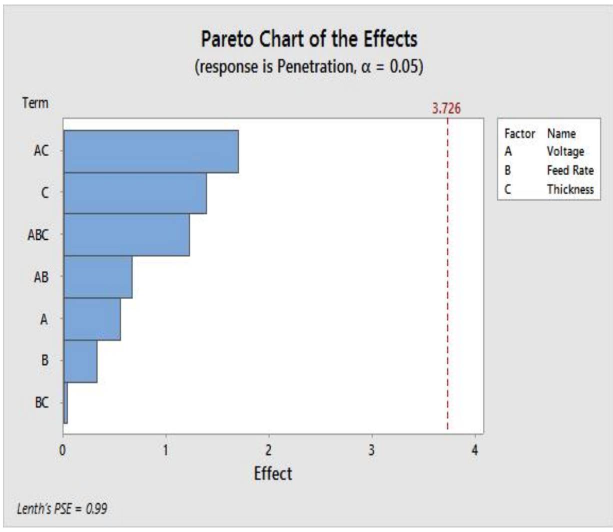

Fig.4 Pareto plot for Penetration

IV .RESULTS AND CONCLUSION

In this 8 experimental runs of welding are done and their readings are taken in terms of bead height, bead width and bead penetration. For which the linear equation are also calculated. From the results obtained we can conclude that the voltage has more predominant effect on the bead height, bead width and bead penetration than wire feed rate and wire thickness. Strength test is to be carried out in the future work.

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