Effect of Process Parameters on Weld Bead Geometry in Mig Welding

M. Ahira Grace[1], P. Jaganmohan Rao[2]
M.tech Scholar[1], Professor[2]
Department of mechanical Engineering
Chaitanya Engineering College,
Vishakhapatnam-530048, AP, India.

Abstract: **In this experimental study, an effort is made to find the effect of process parameters on bead geometry of in metal inert gas welding. In this experiment the wire feed rate, amplitude and welding speed taken as an input parameters. For each input parameters 3 levels are taken. L9 array experiments are designed to know the effect of process parameters on the weld bead geometry using by using DOE method. The output parameters height, width, penetration are taken as bead geometry. Main effect and interaction effect of process parameters on the output parameters are analyzed by parametric Analyses of Variance (ANOVA). And the mathematical models for all output parameters are developed using multiple regression analysis. It is observed from the studies that wire feed rate has maximum effect on bead geometry followed by welding and amplitude.**

Keywords: **Wire feed rate, Welding speed, amplitude, multiple regression analysis and aluminium alloy.**

I. Introduction

Quality of a weld joint is strongly influenced by process parameters during the welding process. This work focuses on the development of mathematical models for the selection of process parameters and the prediction of weld bed geometry.

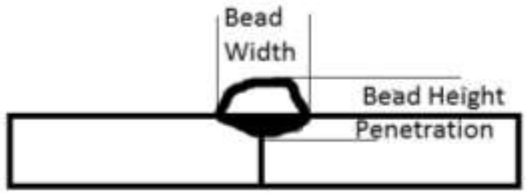

Fig. 1 weld bed geometry

Susheel Kumar Sharma et al. [1] conducted welding on low carbon alloy steel with carbon content of 0.14%. The input parameters considered for welding are welding current, arc voltage, welding speed and heat input rate, where the welding current and arc voltage are kept constant for entire welding process. It was observed that increasing the welding speed and maintaining constant arc voltage and current increases penetration until an optimum speed is reached at which penetration is maximum and increasing the welding speed beyond the optimum limit results in decrease of penetration.

Biswajit Das et al. [3] conducted experiment on mild steel specimen of grade EN-3A using Metal Inert Gas welding process to investigate the effect of various process parameters on depth of penetration. The test specimens were initially prepared with a groove angle of 30°. The welding input process parameters considered for welding are welding current, arc voltage and welding speed with five levels each and Taguchi L_{25} orthogonal array is used to reduce the number of experimental runs. The root gap between the two plates for butt joint is maintained constantly at a distance of 0.75mm. The filler wire used for conducting the experiment is copper coated mild steel wire of 1.25mm which is fed by welding gun by a roller feed system. It is observed that higher voltage and higher current can abruptly increase depth of penetration, where as high the welding speed results in decreased depth of penetration.

D W Cho et al. [4] performed study on three-dimensional transient numerical simulations for welding using the method “volume of fluid” in a gas metal arc welding process with v-groove for flat, overhead and vertical welding positions. The study is performed with and without root gap using simulation.

Kamal Pal et al. [5] describes about the effect of pulse parameters on the weld quality in pulsed gas metal arc welding. The quality of the welded joint depends on the bead geometry and the microstructure. The higher heat-affected zone, coarse-grained weld microstructure, lower penetration with higher reinforcement reduces the life of the weld joint in continuous mode of gas metal arc welding. In order to overcome this defect, pulsed gas metal arc welding process is widely used now-a-days.

S CJuang et al. [8] used Taguchi method to reduce the number of experiments to be carried for welding S304 stainless steel plates. In this study the four parameters with four levels each were considered. A total of 4^4 = 256 experiments are to be carried out, but by using Taguchi method only 16 experiments were carried out by using L_{16}orthogonal array. The interaction effects were neglected to reduce the total number of experiments. The initial process parameters are arc gap, flow rate, welding current and welding speed. After the welding is performed, the front height, front width, back height and back width are found out. The weighting factor for front height and back height is considered as 0.4 and the weighting factor for front width and back width is considered as 0.1. The S/N ratios are calculated and it is found that smaller-the-better quality characteristics are suitable for optimal weld pool geometry.

II. Experimental Procedure

For the experimental study, aluminium alloy 5083 H111, plate thickness 6 mm is used as base material. The chemical composition of the base material and filler wire is shown in Table 1.

TABLE 1
CHEMICAL COMPOSITION OF BASE METAL AND FILLER WIRE

Element Weight %	Material used	
	5083 H111	5183
Si	0.1	0.17
Fe	0.16	0.24
Cu	0.02	0.05
Mn	0.5	0.78
Mg	4.6	4.95
Cr	0.07	0.08
Zn	0.03	-
Ti	0.06	0.02

The L9 design matrix was selected to conduct the experiments based on DOE method. Aluminium plate of 6mm thickness was cut into the required sizes. The top surfaces of weld specimens were cleaned with the help of wire brush to remove the oxide layers and rust. The experiments were conducted by placing two plates with same Aluminium plates using aluminium 5183 wire 1.2mm diameter. Experiments were carried at using the PROMIG welding machine.

The three input parameters considered for conducting the experiments are wire feed rate (WFR), welding speed (S) and Amplitude. The selected process parameters and their levels are given in Table 2. Three parameters with three levels each are considered for conducting the experiments.

TABLE 2
INPUT PARAMETERS AND LEVELS USED

Parameters	Level 1	Level 2	Level 3
Wire feed rate (m/min)	4.0	5.5	7.0
Welding speed (cm/min)	15	20	25
Amplitude (amps)	0.4	1.2	2

Once the welding is carried out based on the design matrix, the weld pieces are cut perpendicular to the cross-section of the weld. The cut pieces are grinded, fine grinded on emery paper polished and etched with 10% nital solution to obtain the visible grain boundary. The photographs of visible grain boundaries are obtained and these photographs are imported into AutoCAD to obtain the desired bead dimensions.

TABLE 3
DESIGN MATRIX

Ex No	WFR (m/min)	Welding speed (cm/min)	Amplitude (amps)
1	4	15	0.4
2	4	20	1.2
3	4	25	2
4	5.5	15	1.2
5	5.5	20	2
6	5.5	25	`0.4
7	7	15	2
8	7	20	0.4
9	7	25	1.2

Work pieces after welding process:

Fig. 2 Work pieces 1 after welding process

Fig. 3 Work pieces 4 after welding process

III. Development of Mathematical Model

The relation between input parameters and output parameters are established by regression analysis. Minitab17 was used for the regression analysis. The regression equations given by the Minitab are below

Height = 4.11 + 0.273 WFR – 0.054 WS -1.39 A – 0.0122 WFR * WS + 0.033 WFR * A + 0.0321 WS *A

Width = -3.03 + 2.75 WFR + 0.368 WS – 13.60 A - 0.106 WFR * WS + 1.125 WFR * A + 0.362 WS * A

Penetration = -3.639 + 1.184 WFR + 0.1038 WS – 0.897A – 0.0341WFR *WS + 0.0310 WFR * A + 0.0318 WS * A

IV. Results and Discussions

The main effect plot graphs are shown in the Fig 2 and 3.

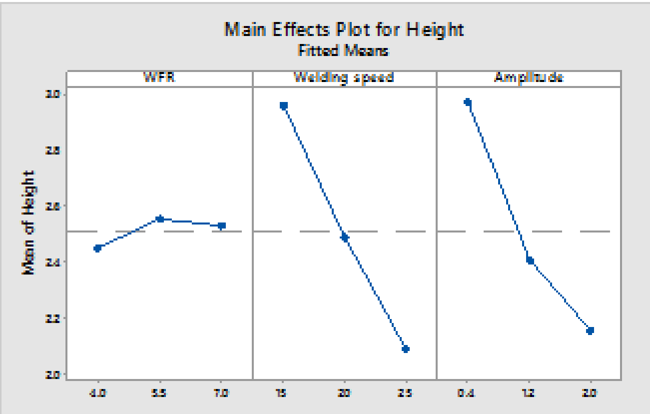

Fig. 4 Main effect plot for height

From the above figure 4 it is observed that height decreases with increase in welding speed and amplitude and with the increase in wire feed rate, the height slightly increases.

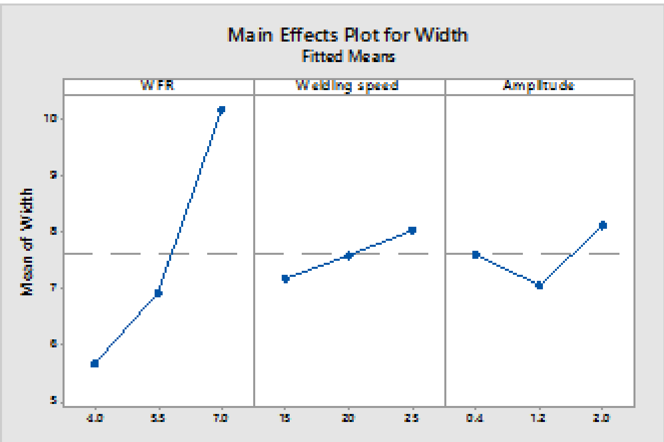

Fig. 5 Main effect plot for width

From the above figure 5. It is observed that width increases with increase in wire feed rate, increases and decreases with increase of amplitude.

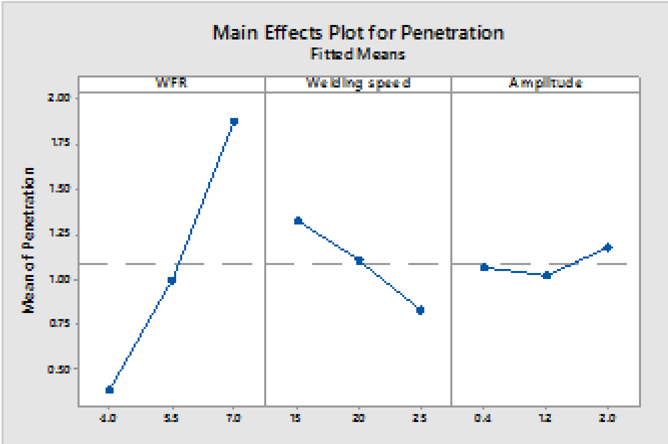

Fig. 6 Main effect plot for penetration

From the above figure 6 it is observed that penetration increases with increase in wire feed arte, and decreases with welding speed and slightly increase with amplitude groove angle.

Some of surface plots are given below:

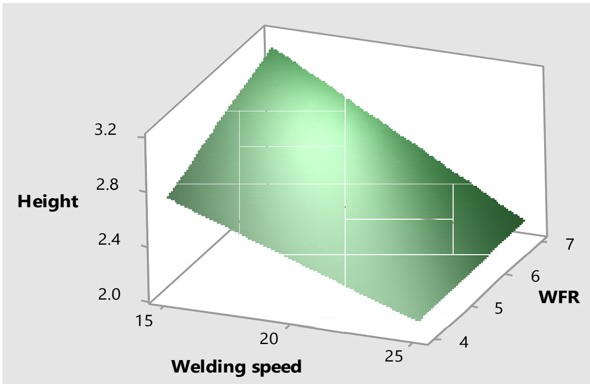

Fig. 7 surface plot of Height vs WFR, Welding speed

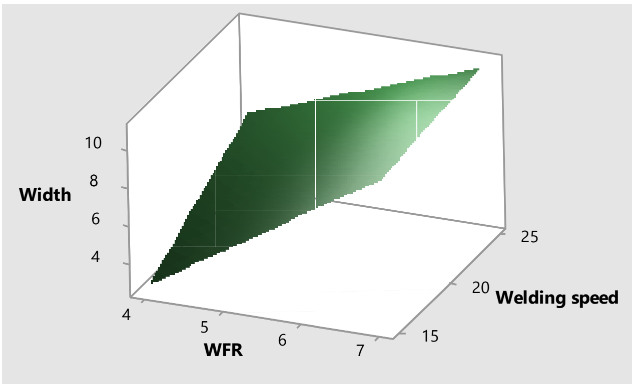

Fig. 8 surface plot of Width vs WFR, Welding speed

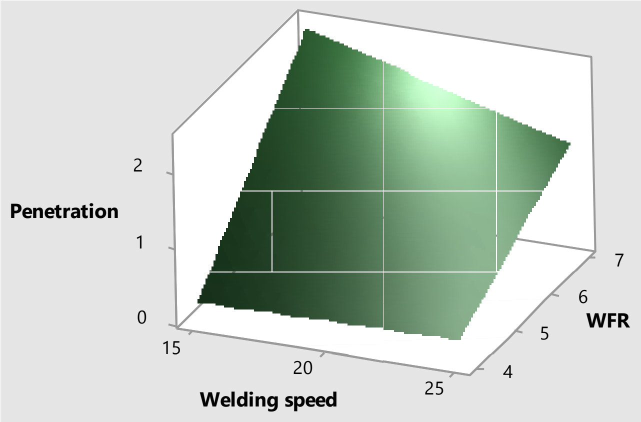

Fig. 9 surface plot of Penetration vs WFR, Welding speed

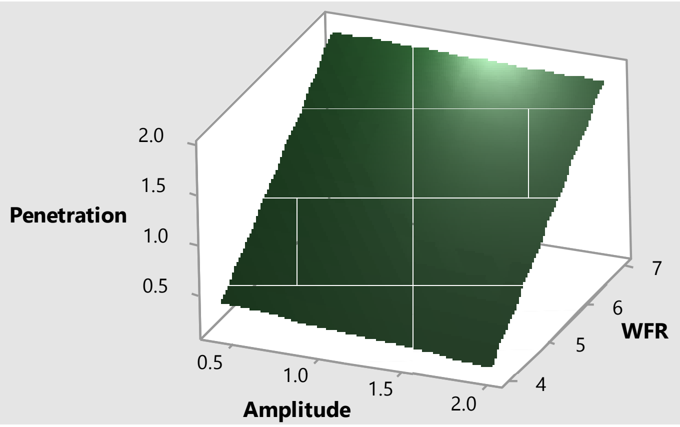

Fig. 10 surface plot of Penetration vs WFR, Amplitude

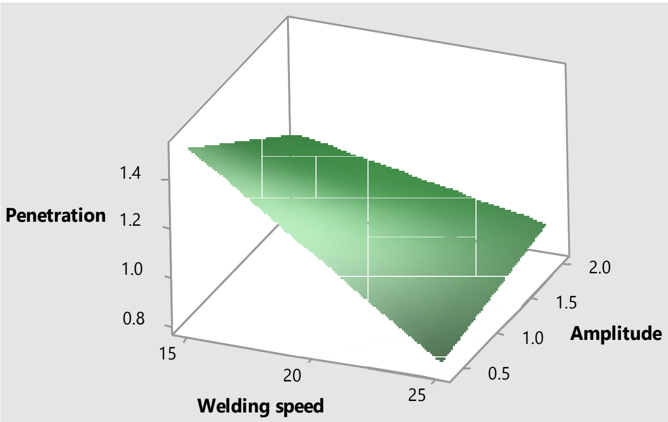

Fig. 11 surface plot of Penetration vs Amplitude, Welding speed

V. CONCLUSIONS

Effect of the process parameters on weld bead geometry have been studied in metal inert gas welding on aluminium alloy. And the mathematical models of these experimental data are employed to study the relation between process parameters and weld bead geometry. The main and interaction effect of process parameters on weld bead geometry have been studied by using ANOVA. Compare to the other input parameters Wire feed rate has maximum effect on all bead geometry followed by welding speed and amplitude. Height is mostly effect by the welding speed and amplitude. Wire feed rate is mostly affecting parameter on both width and penetration followed by welding speed and amplitude.

REFERENCES

[1] Susheel Kumar Sharma and Syed Hasan Mehdi, “Influences of the Welding Process Parameters on the Weldability of Material”, *International journal of engineering and advanced technology*, 2013, Vol.2, PP: 361-363.

[2] K Abbasi, SAlam and Dr.M I Khan, “An Experimental Study on the Effect of MIG welding parameters on the Weld-Bead Shape Characteristics”, *Journal of engineering Science and technology*, 2012, Vol.2,pp: 599-602.

[3] Biswajit Das,BDebbarma, R N Rai and S C Saha, “Influence of process parameters on depth of penetration of welded joint in MIG welding process”, *International journal of research in engineering and technology*, 2013, Vol.2, pp: 220-224.

[4] D W Cho, S J Na, M H Cho and J S Lee, “A study on V-groove GMAW for various welding positions”, *Journal of materials processing technology*, 2013,Vol.213, pp: 1640-1652.

[5] Kamal Pal and Surjya K Pal, “Effect of pulse parameters on weld quality in pulsed gas metal arc welding”, *Journal of materials engineering and performance*, 2011,Vol.20, pp: 918-931.

[6] I S Kim, J S Son, I G Kim, J Y Kim and O S Kim, “A study on relationship between process variables and bead penetration for robotic CO2 arc welding”, *Journal of materials processing technology*, 2003, Vol.136, pp: 139–145.

[7] J P Ganjigatti, D K Pratihar and A Roy Choudhury, “*Modeling of the MIG welding process using statistical approaches*”, International journal of advanced manufacturing technology, 2006, Vol.10, pp: 215-227.

[8] S C Juang and Y S Tarng, “Process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel”, *Journal of materials processing technology*, 2002, Vol.122, pp: 33–37.

[9] J Chen, C Schwenk, C S Wu and M Rethmeier, “Predicting the influence of groove angle on heat transfer and fluid flow for new gas metal arc welding processes”, *International Journal of heat and mass transfer*, 2012, Vol.55, pp:102-111.

[10] Sukhomay Pal, Santosh K Malviya, Surjya K Pal and Arun K Samantaray, “Optimization of quality characteristics parameters in a pulsed metal inert gas welding process using grey-based Taguchi method”, *International journal of advanced manufacturing technology*, 2009, Vol.44, pp: 1250-1260.

