Optimization of Weld Bead Geometry In Metal Active Gas Welding Process Using Taguchi Method

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Abstract--- Gas Metal Arc Welding is a process in which the source of heat is an arc format between consumable metal electrode and the work piece with an externally supplied gaseous shield of gas either inert such as argon, helium and Carbon dioxide etc. In this study attempts to optimize the Metal active gas Welding (MAG) process parameters (Gas flow rate, Power, Wire feed rate.) on responses (like: Bead Geometry, Means Bead width and Bead Height) using Taguchi techniques. The MS C20 material was chosen For the study. L16 orthogonal array is selected for experimentation and Regression analysis will used for modelling the responses. The most significant parameter for Bead Width and Bead Height is Power. In case of Bead Width and Bead Height the Power % Contribution is 89.71% and 70.49% respectively.

I. INTRODUCTOIN

Gas metal arc welding (GMAW) also called MIG (metal inert gas) if the shielding gas is inert, for example argon, or MAG (metal active gas) if the gas has a content of an active gas such as CO2. In Europe the process is usually called MIG/MAG or just MIG welding. M SUBAN, J TUSEK (2001), [1] studied the various types of shielding gases and mixture of various shielding gases on the performance of welding. the paper describes a study on welding productivity i.e. melting efficiency of the filler material (solid and cored wire) in various shielding media (for shielding gases and a welding flux).A mathematical for prediction of melting rate in time welding with solid and cored wires is presented too. A comparison of mathematical models for MIG/MAG welding in Ar/Co2 gas mixture and TIME mixture, respectively is also made. G. Casalino [2] (2007) studied the innovative arc-laser welding process (hybrid welding) is investigated by means of a regression model and a full factorial experiment. Both the regression model and the factorial experiment output were checked by the analysis of variance. J.P. Ganjigatti et. al. [3] (2007) attempt is made to establish input–output relationships in MIG welding process through regression analyses carried out both globally (i.e., one set of response equations for the entire range of the variables) as well as cluster-wise. Ugur Esme et. al. [4] (2009) investigated the multi-response optimization of tungsten inert gas welding (TIG) welding process for an optimal parametric combination to yield favorable bead geometry of welded joints using the Grey relational analysis and Taguchi method. Manoj Singla, Dharminder Singh et. al. (2010), [5] optimizing various Gas Metal Arc welding parameters including welding voltage, welding current, welding speed and nozzle to plate distance (NPD) by developing a mathematical model for sound weld deposit area of a mild steel specimen. Kamal Pal, Surjya K. Pal [6] (2010) present work focuses on the influence of pulse parameters at various torch angles on the tensile properties of low carbon steel butt weld in pulsed metal inert gas welding. The interface of weld zone and heat affected zone was found to be the weakest area due to significant variation of weld microstructure. The weld bead characteristics strongly influenced the joint strength. M.M.A. Khan, L. Romoli et. Al. (2011), [7] presents an experimental design approach to process parameter optimization for the laser welding of martensitic AISI416 and AISI440FSe stainless steels in a constrained overlap configuration in which outer shell was 0.55mm thick. To determine the optimallaser-welding parameters, a set of mathematical models were developed relating welding parameters to each of the weld characteristics.

II. EXPERIMENTAL PROCEDURE

Experiments will conduct on an QCM-250 MAG machine (refer figure 4.1) manufactured by Quality Engineering (baroda) pvt. Ltd. The electrode is fed constantly by wire reel. There is CO2 gas cylinder which provides gas as set by pressure gauge. **MS C20** material is selected as a work-piece material A series of test will be conducted in order to compare MAG conventional process performance on widely used industrial material **MS C20**.

III. DESIGN OF EXPERIMENTS

The selected process variables were varied up to four levels and L 16 orthogonal array was adopted to design the experiments. The process variables and their ranges are given in Table I.

Table. 1: Process Parameters with their levels

Level	1	2	3	4
Power (W)	900	1000	1100	1200
Wire feed rate (mm/s)	3	4	5	6
Gas flow rate (l/min)	17	18	19	20

Experiments were conducted according to the test conditions specified by the Taguchi L 16 Orthogonal array. Experimental results are given in Table II for Bead Width and Bead Heigth.

Table. 2: Observed Values for Performance Characteristics

Sr. No.	Bead Height (mm)	Bead Width (mm)
1	2.126	4.216
2	2.015	4.167
3	1.986	4.056
4	1.913	4.006
5	2.589	4.678
6	2.456	4.611
7	2.356	4.583
8	2.312	4.498
9	2.986	4.985
10	2.886	4.923

11	2.812	4.859
12	2.785	4.752
13	3.125	5.365
14	3.015	5.265
15	2.988	5.121
16	2.856	5.005

IV. Result And Discussions

Table. 3: Signal to Noise Ratios of Bead Width

Level	P	F	v
1	12.44	13.77	13.66
2	13.31	13.56	13.48
3	13.77	13.42	13.40
4	14.45	13.21	13.43
Delta	2.01	0.56	0.26
Rank	1	2	3

Table, 4: Response for Means of Bead Width

Level	P	F	v
1	4.139	4.893	4.822
2	4.631	4.780	4.738
3	4.880	4.713	4.701
4	5.227	4.595	4.719
Delta	1.084	0.298	0.121
Rank	1	2	3

- The significant parameters can be easily identified and rank the parameter as per the response table for S/N Ratio and means.
- The most significant parameter for Bead Width is Power.
- The optimum condition for maximum Bead Width P (1200 W), f (6 mm/s), v (17 l/min).

Table. 5:Analysis of Variance for Bead width

Source	df	Seq ss	Adj ss	Adj ms	F	p	% Contribution
Power	3	2.47575	2.47575	0.82525	78.78	0.000	89.71
Feed rate	3	0.18625	0.18625	0.06208	5.93	0.032	6.74
Gas flow rate	3	0.03463	0.03463	0.01154	1.10	0.418	1.25
Error	6	0.06285	0.06285	0.01048			0.227
Total	15	2.75948					
R-Sq = 97.72% R-Sq(adj) = 94.31%							

- The Analysis of Variance table can also justify the rank order of significant parameter as P (89.71%), f (6.74%), v (1.25%).
- The value of R-Sq is 97.72% it means the experimentation of MAG welding is good

Table 6: Signal to Noise Ratios of Bead Height

Level	P	F	v
1	6.340	9.606	8.258
2	7.926	8.247	8.416
3	9.226	7.979	8.245
4	10.061	7.722	8.634
Delta	3.721	1.884	0.389
Rank	1	2	3

Table. 7: Response for Means of Bead Height

Level	P	F	v
1	2.080	3.077	2.595
2	2.500	2.620	2.666
3	2.895	2.537	2.631
4	3.216	2.457	2.799
Delta	1.135	0.620	0.204
Rank	1	2	3

- The significant parameters can be easily identified and rank the parameter as per the response table for S/N Ratio and means.
- The most significant parameter for Bead Height is Power.
- The optimum condition for Bead Height is P (1200 W), f (6 mm/s), v (20 l/min).

Table. 8: Analysis of Variance for Bead Height

Source	df	Seq ss	Adj ss	Adj ms	F	p	% Contribution
Power	3	2.89875	2.89875	0.96625	29.84	0.001	70.49
Feed rate	3	0.92428	0.92428	0.30809	9.51	0.011	22.47
Gas flow rate	3	0.09460	0.09460	0.03153	0.97	0.465	2.30
Error	6	0.19429	0.19429	0.03238			4.72
Total	15	4.11191					
R-Sq = 95.27% R-Sq(adj) = 88.19%							

- The Analysis of Variance table can also justify the rank order of significant parameter as P (70.49%), f (22.47%), v (2.30).
- The value of R-Sq 95.27% which is significant.

V. Regression Analysis

- S: Significant, NS: Not Significant
- The regression equation is
- Bead Width = 2.43 + 0.00350 Power - 0.0960 Feed rate - 0.0346 Gas flow rate

Table. 9: Estimated Regression Coefficients for Bead Width:

Predictor	Coef	SE Coef	T	P	Significant or not
Constant	2.4301	0.4604	5.28	0.000	S
Power	0.0035	0.0002	17.17	0.000	S
Feed rate	-0.0960	0.02039	-4.71	0.001	S
Gas flow rate	-0.0346	0.02039	-1.70	0.115	NS
R-Sq = 96.4% R-Sq(adj) = 95.5%					

Table. 10: Analysis of Variance for Bead Width

Source	DF	SS	MS	F	P
Regression	3	2.65973	0.88658	106.65	0.000
Residual Error	12	0.09975	0.00831		
Total	15	2.75948			

Table. 11: Estimated Regression Coefficients for Bead

Predictor	Coef	SE Coef	T	P	Significant or not
Constant	-0.9259	0.9251	-1.00	0.337	NS
Power	0.0038	0.0004	9.28	0.000	S
Feed rate	-0.1942	0.0409	-4.74	0.000	S
Gas flow rate	0.0575	0.0409	1.41	0.185	NS
R-Sq = 90.2% R-Sq(adj) = 87.8%					

- The regression equation is
- Bead Height = - 0.926 + 0.00380 Power - 0.194 Feed rate + 0.0576 Gas flow rate

Table. 12: Analysis of Variance for Bead Height

Source	DF	SS	MS	F	P
Regression	3	3.7091	1.2364	36.84	0.000
Residual Error	12	0.4028	0.0336		
Total	15	4.1119			

VI. CONCLUSION

This study highlights the development of a comprehensive mathematical model for influences of various MAG cutting parameters through, utilizing relevant experimental data as obtained through experimentation. Minitab 16 software was used for analyze the experimental data. Following conclusions drawn after analysis.

- The most significant parameter for Bead Width and Bead Height is Power. In case of Bead Width and Bead Height the Power % Contribution is 89.71% and 70.49% respectively.
- The Wire feed rate is the significant parameter after the Power.
- The optimum condition for maximum Bead Width P (1200 W), f (6 mm/s), v (17 l/min).
- The optimum condition for Bead Height is P (1200 W), f (6 mm/s), v (20 l/min).
- The developed Multi linear mathematical model for responses like Bead Width and Bead Height having R-Sq value is more than 90% that means the model is accurate.

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