Effect of Various Parameters on the Bead Geometry and Flexural Strength of MIG Welded Joint

P.V.R Ravindra Reddy, G.Chandra Mohan Reddy, B.V.S Rao, G.Laxmaiah

Abstract: *Metal inert gas welding is the process in which a continuous coil of consumable electrode is used with inert gas shielding. It was extensively being used for Aluminum and Mg Alloys. But due to other alternatives available for, the cost of inter gas prohibited the use of MIG welding of steels. After the introduction of carbondioxide as shielding gas the economical viability in welding of steels was realized. The quality of weld joing and its productivity is influenced by the parameters such as arc current, wire feed rate, voltage, welding speed, torch angle, , nozzle to plate distance, welding position and gas flow direction. In the present work effect of gas flow rate, voltage and current are studied using Taguchi L-9 orthogonal array. The flexural strength, tensile strenght and bead geometry for various trails are computed and the optimum combination is obtained.*

Keywords : MIG welding, Taguchi, Flexural strength, Bead geometry.

I. INTRODUCTION

Metal inert gas (MIG) welding is a multi-factor and multi-objective welding process in which there is complex interaction of various process parameters which directly or indirectly influence the bead geometry, mechanical properties of the weldment [1].In conventional design optimization feasible design is obtained by trial and error, varying one parameter at a time and keeping all other parameters constant which is repeated for all the parameters under study [2].But this approach may take very long time making the approach to be expensive and sometimes infeasible [3]. So Taguchi developed an approach of taking all the parameters under study at a time and establish the individual and combined effect of the the parameters. [4]. According to Taguchi the parametric design experiment aims at the identification of the process parameters that influence the process the most and optimize them and make the process less sensitive to the noise[5]. The scope of this approach ranges from raw materials, systems and products.

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The steps involved in parametric design are: determination of the quality characteristic which is aimed to be optimized, Identification of the noise parameters and test conditions, identification of the control parameters, how many levels and their levels, selection of the suitable orthogonal array (OA), conduction of the experiments according to the selected OA, analysis of the data and finding the most influencing parameters, their contribution and proposing the optimum levels and performance prediction at these levels [6].

II. OA SELECTION AND THE DETERMINATION OF THE LEVELS

In the present work, the flexural strength, tensile strength and bead geometry are considered as the out parameters. Environments conditions such as temperature, humidity etc are considered as noise factors. The control parameters identified are current, voltage and gas flow. Three levels are taken for the control parameters based on the initial tests. Since there are three parameters and three levels full factorial experimentation is done by selecting the orthogonal array L-9.

Table 1: Levels chosen

Parameter	Level 1	Level 2	Level 3
Voltage (V)	25	26	27
Current (A)	75	100	125
Gas flow rate (liters/Min)	9	12	15

Table 2: OA after assignment

Trial	Current	Voltage	Gas flow rate
1	75	25	9
2	75	26	12
3	75	27	15
4	100	25	12
5	100	26	15
6	100	27	9
7	125	25	15
8	125	26	12
9	125	27	9

The range of parameters is chosen such that good beads are obtained in all the cases. The parameter levels are shown in table 1. L-9 orthogonal array after the assignment of the values the L9 OA looks as in table 2.

III. EXPERIMENTATION

Three samples of mild steel of 6 mm thickness are prepared for each trail.

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TCVR-400 MIG welding machine shown in Fig 1 is used for the conduction of experiments. Experiments are conducted as per the OA shown in table 2.

A welded sample is given in Fig 2. Tesile and flextural strength are found out by nano UTM presented in Fig 3. A sample graph obtained by 3 point bend test is shown in Fig 4.

Fig 1: MIG Welding Equipment Used for Experiment

Fig 2: A welded sample

Fig 3: Tensile test on Nano UTM

IV. RESULTS AND DISCUSSION

The results of the 9 trails are shown in Table 3. The results of bead geometry is presented in Table 4. S/N Analysis is conducted for all output parameters. For Flexural strength, Tensile strength, and penetration higher the better formula presented in equation (1) is used and the smaller the better formula shown in equation (2) is used for width and reinforcement.

$$SN_i = -10\, log\left[\frac{1}{N}\sum_{u=1}^{N_i}\frac{1}{y_u^2}\right] \dots\dots\dots (1)$$

$$SN_i = -10\, log\left[\frac{1}{N}\sum_{u=1}^{N_i} y_u^2\right] \dots\dots\dots (2)$$

Where SN_i is the S/N ration of ith variable, N is the no.of observations, y_u is the value of uth observation.

The results of S/N Analysis for Flexural strength obtained by Eq(1) and Eq (2) are presented in Table 5 and the maen S/N ratio for the above parameters at the chosen levels are calculated and shown in table 6.

From the table 6 it is found that gas flow rate has maximum influence in flexural strength and tensile strength in chosen range. The mean S/N vales for bead geometry at the three levels are shown in table 7.

From table 7 it is identified that gas flow rate is the maximum influencing parameter for penetration and width and current is the most significant parameter for reinforcement. The Mean S/N values for flexural strength, tensile strength, penetration width and reinforcement are plotted in Fig 5, Fig 6, Fig 7, Fig 8 and Fig 9 respectively.
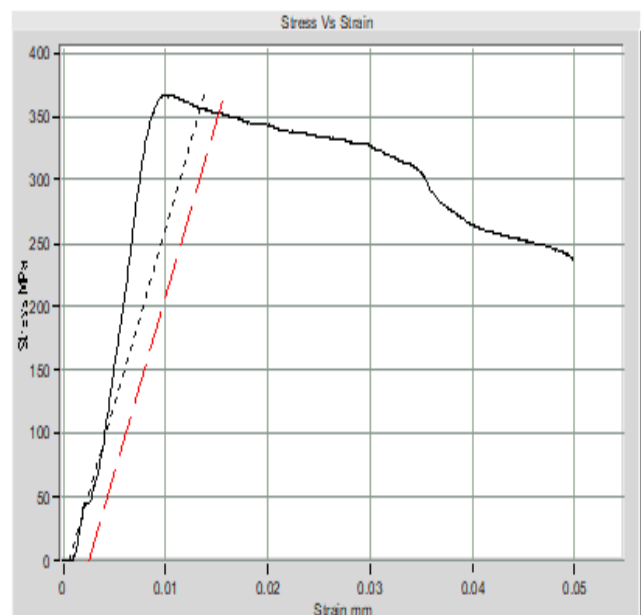
Fig 4: 3-point bend test graph

Table 3: Results of Flexural and Tensile Strength

Trial	Current (A)	Voltage (V)	Gasflow (liter/min)	Flexural Strength (MPa)			Tensile strength (MPa)		
1	75	25	9	185	189.3	182.3	210.8	209	211
2	75	26	12	257	261.2	252.4	370.4	371	369
3	75	27	15	101	104.2	109.4	186.7	185	187
4	100	25	12	114	117.6	119.2	221.7	220	222
5	100	26	15	159	156.8	158.6	220	231	229
6	100	27	9	119	123.2	126.4	160.9	159	161
7	125	25	15	119	120.1	121.3	155.8	156	154
8	125	26	12	365	326.1	317.3	359.3	360	358
9	125	27	9	178	179.9	181.9	292.4	293	291

Table 4: Results of bead geometry

Trial	Current	Voltage	Gas flow	Penetration (mm)			Reinforcement (mm)			Width (mm)		
1	75	25	9	2.5	2.6	2.4	3	3.1	2.9	8	9	7
2	75	26	12	2.2	2.2	1.8	2	2.1	1.9	9	10	8
3	75	27	15	1.2	1.2	0.8	3	2.9	3.1	5	4	6
4	100	25	9	3.2	3.2	2.8	4	3.9	4.1	5	6	4
5	100	26	12	1.2	1.2	0.8	3	2.9	3.1	5	6	4
6	100	27	15	2.2	2.2	1.8	2.5	2.4	2.6	6	7	5
7	125	25	9	2.2	2.2	1.8	4	3.9	4.1	4	5	3
8	125	26	12	3.2	3.2	2.8	5	4.9	5.1	5	6	4
9	125	27	15	2.2	2.2	1.8	4	3.9	4.1	7	8	6

Table 5: S/N Analysis of Tensile strength, flexural strength, bead geometry

Trial	Current	Voltage	Gas flow	S/N Ratio of Flexural Strength	S/N Ratio of Tensile Strength	S/N Ratio of Penetration	S/N ratio Width	S/N Reinforcement
1	75	25	9	45.36531	46.45517	7.944888	18.1068	9.545641
2	75	26	12	48.1916	51.3671	6.186652	19.12045	6.027832
3	75	27	15	40.39871	45.40086	0.070948	14.09369	9.545641
4	100	25	12	41.35421	46.8968	9.681023	14.09369	12.04301
5	100	26	15	43.97999	47.10185	0.070948	14.09369	9.545641
6	100	27	9	41.78071	44.09824	6.186652	15.64271	7.96343
7	125	25	15	41.59247	43.82113	6.186652	12.21849	12.04301
8	125	26	12	50.48301	51.10424	9.681023	14.09369	13.98056
9	125	27	9	45.10121	49.31151	6.186652	16.96065	12.04301

Table 6: Mean S/N Ratios of the factors for Flexural Strength and Tensile Strength

Levels	Flexural Strength			Tensile Strength		
	Current	**Voltage**	**Gas Flow**	**Current**	**Voltage**	**Gas Flow**
1	44.65188	42.77067	44.08241	47.74104	45.72437	46.62164
2	42.37164	47.55153	46.67627	46.0323	49.85773	49.78938
3	45.72557	42.42688	41.99039	48.07896	46.2702	45.44128
Range	3.35393	5.124656	4.685882	2.046663	3.587524	4.348104

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Table7: Mean S/N Ratio of the parameters for Bead Geometry

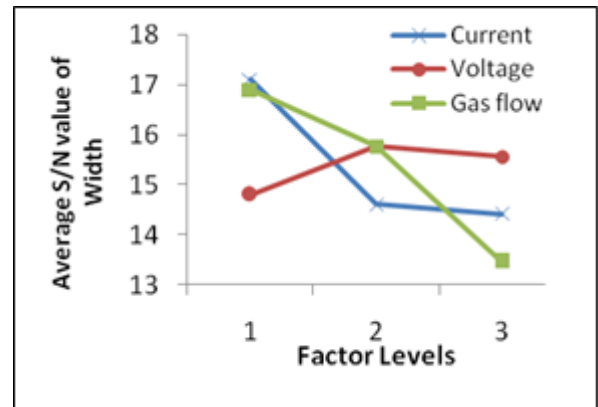| Levels	Penetration			Reinforcement			Width		
	Current	Voltage	Gas Flow	Current	Voltage	Gas Flow	Current	Voltage	Gas Flow
1	4.73416	7.93752	6.77273	8.37303	11.2105	9.85069	17.1069	14.8063	16.9033
2	5.31287	5.31287	8.51623	9.85069	9.85134	10.6838	14.6100	15.7692	15.7692
3	7.35144	4.14808	2.10951	12.6888	9.85069	10.3781	14.4242	15.5656	13.4686
Range	2.61728	3.78943	6.40671	4.31582	1.35986	0.83310	2.68270	0.96295	3.43476
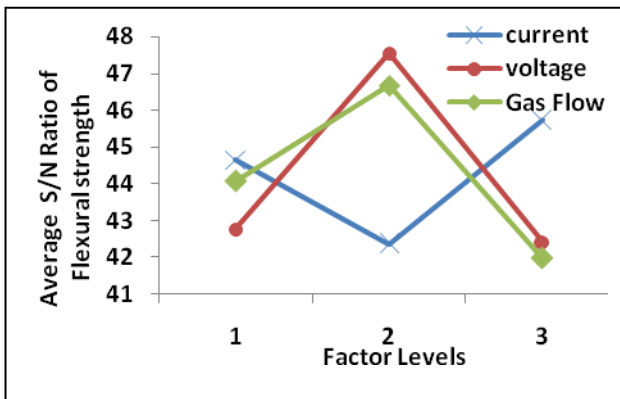
Fig 5: Mean S/N Values of Flexural strength
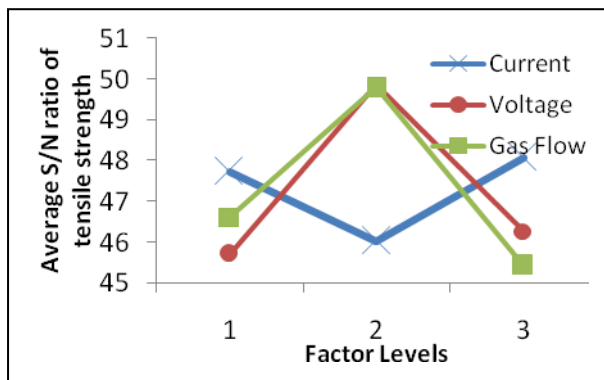

Fig 6: Mean S/N Values of Tensile strength

From Fig 5 and Fig 6, it is found that a current and voltage at level 2 and gas flow rate at 3 are optimum values for flexural strength and tensile strength
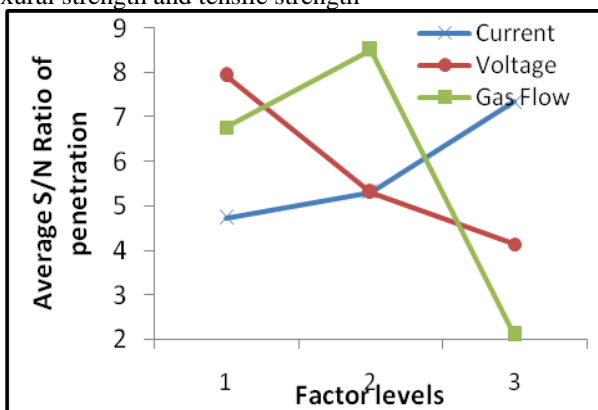

Fig 7: Mean S/N Values of Penetration

Fig 8: Mean S/N Values of Width

From Fig 7, Fig 8, Fig 9 it is found that Current-3, voltage-1 and gas flow-2 give higher penetration. Current-3, voltage-3 and gas flow-3 are optimum for lower width. Current-1, voltage-2 and gas flow-3 are optimum for reinforcement.

V. CONCLUSIONS

The following conclusions are drawn from the current work.

- Among the selected range, a current of 100A , voltage of 27 V, and gas flow of 15 liter/min gives higher flexural strength and tensile strength.
- 120 A current, 25V voltage and 9 liter/min gas
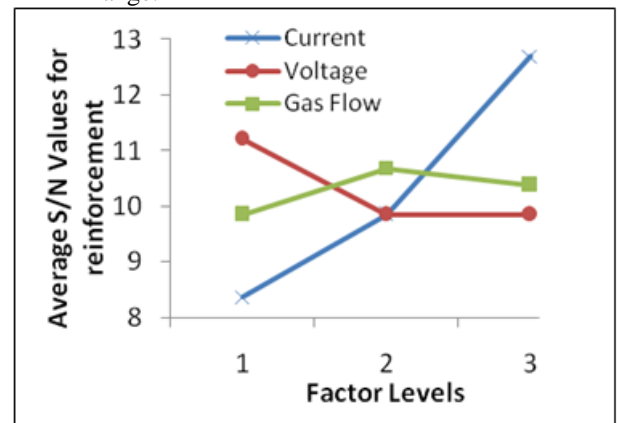- flow rate gives deeper weld bead in the selected range.

Fig 9: Average S/N Values of Reinforcement

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REFERENCES

1. Ugur Esme; Melih Bayramoglu; Yugut Kazancoglu; Sueda Ozgun: Optimization of Weld Bead Geometry In TIG Welding Process Using Grey Relation Analysis and Taguchi Method, 'Materials and technology' vol. 43, no.3, 2009, 143–149.
2. Phadke, S. M: Quality Engineering Using Robust Design, Prentice Hall, Englewood Cliffs, N.J., 1989.
3. Resit Unal; Edwin, B; Dean: Taguchi Approach To Design Optimization For Quality And Cost: An Overview 'Annual Conference of the International Society of Parametric Analysts' 1991, 1-10
4. Kackar; Raghu: Off-Line Quality Control, Parameter Design, and the Taguchi Method, 'Journal of Quality Technology' 1985, vol. 17, no.4, 176-188.
5. Prabir Kumar Chaulia; Reeta Das: Process Parameter optimization for Fly Ash Brick by Taguchi Method, 'Materials Research' 2008, vol.11, no.2, 159-164.
6. Dalgobind Mahto; Anjani Kumar: Optimization of Process Parameters in Vertical CNC Mill Machines Using Taguchi's Design of Experiments 'ARISER' 2008, vol. 4 no. 2, 61-75.

AUTHORS PROFILE

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