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Performance Evaluation of Significant Process Parameter in Metal Inert Gas Welding of Mild Steel by Analysis of Variance (ANOVA)

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ABSTRACT: The aim of the present study is to show the influence of different input parameters such as welding current, root gap and gas flow rate on the mechanical properties during the Metal Inert Gas Welding (MIG) of mild steel 1020 grade. The hardness, tensile strength of weld specimen are investigated in this study. The selected three input parameters were varied at three levels. On the analogy, nine experiments were performed based on L9 orthogonal array of Taguchi's methodology, which consist three input parameters. Analysis of variance (ANOVA) was employed to find the levels of significance of input parameters. Arc current is significantly affects the Tensile strength followed by root gap and gas flow rate. Root Gap is significantly affects the Hardness followed by arc and Gas Flow Rate.

Key words: GMAW, MIG, Mild Steel, Welding Taguchi, ANOVA.

I. INTRODUCTION

Metal Inert Gas Welding which is also known as Gas Metal Arc Welding (GMAW) uses a consumable metal electrode and an inert gas or an active gas. It is the process in which source of heat is an arc formed between a consumable metal electrode and the work piece. The arc and molten puddle are protected from contamination by the atmosphere with an externally supplied gaseous shield of inert gas or active gas [1-2]. In this process carbon is used as shielding gas and plate of 12 mm is welded using MIG welding. Hardness testing of metals, ceramics, and composite is useful for a variety of applications for which hardness measurements are unsuitable. Hardness testing gives an allowable range of loads for testing with diamond indenter. The resulting indentation is measured and converted to a hardness value. Taguchi method [3-4] is a systematic application of design and analysis of experiment for designing purpose and product quality improvements. In this research work tensile strength and hardness of specimen 1020 mild steel welded by MIG welding are evaluated. In this paper, analysis of variance (ANOVA) is used to determine most significant welding parameter.

Suresh Kumar (2002) discusses microstructural development during MIG welding of copper with iron filler. During the experimental work they consider voltage, current and travel speed as welding parameter. They investigate needle shaped morphology of iron matrix typical of martensite and at copper iron interface bended microstructure was observed which varied with travel speed [6].

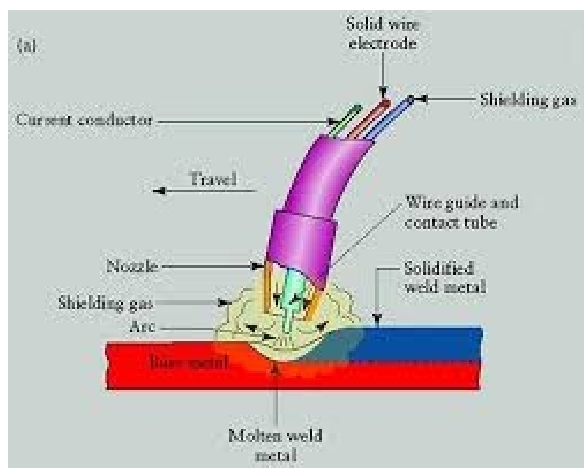

Fig. 1. MIG welding of Mild Steel.

Haragopal (2011) investigate the mechanical properties of Al-65032 alloy using Taguchi technique and result shows that current is the most influencing parameter for ultimate tensile strength and pressure is most significant parameter for proof stress [7].

Sapakal (2012) investigate the influence of welding parameter like welding current, welding voltage, welding speed on penetration depth of mild steel during welding by using Taguchi design method. Result shows the welding voltage has large effect on penetration [8].

A consumable electrode of mild steel with 2mm diameter shielded by carbon dioxide (CO_2) gas is used to produce an electric arc with the base metal as shown in figure 1. The heat generated by electric arc is used to melt the filler electrode and base metal.

As discussed earlier, Taguchi Approach is applied in this process for the analysis. It help to determine the best level of parameter used to analyzed the best performance of the result.

II METHDOLOGY

In this experimental work, the specimen is welded at three different levels of welding parameter i.e. current, voltage and root gap as shown in Table 1.

Table 1: Welding parameter and their levels.

Parameters	Welding Current (A)	Root gap (B)	Gas flow rate (C)
Unit	Amp	mm	cfh
Level 1	160	0	20
Level 2	170	2	22
Level 3	180	4	23

Table 2: Chemical Composition of Base Metal Mild Steel 1020.

Element	Weight%
C	0.17 to 0.23
Si	0.09
Mn	0.37
P	0.040
S	0.050
Fe	99.08

Fig. 2. Cutting of Sample from Strip.

Samples of size 250×100×12mm were cut with the help of Power Hacksaw. A groove of 60 degree was also made on each sample with the help of Power Grinder. The chemical composition of mild steel sheet using for present study is shown in Table 2. Figure 2 shows the cutting of the sample from the big strip with help of power hacksaw. All eighteen samples are cut in same size and their pictorial view is shown in figure 3. The working range of welding parameter were fined by conducting trial run and satisfactory values obtained are used to conduct the experimental work. L9 orthogonal array is used for analysis purpose and standard table of three variables with three different levels of input parameters is shown in table 3 and actual value of selected input parameter arc shown in table 4.

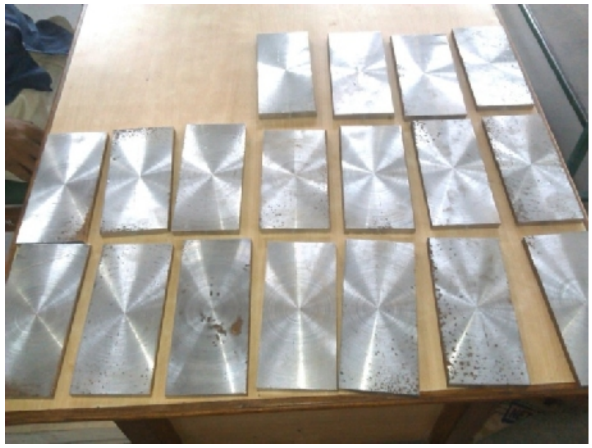

Fig. 3. Final Cutting Sample for Welding.

Table 3: L9 Orthogonal Array Design Matrix.

Experiment Number	Welding Current (Amp)	Root gap (mm)	Gas flow rate
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 4: L9 Matrix with Actual Value of Parameters.

Experiment Number	Welding Current (Amp)	Root gap (mm)	Gas flow rate
1	160	0	20
2	160	2	22
3	160	4	23
4	170	0	22
5	170	2	23
6	170	4	20
7	180	0	23
8	180	2	20
9	180	4	22

The nine experiments were performed based on the L9 array. The effect of different parameters such as welding current, gas flow rate and root gap of mild steel 1020 is analyzed. The tensile strength and hardness of all nine weld specimen were checked carefully and the observed value of tensile strength and hardness with their S/N ratios are shown in table 5 and in table 6.

Figure 4 shows photograph of welded sample. The samples used for measuring micro-hardness are rubbed first using emery paper of size no. 400, 600, 1000 & 2000 and then clean with acetone solution. The diagonals of the indents formed by pyramid- shaped diamond indenter on the samples gives the value of micro-hardness in Vickers.

Fig. 4. Welded Sample of Mild Steel.

Table 5: Result for Tensile Strength.

Experiment Number	Welding Current (Amp)	Root gap (mm)	Gas flow rate	Tensile Strength	S/N Ratio
1	160	0	20	320.61	50.1195
2	160	2	22	353.07	50.9572
3	160	4	23	283.51	49.0514
4	170	0	22	339.56	50.6183
5	170	2	23	405.40	52.5277
6	170	4	20	477.72	53.5835
7	180	0	23	412.03	52.2986
8	180	2	20	415.35	52.3683
9	180	4	22	338.11	50.5812

Table 6: Result for Hardness.

Experiment Number	Hardness WZ (Hv 10)	Hardness PM (Hv 10)	Hardness HAZ (Hv 10)	S/N Ratio
1	232	171	362	8.3458
2	199	180	232	17.7752
3	195	182	232	17.8698
4	232	172	401	7.0812
5	175	172	217	17.4691
6	199	180	223	19.3812
7	172	172	219	16.7970
8	174	180	232	15.7409
9	203	180	251	15.3189

III RESULTS AND DISCUSSIONS

In the present study tensile strength and Hardness of the weld specimens were identified as the responses, therefore, "higher the better" characteristic chosen for analysis purpose.

$$HB : S/N\ ratio = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n} yi^{-2}\right]$$

Where yi represents the experimentally observed value of the with experiment, n is the repeated number of each experiment, is the mean of samples and s is the sample standard deviation of n observations in each run.

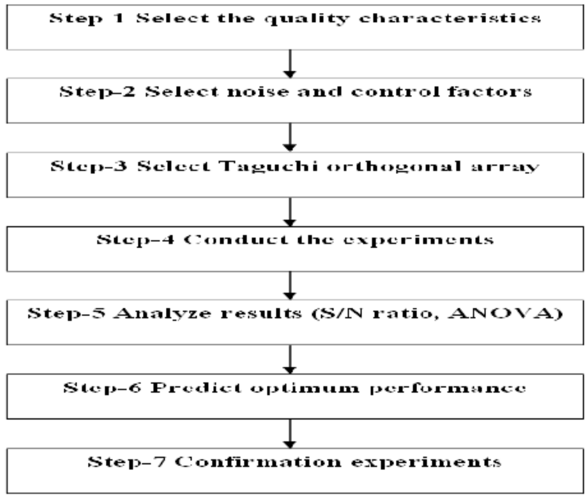

Fig. 5. Steps for Taguchi's analysis.

Tensile Strength. Tensile strength is calculated experimentally and Taguchi method is applied for analysis with the help of ANOVA. On basis of data analyzed, plots for signal-to-noise (S/N) ratio are shown in Figure 6. The calculated S/N ratio has been tabulated in Table 5.

Analysis of variance for S/N ratio is summarized in Table 7 and it is observed that arc current is the most prominent factor which effects tensile strength maximum with percent contribution of 47% followed by root gap with percent contribution 21% then gas flow rate with percent contribution 17%.

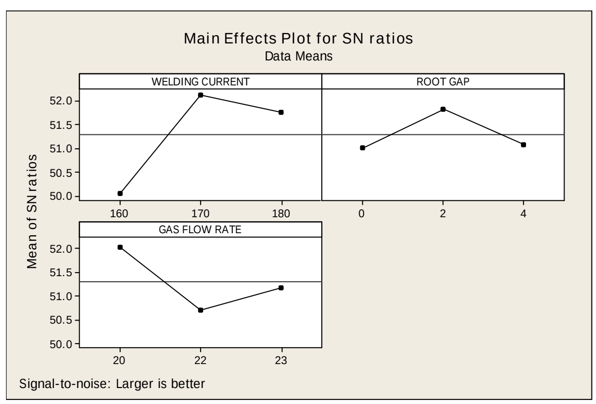

Fig. 6. Effects of process parameters on tensile strength S/N ratio.

Table 7: Analysis of Variance for Signal to Noise Ratio.

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
Arc Current	2	7.364	7.364	3.682	1.67	0.374	47
Root Gap	2	3.240	3.240	1.62	0.28	0.780	21
Gas Flow Rate	2	2.636	2.636	1.3179	0.60	0.625	17
Residual Error	2	1.397	1.397	0.698			15
Total	8	15.637					

The response values for S/N ratio for each level of identified factors have been listed in Table 8 which, shows the factor level values of each factor and their ranking.

Hardness. The samples used for measuring Hardness are first rubbed with emery paper of size no. 400, 600, 1000 & 2000 and then cleaned with acetone solution. The diagonals of the indents formed by pyramid-shaped diamond indenter on the samples

Table 8: Response Table for Signal to Noise Ratio of Tensile Strength.

Level	CURRENT (Amp.)	Root gap (mm.)	Gas Flow Rate
1	50.04	51.01	52.02
2	**52.12**	**51.83**	**52.72**
3	51.75	51.07	51.17
Delta	2.08	0.82	1.30
Rank	1	3	2

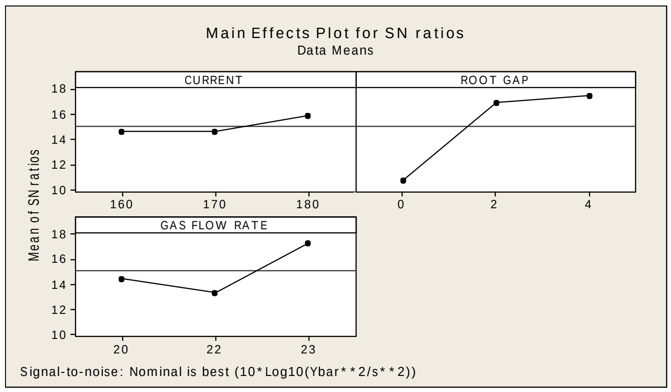

Fig. 7. Effects of process parameters on Hardness S/N ratio.

Analysis of variance for S/N ratio is summarized in Table 9 and it is observed that root gap is the most prominent factor which effects Hardness maximum with percent contribution of 57% followed by current with percent contribution 21% then gas flow rate with percent contribution 17%. The response values for S/N ratio for each level of identified factors have been listed in Table 10 which shows the factor level values of each factor and their ranking.

Table 9: Analysis of Variance for Signal to Noise Ratio of Hardness.

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
Arc Current	2	30.373	30.373	15.186	0.09	0.918	21
Root Gap	2	85.383	85.383	42.692	2.26	0.307	57
Gas Flow Rate	2	25.448	25.448	12.724	0.67	0.593	17
Residual Error	2	8.823	8.823	4.411			5
Total	8	150.027					

Table 10: Response Table for Signal to Noise Ratio for Hardness.

Level	Current (Amp.)	Root Gap (mm)	Gas Flow Rate
1	14.66	10.74	14.49
2	14.64	17.00	13.39
3	**15.95**	**17.52**	**17.38**
DELTA	1.31	6.78	3.99
RANK	3	1	2

IV CONCLUSION

The mild steel 1020 was used for the present study to explore the different input process parameters on the tensile strength and hardness of the weld samples. The L9 orthogonal has been used to assign the identified parameters. The highest tensile strength obtained in the research is 477.72 at current (170 amp), gas flow rate (20) and root gap (4 mm). The maximum hardness is obtained at a welding current (170 amp), gas flow rate (22) and root gap (0 mm). So according our results we can conclude that our weldments have lower hardness because both pearlite are soft constituents & there is no sign of formation of Martensite.

REFERENCES

[1]. Juang SC, Tarng YS. Process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel. J Mater Process Technol **122** (2002) 33-37.

[2]. Cary HB. 2nd ed. Modern welding technology. *AWS.* (1981). 82-85.

[3]. P.J. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill, New York, 1988.

[4]. G. Taguchi, Introduction to quality Engineering, Asian Productivity Organisitaion, Tokyo, 1990.

[5]. G.S. Peace, Taguchi Methods: A hand-on Aproach, Assison- Wesley, Reading, M.A, 1993.

[6]. K. Suresh Kumar, G. Phani Kumar, P. Dutta, K. Chattopadhyay (2002), "Microstructural development of Dissimilar Weldments: Case of MIG Welding of Cu with Fe filler", *Journal of Materials Science*, Vol. **37**, pp. 2345-2349.

[7]. G. Haragopal, PVR Ravindra Reddy, G Chandra Mohan Reddy, J V Subrahmanyam (2011), "Parametric design for MIG welding of Al- 65032 alloy using Tagauchi Method ", *Journal of Scientific and Industrial Research*, Vol. **70**, pp.844 – 850.

[8]. S.V.Sapakal, M.T. Telsang (2012), "Parametric Optimization of MIG Welding Using Taguchi Design Method", International Journal of Advanced Engineering Research and Study, Vol. 1, pp.28-30.

[9]. "Welding Process and technology" R.S. Parmar, Khanna Publishers, ISBN No. 81-7409-126-2.

[10]. "A Course in workshop technology", B.S. Raghuwanshi, Dhanpat Rai & Co. 2008 Edition.

[11]. "A Text book of Welding Technology", O.P. Khanna, Dhanpat Rai Publications, Edition 2005.