Parametric Optimization of Gas Metal Arc Welding Process Using Activated Flux for SS 304 by Taguchi Method

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ABSTRACT: Gas metal arc welding has wide application in industries due to its advantages such as high reliability, all position welding capability, low cost, high productivity etc. To increase the productivity and decrease the cost advanced techniques are used in welding. Activating flux is a concept, which used in different welding process like GTAW, EBW, LBW, and PAW. The flux ingredient, which is inorganic compound (which can be used to produce deep penetration and arc constriction) are available in variety of range and compositions. In the present work, an attempt has been made to use of activated flux for improving depth-to-width ratio as well strength of welding joint. Taguchi gives optimum values of process parameters which will better performance of weld joint.

Key words: Welding, Penetration, Depth-to-width ratio, Strength.

I. INTRODUCTION

Gas Metal Arc Welding (GMAW) is an arc welding process that joins metals together by heating them with an electric arc that is established between a consumable electrode (wire) and the work piece. An externally supplied gas or gas mixture acts to shield the arc and molten weld pool. Although the basic GMAW concept was introduced in the 1920s, it was not commercially available until 1948. At first, it was considered to be fundamentally a high current density, small-diameter, bare-metal electrode process using an inert gas for arc shielding. Its primary application was aluminum welding. As a result, it became known as metal-inert gas (MIG) welding, which is still common nomenclature. Subsequent process developments included operation at low current densities and pulsed direct current, application to a broader range of materials, and the use of reactive gases (particularly CO_2) and gas mixtures. The latter development, in which both inert and reactive gases are used, led to the formal acceptance of the term gas-metal arc welding. The GMAW process can be operated in semi-automatic and automatic modes. All commercially important metals, such as carbon steel, high-strength low-alloy steel, stainless steel, and aluminum, copper, and nickel alloys can be welded in all positions by this process if appropriate shielding gases, electrodes, and welding parameters are chosen [5].

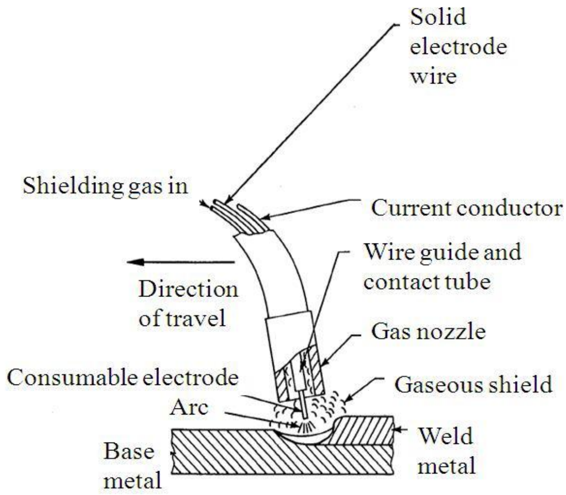

Fig 1: GMAW Process

II. A-GMAW PROCESS DESCRIPTION

The study was concerned with the activating flux gas metal arc welding. The flux ingredient, which is inorganic compound (which can be used to produce deep penetration and arc constriction) are available in variety of range and compositions. Some of fluxes have been reported effective for particular materials. Activating fluxes contain oxides and halides (chlorides and fluorides). Oxide coating consists of iron, chromium, silicon, titanium, manganese, nickel, cobalt, molybdenum and calcium are reported to improve weld ability and increase the welding speed. The halogens, calcium fluoride and AlF_2, have claim to constrict the arc and increase weld depth of penetration Activated flux is a mixture of inorganic material suspended in volatile medium (acetone, ethanol etc.). Inactivated flux GMAW process, a thin layer of the fine flux is applied on the surface of the base metal with brush before welding. Flux mixed with acetone to make it in a paste form as shown in the Fig 2 During activated flux, welding a part or all the fluxes is molten and vaporized. There is different types of fluxes (oxides) used in welding like Fe_2O_3, SiO_2, $MgCO_3$, Al_2O_3 etc. As a result, the penetration of the weld bead is significantly increased [6].

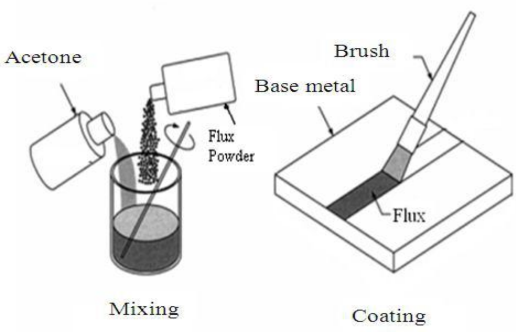

Fig 2: Method Of Applying Flux

III. EXPERIMENTAL PROCEDURE

Design of experiments has become an important methodology that maximizes the knowledge gained from experimental data by using a smart positioning of points in the Engineering. This

methodology provides a strong tool to design and analyze experiments; it eliminates redundant observations and reduces the time and resources to make experiments.
The design of experiment based on

- Factorial design
- Taguchi method
- Response surface method

Chemical Composition of SS 304 are shown in Table 1.

Table 1. Chemical Composition of SS304

USN	ASTM	C%	Mn%	Si%	S%	P%	Cr%	Ni%	N%
S30400	304	0.07 max	2.0 max	0.75	0.03 max	0.045	17.5-19.5	8.0-10.5	0.1

As per welding machine capability welding process parameters were selected on ASME SEC-IX.

Table 2. Welding process variables and experimental design levels used

Variable	Notation	Unit	Level 1	Level 2	Level 3
Welding Current	A	A	240	260	280
Arc Voltage	V	V	26	28	30
Welding Speed	S	mm/min	220	240	260

Taguchi is the one of the Design of Experiment gives orthogonal array without using activated flux given below.

Table 3. Taguchi L_9 Orthogonal array for experimental runs without activated flux

Experiment. No	Welding current (Amp)	Arc Voltage (Volt)	Welding Speed (M/Min)
1	240	26	220
2	240	28	240
3	240	30	260
4	260	26	240
5	260	28	260
6	260	30	220
7	280	26	260
8	280	28	220
9	280	30	240

For improving penetration activated flux is the best way to increase depth-to-width ratio of welding joint which will gives lesser cost of the weld joint. Ultimately reduce the number of passes of welding joint. With the help of $MgCO_3$ on base material was been used for improve penetration. With the help of TiO_2 on base material was been used for improve penetration before comesement of welding.

Table 4. Taguchi L_9 Orthogonal Array for Experimental runs with $MgCO_3$ and TiO_2

Experiment No.	Welding current (Amp)	Arc Voltage (Volt)	Welding Speed (M/Min)
1	240	26	220
2	240	28	240
3	240	30	260
4	260	26	240
5	260	28	260
6	260	30	220
7	280	26	260
8	280	28	220
9	280	30	240

IV. RESULT AND ANALYSIS

After performing analysis of different part of welding joint with various parameters such as welding current, arc voltage and welding speed with and without activated flux in orthogonal array (L_9) and finding out best way to improve penetration of welding joint. Activated flux ($MgCO_3$, TiO_2) were investigated based on variability depend on welding machine range.

Table 5. Results of S/N ratio for penetration of without activated flux

Experiment No	Without Activated Flux		With $MgCO_3$		With TiO_2	
	SN Ratio	Mean	SN Ratio	Mean	SN Ratio	Mean
1	9.8942	3.124	12.9828	4.458	13.9620	4.990
2	10.2243	3.245	12.8631	4.397	11.4109	3.720
3	10.4332	3.324	4.445	12.9574	13.0643	4.500
4	10.4619	3.335	4.582	13.2211	12.1061	4.030
5	10.9948	3.546	4.825	13.6699	13.3304	4.640
6	10.7715	3.450	4.475	13.0159	11.9977	3.980
7	10.7815	3.442	4.805	13.6339	12.7498	4.340
8	10.7614	3.452	4.520	13.1028	12.1491	4.050
9	10.4332	3.421	4.487	13.0391	10.8814	3.500

Minitab offers four types of designed experiments: factorial, response surface, mixture, and Taguchi (robust). The step follow in Minitab to create, analyze, and graph an experimental design are similar for all design types. After conducting the analysis and entering the results, Minitab provides several analytical and graphing tools to help understand the results.
Below graphs indicated SN ratio and Mean value of without using activated flux and with TiO_2, $MgCO_3$ are given below.

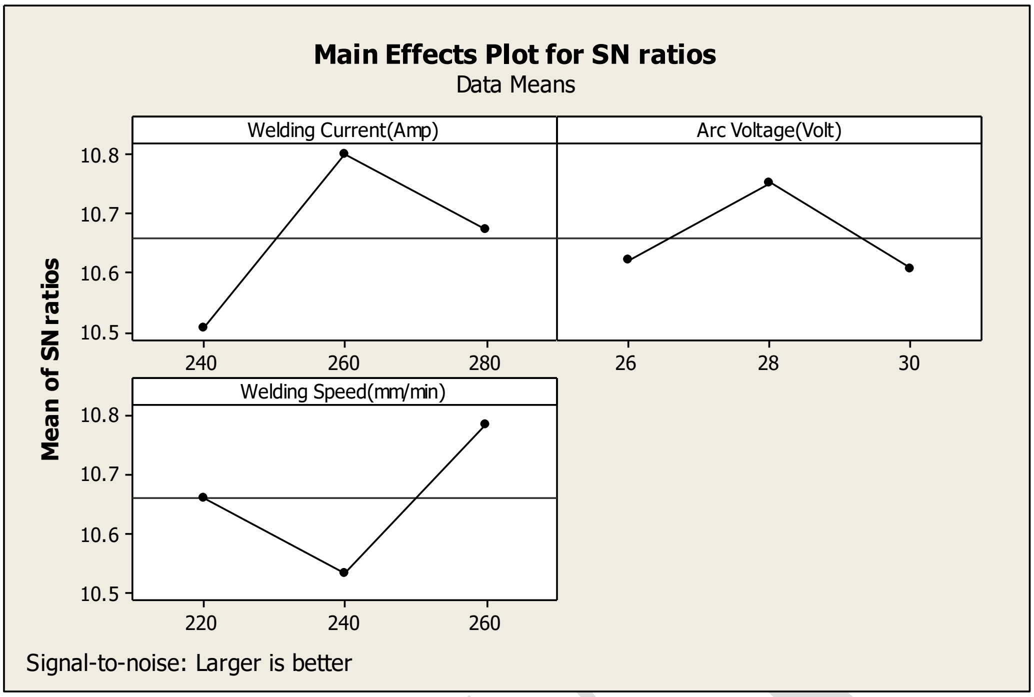

Fig 3: Main effects plot for SN ratios of Penetration of without activated flux

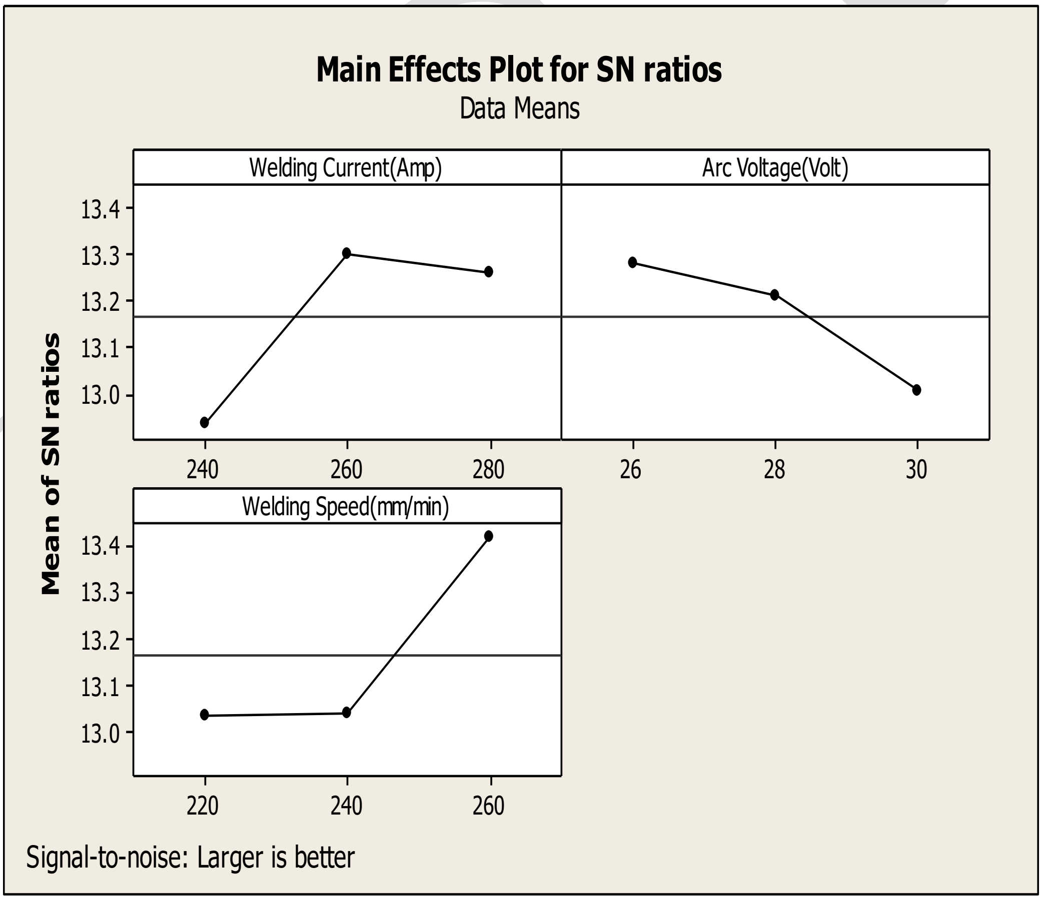

Fig 4: Main effects plot for SN ratios of penetration of with $MgCO_3$

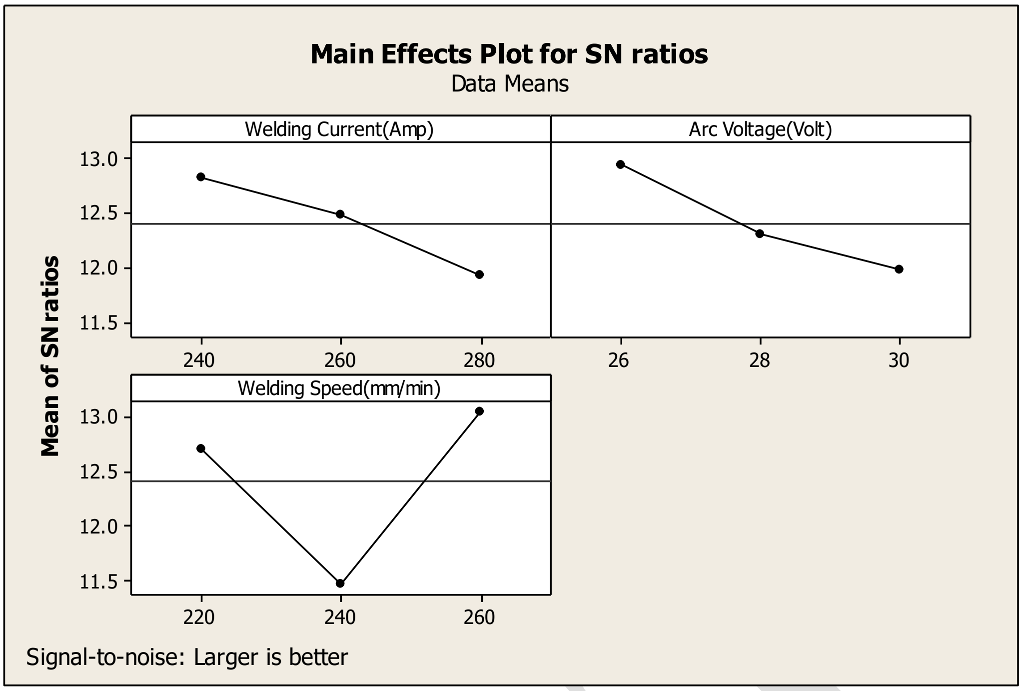

Fig 5: Main effects plot for SN ratios of Penetration with TiO_2

ANOVA gives parentage contribution of each process parameters on out put value. Result of penetration without activated flux are given in Table 6 which gives most affected parameter.

Table 6. Results of ANOVA for penetration without activated flux

Notation	Sources of variation	DOF	Sum of squares S	Variance (mean Square)	Variance ratio F	Percentage contribution P
C	Factor A	2	0.01832	0.00916	7.328	44.229
A	Factor B	2	0.00603	0.003015	2.412	14.558
S	Factor C	2	0.01456	0.00728	5.824	35.155
Error	Error E	2	0.00251	0.00125	1	6.0598
	Total	8	0.041426			100

Table 6 shows the percentage contribution of individual parameters on Penetration. The percentage contribution of Welding Current is 44.22 %, Arc Voltage is 14.55% and Welding Speed is 35.15 % parametric analysis is carried out for the quality of the sample. i.e. Penetration.

Table 7. Results of ANOVA for penetration

Notation	DOF	Sum of squares S	Variance (mean Square)	Variance ratio F	Percentage contribution P	DOF
C	2	0.06730	0.03365	8.04446	34.5376	2
A	2	0.03497	0.017485	4.1800	17.9456	2
S	2	0.08423	0.042115	10.06813	43.2245	2
Error	2	0.008366	0.004183	1	4.2932	2
	8	0.194866			100	8

Table 7 shows the percentage contribution of individual parameters on Penetration. The percentage contribution of Welding Current is 34.5376 %, Arc Voltage is 17.9456 % and Welding Speed is 43.2245 % parametric analysis is carried out for the quality of the sample. i.e. Penetration.

Table 8. Results of ANOVA for penetration without activated flux

Notation	DOF	Sum of squares S	Variance (mean Square)	Variance ratio F	Percentage contribution P	DOF
C	2	0.29345633	0.146728	1.488207	16.7955	2
A	2	0.332423	0.1662115	1.68582101	19.02579	2
S	2	0.924156	0.462078	4.686684	52.8928	2
Error	2	0.19718767	0.0985938	1	11.28577	2
	8	1.747223			100	8

Table 8 shows the percentage contribution of individual parameters on Penetration. The percentage contribution of Welding Current is 16.7955 %, Arc Voltage is 19.02579 % and Welding Speed is 52.8928 % parametric analysis is carried out for the quality of the sample. i.e. Penetration.

V. CONCLUSION

- The work presented in this thesis has focused on optimization of process parameter of a GMAW process with most emphasis on finding optimal welding parameter for Penetration using Activated Flux.
- One of the aim of this research was to find out the Penetration of the weld joint, and also the find out which parameter is most effective on tensile strength of the weld joint using Activated flux.
- The experiment was carried out by three processing parameter And with and without Activated Flux that the Welding Current, Arc Voltage and Welding Speed the study presented that the Welding Current, Arc Voltage and Welding Speed this three parameter are affecting the Penetration of the weld joint of gas metal arc welding process.
- After the welding with using Activated Flux it was investigated that $MgCO_3$ play a noticeable effect on Penetration and also it was passed tests like Macro Test, DP, X-Ray Test, Tensile Test, Impact test.
- By ANOVA analysis conclude that our optimum set parameters Welding Current, Arc Voltage, Welding Speed and Activated Flux is 260 Amp, 28 Volt, 260 mm/min with $MgCO_3$ Activated Flux gives lesser errors.

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