Parametric Study and Optimization of MIG Welding on SS304 Using Taguchi Method

Prof. Jitendra K. Prajapati[1] Mistry Kush P.[2]
[1]Assistant Professor [2]Student
[1,2]Department of Mechanical Engineering
[1,2]Monark University, Ahmedabad, India

Abstract — Many different types of industrial processes make use of the Metal Inert Gas (MIG) welding technique. The most important factors that determine the quality, productivity, and cost of welding are the GMA welding parameters. We assessed the welded metal's quality using the MIG technique. Using SS304 as my material of choice, I will study how changing the current, voltage, and wire speed impacts the width and height of the beads. A Taguchi L9 orthogonal array with three levels of input parameters was used to design the experiment. Analysis of variance (ANOVA) will be performed to interpret the results, with the optimal parameters chosen based on the signal-to-noise ratio. This will validate the experimental outcome. Determine the input parameter's most significant impact on the output parameter.

Keywords: Tig welding, Anova, Taguchi method, Minitab, Stainless Steel

I. Introduction

Metal inert gas, or MIG, refers to gas metal arc welding where the shielding gas is inert, such as argon. A gas is referred to be MAG (metal active gas) when it contains an active component, such CO2. In Europe, MIG/MAG or just MIG welding is the more frequent name for the process.

Despite its prevalence in thin sheet welding, the method finds extensive application throughout a spectrum of plate thicknesses. This is because of its relatively high output and its simplicity of starting and stopping. This approach is preferable to stick electrode (MMA) welding because it does away with the hassle of cleaning up slag and changing electrodes.

In metal-arc gas welding, also known as MAG welding, a metallic wire is heated in an arc and then passed through a welding gun. The wire carries current and fills gaps in welds simultaneously. The welding arc is powered by electrical energy that is supplied by a power source. A protective gas, either inert or active, encircles the arc and the pool of molten metal to keep them safe. Gases that do not react chemically when combined with liquids are called inert gases.

II. Objective

- To perform MIG welding on SS304 material (3 mm thickness).
- To design experiments using the Taguchi L9 method.
- To analyze data using Minitab software.
- To study the effect of welding parameters (current, voltage, gas flow rate).
- To measure bead width and bead height.
- To find the optimal welding parameters for better weld quality.

III. Design of Experiment

Determining the best potential combination of variables is the main objective of a DOE experiment, which involves defining and testing all conceivable combinations. Various components are listed with their corresponding levels in this. One wonderful use of design of experiments is to combine materials at appropriate amounts, within their respective acceptable ranges, such that the results are maximised with low variation around the best results. Using the design of experiment, the several conditions that are going to be studied are put out. An experiment design must accomplish two goals: first, it must specify the total number of trails; and second, it must detail the conditions under which each trail will operate. It is essential to have a solid grasp of the researched product or process before developing an experiment design. You can learn more about the factors that may affect the outcome by doing this. The Design of Experiments (DOE) is a method for identifying and fixing process issues, finding the most important process elements, and learning the probability of estimating interactions.

A. *Taguchi design*

Taguchi suggests an experimental design that saves time and resources by collecting the data needed to determine which factor most affects product quality with a minimum amount of experimentation. It uses an orthogonal array to organise the process parameters and the levels at which they should be varied.

1) *Process Parameters*

Input Parameter:
- Factor A: Welding Current (Amp)
- Factor B: Voltage (V)
- Factor C: Gas flow rate (LPM)

Constant parameter:
- Work Piece Thickness

Output Parameter:
- Bead Width
- Bead Height

Thickness	Parameters	Level1	Level2	Level3
3mm	Welding Current	150	170	190
	Voltage	23	25	27
	Gas Flow Rate	12	15	18

Table 1: Process Parameter Level

Ex.No.	Welding Current (A)	Voltage (V)	Gas Flow Rate (LPM)
1	150	23	12
2	150	25	15
3	150	27	18
4	170	23	15
5	170	25	18

6	170	27	12
7	190	23	18
8	190	25	12
9	190	27	15

Table 2: Taguchi Design Factor

IV. EXPERIMENTAL WORK

A. Working Procedure

- Material selection
- Material testing

B. Specimen Preparation

- Experiment work
- Testing result

Fig 1: MIG Welding Machine set-up

C. Work Piece Detail

This analysis is focused on SS304 due to its extensive usage in the process industry. A thickness of 3 mm has been selected for the material.A 60 mm x 40 mm specimen was selected in accordance with ASTM standards.

Fig. 2: The SS304 material thicknesses used for the work piece

Welding performance of tig welding machine

Fig. 3: welded work

Checking the work part's penetration after welding is done visually. Rejects are made due to insufficient penetration specimens. Using a travelling microscope to examine the width and height of beads allows one to investigate the impact of welding conditions on bead geometry.

Ex. No.	Welding Current	Voltage	Gas Flow Rate	Bead Width	Bead Height
1	40	23	2.4	5.12	4.17
2	40	25	3.2	4.53	4.30
3	40	27	4.0	4.95	4.14
4	40	23	4.8	4.55	4.12
5	60	25	2.4	5.21	4.62
6	60	27	3.2	4.64	4.56
7	60	23	4.0	5.08	5.03
8	60	25	4.8	5.22	4.92
9	70	27	2.4	5.88	5.00

Table 3: Experiment Work

EX.NO.	BEAD WIDTH (mm)	S/N RATIO B.W.	BEAD HEIGHT (mm)	S/N RATIO B.H.
1	4.00	-12.0412	2.01	-6.06392
2	3.57	-11.0534	1.71	-4.65992
3	3.93	-11.8879	1.82	-5.20143
4	4.19	-12.4443	3.03	-9.62885
5	3.62	-11.1742	1.57	-3.91799
6	3.94	-11.9099	1.75	-4.86076
7	4.86	-13.7327	1.51	-3.57954
8	4.35	-12.7698	1.15	-1.21396
9	4.20	-12.4650	1.47	-3.34635

Table 4: A ratio of SN for the width and height of beads

V. RESULTS & DISCUSSION

A. Bead Width Effect

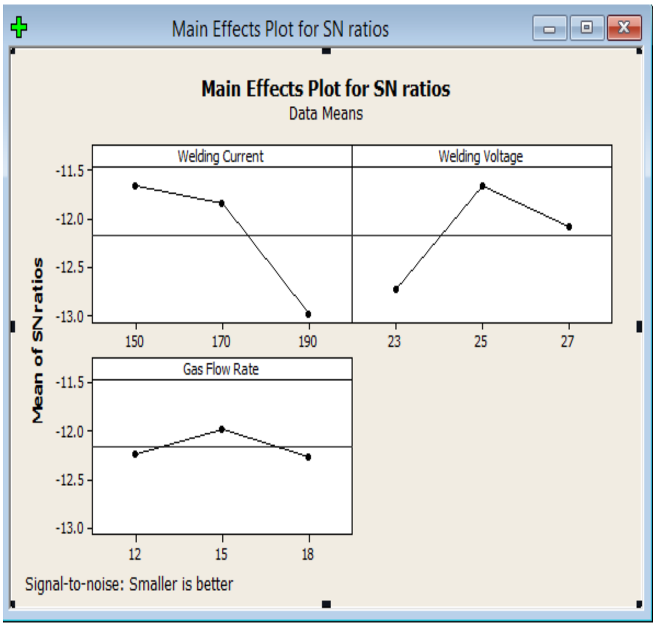

Fig. 4: Main Bead Width Effect Plot

B. Effect of Bead Height

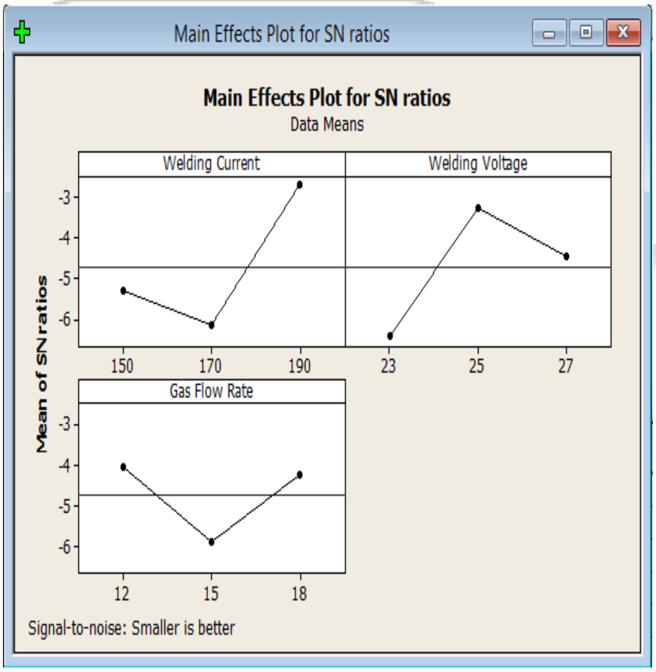

Fig. 5: Main effect plot of bead height

VI. CONCLUSION

The breadth and height of beads on SS304 material with a plate thickness of 3 mm were measured in the current inquiry using minitab and anova analysis. The L9 orthogonal array is used to perform tests by welding current and gas flow rate. The experimental data was assessed using Minitab 16.

The analysis has led to the following conclusions. Process settings have different effects on each answer. The significant parameter and its percentage contribution are influenced by the behaviour of the parameter with the objective response.

According to the testing results, the highest bead width (4.86 mm) was obtained at welding current of 190 AMP, voltage of 23 V, and gas flow rate of 18 LPM, while the lowest bead width (3.57 mm) was obtained at welding current of 150 AMP, voltage of 25 V, and gas flow rate of 15 LPM. Additionally, 190 AMP of welding current, 25 V of voltage, and a gas flow rate of 12 LPM produced the lowest bead height (1.15 mm); 170 AMP of welding current, 23 V of voltage, and 15 LPM of gas flow rate produced the maximum bead height (3.03 mm).I have determined that the most important factor affecting output parameters is the welding current based on Anova analysis and experimental data. When compared to welding current, voltage and gas flow rate have the least impact on output characteristics, while voltage has a greater impact than gas flow rate.

ACKNOWLEDGEMENT

Verbalising gratitude is short of conveying the full extent of one's emotions. Words spoken from the depths of one's soul can accomplish much, but just that.Here's another modest attempt at the same. To begin, I would like to sincerely thank my esteemed advisor, Professor Jitendra Prajapati, who has been an invaluable resource to me during my studies at Monark University's Department of Mechanical Engineering. While we were working on the project, he provided me helpful suggestions and encouraged me to speak my mind. Finding a topic for my dissertation's first part was an educational experience in and of itself.

Last but not least, I owe a great debt of gratitude to my parents, who always had my back and gave me the strength I needed, as well as to all my friends, who have assisted me in any way, shape, or form throughout this project.

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