Experimental Investigation and Optimization of Welding Parameters for A TIG Welding With SS316 Using Taguchi Method

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Abstract— Tungsten Inert Gas welding is one of the most widely used techniques for joining ferrous and non-ferrous metal. In which the arc is generated between a non-consumable tungsten electrode and work-piece, and the molten metal is protected from the atmosphere by using the shielding of inert gas argon. In this project SS316 sheet material having 2 mm thickness were weld using TIG welding. The input parameter chosen welding current, welding voltage and gas flow rate And Output Parameter is Front width and Hardness. The Taguchi method advocated the use of orthogonal array design to assign the factors chosen for the experiment. 9 experiments have been designed using L9 orthogonal array of Taguchi method. Analysis of variance (ANOVA) and signal-to-noise (S/N) ratio have been employed to investigate & optimize the welding parameters. After analysis we find most significance control factor for front width and back width.

Keywords: Tig Welding, Anova, Taguchi Method, Minitab, Stainless Steel

I. INTRODUCTION

Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of filler material. The result is a continuity of homogeneous material, of the composition and characteristics of two-part which are being joined together. The application of welding are so varied and extensive that it would be no exaggeration to say that there is no metals industry and no branch of engineering that does not make use of welding in one form or another. In fact, the future of any new metal may depend on how far it would lend itself to fabrication by welding. The term "weldability" has been defined as the capacity of being welded into inseparable joints having specified properties such as definite weld strength, proper structure, etc. This means, of course, that if a particular metal is to have food weldability, it must be welded readily so as to perform satisfactorily in the fabricated structure.

II. DESIGN OF EXPERIMENT

DOE is a technique of defining and investigating all the possible combinations in an experiment involving multiple factors and to identify the best combination. In this, different factors and their levels are identified. Design of experiments is also useful to combine factors at appropriate levels, each within the respective acceptable range to produce the best results and yet exhibit minimum variation around the optimum results. The design of experiment is used to develop a layout of the different conditions to be studied. An experiment design must satisfy two objectives: first the number of trails must be determined and second the conditions for each trail must be specified. Before designing an experiment, the knowledge of the product/process under investigation is prime importance for identifying the factors likely to influence the outcome. The Design of Experiments (DOE) is a method to identify the important factors in a process, identify and fix the problem in a process, and also identify the possibility of estimation interactions.

A. Taguchi Design

This experiment design proposed by Taguchi involves using orthogonal array to organize the parameters affecting the process and the levels at which they should be varied; it allows for the collection of the necessary data to determine which factor most affect product quality with a minimum amount of experimentation, thus saving time and resources.

B. Process Parameters

Input Parameter:

1) Factor A: Welding Current
2) Factor B: Welding Voltage
3) Factor C: Gas Flow Rate

Constant parameter:

1) Work Piece Thickness

Output Parameter:

1) Front Width
2) Hardness

Thickness	Parameters	Level1	Level2	Level3
2mm	Welding Current	80	90	100
	Welding Voltage	18	22	24
	Gas Flow Rate	1.5	2.5	3.5

Table I: Process Parameter Level

Ex. No.	Welding Current	Welding Voltage	Gas Flow Rate	Plate Thick Ness
1.	80	18	1.5	2
2.	80	22	2.5	2
3.	80	24	3.5	2
4.	90	18	2.5	2
5.	90	22	3.5	2
6.	90	24	1.5	2
7.	100	18	3.5	2
8.	100	22	1.5	2
9.	100	24	2.5	2

Table II: Taguchi Design Factor

III. EXPERIMENTAL WORK

A. Working procedure

- Material selection
- Material testing
- Specimen preparation
- Experiment work

– Testing result

B. TIG welding machines specifications are as

– Make-HALLMARK
– Code- TIG 200A
– Volatge-230 V AC
– Curent-25-200 A
– Electrode-Tungsten

Fig. 1: TIG Welding Machine set-up

C. Welding Torch

Specifications of the welding torch which is used for these experiments are Forced Air cooled cooling system Collets for 0.8-1.6. Φ electrode.

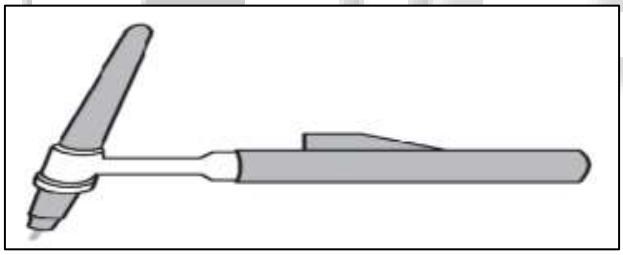

Fig. 2: Welding Torch

D. Material selection

Material selected for welding trials and experiments is SS316. Austenitic Cr-Ni stainless steel has Better corrosion resistance than Type 302. High ductility, excellent drawing, forming, and spinning properties. Essentially non-magnetic, becomes slightly magnetic when cold worked. Low carbon content means less carbide precipitation in the heat-affected zone during welding and a lower susceptibility to intergranular corrosion.

Chemical	3mm
%C	0.08
%Mn	2.00
%Si	0.75
%Cr	16.00-18.00

Table III: Chemical Composition

Density	8 gm/cc	Chemical	3mm
Melting Point	1450°C	%C	0.08
Thermal Expansion	17.2 x 10^{-6}/K	%Mn	2.00

Table IV: Physical properties of SS316

E. Work piece detail

For study SS316 is selected, as it has a very large scale application in the process industry. The material selected thicknesses as 2mm.The specimen size selected is 60mm X 40mm as per ASTM standards.

Fig. 3: Thicknesses of work piece material of SS316

F. Welding performance of tig welding machine

Fig. 4: Welded Job

After welding the work pieces, penetration is checked by visual observations. Specimens with improper penetration are rejected. The effect of welding parameters on Bead Geometry is studied by measuring front width and back width by using Travelling microscope

Fig. 5: Travelling Microscope

E- eyepiece V- Vernier
O- objective R- rail
K- knob of focusing S- screw

Ex.No	Welding Current	Welding Voltage	Gas Flow Rate	Plate Thick Ness	Front Width	Hardness
1	80	18	1.5	2	5.15	65.33
2	80	22	2.5	2	5.04	90.33
3	80	24	3.5	2	4.35	83.66
4	90	18	2.5	2	4.90	77.33
5	90	22	3.5	2	5.41	88.33
6	90	24	1.5	2	5.75	93.00
7	100	18	3.5	2	5.95	94.33
8	100	22	1.5	2	6.10	105.33
9	100	24	2.5	2	5.80	115.00

Table V: Experiment

IV. OBJECTIVES

1) I have selected SS316 sheet material With Thickness 2mm for carried out the experiment.
2) Selected Taguchi Method With L9 Orthogonal Array
3) Minitab software is used for analyze the experimental data
4) Prepare Tig Welding Job And Find out front width and Hardness of Welding Job
5) Analyze effect of welding process parameter on the weld bead geometry and optimize the process parameter with this work.

V. CONCLUSION

- In present study parametric analysis has been carried out for front width and hardness on SS316 material. Experiments are carried out using Taguchi Method by varying welding current, welding voltage and gas flow rate for 2mm thickness of SS316 material. Minitab 16 software was used for analyze the experimental data.
- I have concluded that at welding current(100A), welding voltage(22V) and gas flow rate(1.5LPM), at that point measure the maximum F.W.(6.10 mm) and welding current(80A), welding voltage(24V) and gas flow rate(3.5 LPM), at that point measure the minimum F.W.(4.35 mm).and at the welding current(100A), welding voltage(24V) and gas flow rate(2.5 LPM), at that point measure the maximum hardness(115 HRB) and welding current(80A), welding voltage(18V) and gas flow rate(1.5 LPM), at that point measure the minimum hardness (65.33 HRB)
- Welding current increase with increase front width and gas flow rate and voltage increase with increase front width up to certain limit then after decrease.
- Welding current and voltage increase with increase hardness and gas flow rate increase with increase hardness up to certain limit then after decrease
- Welding current is most significant control factor front width and hardness.

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