Experimental Determination and Optimizing The Process Parameters Of AISI 304 Using GTAW

[1]Matam.Prasad [2]Y.Madhu Maheswara Reddy
[1]Asst.Professor, [2]Asst.Professor
[1]Department of Mechanical Engieering
[1]Methodist College Of Engineering And Technology

Abstract: The effects of various process parameters on Weld ability of Stainless Steel are studied for Tungsten Inert Gas Welding process by adapting Automation Mechanism. Major welding process parameters including Current, Gas flow rate, and Travel speed are varied and their effect on Tensile strength and Hardness will be examined using a systematic design of experiment method known as "Taguchi Robust Design Method". The combinations of three factors and three levels of these factors are tested in the experiment and the corresponding welded specimens are tested for Tensile strength. As an experimental method to estimate the weld strength and quality, the three - stage, sliding level design of experiment is used to consider the linear effects of the process parameters. Through the analysis, Graphical models are established in MINITAB V.16 Software, based on which the influences of the welding parameters on the weld joint strength are discussed. The significance of the process abnormalities and the recommendations for better weld quality are also presented.

IndexTerms – Adapting Automation Mechanism, Taguchi Robust Design Method, MINITAB V1.6.

I. Introduction

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation

II. GTAW

The necessary heat for Gas Tungsten Arc Welding (TIG) is produced by an electric arc maintained between a non-consumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal, and the tungsten electrode are all shielded from the atmosphere by a blanket of inert gas fed through the GTAW torch. Inert gas is that which is inactive, or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. It does not burn, and adds nothing to or takes anything from the metal. Inert gases such as argon and helium do not chemically react or combine with other gases. They possess no odor and are transparent, permitting the welder maximum visibility of the arc. In some instances a small amount of reactive gas such as hydrogen can be added to enhance travel speeds. The GTAW process can produce temperatures of up to 35,000° F/ 19,426° C. The torch contributes only heat to the work piece.

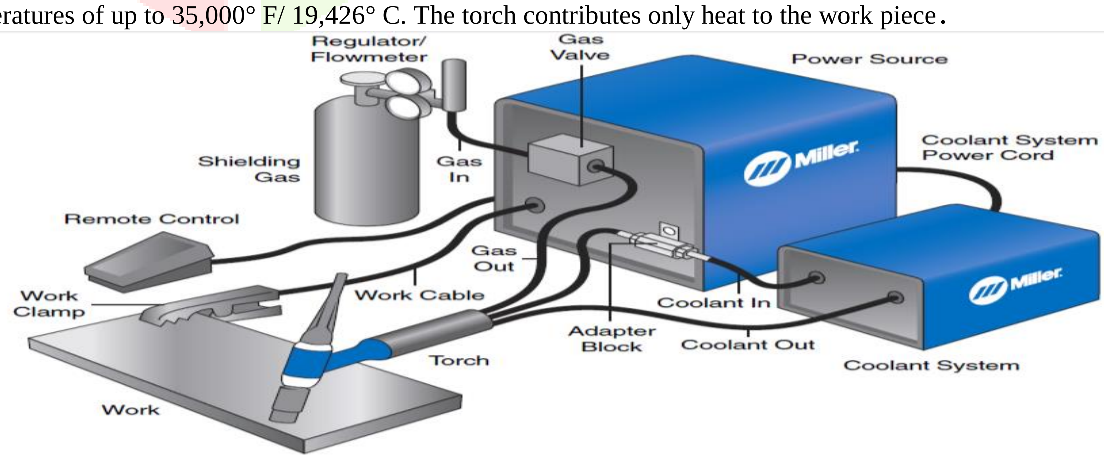

Figure1: Essentials of GTAW Process (water cooled).

III. EXPERIMENTATION

This paper aims at the experimental study on GTAW of AISI304.

Material used: -AISI 304

Specifications of work piece

Length of plate : 150mm

Length of plate : 150mm

Width of plate : 50mm
Thickness of plate: 3mm
Total length : 300mm

Table1: Chemical Composition of AISI304.

Element	c	S	p	Mn	Si	Cr	Ni	Mo	Fe
Percentage	0.08	0.03	0.0045	2	1	18	8	N/A	99.446

Material properties
Yield strength : 215 N/mm^2.
Ultimate tensile strength : 505 N/mm^2.
Hardness : 123BHN

Figure2: GTAW setup.

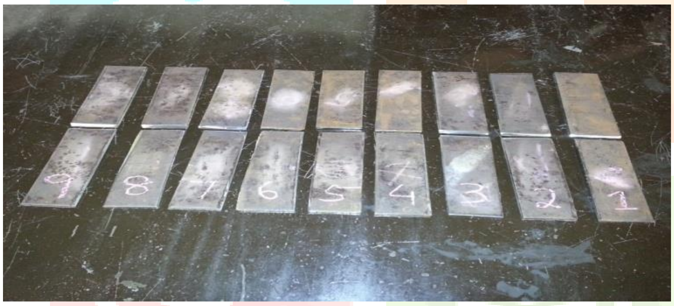

Figure3: Specimens before welding.

Figure4: Types Of Joints SV, SS, VV.

Figure5: Specimens Before Tensile Test.

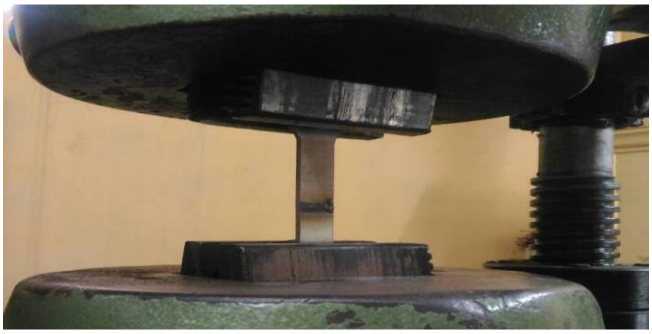

Figure6: Breaking Of Specimen.

Figure7: Specimens after Tensile Test.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

Once the experimental design has been determined and the trials have been carried out, the measured performance characteristic from each trial can be used to analyze the relative effect of the different parameters. To demonstrate the data analysis procedure, the following L9 array will be used, but the principles can be transferred to any type of array. In this array, it can be seen that any number of repeated observations (trials) may be used. Ti, j represents the different trials with i = experiment number and j = trial number. It should be noted that the Taguchi method allows for the use of a noise matrix including external factors affecting the process outcome rather than repeated trials, but this is outside of the scope of this article

Table2: Analysis of Experimental Results Based On Taguchi Method for Hardness

Experiment Number	P1	P2	P3	P4	T1	T2	...	TN
1	1	1	1	1	$T_{1,1}$	$T_{1,2}$	...	$T_{1,N}$
2	1	2	2	2	$T_{2,1}$	$T_{2,2}$	...	$T_{2,N}$
3	1	3	3	3	$T_{3,1}$	$T_{3,2}$	...	$T_{3,N}$
4	2	1	2	3	$T_{4,1}$	$T_{4,2}$	...	$T_{4,N}$
5	2	2	3	1	$T_{5,1}$	$T_{5,2}$	...	$T_{5,N}$
6	2	3	1	2	$T_{6,1}$	$T_{6,2}$	...	$T_{6,N}$
7	3	1	3	2	$T_{7,1}$	$T_{7,2}$	...	$T_{7,N}$
8	3	2	1	3	$T_{8,1}$	$T_{8,2}$	...	$T_{8,N}$
9	3	3	2	1	$T_{9,1}$	$T_{9,2}$	...	$T_{9,N}$

Table3: Analysis of Experimental Results Based on Taguchi Method for Hardness

S. no.	Type of joint	Current(amps)	Welding time(sec)	BHN
1	SS	160	23	254.74
2	SV	160	26	269.28
3	VV	160	29	241.31
4	SS	200	26	254.74
5	SV	200	29	269.28
6	VV	200	23	284.99
7	SS	220	29	241.31
8	SV	220	23	254.74
9	VV	220	26	217.35

Table4: Response table for means

Levels	Current(amps)	Type of Joint	Time of Weld(s)
1	255.1	250.3	264.8
2	269.7	264.4	247.1
3	237.8	247.9	250.6
Delta	31.9	16.6	17.7
Rank	1	3	2

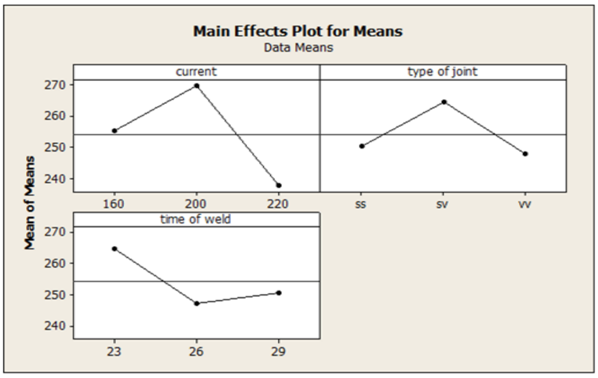

Figure 8: Main Effects plot for means

Factor levels for predictions

Current(V) 200
Type of joint SV
Weld time (S) 23
Factor levels for predictions of hardness is 290.54 BHN
Now comparing the results with initial process parameters

Table5: comparison the results with initial process parameters

	Initial process parameters	Optimal process parameters
Levels	A2B2C1	A2B2C1

Table 6: Analysis of Experimental Results Based on Taguchi Method for Tensile strength

S. no.	Current(amps)	Type of joint	Welding time(s)	Strength (N/mm^2)
1	160	SS	23	182.083
2	160	SV	26	260.582
3	160	VV	29	374.411
4	200	SS	26	230.183
5	200	SV	29	374.836
6	200	VV	23	500.247
7	220	SS	29	379.881
8	220	SV	23	386.415
9	220	VV	26	621.217

Table 7: Response table for means

Levels	Current(amps)	Type of joint	Welding time
1	272.4	875.6	356.2
2	368.4	857.8	370.7
3	462.5	498.6	376.4
Delta	190.1	234.6	20.1
Rank	2	1	3

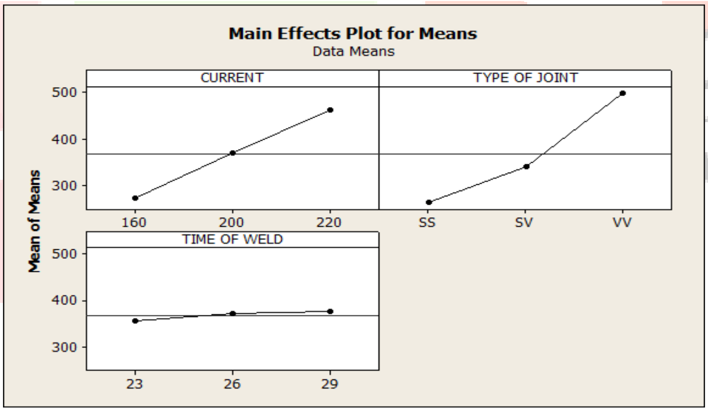

Figure 9: Main Effects plot for means

Current(amps) 220
Type of joint vv
Weld time (S) 29
Factor levels for predictions of Tensile strength is 601.982 N/mm^2
Now comparing the results with initial process parameters

Table8: comparison the results with initial process parameters

	Initial process parameters	Optimal process parameters
Levels	A3B3C3	A3B3C3

V. RESULTS & CONCLUSION

Mechanical behaviour of AISI 304 after GTAW is studied by the Taguchi design of experiment and the optimal value of process variables for a higher hardness are found to be current (200amps) type of joint (SV) welding time(23Secs)

Mechanical behavior of AISI 304 after GTAW is studied by the Taguchi design of experiment and the optimal value of process variables for a higher tensile strength are found to be current (220amps) type of joint (VV) welding time(29Secs)

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