Effect of Process Parameters on Pulse TIG Welding for Stainless Steel 304

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***Abstract*— Stainless steels 304 are preferred to be used in manufacturing automobiles components, thermal power plant, and pressure vessels because of their non-requirement of post hardening process like annealing, good inter granular corrosion resistance, and superior fracture toughness. HAZ (Heat Affected Zone) decreases the strength of the weld thus Pulsed TIG welding is is one of the Welding process that decreases the heat affected zone and thus maximum strength is obtained. Some inherent properties of the material most of the cases reduces the crack growth when the pressure is high and this leads to the increase in automobile components and the pressure vessels efficiency, when it is operated at pressure which is consider to be high. This paper describes the effects of process parameters like current, travel speed, and gas flow rate to improve quality of the weld. In this investigation Taguchi method has been implemented to optimal the output parameters. In Taguchi method, L9 orthogonal array has been used to carry out the experimentation. Further, the experimental results, various positions of the input process parameters are sustain as input to Taguchi and finally the S/N ratio values are observed. Travel speed and weld current are considered to be the most significant parameters. The strength of the weld finally obtained by tensile test.**

Keywords*— *Stainless Steel, Pulsed TIG welding, Taguchi Method, Strength testing.

I. INTRODUCTION

Welding of thin sheets is one of the challenging task in today's engineering field. Perfection is the main cause behind the crucial statement. Three pass or two pass of welding cannot be implemented for joining thin sheet metal f thickness below 4 mm. The effect of above mentioned welding results reduction of tensile strength and hole formation. Optimization of parameters in such cases of welding plays predominant factor. Joining of thin sheet metal by welding process is one of the most important investigation in today's scenario of welding. The main content of this paper is to depict the optimization of process parameter to get the best result of welding A material of stainless steel 304 of thickness 3 mm has been selected just to obtain the best corrosion resistance which leads to increase the span of life of various components of pressure vessels as well as of automobile. Fracture toughness has also been reduced under the condition of high pressure; eliminating initiation of crack as well as crack growth. Initiation of crack and crack growth are the two most vital factors that lead to maximum pressure. HAZ generated in welding is reduced by implementing pulse-TIG welding. To obtain maximum strength rapid cooling and melting is done for various material while performing welding. This also results in to obtain best quality layer, boundary of grain structure. Post analysis process like hardening of material by annealing process is not required. Automatically there is an increase in mechanical strength of the material. To obtain best quality weld; protrusion of weld is made face to root of the weld. Certain parameters like voltage, SOD, welding current, pulse-on-time, pulse-off-time are optimized to obtain best output like tensile strength and hardness of the weld. Taguchi method is one of the optimization tool that has been implemented to carry out less experimental work. Many traditional processes are there which consume more time to carry out the experiment. Taguchi method is a feasible method with respect to other traditional processes. It also decreases the characteristic quality of sensitivity.

In case of pulse current GTA welding toughness is obtained in the microstructure by implementing various process parameters over Ti alloy [1]. Many advantages are obtained for pulse current welding with respect to any other conventional processes. Ti-3Al-2.5 volt tubes alloy has been investigated and analyzed with pulse-TIG and laser cleaning processes. Laser cleaning process has been considered to obtain best quality welding sample [2]. Delta ferrite content is obtained by implementing various parameters in case of pulse-TIG welding. In case of SS plate the off-course as well as shape factors are obtained by implementing orbital welding [4]. Nitrogen gas covers the highest percentage in the shield gas; thus it leads to uses of lowest amount of pulse-current with respect to any other welding position [5]. To obtain porosity free weld-bead radiography screening is made. To optimize weld-pool while welding SS using TIG is one of the important factor. Certain parameters like front height, back height, back width and front width are considered for the weld pool [8]. To weld austenitic steel colmonoy powder has been used for laser cladding. This makes the increase in corrosion resistant or austenitic steel [15]. Thus the above literature reviews try to reveal the various aspect to increase the welding quality for thin sheet material. In a normal welding HAZ obtained in greater amount with respect to pulse-TIG process. To increase the mechanical properties of pressure vessels while carrying out welding HAZ has to be deducted. Finally, to obtain high quality welding product; optimization of process parameters is very essential along with reduction of HAZ.

II. METHOD IMPLEMENTED: TAGUCHI

Taguchi's method involves below mentioned procedure:

a. Determination of Quality Performance and optimization.

b. Identification of Factors and to obtain test results
c. To obtain various levels of Control Factor.
d. To get Experimental Design to obtain procedure for Analysis of Data.
e. To perform Experimental Design.
f. To determine the optimum Input Factors.
g. Prediction the level of performance.

A. Taguchi Design of Experiment (DOE) in MINITAB

While performing the experiments following steps should be followed:

i. Before starting MINITAB, some trial runs has to be performed.
ii. Selection of input process parameters and their various levels.
iii. Create Design of Experiment to perform experiments.
iv. Output results are used for analysis purpose.
v. Optimal parameters are obtained to get the best desired output.

Signal-to-noise ratio	Experimental Goal	Characteristics Data
Better : Large Value	The response is maximized	Obtained Positive Data
Best is Nominal	Response is consider on the bases of Noise to Signal ratios	Either Positive or zero or negative
Best is Nominal (default)	Response is consider on the bases of Noise to Signal ratios	Positive and zero where the standard deviation= 0 and the mean = 0
Best: Smaller Value	Minimum Response	Positive and having a target value= 0

III. EXPERIMENTAL DETAILS

A. EXPERIMENTAL SETUP

In this investigation SS-304 Grade metal has been selected as a work piece material. Butt Welding process is used for carrying out experiment with Pulse-TIG welding. Figure 1 shows the experimental set up in which experiments were carried out.

Figure 1. Experimental Setup

B. WORK PIECE DETAILS

In this investigation SS-304 Grade metal has been selected as a work piece material. The thickness of the material has been considered as 3mm. Butt joining process is used in this Pulse-TIG welding for carrying out the experiment.

C. SELECTION OF PROCESSES PARAMETERS

3 levels of three different parameters has been used to carry out the experiment. Table 2 shows the L_9 orthogonal array for the experiment.

Table 1: Input Parameters

SL. No.	PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
01	Current (Amp)	80	90	100
02	Travel Speed (cm/sec)	5.2	6.5	7.2
03	Gas Flow Rate (lit/min)	8	9	10

Table 2: DOE using Orthogonal Array (L_9)

Sl. No	CURRENT (Amp)	TRAVEL SPEED (mm/sec)	GAP (mm)
1	80	5.2	8
2	80	6.5	9
3	80	7.2	10
4	90	5.2	9
5	90	6.5	10
6	90	7.2	8
7	100	5.2	10
8	100	6.5	8
9	100	7.2	9

D. WORKPIECE AFTER MACHINING

Figure 2 Workpieces after Machining

IV. RESULTS AND DISCUSSION

A. MEASUREMENTS OF ULTIMATE TENSILE STRENGTH

In this experiment SS-304 Grade metal as a work piece has been used. Butt joining process is used in this Pulse-TIG experimental welding. After completing the SS-304 metal welding, we measured the output parameters i.e. Ultimate Tensile Strength of the welded metal. The welded joint efficiency also evaluated in here.

Table 3: Ultimate tensile Strength for each sample

Sl. No.	Current (Amp)	Travel Speed (cm/sec)	Gas Flow Rate (Litre/Minute)	Ultimate Tensile Strength (MPa)
1	80	5.2	8	380
2	80	6.5	9	360
3	80	7.2	10	370
4	90	5.2	9	448
5	90	6.5	10	440
6	90	7.2	8	432
7	100	5.2	10	420
8	100	6.5	8	412
9	100	7.2	9	350

B. GRAPHICAL ANALYSIS

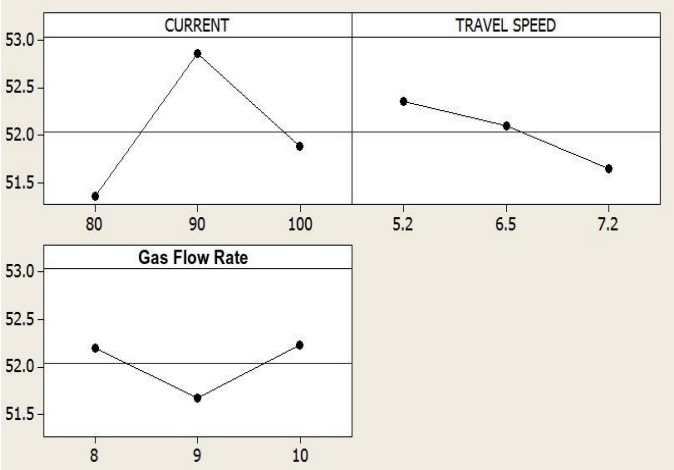

Figure 3: Graphical Analysis for Ultimate Tensile Strength

From the Figure 3 it can be concluded that with increase in current the Ultimate tensile strength increases first and then it decreases. It can be also concluded that with increase in travel speed the ultimate tensile strength decreases and finally with increase in Gas flow rate the ultimate tensile strength first decreases and then increases.

V. CONCLUSION

Pulse TIG is one of the preferred welding process in manufacturing industries. Great care, short arc length, and operating skills are preferred to carry out welding just to prevent the contact between the electrode and the workpieces. Thin stainless steel materials are welded by using Pulse TIG. Pulse TIG is also used for non-ferrous metals like aluminum, copper alloys, and magnesium. The various aspect to increase the welding quality for thin sheet material is performed by Pulse TIG Welding. In a normal welding HAZ obtained in greater amount with respect to pulse-TIG process. To increase the mechanical properties of pressure vessels while carrying out welding HAZ has to be deducted. Finally, to obtain high quality welding product; optimization of process parameters is very essential along with reduction of HAZ.

The health of the welder is affected by the fumes of tungsten and thus automation is preferred for Pulse TIG Welding. Hence, in this investigation a customized setup has been made on Pulse TIG welding. At low cost automated Pulse-TIG can be customized with respect to SPM (Special Purpose machines) that are available in the market.

Therefore, series of experiments has been conducted on SS 304 using the DOE obtained from L9 orthogonal array in Taguchi. The experiments evaluate the following results:

By taking Tensile Strength into consideration, the following combination can be welded to obtain optimized one i.e. 448 MPa:

Gas flow rate 9 litre/minute, Current 90Amps and Travel speed 5.2 mm/sec.

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