Optimization of Process Parameters and Experimental Investigation MIG Welding for Stainless Steel 304 and Mild Steel 2062

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ABSTRACT

This paper presents the influence of welding parameters like welding current, welding voltage, gas pressure on ultimate tensile strength (UTS) of AISI 304 & IS 2062 material during welding. A plan of experiments based on the Taguchi technique has been used. An Orthogonal array, Taguchi design, S/N ratio, and ANOVA are applied to study the welding characteristics of the material and their effects & optimize the welding parameters. The result computed is in the form of contribution from each parameter with the help of Minitab 17, through which optimal parameters are identified for maximum tensile strength. From this work, it is observed that welding current and welding voltage are major parameters that influence the tensile strength of the welded joint. Also studies the effect on microstructure while welding of AISI 304 & IS 2062.

Keywords: - *MIG, AISI 304, IS2062, Taguchi, ANOVA.*

I. INTRODUCTION

The problem that has featured the manufacturer is that the management of the method input parameters to get a good welded joint with the desired weld quality. It's been necessary to check the weld input parameters like welding current, voltages, shielding gas, force per unit area, and speed for welded products to get a welded joint with the desired quality. To do so requires a time-consuming trial and error development method. Then welds are checked whether they meet the requirement or not. Finally, the weld parameters can be chosen to produce a welded joint that closely meets the requirements. .Also, what's not achieved or usually considered is associate optimized welding parameters combination, since welds will usually be shaped with terribly completely different parameters. In alternative words, there's usually a lot of ideal welding input parameter combinations, which may be used. To overcome this problem, various improvement ways will be helpful to define the required output variables by developing mathematical models to specify the link between the input parameters and output variables. The design of experiment (DoE) techniques has been applied to carry out such improvement. Taguchi technique is adapted for several applications in several areas.

II. LITERATURE REVIEW

It is observed that process of welding depends on the process parameters used during the welding process. Various characteristics of the welded material such as Strength, mechanical properties, microstructure depends largely on the proper selection of process parameters. V. Subravel et al. [1] studied the effect of welding parameters on tensile and microstructural characteristics of pulsed current gas tungsten arc welded joints. At lower welding speed; the burn-through of the weld was observed due to higher heat input. They observed that a tensile property of the welded joints gets affected by welding speed. Vineeta Kanwal and R.S.Jadoun et al [2**]** have studied Optimization of MIG Welding Parameters for Hardness of Aluminum Alloys Using Taguchi Method; parametric optimization of MIG welding for Hardness has been performed by using Taguchi method. Welding Speed, Welding Current, and Welding Voltage were chosen as welding parameters. It was found that welding current has a major influence on the hardness of welded joints. B. Mishra, R.R. Panda and D.K Mohanta et al [3] studied Metal Inert Gas (Mig) Welding Parameters Optimization; Metal Inert Gas welding (MIG) process is an important welding operation for joining ferrous and non-ferrous metals. The MIG input welding parameters are the most important factors affecting the strength of the welding joint. Subodh Kumar et al. [4] have studied the influence of heat input on the microstructure and mechanical properties of gas tungsten arc welded 304 stainless steel (SS) plates. From this research, it was concluded that low heat input should be preferred for welding AISI 304 SS using the GTAW process to obtain better tensile strength. Also, the size of the HAZ and the extent of grain coarsening obtained in these weld joints were less. Wichan Chuaiphana et al. [5] carried out experiments to investigate the effect of welding speed on the microstructures, mechanical properties, and corrosion behavior of AISI 201 stainless steel sheets. Welded joints were made using an automatic gas tungsten arc welding method (GTAW). Based upon their study it was recommended that welding speed of 3.5 mm/s should be preferred when welding AISI 201 stainless steel using the GTAW process to achieve good mechanical properties and high corrosion resistance.

III. OBJECTIVE

- To decide the range of process parameters with the help of pilot experiments.
- To study the effect of these process parameters on the tensile strength of welded joints.
- To characterize and optimize the process for obtaining maximum tensile strength.
- To develop an analytical approach by using the Taguchi method for predicting the effect of process parameters on the tensile strength of the welded joints.

IV. EXPERIMENTAL PROCEDURE

In the present work, to identify the process parameters and their effect on microstructure relative to the maximum ultimate tensile strength in the GMAW for plain carbon steel, the Taguchi method was used. Three three-level process parameters, i.e. welding current, voltage, and Gas Pressure were considered. Based on theoretical and experimental viewpoints, the respective levels are set. The levels of parameters are listed in Table 1. The experimental layout for the parameters, using the L9 orthogonal array, is shown in Table 2.

TABLE I. LEVELS OF PROCESS VARIABLES

Variables	Unit	Level 1	Level 2	Level 3
Gas Pressure	Psi	12	15	18
Welding Current	Amp	150	170	190
Welding Voltage	V	15	20	25

TABLE II. EXPERIMENTAL LAYOUT USING L9 ORTHOGONAL ARRAY

Experiment No.	Gas Pressure (Psi)	Welding Current (Amp)	Welding Voltage (V)
1	12	150	15
2	12	170	20
3	12	190	25
4	15	150	20
5	15	170	25
6	15	190	15
7	18	150	25
8	18	170	15
9	18	190	20

In the welding experiments, a carbon steel wire with a 1.2 mm diameter was used. The work-pieces consisted of AISI 304 carbon steel and IS 2062 with a thickness of 5 mm. The chemical composition (wt.%) of both base metal and electrode wire is given in Table 3. The GMAW process was used for the welding of a single V-butt joint with a single pass on 150x35 mm plates. Argon (100%) gas was used as shielding gas with variable pressure.

TABLE III. CHEMICAL COMPOSITION (WT.%) OF WORK MATERIAL

	C	**Si**	**Mn**	**P**	**S**
AISI 304	0.08	0.75	2.00	0.045	0.030
IS 2062	0.22	0.04	1.5	0.045	0.045

A. Taguchi design

Taguchi Technique is employed to set up the experiments. The Taguchi methodology has become an important tool for improving output throughout analysis and development, so better quality products may be produced quickly and at a minimum price. Dr.Taguchi of Japan has developed the techniques of optimization of various factors and parameters which affect the relative performance of the object. Taguchi design involves orthogonal array, S/N ratio, and mean of the distribution S/N ratios (S/N), that is log functions of relative output, function objective functions in improvement, help in data analysis, and estimation of optimum results. The signal-to-noise (S/N) ratio for each level was based on the S/N ratio analysis. Based on the tensile strength of the weld joint (larger-the-better), a higher S/N ratio produced better quality. The standard S/N ratio formula for this type of response is:

$$(S/N)=-10 \log (M.S.D) \qquad (1)$$

Where M.S.D. is the mean square deviation for the output characteristic.

$$n_i = -10 \log \left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_{ij}^2}\right] \qquad (2)$$

Where ‘i’ is the number of a trial; ‘Yij’ is the quality of the ith trial and jth experiment; ‘n’ is the total number of experiments.

B. Analysis of Variance (ANOVA)

ANOVA is a statistically based, objective decision-making tool for determining any differences in the average execution of groups of items tested. ANOVA helps informally testing the significance of all main factors and their interactions by comparing the mean square against an approximation of the experimental errors at specific confidence levels. ANOVA intends to examine which welding process parameters significantly affect the superior characteristic. This is achieved by separating the total variability of the S/N rations which is measured by the sum of the ratio, into endeavor by each of welding process parameters in the total sum of the squared deviations can be used to evaluate the value of process parameter change on the choice of characteristics.

V. RESULT AND DISCUSSION

In this work effect of main input welding parameters on the tensile strength of the welded joints in the gas metal arc welding process was investigated.

TABLE IV. EXPERIMENTAL RESULT FOR UTS AND S/N RATIO IN MINITAB 17

Worksheet 2 ***

↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	GP	I	V	UTS	SNRA1	MEAN1				
1	12	150	15	231.4	47.2873	231.4				
2	12	170	20	245.9	47.8152	245.9				
3	12	190	25	256.8	48.1919	256.8				
4	15	150	20	260.2	48.3061	260.2				
5	15	170	25	276.4	48.8308	276.4				
6	15	190	15	287.9	49.1848	287.9				
7	18	150	25	294.8	49.3905	294.8				
8	18	170	15	286.2	49.1334	286.2				
9	18	190	20	291.5	49.2928	291.5				
10										

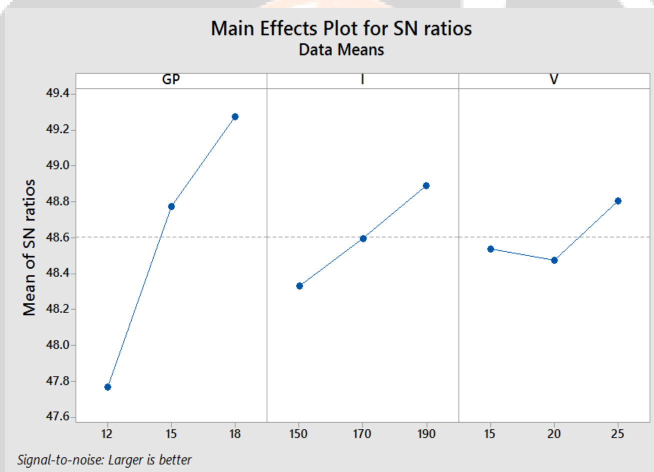

Figure 1 Main effect Plot for SN Ratios

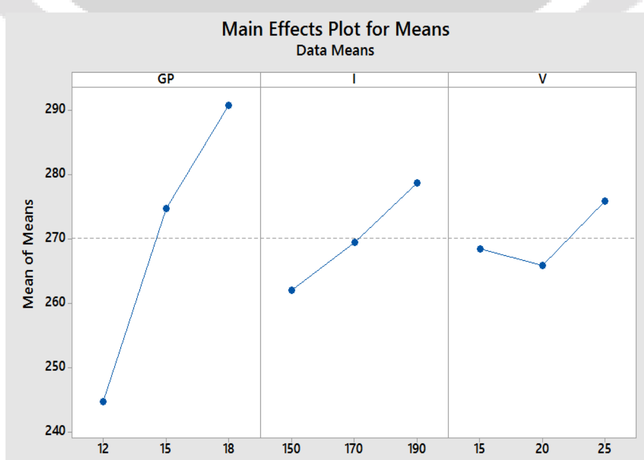

Figure 2 Main effect plot for Means.

TABLE V. Response table for Signal to noise ratio (Larger is better)

Level	GP	I	V
1	47.76	48.33	48.54
2	48.77	48.59	48.47
3	49.27	48.89	48.80
Delta	1.51	0.56	0.33
Rank	1	2	3

TABLE VI. Response table for Signal to noise ratio

Level	GP	I	V
1	244.7	262.1	268.5
2	274.8	269.5	265.9
3	290.8	278.7	276.0
Delta	46.1	16.6	10.1
Rank	1	2	3

A. Microstructure Examination

In this experiment microstructure was observed at the center of welded joint of AISI 304 & IS 2062 at 150x magnification is observed as follows:

Figure 3 Microstructure of MIG Welding sample of AISI 304 & IS 2062

B. Finite Element Analysis

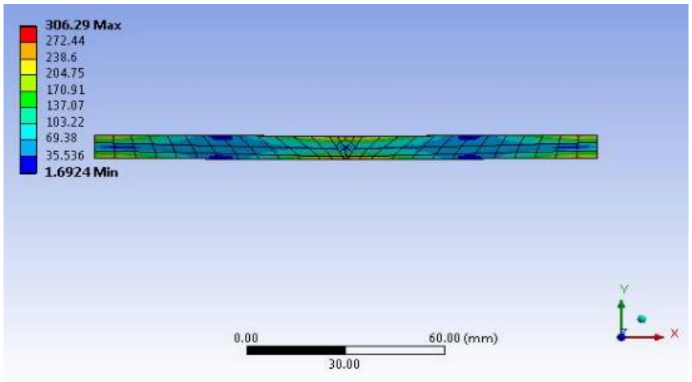

Figure 4 Von – Misses stress of Welded joint

The value of von-misses stresses developed in the welded joint in the model is 272.44 MPa of the tensile nature and 168.22 MPa of the compressive nature. The maximum tensile stress is located at the center of the welded joint of AISI 304 and IS 2062 and is much concentrated.

V. CONCLUSIONS

The study found that the control factors had varying effects on the Tensile strength, welding voltage having the highest effects. They affect the weld quality in terms of mechanical properties and weld bead geometry. The methods that can be applied for welding process parameter optimization work are Grey Relation Analysis and ANOVA (Analysis of variance). Welding current, arc voltage, type of shielding gas, gas flow rate, wire feed rate, the diameter of the electrode, etc. are the important control parameters of the Metal Inert Gas Welding process. The optimum welding condition obtained for the highest tensile strength by Taguchi Method is at gas flow rate 18Psi, Welding current 150 Amp, welding voltage 25 volt.

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