PARAMETRIC OPTIMIZATION OF TIG WELDED DISSIMILAR METAL JOINT OF SS304 & SS202 BY TAGUCHI METHOD

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Abstract

The main objective of this research work is to find out optimize GTA welding parameters of some economically important dissimilar materials. The dissimilar materials chosen in this work was Stainless steel 304 and SS202.The Input parameters selected for this work was welding current, gas flow rate and electrode diameter, the output responses chosen were the Tensile strength and hardness. After analysis, the results have shown that optimum parameters - current out of the three-weld current used (110A, 130A and 150A) is 150A, gas flow rate (9, 11 and 13Lit/min) is 9Lit/min and mm and electrode diameter of 1.5mm/sec resp.

Keywords: Welding, Stainless steel, GTAW, Hardness, strength

INTRODUCTION

There are many applications such as nuclear reactors, petrochemical, power generation, electronic and chemical industries, in which joining of dissimilar metals are extensively useful. But there is a variation of thermal, mechanical and chemical properties in dissimilar metals, due to this effective welding of dissimilar metals has represented a major challenge. A variety of problems come up during dissimilar welding like cracking, large weld residual stresses, migration of atoms during welding causing stress concentration on one side of the weld, compressive and tensile stresses, stress corrosion cracking, etc. In order to avoid from these types of problems, we need to control the selected welding parameters as per ASME Section IX.

The input process parameters are directly linked with the quality of the weld joint. The common problem for manufacturer is to control the input process parameters to obtain a good welded joint with the required weld quality. Traditionally, for producing quality joint with required specifications, trial and error method was used by skilled operators or engineers to choose parameters, but this method was time consuming for every new welded product. After that the welds are examined to determine whether they meet the specification or not [6]. Nowadays, advanced methods such as application of design of experiment (DOE), evolutionary algorithms and computational network are widely used to create mathematical relationships between the welding process input parameters and the output responses of the weld joint in order to find out whether the selected input parameters lead to the desired weld quality or not. Ibrahim et al. Studied the Effect of different welding parameters (GMAW) on mechanical properties. The welding was carried out on mild steel. The variables chosen in this study were arc voltage, welding current and welding speed. The penetration, microstructure and hardness were measured for each specimen after welding process and effect of it was studied. Results show that the increased value of welding current increased the value of depth of penetration. Arc voltage and welding speed were another factor that influenced the value of depth of penetration. Patel and Chaudhari applied Taguchi method to investigate the effect of process parameters on the weld bead hardness of AISI 1020 material for TIG and MIG welding processes. Sathish et al. applied Taguchi method to optimize the TIG welding parameters for dissimilar pipe joints using Taguchi method. They concluded that higher heat input resulted in lower tensile strength.

Experimental procedure

In this research work, SS304 and SS202 stainless steel are selected, because there are opine number of benefits as compared with other materials such as its distinct properties, cheaper cost and its availability in the market. Also, it has no of applications - pressure vessels and boilers dairy containers etc. The spectrometric analysis of the specimen is done by using Spectrometer and the chemical composition and mechanical properties of base metals is given in the Table 1 and 2 respectively.

The work piece detail is as under:

Dimensions of specimen: 150mm*100mm*4mm

No. of specimens: 9

Table 1: Chemical Composition of SS304 and SS202 (Wt.%)

Main chemical constituents						
Metal	C	Cr	Ni	P	Mn	Si
SS304	.06	18.65	8.01	.03	1.12	.26
SS204	.11	15.65	.330	.03	10.4	.33

Table 2: Mechanical properties of SS 304 & SS202

Grade	**Tensile strength (MPa) min**	**Yield Strength 0.2% Proof (MPa) min**	**El (%)**	**Hardness**	**Hardness**
				ockwell (HRB) max	**Brinell (HBC) max**
SS 304	515	205	40	92	201
SS 202	515	275	40	100	219

The parameters selected in this research work are welding current, gas flow rate and electrode diameter. Design of Experiment designed for Taguchi method by using Minitab software is shown below in table 3.

Table 3: Designs of experiments by Taguchi method

Exp no.	Current (Amp)	Gas flow rate (L/Min)	Elec dia (mm)
1	110	9	.5
2	130	11	1.0
3	150	13	1.5
4	110	9	1
5	130	11	1.5
6	150	13	.5
7	110	9	1.5
8	130	11	.5
9	150	13	1

Figure 1: Work piece after welding

After joining of plates, some mechanical tests are carried to check the quality and to find out effect of input parameters on output responses of welding. Tensile strength and hardness properties were taken as output responses.

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Figure 2: Specimen prepared for Tensile Test

Figure 3: Specimen after Tensile Test

The result of tensile test is given in below table 4:

Table 4: Tensile Test results

S.no	Cur (A)	Gas flow rate (L/min)	Elec dia (mm)	Tensile Strength (Mpa)
1	100	9	.5	474.77
2	130	11	1	496.11
3	150	13	1.5	630.55
4	100	9	1	509.43
5	130	11	1.5	498.25
6	150	13	.5	472.24
7	100	9	1.5	541.54
8	130	11	1	459.63

As seen from results, maximum tensile strength is 630.55 Mpa at 150 A Current and 13 lit/min gas flow rate and 1.5mm of electrode diameter. The output values of hardness at base metal, HAZ and weld metal for all 9 pieces is shown in table 5.

Table 5: Hardness Test Results

S.NO	1	2	3	4	5	6	7	8	9
Base	97	96	98	96	96	97	96	95	97
HAZ	99	98	104	99	101	105	103	102	104
WELD	103	100	105	107	105	111	109	113	116

It clears that hardness increases with increasing in gas flow rate and current both. It clear that hardness is more at weld metal compare to both base metal and HAZ and hardness of HAZ is more than base metal. The statistical techniques analysis of variance and signal-to-noise ratio has been applied output responses to clarify the effect of input responses on tensile strength and hardness.

Analysis of results – The main effects plot of tensile strength and hardness for means and S/N ratio is shown in Fig.

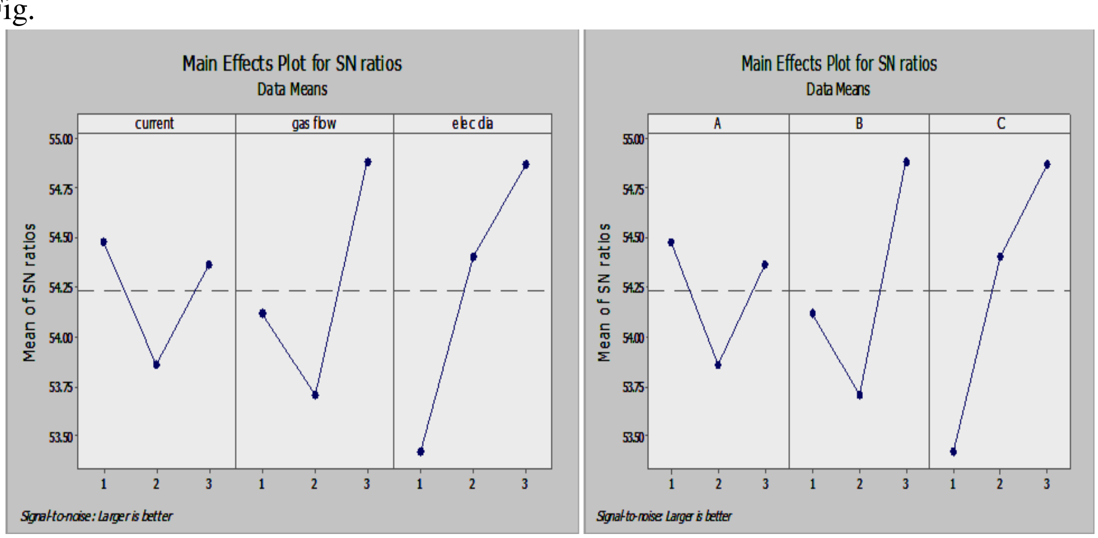

Figure 4: Main Effects Plot for means and S/N ratio of tensile strength

The graph shows that, tensile strength decreases with an addition in welding current. With increase in gas flow rate, first hardness decreases, with further increase in welding gas flow rate, hardness increases. This may be because of change in the structural behavior of welded joint during solidification and chance of forming the defects in different conditions of welding. With increase in electrode diameter, strength increases as electrode diameter is directly proportional to strength. These phenomena can also be related to metallurgical behavior of weld melt during solidification.

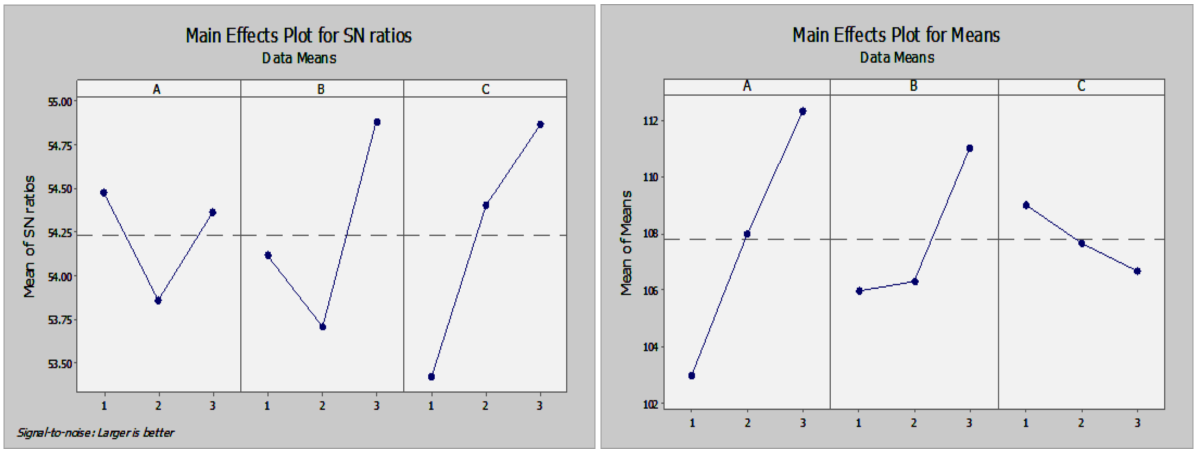

Figure 5: Main Effects Plot for hardness

Table 5: Response table for S/N Ratios (tensile strength)

Level	Current (Amp)	Gas flow rate (L/min)	Elecddia (mm)
1.	54.48	54.11	53.42
2.	53.86	53.70	54.41
3.	54.36	54.88	54.87
4.	.62	1.18	1.45
5.	3	2	1

From delta and rank values as shown in table, electrode diameter gives us a high mean of means as compared to gas flow rate and current.

Table 6: Response table for S/N Ratios (Hardness)

Level	Current(Amp)	Gas flow rate(L/min)	Electrode diameter (mm)
1	533.8	508.6	468.9
2	493.3	484.7	526.3
3	525.8	558.7	556.8
4	40.5	74	87.9

5	3	2	1

Response Table for Means

From the Response Table 6, we can conclude that electrode diameter gives us a high mean of means as compared to gas flow rate and current. So, electrode diameter is highly effective as compared with the Gas flow rate and welding current.

CONCLUSIONS

- Maximum result achieved at 150 Amp Current and 13 Lit/min Gas flow rate and 1.5 mm diameter. At this parameter, obtain value for Tensile Strength 630.55 N/MM^2.
- Hardness is more at weld metal compare to both base metal and HAZ and maximum hardness is 116 at input values of 150-amp welding current, 13 L/Min gas flow rate and 1mm diameter resp.

FUTURE SCOPE

- Apply this technique to optimize other dissimilar welding and different joint configurations.
- Apply this technique to optimize other welding process parameters such as types of gas, different included angles and types of electrode material.

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