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Experimental Investigation of TIG welding of Stainless Steel 202 and Stainless Steel 410 using Taguchi Technique

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Abstract: Modernization of TIG process can be done after thoroughly examining its various parameters and their effect on the strength of the welds produced. Welded stainless steel finds application with aerospace, nuclear and underwater industries. Main objective of the experiment is to optimize the factors affecting the tensile strength of austenitic stainless steel at varied welding parameters. SS202 and SS410 stainless steel of 3 mm thick is taken for experiments. The Taguchi method is applied using input parameters viz. current, gas pressure and weld rate and the desired response output namely ultimate tensile strength was evaluated. It is clear that there are highly non-linear relationship between current & UTS and welding speed & UTS.

Keywords: *TIG welding, stainless steel, Taguchi method, ultimate tensile strength.*

1. INTRODUCTION

Welding is a joining process in which we can make permanent joint at contacting surfaces of metals, alloys or plastics by application of heat and or pressure. In welding, the work-pieces are melted at the interface and after solidification a permanent joint at interface can be achieved. In some welding a filler material is added for forming weld pool of molten material, which after solidification provides a strong bond between the materials. The ability of a material to be welded is known as weldability of a material and it depends on different factors like melting point of metal, thermal conductivity, reactivity of material with surrounding, material's coefficient of thermal expansion etc. The present study would be beneficial in gaining an understanding of different heat input combinations for welding dissimilar metals for better mechanical properties.

2. LITERATURE SURVEY

S.C. Juang and Y.S. Tarng used Taguchi method to analyse the weld pool geometry and showed that the quality characteristics i.e. front height; front width, back height and back width were greatly improved by using this approach. Ahmet Durgutlu et al investigated the effect of hydrogen in argon as shielding gas for TIG welding of 316L austenitic stainless steel. They used current 115 A, welding speed 100 mm/min and gas flow rate 10 l/min for welding of 4 mm thick plate. The highest tensile strength was obtained for the sample welded under shielding gas of 1.5%H2–Ar. Wang Rui et al investigated the effect of process parameters i.e. plate thickness, welding heat input on distortion of Al alloy 5A12 during TIG welding. For welding they used current (60-100) A, welding speed (800-1400) mm/min and thickness of w/p (2.5-6) mm. The results show that the plate thickness and welding heat input have great effect on the dynamic process and residual distortion of out-of-plane.

3. EXPERIMENTAL DETAILS

Tungsten Inert Gas (TIG) welding is an arc welding process in which a non-consumable tungsten electrode is used to produce the weld

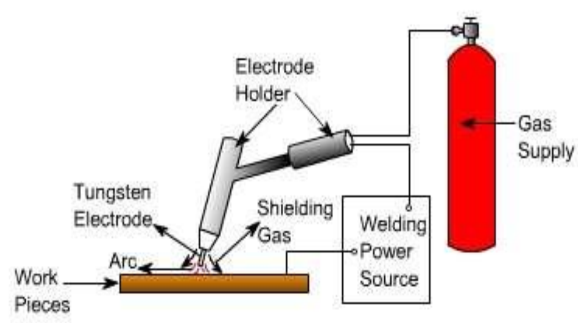

Figure 1: Schematic diagram of TIG welding and mechanism of TIG welding

In TIG, metals are fused together at the interface by heating them with an electric arc produced between electrode and workpiece. Filler metal may or may not be used depending on the design of the joint. The weld area is shielded from the atmosphere by an inert gas (argon or helium). This welding can be performed in any welding position. TIG welding generally uses a constant current type of power source The thickness of the metal to join and the type of current being used determines the size of the tungsten electrode. The electric arc can produce temperatures of up to 20,000 ºC.

4. MATERIAL REQUIREMENTS

In this project we have taken stainless steel 202 & 410 fabrication of Tungsten inert gas welding. Two metal plates are taken with 100 mm x100 mm x 3 mm size and the two plates are clamped rigidly by clamps and bolts in the Vice. The dissimilarity of the metals may arise due to the difference in chemical composition.

Figure 2: TIG Welded Pieces

6. DESIGN OF EXPERIMENT AND SOFTWARE ANALYSIS

Taguchi analysis was carried out using L9 array of design of experiments. Austenitic stainless steels (202 & 410) are selected because of its low cost, easy availability in the market. Semi-automatic TIG welding process are chosen to carry out the experimental analysis on austenitic stainless steels. In this analysis, nine sample plates (9 pieces of AISI 202 and 9 pieces AISI 410) of austenitic stainless steels are taken for welding.

Table 1: Design of Experiment

S. No	C1	C2	C3	C4	C5	C6
	Current (A)	Gas Pressure	Speed (mm/s)	UTS (N/mm^2)	SN Ratio	Mean
1	70	5	2.1	188.7	45.5154	188.7
2	100	8	2.8	218.9	46.8049	218.9
3	130	10	3.5	698.9	56.8883	698.9
4	70	5	2.8	295.5	49.4111	295.5
5	100	8	3.5	189.8	45.5659	189.8
6	130	10	2.1	276.5	48.8339	276.5
7	70	5	3.5	89.4	39.0268	89.4
8	100	8	2.1	579.1	55.2551	579.1
9	130	10	2.8	808.3	58.1515	808.3

5. RESULT AND DISCUSSION

Welding experiments are conducted on TIG welding machine with different welding parameters. The Taguchi design is for getting the input welding parameters. SS plates (100x100x3mm) are involved with welding for optimizing the welding parameters with Taguchi analysis by using Minitab-14 software have optimized the welding parameters.

Taguchi Analysis: UTS versus Current, Gas Pressure, Speed
Response Table for Signal to Noise Ratios
Larger is better

Gas Pressure

Level	Current	Pressure	Speed
1	49.74	44.65	49.87
2	47.94	49.21	51.46
3	50.81	54.62	47.16
Delta	2.87	9.97	4.30
Rank	**3**	**1**	**2**

Response Table for Means
Gas Pressure

Level	Current	Pressure	Speed
1	368.8	191.2	348.1
2	253.9	329.3	440.9
3	492.3	594.6	326.0
Delta	238.3	403.4	114.9
Rank	**2**	**1**	**3**

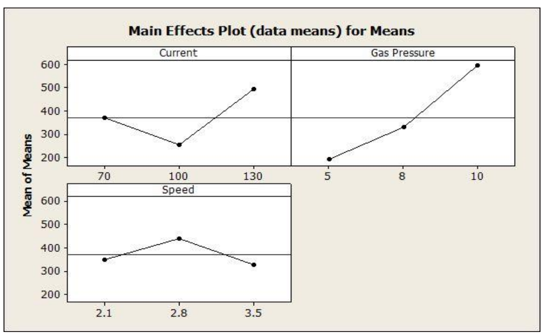

Fig 3 Main effects plot (data means) for Means

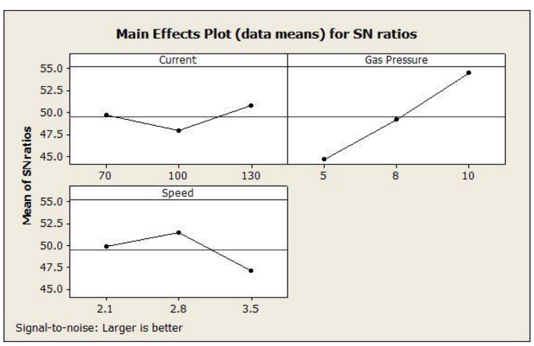

Fig 4 Main effects plot for S/N ratios

A. Effect of various input parameters on output characteristic (Ultimate Tensile Strength)

The Ultimate Tensile Strength at each parameter (current, gas pressure, weld speed) is computed and the results are tabulated. Similarly the result obtained for S/N data (db) are given. The main effect along with the corresponding S/N ratio value and Mean is plotted.

1) Effect of current on UTS

It is observed that with increase in current, the ultimate tensile strength increases. It is seen that the maximum ultimate tensile strength is obtained at the third level (130 A).

2) Effect of gas pressure on UTS

In this investigation the gas pressure was found to more effective parameter. The SN ratio increases almost linearly with increase in gas pressure, which means the ultimate tensile strength also increases with this input parameter. The signal to noise ratio of 58.1515 is maximum for gas pressure of 10 kg/cm^2.

3) Effect of weld speed on UTS

The following graph shows that the weld speed should be kept an average of the minimum and maximum speeds that is 2.8 mm /s for best results. The S/N ratio reaches maximum at 2.8 mm/s and then decreases beyond it. According to the main effects plot, the optimal conditions for Ultimate Tensile strength are:

- Welding current at level 3 (130 A)
- Gas Pressure at level 3 (10 kg/cm^2)
- Weld Speed at Level 2 (2.8 mm/s)

The predicted value for the above parameters comes out to be 784.378 N/mm^2.

7. CONCLUSION

The following are the conclusions drawn from the work done in this investigation-

Main effects plots reveal that current, gas pressure and weld rate are the factors which have considerable influence on ultimate load.

Optimum parameter setting for Ultimate Tensile strength of 808.3 N/mm^2 is obtained at a welding current of 130 A, gas pressure of 10 kg/cm^2 and weld speed of 2.8 mm/s experimentally. For the same values, the predicted UTS came out to be 784.378 N/mm^2.

It is clear that there are highly non-linear relationship between current and UTS and welding speed and UTS.

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