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Influences of TIG Welding Parameters on Tensile behavior of Aluminium AA 6061 alloy V-Groove Joint

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Abstract—*In the present work an attempt to improve tensile behavior of the AA 6061 alloy V- joint was made. Tungsten inert gas (TIG) welding is a high quality welding process used to weld the thin metals and their alloy 6061 Aluminium alloys play an important role in engineering and aerospace, metallurgy field because of excellent corrosion properties, ease of fabrication and high specific strength coupled with best combination of toughness and formability. TIG welding technique is one of the precise and fastest processes used in aerospace, ship and marine industries. TIG welding process is used to analyze the data and evaluate the influence of input parameters on tensile strength of 6061 Al-alloy specimens with dimensions of 100mm long x 30mm wide x 6mm thick. Welding current (I), gas flow rate (G) and welding speed (S) are the input parameters which effect tensile strength of 6061 Al-alloy welded joints. As welding speed increased, tensile strength increases first till optimum value and after that both decreases by increasing welding speed further. Results of the study show that maximum tensile strength of 149 mPa of weld joint are obtained at welding current of 250 Amps, gas flow rate of 7 Lt/min and welding speed of 98 mm/min. These values are the optimum values of input parameters which help to produce efficient weld joint that have good mechanical properties.*

Keywords: *6061 Aluminium alloy, TIG welding, welding current, welding speed, gas flow rate and tensile strength*

1. INTRODUCTION

AA 6061 is a commonly used aluminium alloy of heat treatable and high strength material [1-3]. Aluminium alloy has excellent performance so used in aerospace industry, aviation, marine industry, automobile, defense and others. TIG TUNGSTEN Inert Gas (TIG) welding is a welding process used for high quality welding of a variety of materials with the coalescence of heat generated by an electric arc established between a non-consumable tungsten electrode and the metal. The process of melting the work piece and filler rod to form a weld results in the formation of fumes and gases. Helium and argon used as shielding gases because they do not chemically react. Most commonly, Argon, helium and their mixture are preferred to use as a shielding gases for better welding because of does not chemically react or combine with each other. The inert gas : i) shield the welding area from air, preventing oxidation ii) transfer the heat from electrode to metal and iii) helps to start and maintain a stable arc due to low ionization potential. Welding parameters such as welding current, gas flow rate and welding speed are taken into account which influences the tensile strength of aluminium alloy joint. The purpose of the present investigation is to optimize the TIG welding process parameters for increasing the mechanical properties using Taguchi method. Taguchi method is a systematic approach to design and analyze experiments for improving the quality characteristics. Taguchi method [4-7] permits evaluation of the effects of the effects of individual parameters independent of other parameters and interactions on the identified quality characteristics such as Tensile strength. Nowadays, Taguchi method has become a practical tool for improving the quality of the output without increasing the cost of the experimentation by reducing the number of experiments.

Welds are made with the use of optimum condition and these were subjected ultimate tensile testing to predict the tensile behavior of the AA 6061 V-groove joint.

2. SCHEME OF INVESTIGATION

In order to achieve maximum quality characteristics, the present investigation has been made with the following planned sequence.

- Selection of the base material and the filler material
- Identifying the important TIG welding parameters
- Find the upper and lower limits of the identified welding parameters
- Developing the experimental design matrix(orthogonal array)
- Conduct the experiments as per the selected array
- Recording the responses, such that Tensile Strength
- Find the optimum condition for maximizing the mechanical properties
- Effect of welding parameters on tensile strength

Selection of the base material and the filler material

The base material is 6061 Al-alloy of 6mm thickness which is welded by TIG welding process. The chemical composition of 6061 Al-alloy is shown in the table 1.

Table 1: Chemical composition of 6061 Al-alloy (wt %)

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others	Al
0.8	0-0.7	0.15-0.4	0-0.15	0.8-1.2	0.04-0.35	0-0.25	0-0.15	0.05-0.15	balanced

The filler wire used to transfer the extra material to composition of base metal. There are different types of filler wires (5183, 5356, 5556, 4043, etc) available in the market on the basis of base metal composition of 6061 Al-alloy. In this study, the filler metal of 4043 graded is used for welding the specimens because of its good physical, mechanical, properties for obtaining the best joint.

The chemical composition filler wire used i.e. 4043 is shown in the table 2

Table 2: The Chemical composition of 4043 filler wire (wt %)

Al	Si	Fe	Cu	Ti	Zn	Mn	Mg	Others
6	0.6	0.3	0.15	0.1	0.15	0.2	0.05	0.15

Identifying the important TIG welding parameters

The independently controllable predominant TIG welding parameters were identified to enable to carry out the experimental work and identify the influencing factors on tensile properties they are shown in table 3.

Table 3: Welding Parameters

Welding mode	Welding current(ampere)	Gas flow rate(lit/min)	Welding speed(mm/min)
1	210	7	89
2	230	6	98
3	250	5	102

Find the upper and lower limits of the identified welding parameters

A large number of trial runs have been carried out using 6mm thick rolled plates of AA 6061 aluminium alloy to find out the feasible working limits of TIG welding parameters. AA 4043 (Al-5%Si) aluminium alloy of 3mm diameter has been used as the filler metal. Different combinations of welding current parameters have been used to carry out the trial runs. The welding current, welding speed, gas flow rate and weld quality have been inspected to identify the working limits of the welding parameters. From the above analysis following observations have been made:

(i) If welding current is less than 210A, then incomplete penetration and lack of fusion have been observed. At the same time, if peak current is greater than 250A, then undercut and spatter has been observed on the weld bead surface.
(ii) If shielding gas less than 5 lit/min the weld penetration was not done properly, if it is more than 7 lit/min the weld penetration is not uniform.
(iii) If welding speed is less than 89mm/min a small weld bead is observed. If it is more than 102mm/min a larger weld bead which results in less strength.

Developing the experimental design matrix (orthogonal array)

Number of process parameters considered under this study is three and degrees of freedom are 8(=9-1) was selected for the present analysis. The standardized Taguchi based Experimental design used in this study was L9 orthogonal array.

Conduct the experiments as per the selected array

The base metal sheets dimensions 100mm long x 30mm wide x 6mm thick have been prepared and V groove Joints were made using the experimental layout shown in table 4 and record of tensile strength was made.

Table 4

Specimen	Welding current (amps)	Gas flow rate (lit/min)	Welding speed (mm/min)	Tensile Strength mpa
1	210	5	89	125
2	210	6	102	112
3	210	7	98	105
4	230	5	102	137
5	230	6	98	122
6	230	7	89	109
7	250	5	98	149
8	250	6	89	135
9	250	7	102	127

The fabrication of the welding Joint was made with TIG welding Equipment shown in the Fig. 1.

Fig. 1: TIG Welding Equipment

The sample welding Joint fabricated is show in the Fig. 2.

Fig. 2: sample weld Joint

Recording the responses, such that Tensile Strength

Specimens for tensile testing were taken at the middle of all the Joints and machined to ASTM E8 standards [8]. The configuration of specimen used under tensile testing is in Fig. 3. Tensile test was conducted using a computer controlled universal testing machine. All the welded specimens were failed in the weld region. The ultimate tensile strength of the weld joint is the strength of the weld.

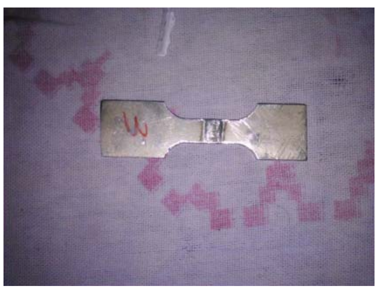

Fig. 3: Tensile Test Specimen

Find the optimum condition for maximizing the mechanical properties

The optimization of Processes parameters using Taguchi method [9-10] permits the evaluation of individual parameters and also of their interactions on the identified quality characteristic, i.e., ultimate tensile strength (UTS) and their S/N ratios were computed using statistical software mini tab 17

Table 5

Response Table for Means

Level	Welding current(ampere)	Gas flow rate(lit/min)	Welding speed(mm/min)
1	114.0	113.7	123.0
2	122.7	123.0	125.3
3	137.0	137.0	125.3
Delta	23.0	23.3	2.3
Rank	2	1	3

The main effects for the welding current, gas flow rate and welding speed to UTS are given in the Fig. 4.

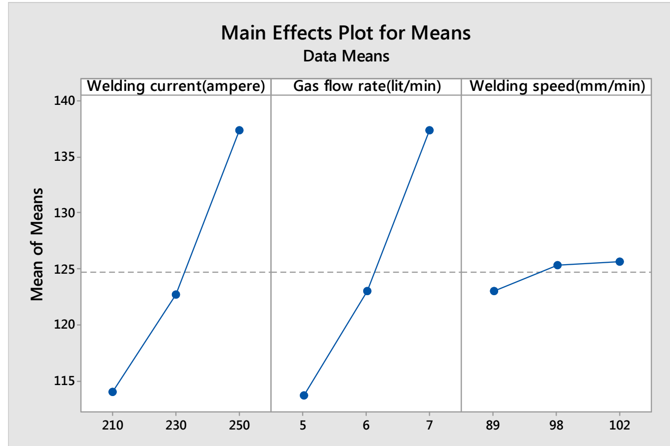

Fig. 4: mean effects plot

According to the nominal is the best gas flow rate is ranked 1, welding current is ranked 2 and welding speed is ranked 3.

Effect of welding parameters on tensile strength

By using the above developed models, the tensile strength of the AA 6061 strength of the joint made of TIG welding are analyzed

1. The Effect of Welding Current on Tensile Strength of Weld Joint

This phase reveals the effect of welding current of different levels such as 210amps, 230amps, 250amps on mechanical properties of weld joint such as tensile strength. As welding current increases at constant gas flow rate, the tensile strength increases till the optimum value of 250amps current that shows the maximum tensile strength of 149 Mpa of weld joint.

2.Effect of Gas Flow Rate on Tensile Strength and Weld Joint

In this, the effect of shielding gas flow rate of 5lit/min, 6lit/min and 7lit/min of 3 different levels on mechanical properties as a Tensile Strength of weld joint is described The Tensile Strength increases by the variation of shielding gas in increasing order till an optimum value of 7 lit/min that shows the maximum tensile strength of 149mpa of Weld joint.

3. Effect of Welding Speed on Tensile Strength of Weld Joint

This phase reveals the effect of the different values of Welding speed on mechanical properties of weld joint such as tensile strength. The tensile strength increases by increasing the welding speed at constant current till optimum value of 98 mm/min at current of 250 amps that shows the maximum tensile strength of 149 MPa of weld joint. After that tensile strength starts to decrease by further increment of welding speed.

3. CONCLUSIONS

All the experimental trials are analyzed under precautionary measures in order to keep the error factors low and optimize the reliability of results to produce the efficient weld joint with 6061 Al-alloy specimens. The following conclusions are drawn from the analysis of collected data of input and output parameters:-

Maximum tensile strength of 150MPa is obtained at welding current of 250 amps, gas flow rate of 7 Lt/min and welding speed of 98 mm/min.

The tensile strength of weld joint in 6061 Al-alloy plate increases by increasing welding speed up to an optimum value of 98 mm/min for current of 250 amps and after that tensile strength decreases by further increasing welding current.

The optimum range of input parameters are evaluated as 250 amps of welding current, 7 Lt/min of gas flow rate and 98 mm/min of welding speed by which efficient weld joint is produced with good tensile strength of weld joint.

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