

Optimization of Process Parameters on Tig Welding to Enhance Mechanical Properties of AA-6351 T6 Alloy

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materials by means of heat. Pressure may be also employed in many processes. There are various ways of classifying the welding and allied processes on the basis of

- Source of heat, i.e., flame arc, etc.
- Type of interaction i.e. liquid/liquid (fusion welding) or solid/solid (solid state welding).

In general various welding and allied processes are classified as follows:

1. Gas welding

- a. Air-acetylene welding
- b. oxy-acetylene welding
- c. oxy-hydrogen welding
- d. pressure gas welding

2. Arc welding

- a. Carbon Arc welding
- b. shielded metal Arc welding
- c. Flux cord Arc welding
- d. submerged Arc welding
- e. TIG (GTAW) welding
- f. MIG (GMAW) welding
- g. plasma Arc welding
- h. Electro slag welding and electro gas welding
- i. stud Arc welding

ABSTRACT

Tungsten Inert Gas (TIG) welding is widely used for weld the thin metal. Alloying metal is also welded by this process. Appearance and quality TIG weld is very superior as compare to other welding process. Melting the work piece and filler rod result in formation of smoke and gases. Helium and Argon are non reactive gases by this property it is used as a shielding gas. Most commonly mixture of Argon and Helium are favored to use for enhanced welding quality because they do not react with each other. Argon and Helium gases protect the welding area from outer environment and helps to maintain a stable arc due to low ionization potential. Aluminum is light in weight and for excellent performance it is used in aerospace industry, aviation, marine industry, automobile, defence and others. TIG welding parameters such as welding current, gas flow rate and welding voltage are taken into account which influences the tensile strength, Hardness and Toughness of aluminum weld joint. Welding parameters are controlled with electronic control units. AC power supply is prefer to used for aluminium as compare to DC power supply because of its low melting point aluminium melt at low temperature

Keywords: Aluminum Alloy Aa 6351-T6, Mechanical Properties, Tig Welding

I. INTRODUCTION

Welding is a process for joining different materials. The large bulk materials that are metals, their alloys and other materials such as thermoplastics are joined by welding process. Welding process may be defined as join of similar and dissimilar

3. Resistance welding

- a. Spot welding
- b. seam welding
- c. projection welding
- d. Resistance Butt welding
- e. flash butt welding
- f. Percussion welding
- g. High frequency Resistance Welding

4. Solid state welding

- a. Cold welding
- b. diffusion welding
- c. Explosive welding
- d. forge welding
- e. friction welding
- f. hot pressure welding
- g. roll welding
- h. ultrasonic welding

5. Thermo chemical welding process

- a. Thermit chemical welding
- b. atomic hydrogen welding

6. Radiant energy welding process

- a. Electron beam welding
- b. laser beam welding

Tungsten inert-gas welding, as the name suggests, is a process in which the source of heat is an arc formed between a non-consumable tungsten electrode and the work piece, and the arc and the molten puddle are protected from atmospheric contamination (i.e. oxygen and nitrogen) with a gaseous shield of inert-gas such as argon, helium or argon-helium mixture. Filler metal, if required, is added externally to the arc in the form of bare wire by the welder. It is often referred to in abbreviated form as TIG welding some authors prefer to call it inert gas tungsten arc welding. This is a transformer, a rectifier or a motor generator set, depending on the application. The Power source characteristic is essentially drooping type, which means that power sources designed for and used in manual metal arc welding (MMAW) can be directly used for TIG welding. For better arc stability and a smooth arc, the OCV of the power source should be between 70 and 80V (RMS). Argon is monatomic gas (i.e. its molecule consists of one atom instead of two atoms in the case of common gases like oxygen, nitrogen, chlorine, etc.) it is extracted from the atmosphere by liquefaction of air and refined to 99.9% purity. It is supplied as compressed gas in cylinders.

II. LITERATURE REVIEW

A. Kumar, P. Shailesh, S. Sundarrajan (2009) analysis the optimization of TIG welding parameter on mechanical properties of aluminium alloy. AA5456 aluminium alloy is used for this study work. Taguchi method is used to optimize the process parameter of AA5456 alloy to better improve the mechanical properties of weld metal. After select the weld parameters microstructure of all weld pieces is also studied.

A. K. Hussain, A. Lateef, M. Javed (2010) analysed the effect of welding speed on the tensile strength of welded joint in TIG weld. Ferrous and non ferrous metals are significantly joint by TIG welding. By this process joint dissimilar metals. Low heat is produced and slag formation is also low as compare to MIG weld. Accuracy and quality of weld is largely depend upon the polarity of power supply used, speed of welding and type of protected gas is used. In this study investigate the effect of welding speed on tensile strength. Sample prepared for this study is single v-butt at different bevel angles and bevel heights.

C. Lindon, P.N Kumar (2011) analysed the characterization of Aluminium 6061 alloy with the use of Pulsed Tungsten Arc welding. This experiment is done on specially designed fixture and the single pass v-butt joint shape specimen is used. Pulsed current is more beneficial over conventional continuous current. The specimen thickness is more as compare to other specimen which are generally welded. The thickness is around 10 mm. In this investigation two different filler material are used. The input parameters are Pulsed current, Secondary current, Pulsed frequency are taken for this investigation and for shielding gas helium and argon is used for better weld geometry. Manual Welding is done in this investigation.

Y. Dongxia, L. Xiaoyan (2012) welded the Al-Mg-Mn alloy joint with TIG and Laser beam welding and analysed the Microstructure and mechanical properties are studied by TIG welding and laser beam welding separately. The result shows that Tensile strength of LBW joint is 10% more than the TIG welding joint. It is also found that Mg concentration is lower in fusion zone as compare to base metal.

S. Irfanand, V. Achwal (2014) welding parameters are the most important factors affecting the quality, productivity and cost of welded joint, Weld bead size, shape and penetration depend on number of parameters. Lot of research work has been done regarding the effect of

variables on the process. The quality of a welded joint is directly influenced by the welding input parameters. Inadequate weld bead dimensions such as shallow depth of penetration may failure of a welded structure since the effect of various welding process parameters on the weld ability of galvanized Steel specimen having dimensions 50 mm × 40 mm × 5 mm, welded by metal inert gas welding were investigated. The welding current, arc voltage, welding speed, are chosen as welding parameters.

R. Ranjan, A. Kumar, A. Pratik (2016) study the effect of various welding parameters on bead geometry of mild steel specimen having 5.5mm thickness welded by Gas Metal Arc welding process. The welding current, arc voltage and welding speed were chosen as variable parameters. Tests were conducted using CO₂ as shielding gas (MAG welding) and shielding gas (MIG welding). The bead height and depth of penetration were measured for each specimen after the welding operation. Further the ultimate tensile strength, Vickers hardness test, flaw detection and grain structure study was conducted and the effect of the variable parameters were studied.

Çam, G. İpekoğlu (2017) study some drawbacks like the difficulty in welding them and, in last year, there have been many research works to overcome some of these limitations. This work is focused in the improvement of welding the 6082-T6 aluminum alloy with the process of gas metal arc welding (GMAW) or metal inert gas (MIG).

S. A Rizvi, S. P. Tiwari (2018) examination and explored the flow of three welding parameters (wire feed speed, circular segment voltage, and protecting gas flow rate) for SS 304H by utilizing Taguchi based Grey relational analysis. In this exploration work, unadulterated argon was utilized as protecting gas. Quantities of preliminaries were executed according to L16 (4x3) symmetrical cluster plan and the mechanical quality such extreme elastic quality, micro hardness, Toughness, and microstructure of SS304H improved by Grey based Taguchi examination and result demonstrates that the ideal parameters mix were as A4B4C3 for example flow rate at 23L/min, voltage at 25 V and welding speed at 350IPM and it was seen that wire feed speed had the most huge impact pursued by voltage and gas flow rate.

III. MATERIALS USED

Chemical composition of the base metals, filler metal and shielding gas used in the experiments is given below. These materials were selected because of their availability. And wide usage in the industry

3.1 Base Metals

Probably the most important factor relating to the weld ability of aluminium alloys is their chemical composition. The term weld ability has no universally accepted meaning and the interpretation place upon term varies widely according to individual viewpoint. The American welding society defines weld ability as the capacity of a metal to be welded under the fabrication conditions imposed, into a specific, suitably designed structure, and to perform satisfactorily in the intended service. During the experiments AA 6351-T6 plates used. 6351-T6 aluminium alloy with the dimensions of 76 mm (l) × 40 mm (w) × 6 mm (t) was selected to represent the aluminium alloy. It contains silicon, magnesium and manganese as main alloying element. The chemical composition of AA 6351-T6 aluminium alloy is given at table

Table: 3.1 Chemical composition of base metal.

Copper	0.10
Magnesium	0.61
Silicon	1.00
Iron	0.16
Manganese	0.58
Nickel	0.004
Zinc	0.002
Lead	0.001
Tin	0.018
Titanium	0.019
Chromium	0.03
Aluminium	97.41

“The weld ability of aluminium alloy, discounting such factors as thickness and joint geometry, is a function of the silicon, magnesium and manganese contents. All carbon

steels can be welded by metal-arc welding. Where the silicon content does not exceed .5% and magnesium does not exceed .896 depending on the thickness of the material, this material can be welded by TIG welding which will assure proper penetration and fusion”.

3.2 Filler Metal

The majority of arc welding is done with the addition of a filler metal that plays a major role in determining the composition and microstructure of the weld. The consumable electrode wire was selected based on properties and characteristics of the base material, weld dimensions.

AA 4043 wire electrode having 2.8 mm diameter was used as filler metal. The following table entails the chemical composition of the filler material according to AWS used in TIG:

Table: 3.2 Chemical composition of filler material

Weld metal	Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
Chemistry (%)	4.5-6.0	0.8max	0.3max	0.05max	0.05max	0.10max	0.20max	95max

3.3 Shielding Gas

The main function of the shielding gas is to displace the air in the weld zone and thus prevent contamination of the weld metal by nitrogen, oxygen and water vapour the selection of the best shielding gas is based on consideration of the materials to be welded and type of metal transfer that will be used. For the experiments, argon is used because it is only available in India and also produces deeper penetration.

Welding conditions and process parameters

Gas tungsten Arc welding is governed by a set of factors and conditions such as amount of current, welding voltage, Gas flow rate, etc which are called as process parameters. The optimum process parameters generally maintained during the welding processes for aluminium alloy are given in table.

Table: 3.3 Welding conditions and process parameters

Parameters	TIG
Joints	Butt Joint
Arc Voltage(volt)	16,18,20
Welding speed	Constant
Welding current(amp)	90,110,130
Electrode Diameter(mm)	2.8
Shielding Gas	Argon
Gas flow rate (lit/min)	2,4,6

IV. EXPERIMENTAL PROCEDURE

Aluminium alloy plates (AA 6351-T6) with the dimensions 76 mm (l) x 40 mm (w) x 6 mm (t) were prepared with V butt joint 45 deg groove angle as welding current and gas flow rate are taken as process variables. The welding current values were taken as 90, 110 and 130 ampere and the gas flow rate values were 2, 4 and 6 lt/min.

Then plates were welded through TIG welding by using 2.8 mm AA4043 wire electrode and Ar gas. Nine experiments were performed.

Table:4.1 Orthogonal Array after assigning the Parameter range

Specimen No	Welding current	Welding voltage	Gas flow rate
1	90	16	2
2	90	18	4
3	90	20	6
4	110	16	4
5	110	18	6
6	110	20	2
7	130	16	6
8	130	18	2
9	130	20	4

V. RESULT AND DISCUSSION

Hardness is checked by Vickers hardness tester in the lab very carefully. Table 5.1 represents the Taguchi analysis of hardness result.

Table: 5.1 Taguchi analysis Result of Hardness

Specimen No.	Welding current(Amp)	Welding voltage(Volt)	Gas flow rate(lt/min)	Hardness(VHN)	S/N Ratio
1	90	16	2	86	38.6900
2	90	18	4	88	38.8897
3	90	20	6	100	40.0000
4	110	16	4	96	39.6454
5	110	18	6	83	38.3816
6	110	20	2	85	38.5884
7	130	16	6	80	38.0618
8	130	18	2	75	37.5012
9	130	20	4	70	39.9020

Table5.2 Response table for S/N ratio (Hardness)

Level	Welding current	Welding voltage	Gas flow rate
1	39.19	38.26	38.26
2	38.87	38.26	38.48
3	37.49	38.50	38.81
Delta	1.70	0.54	0.55
Rank	1	3	2

Table 5.2 and fig 5.1 shows that experimental analysis for Hardness. In this experimental analysis, mainly the ranks show that Welding current has the greatest influencing parameter for the S/N ratio. For the S/N ratio, Welding voltage has the second greatest influencing parameter, and welding voltage has least influencing parameter in this experiment. Here, because our aim is to Higher the Hardness, we want factor levels that produce the highest S/N Ratio. Taguchi experiments, we always want to maximize the S/N ratio. The level averages in the response tables show that the S/N ratio is maximized when the Welding current 90 amps, the Welding voltage 16 volts and the gas flow rate is 6 lt. So, the optimal parameters combination for AA 6351 T6 alloy is Welding current 90 amps, Welding voltage 16 volts and and the gas flow rate is 6 lt/min

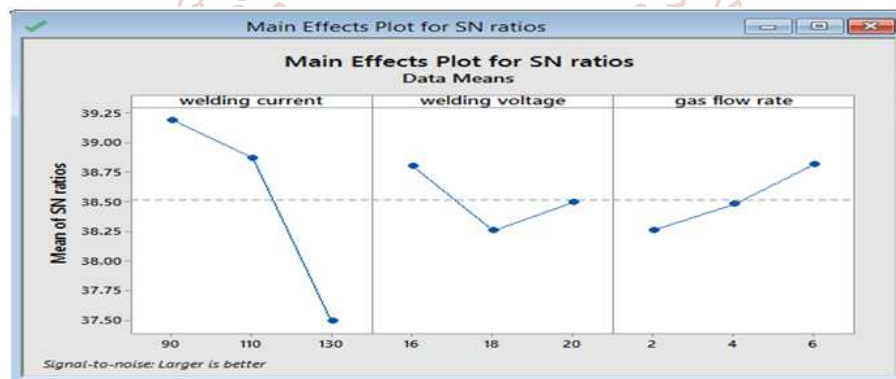


Fig.5.1 Main effect Plot for S/N Ratio (Hardness)

Tensile Analysis

Tensile test is performed on UTM of capacity 600KN of speed 1mm/min. Table 5.3 & Figure 5.2 shows that experimental analysis for Tensile Strength. In this experimental analysis, mainly the ranks show that Welding current has the greatest influencing parameter for the S/N ratio. For the S/N ratio, Welding voltage has the second greatest influencing parameter, and the gas flow rate has least influencing parameter in this experiment. Here, because our aim is to Higher the Tensile Strength, we want factor levels that produce the highest S/N Ratio Taguchi experiments, we always want to maximize the S/N ratio. The level averages in the response tables show that the S/N ratio is maximized when the Welding current 110 amps, the Welding voltage 20 volts and the gas flow rate is 2lt/min. So, the optimal parameters combination for AA 6351 T6 alloy is Welding current 110 amps, Welding voltage 20 volts and and the gas flow rate is 2 lt/min.

Table 5.3 Response table for S/N ratio (Tensile Strength)

Level	Welding current	Welding voltage	Gas flow rate
1	115.6	108.9	114.0
2	115.6	113.2	112.2
3	107.6	116.6	112.6
Delta	8.1	7.7	1.8
Rank	1	2	3

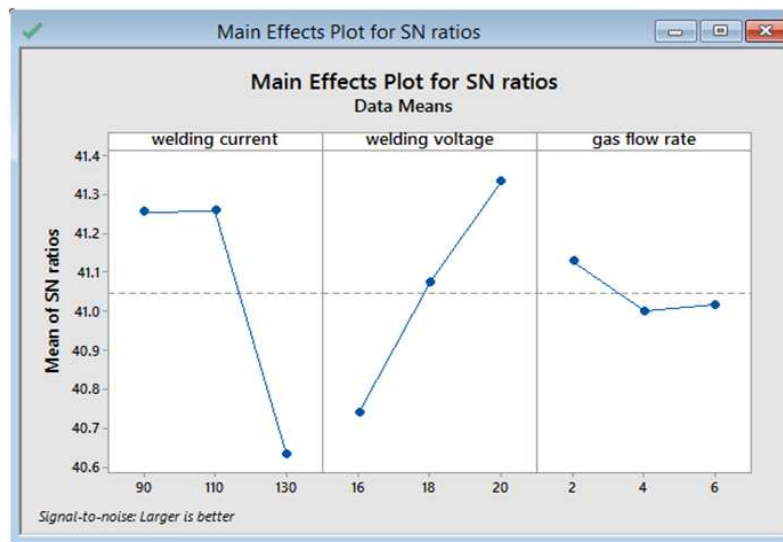


Fig 5.2 .Main Effect Plot for S/N Ratio (Tensile Strength)

VI. CONCLUSION:

- The optimal parameters combination for Tensile strength for AA6351 T6 Alloy is Welding current 110 amps, Welding voltage 20 volts and Gas flow speed is 2 lt/min
- Welding current significantly affecting the Tensile strength and Welding voltage has the second greatest influencing parameter, and gas flow speed has smallest amount influencing parameter in this experiment. These are the optimized results of special Process Parameter on Tensile strength. The optimal parameters combination of Hardness for AA6351 T6 Alloy is Welding current 90 amps, Welding voltage 16 volts and Gas flow speed is 6 lt/min Welding current significantly affecting the Hardness. The optimal parameters grouping of Hardness for AA6351 T6 Alloy is Welding current 110 amps, Welding voltage 18 volts and Gas flow speed is 2 lt/min Welding current significantly affecting the Toughness. Gas flow rate has the second greatest influencing parameter, and the welding voltage has least influencing parameter in this experiment. These are the optimized results of different Process Parameter for Hardness.

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