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Welding Parameters on TIG Welding of Aluminium Plate

Pramod Kumar[1], Kapil Sharma[2]

[1]Assistant Professor, Department of Mechanical Engineering, Rattan Institute of Technology and Management, Haryana, India
[2]Research Scholar, Department of Mechanical Engineering, Rattan Institute of Technology and Management, Haryana, India

ABSTRACT

To improve welding quality of Aluminum (Al) plate an automated TIG welding system has been developed, by which welding speed can be control during welding process. Welding of Al plate has been performed in two phases. During 1st phase of welding, single side welding performed over Al plate and during 2nd phase both side welding performed for Al plate by changing different welding parameters. Effect of welding speed and welding current on the tensile strength of the weld joint has been investigated for both type of weld joint. Optical microscopic analysis has been done on the weld zone to evaluate the effect of welding parameters on welding quality. Micro-hardness value of the welded zone has been measured at the cross section to understand the change in mechanical property of the welded zone.

INTRODUCTION

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond between the materials. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position.

1.1 Different type of welding processes

Based on the heat source used welding processes can be categorized as follows:

1.1.1 Arc Welding: In arc welding process an electric power supply is used to produce an arc between electrode and the work-piece material to joint, so that work-piece metals melt at the interface and welding could be done. Power supply for arc welding process could be AC or DC type. The electrode used for arc welding could be consumable or non-consumable. For non-consumable electrode an external filler material could be used.

1.1.2 Gas Welding: In gas welding process a focused high temperature flame produced by combustion of gas or gas mixture is used to melt the work pieces to be joined. An external filler material is used for proper welding. Most common type gas welding process is Oxy- acetylene gas welding where acetylene and oxygen react and producing some heat.

1.1.3 Resistance Welding: In resistance welding heat is generated due to passing of high amount current (1000–100,000 A) through the resistance caused by the contact between two metal surfaces. Most common types resistance welding is Spot-welding, where a pointed electrode is used. Continuous type spot resistance welding can be used for seam-welding where a wheel-shaped electrode is used.

1.1.4 High Energy Beam Welding: In this type of welding a focused energy beam with high intensity such as Laser beam or electron beam is used to melt the work pieces and join them together. These types of welding mainly used for precision welding or welding of advanced material or sometimes welding of dissimilar materials, which is not possible by conventional welding process.

1.1.5 Solid-State Welding: Solid-state welding processes do not involve melting of the work piece materials to be joined. Common types of solid-state welding are ultrasonic welding, explosion welding, electromagnetic pulse welding, friction welding, friction-stir-welding etc.

Basic mechanism of TIG welding:
TIG welding is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere by an inert shielding gas (argon or helium), and a filler metal is normally used. The power is supplied from the power source (rectifier), through a hand-piece or welding torch and is delivered to a tungsten electrode which is fitted into the hand piece. An electric arc is then created between the tungsten electrode and the work piece using a constant-current welding power supply that produces energy and conducted across the arc through a column of highly ionized gas and metal vapours [1]. The tungsten electrode and the welding zone are protected from the surrounding air by inert gas. The electric arc can produce temperatures of up to 20,000oC and this heat can be focused to melt and join two different part of material. The weld pool can be used to join the base metal with or without filler material. Schematic diagram of TIG welding and mechanism of TIG welding are shown in fig. 1 & fig. 2 respectively.

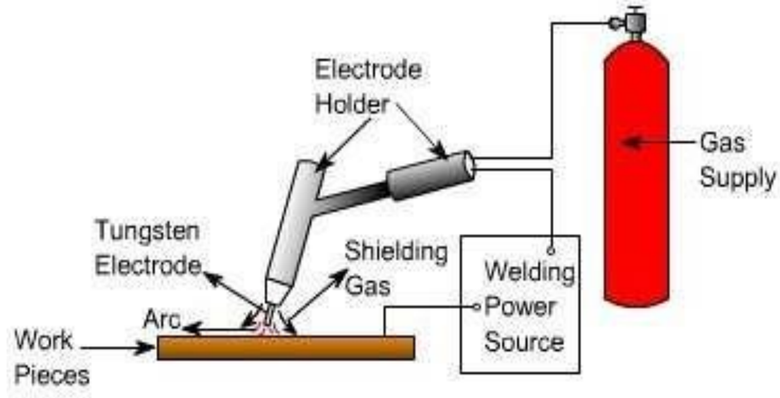

Fig 1: Schematic Diagram of TIG Welding System. [Ref: 1]

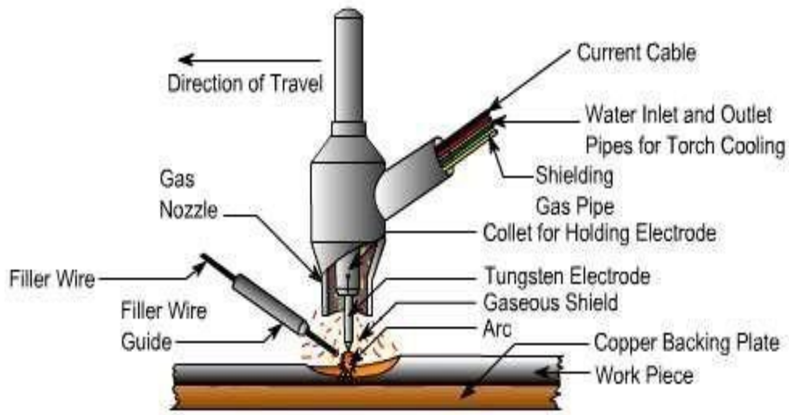

Fig. 2: Principle of TIG Welding. [Ref: 1]

Tungsten electrodes are commonly available from 0.5 mm to 6.4 mm diameter and 150 - 200 mm length. The current carrying capacity of each size of electrode depends on whether it is connected to negative or positive terminal of DC power source.

LITERATURE REVIEW

TIG Welding:

Sanjeev Kumar et. al [5] attempted to explore the possibility for welding of higher thickness plates by TIG welding.

Aluminium Plates (3-5mm thickness) were welded by Pulsed Tungsten Inert Gas Welding process with welding current in the range 48-112 A and gas flow rate 7 -15 l/min. Shear strength of weld metal (73MPa) was found less than parent metal

(85 MPa). From the analysis of photomicrograph of welded specimen it has been found that, weld deposits are form co-axial dendrite micro-structure towards the fusion line and tensile fracture occur near to fusion line of weld deposit.

Indira Rani et. al [6] investigated the mechanical properties of the weldments of AA6351 during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. Welding was performed with current 70-74 A, arc travel speed 700-760 mm/min, and pulse frequency 3 and 7 Hz. From the experimental results it was concluded that the tensile strength and YS of the weldments is closer to base metal. Failure location of weldments occurred at HAZ and from this we said that weldments have better weld joint strength.

Ahmed Khalid Hussain et. al [7] investigated the effect of welding speed on tensile strength of the welded joint by TIG welding process of AA6351 Aluminium alloy of 4 mm thickness. The strength of the welded joint was tested by a universal tensile testing machine. Welding was done on specimens of single v butt joint with welding speed of 1800 -7200 mm/min.

From the experimental results it was revealed that strength of the weld zone is less than base metal and tensile strength increases with reduction of welding speed.

Tseng et. al [8] investigated the effect of activated TIG process on weld morphology, angular distortion, delta ferrite content and hardness of 316 L stainless steel by using different flux like TiO_2, MnO_2, MoO_3, SiO_2 and Al_2O_3. To join 6 mm thick plate author uses welding current 200 Amp, welding speed 150 mm/min and gas flow rate 10 l/min. From the experimental results it was found that the use of SiO_2 flux improve the joint penetration, but Al_2O_3 flux deteriorate the weld depth and bead width compared with conventional TIG process.

Narang et. al [9] performed TIG welding of structural steel plates of different thickness with welding current in the range of 55 -95 A, and welding speed of 15-45 mm/sec. To predict the weldment macrostructure zones, weld bead reinforcement, penetration and shape profile characteristics along with the shape of the heat affected zone (HAZ), fuzzy logic based simulation of TIG welding process has been done.

Karunakaran et. al [10] performed TIG welding of AISI 304L stainless steel and compare the weld bead profiles for constant current and pulsed current setting. Effect of welding current on tensile strength, hardness profiles, microstructure and residual stress distribution of welding zone of steel samples were reported.

For the experimentation welding current of 100- 180 A, welding speed 118.44 mm/min, pulse frequency 6 Hz have been considered. Lower magnitude of residual stress was found in pulsed current compared to constant current welding. Tensile and hardness properties of the joints enhanced due to formation of finer grains and breaking of dendrites for the use of pulsed current.

Raveendra et. al [11] done experiment to see the effect of pulsed current on the characteristics of weldments by GTAW.

To weld 3 mm thick 304 stainless steel welding current 80-83 A and arc travel speed 700-1230 mm/min. More hardness found in the HAZ zone of all the weldments may be due to grain refinement. Higher tensile strength found in the non-pulsed current weldments. It was observed that UTS and YS value of non-pulsed current were more than the parent metal and pulsed current weldments.

Sakthivel et.al [12] studied creep rupture behaviour of 3 mm thick 316L austenitic stainless steel weld joints fabricated by single pass activated TIG and multi-pass conventional TIG welding processes. Welding was done by using current in the range of 160-280 A, and welding speed of 80-120 mm/min. Experimental result shows that weld joints possessed lower creep rupture life than the base metal. It was also found that, single pass activated TIG welding process increases the creep rupture life of the steel weld joint over the multi-pass TIG weld joints.

Tetsumi Yuri et. al [13] investigated high cycle and low cycle fatigue properties of SUS304L, SUS316L steel and the effects of welding structure by TIG welding process. Welding was done with U-shaped groove and the weld was done by multi-passes with voltage of 8-10 V, a current of 120-210 A, and welding speed of 800 mm/min.

From the experimental results it was revealed that in high-cycle fatigue tests, the ratio of fatigue strength to tensile strength of the weld metals is lower than that of base metal. However, in low-cycle fatigue tests, the fatigue lives of the weld metals were slightly shorter than that of base metals.

METHODOLOGY

Development of an automated TIG welding system

For proper welding and control on welding parameters mainly on welding speed an automated welding setup has been developed in-house. The automated welding setup with its main components is shown in fig. 3.1

Fig. 3 – Experimental set-up for TIG welding

The welding setup consists mainly following parts

a) Speed control unit (movable tractor) – Here, speed control unit is a movable tractor which run with a predefined speed required for welding. TIG welding torch is fixed with it using a clamp in a particular angle so that during welding a stable and continuous arc form. Welding speed can be change using a regulator. Distance between the torch tip and work piece and angle of torch tip can also be control using the adjustable knob.
b) Rail track –Movable tractor is run in a particular speed over this rail track in a straight line.
c) TIG Welding torch- Torch is fixed with the movable tractor unit. A tungsten electrode is fixed in the torch and Ar gas is flow through this.
d) TIG welding machine– This is the main part of TIG welding setup by which controlled amount of current and voltage is supplied during welding. A Rectifier (made by FRONIUS) with current range 10-180 A and voltage up to 230 V, depending on the current setting has been used.
e) Gas cylinder- For TIG welding Ar gas is supplied to the welding torch with a particular flow rate so that an inert atmosphere formed and stable arc created for welding. Gas flow is control by regulator and valve.
f) Work holding table- a surface plate (made of grey cast iron) is used for holding the work piece so that during welding gap between the tungsten electrode and work piece is maintained. Proper clamping has been used to hold the work piece.
g) The torch was maintained at an angle approximate 90° to the work piece.

Experimental Procedure:

Commercial Aluminium plate of thickness 3 mm was selected as work piece material for the present experiment. Al plate was cut with dimension of 120 mm x 50 mm with the help of band-saw and grinding done at the edge to smooth the surface to be joined. After that surfaces are polished with emery paper to remove any kind of external material.

After sample preparation, Aluminium plates are fixed in the working table with flexible clamp side by side and welding done so that a butt join can be formed. TIG welding with Alternate Current (AC) was used in experiments as it concentrates the heat in the welding area.

Zirconiated tungsten electrodes of diameter 3.4 mm was taken as electrode for this experiment. The end of the electrode was prepared by reducing the tip diameter to 2/3 of the original diameter by grinding and then striking an arc on a scrap material piece. This creates a ball on the end of the electrode. Generally an electrode that is too small for the welding current will form an excessively large ball, whereas too large an electrode will not form a satisfactory ball at all. After performing the welding, welded specimens were cut with dimension of 100 mm x 25 mm for tensile test, which were further cut in to I shape. Tensile test was performed with universal tensile testing machine (Instron-600) with maximum load capacity of 600 kN.

Further, a 10 mm x5 mm x3 mm specimen were cut at the cross section for microstructural study and micro-hardness measurement from each sample. Before micro- hardness measurement cross section of the welded specimen mounted and polished with 220, 600 and 1200 grit size polishing paper sequentially. Micro-hardness was measured with Vickers micro-hardness tester (LECO micro hardness tester LM 248 AT). Optical image of the cross section of the welded zone was taken with an optical microscope.

CONCLUSION

From the experiment of TIG welding of Aluminium plate following conclusion can be made with the automated welding system uniform welding of Aluminium plate can be possible. Welding strength or tensile strength of the weld joint depends on the welding parameters like welding speed and welding current.

With the increase in current, tensile strength of the weld joint increases. Hardness value of the weld zone change with the distance from weld centre due to change of microstructure. At lower welding speeds strength is more due to more intensity of current. For both side welding tensile strength is found almost equivalent to the strength of base material.

For both sided welding performed with high current (180 A), welding speed have no specific effect on tensile strength of the weld joint.

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