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Experimental Processes of Welding and Planning of TIG Welding of Aluminium Plate

Prashant[1], Mr. Aditya Kaushik[2]

[1]*M.Tech. Student, Mechanical Engg., SBMNEC, Rohtak, Haryana*
[2]*Asst. Professor, Mechanical Engg., SBMNEC, Rohtak, Haryana*

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.

***Keywords*: Automated TIG Welding System, Micro hardness Test, Tensile Test.**

I.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 [1]. 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 [4].

Different *type of welding processes*

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

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 [5].

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 [6].

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 s*eam-welding* where a wheel-shaped electrode is used [7].

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 [8].

II.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 20,000^{o}C 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 [4,5].

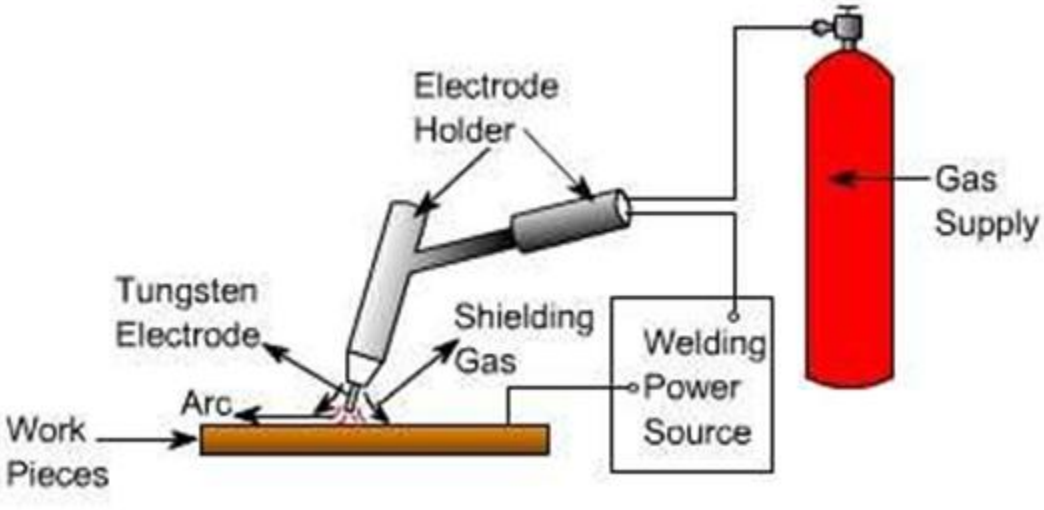

Fig 1: Schematic Diagram of TIG Welding System. [Ref:1]

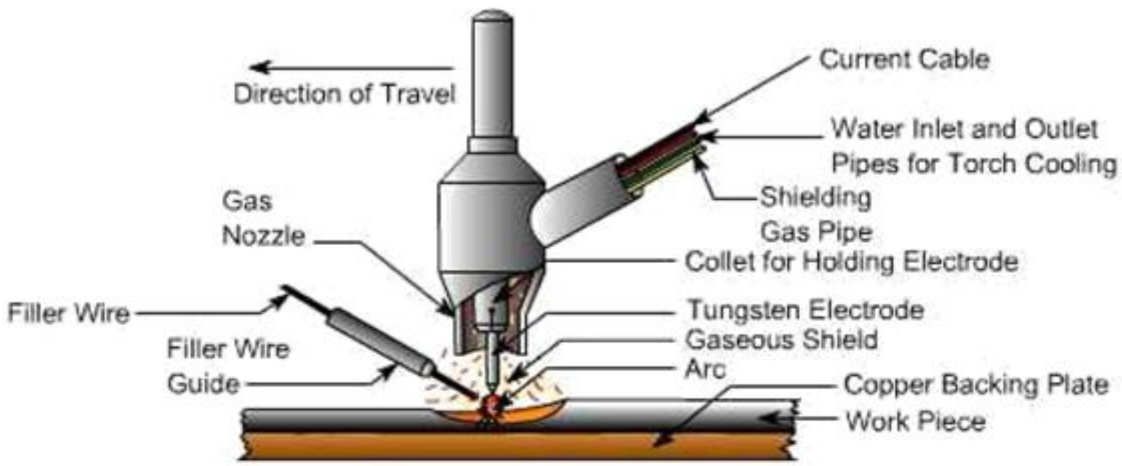

Fig. 2: Principle of TIG Welding. [Ref:1**]**

III.LITERATURE REVIEW

Ahmed Khalid Hussain et. al [1] 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 [2] 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 TiO2, MnO2, MoO3, SiO2 and Al2O3. 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 SiO2 flux improve the joint penetration, but Al2O3 flux deteriorate the weld depth and bead width compared with conventional TIG process.

Sanjeev kumar et. al [3] 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 [4] investigated the mechanical properties of the weldings of AA6351during 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 weldings is closer to base metal. Failure location of weldings occurred at HAZ and from this we said that weldings have better weld joint strength.

Raveendra et. al [5] done experiment to see the effect of pulsed current on the characteristics of weldings 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 weldings may be due to grain refinement. Higher tensile strength found in the non-pulsed current weldings. It was observed that UTS and YS value of non-pulsed current were more than the parent metal and pulsed current weldings.

Sakthivel et.al [6] 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.

Urena et. al [7] investigated the influence of the interfacial reaction between the Al alloy(2014) matrix and SiC particle reinforcement on the fracture behaviour in TIG welded Al matrix composites. TIG welding was carried out on 4 mm thick AA2014/SiC/Xp sheets using current setting in the range of 37-155 A and voltage of 14-16.7 V. From experimental results it was found that, the failure occurred in the weld metal with a tensile strength lower than 50% of the parent material. Fracture of the welded joint was controlled by interface deboning through the interface reaction Layer. Probability of interfacial failure increases in the weld zone due to formation of Aluminium-carbide which lowers the matrix/reinforcement interface strength.

Sivaprasad et.al [8] performed TIG welding of 2.5 mm thick Nickel based 718 alloy using welding current in the range of 44-115 A, voltage 13-15 V and welding speed 67 mm/min. the influence of magnetic arc oscillation on the fatigue behaviour of the TIG weldings in two different post-weld heat treatment conditions were studied.

Wang Xi-he et. al [9] performed TIG welding of SiCp /6061 Al composites without and with Al-Si filler using He-Ar mixed as shielding gas. For the welding authors uses gas flow rate 6.9 l/min, welding speed 1800 mm/min, current-60 A. The results show that addition of 50 vol.% helium in shielding gas improves the arc stability, and quality of welding improves when the Al–Si filler is added. The microstructure of the welded joint shows non-uniformity with SiC particles distributing in the weld centre.

IV.MATERIALS AND METHODS

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. The welding setup consists mainly following parts [15]:

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 [16].

Fig. 3: Experimental set-up for TIG welding [17]

Calibration of speed

Before start the experiment speed of the movable tractor was calibrated to get a required welding speed and found different speed value [18] which is shown in table 1.

Table 1: Speed value on speed controlled tractor

Number on equipment	Speed value(mm/s)
1	2.5
1.5	3
2	3.50
2.5	4.0
3	4.5
3.5	5

4	5.5
4.5	6

V.EXPERIMENTAL PLANNING AND PROCEDURE

For the present work, experimentation was done in two phase. In first phase, butt welding of Al plate (3 mm thickness) done at one side with different current setting and welding speed. In second phase, butt welding of Al plate done both side by varying welding speed and current setting [19].

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 [20].

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.

For the first phase of experiment welding parameters selected are shown in table 2. Before performing the actual experiment a number of trial experiments have been performed to get the appropriate parameter range where welding could be possible and no observable defects like undercutting and porosity occurred [21].

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Table 2: Welding parameters for 1st phase of experiments

Parameters	Range
Welding current	(100-140) A
Voltage	50 v
Speed	(3.5-4) mm/s
Distance of tip from weld centre	3 mm
Gas flow rate	(8-10) l/min.
Current type	AC
Dimension	120mm*50mm*3mm

VI.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.

Future scope

In present work welding is performed without any filler material. A filler rod/wire feeding system can be included in the system so that by using filler rod/wire thicker plate can be welded. Welding setup can also be use for welding of some other materials.

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