Review on Investigate the TIG Welding of Aluminum by Controlling Parameter

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Abstract - To improve welding Strength and weld quality of pure Aluminum (Al) plate, in terms of bead width and depth of penetration an automated TIG welding system has been using, by which welding speed and arc length 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, arc length 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. Also investigate the bead width and depth of penetration by image analysis technique.

Key Words: **Tensile Strength, Hardness, Bead width, Depth of penetration, Welding Current, Speed, Arc Length**

1. INTRODUCTION

Gas Tungsten Arc Welding (GTAW), also known as tungsten inert gas (TIG) welding is a process that produces an electric arc maintained between a non-consumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal, and the tungsten electrode are all shielded from atmospheric contamination by a blanket of inert gas fed through the GTAW torch. Inert gas (usually Argon) is inactive or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. Inert gases, such as Argon and Helium, do not chemically react or combine with other gases. They pose no odour and are transparent, permitting the welder maximum visibility of the arc. In some instances Hydrogen gas may be added to enhance travel speeds.[1]

The GTAW process can produce temperatures of up to 35,000° F (19,426°C). The torch contributes heat only to the work piece. If filler metal is required to make the weld, it may be added manually in the same manner as it is added in the oxyacetylene welding process, or in other situations may be added using a cold wire feeder. [1][31]

GTAW is used to weld steel, stainless steel, nickel alloys such as Monel® and Inconel®, titanium, aluminum, magnesium, copper, brass, bronze, and even gold. GTAW can also weld dissimilar metals to one another such as copper to brass and stainless steel to mild steel. [1]

2. INPUT PARAMETER

2.1 Arc Length:

It is the straight distance between the electrode tip and the job surface when the arc is formed. There are three types of arc lengths:

Medium arc

The correct arc length or normal arc length is approximately equal to the diameter of the core wire of the electrode. This is a stable arc producing steady sharp cracking sound and causing: [21] [31]

Even burning of the electrode, Reduction in spatters, correct fusion and penetration, correct metal deposition [21]

It is used to weld mild steel using a medium coated electrode. It can be used for the final covering run to avoid undercut and excessive convex fillet/ reinforcement. [21[31]

Long arc

If the distance between the tip of the electrode and the base metal is more than the diameter of the core wire it is called a long arc. It makes a humming sound causing:

Unstable arc, Oxidation of weld metal, Poor fusion and penetration, Poor control of molten metal, More spatters, indicating wastage of electrode metal.[21][31]

It is used in plug and slot welding, for restarting the arc and while withdrawing the electrode at the end of a bead after filling the crater. Generally long arc is to be avoided as it will give a defective weld. [21][31]

Short arc

If the distance between the tip of the electrode and the base metal is less than the diameter of the core wire, it is called a short arc. It makes a popping sound causing:

The electrode melting fastly and trying to freeze with the job, higher metal with narrow width bead, less spatters more fusion and penetration. [2][21]

It is used for root runs to get good root penetration, for positional welding and while using a heavy coated electrode, low hydrogen, iron, powder and deep penetration electrode. [2][31]

2.2 WELDING SPEED

Welding speed is the linear rate at which the arc moves with respect to plate along the weld joint. Welding speed generally conforms to a given combination of welding current and voltage. If welding speed is more than required heat input to the joint decreases, less filler metal is deposited than required, Reinforcement height decreases'. If welding speed is slow, heat input rate increases, Weld width increases and reinforcement height also increases more convexity [1] [31]

2.3 WELDING CURRENT

DCSP (Direct Current Straight Polarity): In this type of TIG welding direct current is used. Tungsten electrode is connected to the negative terminal of power supply. This type of connection is the most common and widely used DC welding process. With the tungsten being connected to the negative terminal it will only receive 30% of the welding energy (heat). The resulting weld shows good penetration and a narrow profile. [1][21][23]

DCRP (Direct Current Reverse Polarity): In this type of TIG welding setting Tungsten electrode is connected to the positive terminal of power supply. This type of Connection is used very rarely because most heat is on the tungsten, thus the tungsten can easily overheat and burn away. DCRP produces a shallow, wide profile and is mainly used on very light material at low Amp. [1][21][23]

AC (Alternating Current): It is the preferred welding current for most white metals, e.g. aluminum and magnesium. The heat input to the tungsten is averaged out as the AC wave passes from one side of the wave to the other. On the half cycle, where the tungsten electrode is positive, electrons will flow from base material to the tungsten. This will result in the lifting of any oxide skin on the base material. This side of the wave form is called the cleaning half. As the wave moves to the point where the tungsten electrode becomes negative the electrons will flow from the welding tungsten electrode to the base material. This side of the cycle is called the penetration half of the AC wave forms. [1][21][23]

2.4 GAS FLOW RATE

The choice of shielding gas is depends on the working metals and effects on the welding cost, weld temperature, arc stability, weld speed, splatter, electrode life etc. [21] it also affects the finished weld penetration depth and surface profile, porosity, corrosion resistance, strength, hardness and brittleness of the weld material. Argon or Helium may be used successfully for TIG welding applications. For welding of extremely thin material pure argon is used. Argon generally provides an arc which operates more smoothly and quietly. [21][9]

Penetration of arc is less when Argon is used than the arc obtained by the use of Helium. For these reasons argon is preferred for most of the applications, except where higher heat and penetration is required for welding metals of high heat conductivity in larger thicknesses. Aluminum and copper are metals of high heat conductivity and are examples of the type of material for which helium is advantageous in welding relatively thick sections. Pure argon can be used for welding of structural steels, low alloyed steels, stainless steels, aluminum, copper, titanium and magnesium. Argon hydrogen mixture is used for welding of some grades of stainless steels and nickel alloys. Pure helium may be used for aluminum and copper. Helium argon mixtures may be used for low alloy steels, aluminum and copper. [21]

Shielding gas is necessary for the TIG process. The gas which must be chemically inactive (inert), have several functions in the TIG process: [21] [9]

- To provide the atmosphere needed for ionization, ensuring a stable arc and suitable heat transfer.
- To protect the hot tungsten electrode against the oxidizing effect of the air.

- To protect the molten pool against contamination and oxidation from the air.
- To protect the hot end of the filler metal rod from oxidation.
- To protect melt pool and electrode during cooling after the arc is broken.

Argon has proven to be the most suitable gas for this purpose. It is a colorless and odorless inert gas, heavier than air, non-toxic and nonflammable. It is obtained from air which contains approximately 1% argon. For the TIG process, a purity of 99, 95% is commonly used. It is necessary to adjust the gas flow and a regulator with flow-meter is therefore needed. On board a ship it is necessary to have a flow-meter that functions correctly also when positioned out of vertical. [21][17][22]

3. LITERATURE REVIEW

Subhasmita Mishra and Dr. AM Mohanty et al. [1]all the experiments runs are analyzed by safely measured in order to maintain the low error factor and to determine the result to produce the efficient weld joint with Al alloy specimen. The following conclusion is considered from the collected data by investigate the input and output parameter. Maximum tensile strength of 135.46MPA is obtained at welding current of 200AMP, welding voltage of 18V of gas flow rate 9lt/min. The tensile strength of weld joint of Al alloy increasing by increasing welding current 200AMP forvoltage18V and after that tensile strength decreases by again increasing welding current. The flow 9lt/min should be affect the maximum tensile strength was observed. From this we conclude that the flow required preventing the oxidation and shielding but more flow could be detrimental as could cause cooling.

E. Taban, E. Kaluc et al. [2]the present study has demonstrated that the tensile properties of FS welded joints were satisfactory as/than TIG and MIG welded joints. Though all failure locations were detected as weld metal in fusion welding processes, all failure locations of FS welded specimens were occurred at TMAZ advancing side. Bend tests of welded plates have shown that FS welded specimens do not include any defect like fusion welded specimens. The FSW process is a solid state welding process with process temperatures lower than fusion techniques, thus avoiding problems such as porosity, cracking and distortion. These are also the advantages of FSW process in comparison with fusion welding processes such as MIG and TIG.

Indira Rani et al [3] investigated the mechanical properties of the weldments of AA6351 during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. Experiment carried out with plate dimension 300mm X 150mm X 6mm, 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.

Chen et al. [4] investigated the influence of welding parameters on mechanical properties and microstructure of the welds of laser-TIG double-side welded 5A06 aluminum alloy. Experiment carried out successfully with plate dimension 150mm X 50mm X 4mm.The results show that the weld cross-sectional shape has an intimate relation with the mechanical properties and microstructure of the welds. The good weld profiles and free defects are responsible for the improvement of tensile properties. Due to low hardness of the fusion zone, this region is the weakest area in the tensile test and much easier to fracture. The loss of Mg element is responsible for the decrease of mechanical properties of the joints.

Fahmida et at. [5] Performed systematic investigation on TIG welding of aluminum alloy to improve the structure property relationship of weldment by controlling heat input. Aluminum plates of 1xxx series were welded with filler metal 4043 and with different current settings 145 A, 175 A and 195 A. Experiment carried out with plate dimension 35mm X 16mm X 11mm. The welded samples were examined under optical and scanning electron microscopes and mechanical tests were performed to determine hardness, tensile and impact strengths. A eutectic was found to form. At the highest current setting that is at the highest heat input the eutectic mixture was coarsest and largest in size and tend to form a continuous network. On the other hand at low heat inputs the eutectic mixture did not get sufficient time to grow or to form any continuous network. The change in microstructure with heat input is also supported by the hardness, tensile and impact strength values of these plates. High heat input created more dilution in the weld structure and higher welding current decreased the difference in hardness values at different locations of the weld. The impact energy and tensile strength improved with increase in current content.

Parm et al.[6] An experimental investigation has been carried out on microstructure, hardness distribution and tensile properties of weld butt joints of 6063 T6 aluminum alloy. Experiment carried out with plate dimension 150mm X 75mm X 6mm, welding was performed with gas flow rate 20 lit/min, welding speed 120 mm/min and welding current 90 A. Two different welding processes have been considered: a conventional tungsten inert gas (TIG) process and an innovative solid state welding process known as friction stir welding (FSW) process. In this study it has been found that heat affected zone of FSW is narrower than TIG welding and mechanical properties like tensile strength etc. are within comfort zone and are better than TIG welding method. Microstructure results also favour FSW. Results showed a general decay of mechanical properties of TIG joints, mainly due to high temperature experienced by the material. Instead, in FSW joint, lower temperatures are involved in the process due to severe plastic deformation induced by the tool motion and lower decay of mechanical properties. Hence from industrial perspectives, FSW process is very competitive as it saves energy, has higher tensile strength, lower residual stress values and prevents the joints from fusion related defects.

Din et al. [7] Performed pulsed TIG welding of 304L stainless steel and compare the weld bead profiles for constant current and pulsed current setting. Experiment carried out with plate dimension 150mm X 30mm X 1.6mm, welding was performed with gas flow rate 10 lit/min. 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 75-125 A, welding speed 125-375mm/min, pulse frequency 3 Hz have been considered. From the experimental result it was concluded that most important parameters affecting the responses have been identified as speed and current. Also found that there is good improvement in tensile strength after optimizing while comparing with parent metal and bend test result in no opening or crack formation. Hence a good quality weld is obtained from face to root, the optimized process parameters would definitely solve the problems of corrosion and fatigue faced by the material, by improving the weld quality at the same time, it increases the strength of the weld with minimum heat affected zone.

N.Jeyaprakash, Adisu Haile, M.Arunprasath et al. [8] investigated Automation or mechanization of the TIG process can have a number of benefits. These include the ability to use faster travel speeds, resulting in less distortion and narrower heat affected zones; the better and more consistent control of the welding parameters enables very thin sheet material to be welded; there is a greater consistency in the weld quality; and it is possible to employ operatives with a lesser degree of skill and dexterity than is required for manual welding.

Sanjeev Kumar et. al [9] attempted to explore the possibility for welding of higher thickness plates by TIG welding. Aluminum 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 (85MPa). 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.

Ahmed Khalid Hussain et. al [10] investigated the effect of welding speed on tensile strength of the welded joint by TIG welding process of AA6351 Aluminum 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.

Narang et. al [11] 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 [12] 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 [13] 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.

Wang et. al [14] studied the influences of process parameters of TIG arc welding on the microstructure, tensile property and fracture of welded joints of Ni-base super-alloy. For welding plate width of 1.2-1.5 mm, welding current in the range of 55-90 A, with variable welding speed in the range 2100-2900 mm/min was used. From experimental result it was observed that, the heat input increases with increase of welding current and decrease of welding speed.

A Kumar, S Sundarrajan[15] worked towards improvement of mechanical behavior of AA5456 aluminum alloy welds with pulsed TIG welding process. The effect of welding current, welding speed and frequency on mechanical properties such as ultimate tensile strength (UTS), yield strength, hardness and percent elongation of AA5456 aluminum alloy weldments have been studied. The effect of planishing on mechanical properties was also studied and observed that there was improvement in mechanical properties. It is observed that, there is 10–15% enhancement in mechanical properties after planishing. This is due to fact that, internal stresses are relieved or redistributed in the weld.

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