A Literature Review Of Gtaw Welding On Alluminium And Its Alloys

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Abstract- *There are a various welding techniques available for joining engineering materials, such as AMAW, MGAW, FCAW, SAW, electroslag welding, electron beam welding and GTAW methods. The choice of welding depends on several factors; among them are mainly the range of composition of the material to be welded, the thickness of the base materials and the type of current. GTAW is the most popular gas shielding arc welding process used in many industrial fields such as automobile industries, structural welding agricultural machinery, etc. Other arc welding processes have a limited quality compared to TIG welding processes. However, TIG welding also requires improvements in spatter reduction and bead weld quality. Shielding gas in TIG welding is desirable for protection from atmospheric contamination. The TIG welding process has the potential to become a new welding process with high quality and relatively pollution-free production. This article reviews the introduction of GTAW, various gases used in GTAW, the application of GTAW, and its process parameters to assemble the aluminum alloy.*

Keywords- Gas tungsten arc welding, process parameter, Application of GTAW etc.

I. INTRODUCTION

The GTAW or TIG welding process is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld zone is protected from the atmosphere by a shielding gas generally Argon or Helium or sometimes a mixture of Argon and Helium. Filler metal can also be manually fed for proper welding. The most commonly referred to as TIG welding process was developed during World War II. With the development of the TIG welding process, the welding of difficult-to-weld materials, eg. Aluminum and magnesium become possible. The use of TIG has now spread to a variety of metals like stainless steel, mild steel and high strength steels, Al alloy, titanium alloy. Like other welding systems, TIG welding power sources have also improved, moving from basic transformer types to the highly electronically controlled power source today

The installed tungsten gas arc welding system is shown here in Figure 1.1. Shielding gas is passed through the torch to protect the electrode, the molten weld pool, and the solidifying weld metal from atmospheric contamination. A constant current welding power supply creates energy that is passed through the arc through a column of highly ionized gases and metallic vapors known as plasma. TIG gives the welder greater control over the weld than competitive processes like armored metal arc welding (SMAW) and gas-metal arc welding (GMAW), which enables stronger and better welds. Quality. However, TIG / TIG is comparatively more complex and difficult to control with the stricter tolerance requirements and the filler material usually added from the other side, and also much slower than most other welding techniques. It also covers basic skills such as setting up equipment, prepping materials, assembling, starting an arc, welding pipes and plates, and repairing welds

Equipment used in TIG Welding.

The following equipment is required in TIG welding,

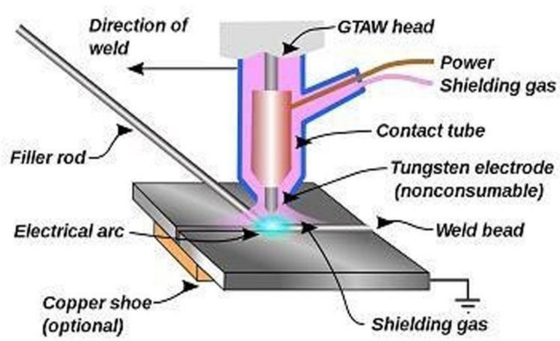

FIG 1 GAS TUNGSTEN ARC WELDING

- DC or AC power source
- TIG torch
- An inert gas cylinder
- Welding cable for electrodes and ground connections.
- Inert gas regulator & flow meter
- Electrode holder

- Non consumable tungsten electrode. etc.

1.1 GTAW's Principle of working

TIG uses the heat produced by the arc between the non-consumable tungsten electrode and the base metal. An inert shielding gas supplied through the torch shields the molten weld metal, heated weld zone, and non-consumable electrode from the atmosphere. The gas protects the electrode and molten material from oxidation, and provides a conducting path for the arc current. An electric current passing through an ionized gas produces an electric arc. In this process, the inert gas atoms are ionized by losing electrons and leaving a positive charge. Then the positive gas ions flow to the negative pole and the negative electrons flow to the positive pole of the arc. The intense heat developed by the arc melts the base metal and filler metal (if used) to make the weld. As the molten metal cools, coalescence occurs and the parts join. There is little or no spatter or smoke. The resulting weld is smooth and uniform, and requires minimum finishing. While there is not need to add filler metal when welding thinner materials, edge joints, or flange joints. This is known as autogenous welding. For thicker materials, an externally fed or "cold" filler rod is generally used. The filler metal in gas tungsten arc welding does not transfer across the arc, but is melted by it. strike the arc in one of three ways:

a) By briefly touching the electrode to the work and quickly withdrawing it a short distance.
b) By using an apparatus that will cause the arc to jump from the electrode to the work.
c) By using an apparatus that starts and maintains a small pilot arc. This pilot arc provides an ionized path from the main arc. The torch then progresses along the weld joint manually or mechanically after remaining in one place until a weld puddle forms. Once the welder obtains adequate fusion, the torch moves along the joint so the adjacent edges join and the weld metal solidifies along the joint behind the arc, thus completing the welding process.

1.2 POWER

TIG welding normally uses constant current type of power source with welding current ranging from 3-200A or 5300A or higher and welding voltage ranging from 10-35V at 60% duty cycle. Pure tungsten electrode of ball tip shape with DCEN provides good arc stability. Moreover, thorium, zirconium and lanthanum modified tungsten electrodes can be used with AC and DCEP as coating of these elements on pure tungsten electrodes improves the electron emission capability which in turn enhances the arc stability. TIG welding with DCEP is preferred for welding of reactive metals like aluminium to take advantage of cleaning action due to development of mobile cathode spots in work piece side during welding which loosens the tenacious alumina oxide layer. This helps to clean the weld pool. DCEN polarity is used for welding of metal such as carbon steel that don't require much cleaning.

1.3 GTAW Torch

The main purpose of the TIG torch is to carry the welding current and shielding gas to the weld. The TIG torch is constructed on the basis of the welding handle and a torch head that is coated with an electrically insulated material. The torch handle is usually fitted with a switch to turn the welding current and the shielding gas on and off. GTAW torch.

- Torch head
- Handle
- Control switch
- Electrode cap
- Sealing ring
- Electrode collet
- Heat shield
- Collet body
- Gas nozzle

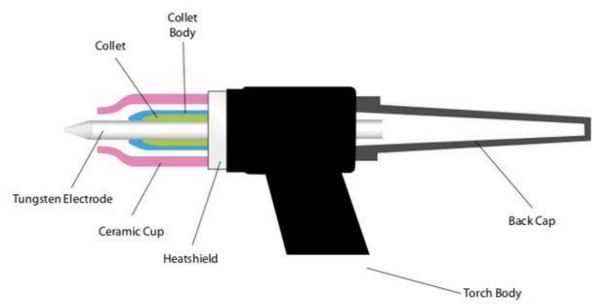

FIG 2 TIG TORCH

1.4 Mechanism of TIG There are two mechanisms that play important role in activating the effect of flux.

Marangoni effect: It refers to the convection movements due to the surface tension gradient on the weld pool surface. During TIG welding the surface tension gradient is negative and the convection movements are centrifugal and it leads to shallow penetration. The addition of activated flux induce an inversion of the convection currents changing the sign of the surface tension gradient, resulting convection movements changed to centripetal. Hence, the penetration depth increases.

The arc constriction effect:

- The flux acts as an insulating layer reducing the current density at the outer radius of the arc column and thus increases the current density at the center, increased magnetic force which leads to strong convective flow downwards in the weld pool and thus to significantly increased weld depth.
- The flux powder (Titanium dioxide) also causes the formation of an anode spot on the surface of the joint which attracts the electrons from the cathode (Tungsten electrode) causing deeper penetration.
- Negative ion formation at the edge of the arc could increase current density at the centre of the anode and thus increase the weld depth. It increases the production rate by three times as compared to manual TIG process and it gives consistent quality and excellent bead appearance.

1.5 PROCESS VARIABLES The principal variables in GTAW are arc voltage (arc length), welding current, travel speed, wire feed speed and shielding gas. Other variables may include shielding gas type, flow rates, nozzle diameter and electrode extension. The amount of energy produced by the arc is proportional to the current and voltage. The amount of energy transferred per unit length of weld is inversely proportional to the travel speed. The arc shielded with helium is generally hotter and more penetrating than the argonshielded arc. However, because all of these variables strongly interact with one another, it is impossible to treat them as truly independent variables when establishing welding procedures for fabricating specific joints.

Welding Current In general, welding current controls weld penetration in gas tungsten arc welding—the effect of current on penetration is directly proportional, if not somewhat exponential. Welding current also affects the voltage. Voltage at a fixed arc length increases in proportion to the current. For this reason, it is necessary to adjust the voltage setting when the current is adjusted to keep a fixed arc length. Gas tungsten arc welding can be used with direct current (dc) or alternating current (ac); the choice depends largely on the metal to be welded. Direct current with the electrode negative (DCEN) offers the advantages of deep penetration and fast welding speed, especially when helium or a helium mixture is used as the shielding gas. Alternating current provides a cathodic cleaning action during the electrode positive portion of the ac cycle, which removes refractory oxides from the metal surfaces. This cleaning action, known as sputtering, eliminates nearly all refractory oxide film from the weld pool surface and facilitates superior welds. In this case, argon must be used for the shielding because sputtering does not occur with helium. Argon is generally the gas of choice because it produces stable arc characteristics, whether used with direct current or alternating current, and it is lower in cost. A third power option is also available, that of using direct current with the electrode positive (DCEP). However, this polarity is rarely used because it causes electrode overheating and reduced heating of the materials to be welded. The effects of polarity are explained in more detail in the section, “Direct Current.”

1.6 Arc Voltage The voltage measured between the tungsten electrode and the workpiece (with the arc initiated) is commonly referred to as the arc voltage. Arc voltage, which is generally proportional to arc length, is a dependent variable that is affected in decreasing amounts by the following

- The distance between the tungsten electrode and the workpiece,
- Welding current,
- Type of shielding gas,
- The shape of the tungsten electrode tip,
- Ambient air pressure

1.7 Travel Speed Travel speed affects both the width and penetration of a gas tungsten arc weld. However, the effect of travel speed on width is more pronounced than its effect on penetration. In some applications, travel speed is defined as an objective, with the other variables selected to achieve the desired weld configuration at that speed. In other cases, travel speed might be a dependent var able, selected to obtain the weld quality and uniformity needed under the best conditions possible with the other combination of variables. Regardless of the objectives, travel speed is generally fixed in mechanized welding while other variables, such as current or voltage, are varied to maintain control of the weld.

1.8 Wire Feed Speed In manual welding, the welder controls the amount of filler metal to be used and the technique for depositing it in the weld pool. By adjusting the wire feed speed, the welder carefully controls the amount deposited to reduce the potential for incomplete fusion. Careful control also influences the number of passes required and the appearance of the finished weld. In mechanized and automatic welding, the wire feed speed determines the amount of filler deposited per unit length of weld. Decreasing wire feed speed increases penetration and flattens the bead contour. Feeding the wire too slowly may produce weld beads that are more concave, which leads to undercut, incomplete joint fill, and the potential for centerline cracking. Increasing wire feed speed produces a weld bead that is more convex, but it may decrease weld penetration.

1.9 ADVANTAGES OF GTAW Gas tungsten arc welding offers advantages for an extensive range of applications, from the high-quality welds required in the aerospace and nuclear industries and the high-speed autogenous welds required in tube and sheet metal manufacturing to the welds typical of fabricating and repair shops, where the ease of operation and the flexibility of the process are welcomed. The process can be automated and is readily programmable to provide precise control of the welding variables with remote welding control capability. Flexibility is gained when using gas tungsten arc welding because the process allows the heat source and filler metal additions to be controlled independently. Excellent control of root pass weld penetration can be maintained. Welds can be made in any position, and applications are almost unlimited. The process is capable of producing consistent autogenous welds of superior quality at high speeds, spatter-free, and generally with few defects. Almost all metals, including dissimilar metals, can be welded with the GTAW process. The process can be used with or without filler metal, as required by the specific application. A further advantage is that relatively inexpensive power sources can be used.

1.1O LIMITATIONS The following limitations of the GTAW process should be considered when selecting a process for a specific application:

1. Deposition rates are generally lower than the rates possible with consumable electrode arc welding processes;
2. Slightly more dexterity and coordination is required of the welder using GTAW than with gas metal arc welding (GMAW) or shielded metal arc welding (SMAW) manual welding;
3. There is a low tolerance for contaminants on filler or base metals;
4. For welding thicknesses under 10 millimeters (mm) (3/8 inch [in.]), the GTAW process produces weld quality comparable to or better than the consumable arc welding processes, but it is more expensive;
5. Magnetic fields leading to arc blow or arc deflection, as with other arc processes, can make gas tungsten arc welding difficult to control; and 6. If welding takes place in windy or drafty environments, it can be difficult to shield the weld zone properly.

1.11 APPLICATION

Gas tungsten arc welding is often selected when critical weld specifications must be met. Because gas tungsten arc welding provides the best control of heat input, it is the preferred process for joining thin-gauge metals, for spot welding in sheet metal applications, and for making welds close to heat-sensitive components. The process is easy to control and offers the option of adding filler metal as necessary to produce high-quality welds with smooth, uniform bead shapes or deposit surfaces. Gas tungsten arc welding can be used to weld almost all metals. It is especially useful for joining aluminum and magnesium, which form refractory oxides, and for reactive metals like titanium and zirconium, which can become embrittled if exposed to air while molten. Gas tungsten arc welding can be used to weld many joint geometries and overlays in plate, sheet, pipe, tubing, and other structural shapes. It is particularly appropriate for welding sections less than 10 mm (3/8 in.) thick.

II. LITERATURE REVIEW

[1]Heiple et al. (1982) revealed that surface active elements in the molten pool change the temperature coefficient of surface tension from negative to positive, thereby reversing the Marangoni convection direction from outward to inward. As the direction of the fluid flow in the molten pool becomes inward, the joint penetration increases dramatically.

[2] Howse et al. (2000) associated the greater penetration of activated TIG welding to a constriction of the arc. Information on these processes is necessary to determine the TIG penetration capability improvement function of the activated flux. Because austenitic stainless steels have a higher coefficient of thermal expansion and lower thermal conductivity than carbon and alloy steel, it can induce a large amount of shrinkage and distortion after welding fabrication. Determining the effect of the activated flux on weld distortion is essential to improving the performance of the stainless steel activated TIG technique. This study used five different kinds of oxide fluxes to investigate the effect of single component flux on the morphology and distortion of Type 316L stainless steel TIG welds. Aside from studying the microstructure and hardness of activated TIG weld metal, this study investigated the theoretical and experimental mechanisms for increasing the A-TIG penetration capability.

[3] Paulo et al. (2000) concluded that without activating flux weld depth achieved is very less and bead width is unnecessarily high. Best result is achieved in case of silicon dioxide, and highest penetration. CaO and Al oxide is not advisable to use because they are giving same or near result as conventional TIG welding.

[4] Huang (2009) investigated that one of the most notable techniques is to use an activated flux in TIG welding process. This novel variant of the TIG process is called A-TIG welding, which uses a thin layer of activated flux on the surface of the joint. The primary benefit of using flux is to reduce the heat energy required for TIG penetration.

[5] Kuang-Hung (2012) revealed that Cr2O3 flux assisted TIG welding can create a high depth-towidth ratio weld. Since the A-TIG welding can reduce the heat input per unit length in welds and the residual stress of the weldment can be reduced. TIG welding with Cr2O3 flux can increase the retained ferrite content of stainless steel 316L weld metal and in consequence, the hot cracking susceptibility is reduced

[6] Mohd. Shoeb, Prof. Mohd. Parvez and Prof. Pratibha Kumari studied the various welding parameters such as welding speed, voltage and gas flow rate on HSLA steel. The effects of these parameters on weld bead geometry such as penetration, width & height have been studied. They also investigated the MIG welding was carried out on DC electrode (welding wire) positive polarity (DCEP). However DCEN in used (for higher burn off rate) with certain self- shielding and gas shield cored wires. Mathematical equations have been developed using factorial technique and the result of various effects are indicated. They also investigated that Penetration is the distance that the fusion zone extends below the original surface of the parts being welded.

[7] Pawankumar, Kolhe K.P And C.K. Datta studied that effects of pulse parameters on the bead geometry of welded Aluminium Alloy 7039. In this paper, the effect of pulse currents, secondary currents, pulse frequencies and pulse duty cycles on the bead geometry of GTA Welded AA7039 has been studied. From this investigation it is observed that the penetration and penetration / width ratio increased with increase in the heat input i.e. pulse currents, secondary currents, pulse frequencies and pulse duty cycles. During welding, they observed that on increasing of frequency, there was a harsh sound in the welding machine.

[8] Kamble A. G, Rao R. V and Kale A.V studied that Welding process aims at obtaining a welded joint with the desired weld bead parameters, excellent mechanical properties with minimum distortion. Quality of weld joint depends upon welding input parameters. Manufacturer are facing problem of controlling the process input parameters to obtain a good welded joint with the bead geometry and also Prediction of weld bead geometry play very important role in determining the quality of weld.

[9] Pawankumar, Kolhe K. P, Morey S. J and Datta C. K has studied the effect of process parameters of pulsed current tungsten inert gas welding on aluminum alloy 6061 using sinusoidal AC wave with argon and helium gas mixture. From the study they have found that pulse current pulse duty cycle, frequency, percentage of helium in argon plays an important role on microstructure, and hardness of weld, Pulsed current plays major role in all of them. Lower micro hardness was observed in the weld zone because of using filler rod, dendrites solidified microstructure and segregated phase. It is also observed that the pulsed parameters play an important role in development of fine microstructure.

[10] Pavankumar, Kolhe K.P and Datta C.K has studied that the Process optimization of pulsed GTAW process for aluminium alloy 7039 using Ar + He gas mixtures. The present paper depicts the application of pulsed gas tungsten arc welding (pulsed GTAW) for aluminium alloy (AA7039) using various Ar + He (Argon + Helium) mixtures as a shielding gas with sinusoidal AC wave. In this investigation, Taguchi method is used to formulate the experimental layout, to analyze the effect of eachprocess parameter on the bead geometry, and to predict the optimum setting for each welding process parameter. AA 7039 is employed in aircraft, automobiles, high speed trains and high-speed ships due to their low density, high specific strength and excellent corrosion resistance.

[11] Kolhe K. P and Dharaskar R. M studied that GTAW welding is mostly used for welding agricultural machines are largely fabricated, by village craftsmen and smallscale industries. Tractor, engines and oil mills are manufactured by organized sectors. The small-scale industries seldom have R/D facilities and they depend upon public institutions for the advance technology. This paper focused on the advance of arc welding technology e.g. electric arc welding, gas metal arc welding, tungsten arc welding, submerged arc welding etc, to improve the mechanical properties such as strength, ductility hardness etc., Microstructure, Heat-affected zone and welded structure of farm machines.

[12] K.Kishore et al. analyzed the effect of process parameters for welding of AA 6351 using TIG welding. Several control factors were found to predominantly influence weld quality. The % contributions from each parameter were computed through which optimal parameters were identified. ANOVA method was used to checking the adequacy of data obtained. The experiment revealed that low current values have created lack of penetration and high travel speed has caused lack of fusion in welding AA6351.

III. RESULT

In this paper the discussion about GTAW Process and its welding techniques & variable process, arc voltage advantages, Travel speed, Mechanism shielding gas if any of this characterization fail it may cause damage and geometric failure in weld bead.

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