A Review Paper on TIG Welding Process Parameters

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Abstract— Tungsten Inert Gas (TIG) welding is welding process of joining different materials with high quality weld bead by electric arc generation between non consumable electrode and work piece under a shielding gas. It is used to weld ferrous and non-ferrous metals. It is also known as Gas Tungsten Arc Welding (GTAW) process. This process imply several advantages like low heat effected zone, joining of unlike metals, absence of slag, high heat concentration etc compared to other welding process. The TIG welding parameters are the most important factors affecting the quality, productivity and cost of welding. Plenty of the problems that are obstructing to achieve good weld quality can be avoided by proper consideration of the particular characteristics and requirements of the process. TIG Welding performance is mostly evaluated based on Tensile Strength of the weld, Weld bead Geometry, Hardness, Depth of Penetration and Width–to-Depth ratio Also known as Aspect ratio. In the present study, we discuss the influence of the different welding parameters such as welding speed, power source, type of current, shielding gas flow rate, electrodes, filer wire, Electrode gap and types of shielding gases which fits best to determine arc stability, arc penetration and defect free welds. Various approaches are proposed in the literature to achieve the solution related with optimization of these parameters. This has been carried out by doing literature survey on the effective point of view which helps to compare their main features and to choose the most suitable approach for a specified application.

Key words: Aspect Ratio, Non Consumable Tungsten Electrode, Optimization, Process Parameters, Shielding Gas, Tungsten Inert Gas, Weld Bead, Welding

I. INTRODUCTION

Welding is the process of permanent joining of similar or dissimilar metal at their contacting surfaces by application of heat and/or pressure [1], [8]. The welding came into existence from “Bronze Age” about approximately 2000 years ago known as forge welding. Egyptian people learned to weld iron pieces together during Iron Age.[2], [4-6]. Temperature of the Welding range is in between 1800ºF- 3600ºF.This has been carried out by melting the work pieces at the interface and a permanent joint can be achieved after solidification.[2]. Filler material is optionally added to generate weld pool of molten material which solidifies as time passes and gives a strong bond between the materials. [4]. Plenty of ways and sources are used in welding process like a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound.[3]. It can be done in many different environments, including open air, underwater and in space. Welding can be classified in Gas welding contains Oxyacetylene Gas welding, in Arc Welding contains SMAW, GMAW, GTAW, SAW and in Energy Beam Welding contains Laser Beam Welding, Electron Beam Welding etc.[5]. Welding technology is used in every stage of production and manufacturing. To generate high quality welds consistently, arc welding requires experienced welding personnel to avoid distortion.[2].

A. TIG Welding

TIG welding process is an Arc welding process developed in late 1930s when a need to weld magnesium became necessity.[8]. TIG welding used when a good weld joint appearance, a high quality weld and stability in the wide range of welding applications are required. TIG welding is a process that melts and joins metals by heating them with an arc established between non-consumable tungsten electrodes and the work piece under a shielding gas.[5]. Following is the schematic diagram of TIG welding shown in figure 1.

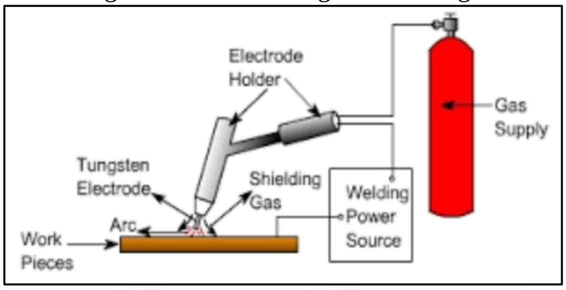

Fig. 1: Schematic of TIG welding [14]

B. Working Principle of TIG Welding

In the Tungsten Inert Gas welding, an arc is maintained between a tungsten electrode and the work piece.[9]. This arc and the weld pool are protected from atmospheric contamination with a gaseous shield of inert-gas such as argon, helium or argon-helium mixture. The filler metal is optionally used depends upon welding requirement. This filler metal can be introduced manually or automatically independent of types of process. The TIG welding process itself can be manual or automatic.[3]. The welding power source delivers direct or alternating current depends upon the heat dissipation required. TIG welding gives better result in welding of difficult to weld materials. TIG welding is used for huge family of materials to achieve high quality welding with the coalescence of heat generated by an electric arc established between a tungsten electrode and the work piece.[10]. Helium and argon gases and fall under the best suitability for the shielding as they are not chemically reactive.[6]. The aim of shielding gas are therefore, to protect the weld pool from surround air thus prevent oxidation, concentrate and transfers the heat during welding and helps to start and maintain a stable arc due to low ionization potential.[7]. This type of welding is also known as “Heliarc” or “Heliwelding”.

C. Mechanism of TIG welding

Available literatures show that some of the mechanisms, which play major role in increase weld quality are Marangoni Effect, Buoyancy force, Electromagnetic force, Arc constriction due to active flux, Arc constriction due to negative ions. Arc concentration effect is explained in Figure 2. As the surface flux evaporates and surrounded by a region of arc as atoms which forms under the high temperature of weld arc. Evaporated atoms seize electrons and shape into the negative ion in the region due to lower temperature inside. Arc conductivity decreased the automatic contraction and the heat concentrated. This concentrated arc permits control of heat input to the work piece resulting in a narrow heat affected zone. This is an advantage because while this process is ongoing, the base metal faces change due to superheating of arc and fast cooling rate. [13].

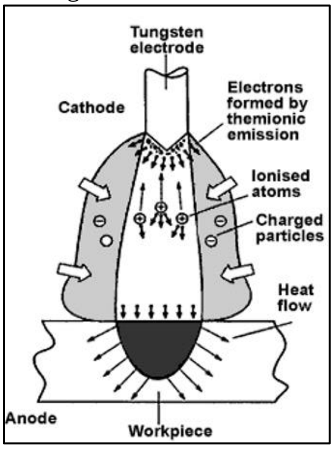

Fig. 2: Arc constriction [13]

D. TIG Welding Process Parameters

The effect of different welding parameters on the weld and its quality are explained below.

1) Voltage

Voltage controls the length of welding arc and resulting width and volume of arc cone. As voltage increases arc length gets longer (and arc cone broader), while as it decreases, the arc length gets shorter (and arc cone narrower).[11]. A high initial voltage allows for easy arc initiation and allows for greater range of working tip distance. Depth of penetration decreases as voltage increases. In GTAW welding process filler feeding or Filler melt off rate should be kept constant since it is manual process. Voltage is a controlling variable in manual processes because in manual process it is very difficult to consistently maintain the same arc length. Hence GTAW is constant current (CC) output method.[8-10].

2) Welding Current and Polarity

The welding current corresponds to the amount of heat applied to the part to affect the weld, and it depends on the material to be welded, material thickness, welding speed, and shield gas. The objective is to achieve defect-free welds with the required penetration. Current has direct influence on weld bead shape, on welding speed and quality of the weld. Most GTAW welds employ direct current on electrode negative (DCEN) (straight polarity) because it produces higher weld penetration depth and higher travel speed than on electrode positive (DCEP) (reverse polarity). Besides, reverse polarity produces rapid heating and degradation of the electrode tip, because anode is more heated than cathode in gas tungsten electric arc.[2],[4],[8-10].

3) Welding Speed

The effect of increasing the welding speed for the same current and voltage is to reduce the heat input.[1]. The weld speed increase produces a decrease in the weld cross section area, and consequently penetration depth (D) and weld width (W) also decrease.[4].

4) Type of Shielding Gas and Its flow rate

The choice of proper shielding gas for TIG welding can significantly affect weld quality and welding speed. Argon, helium and argon-helium mixtures use most widely as they are not reactive on tungsten electrodes. They are not producing any adverse effect on the quality of the weld. Argon gas as a Shielding gas medium is more widely preferred as it provides a softer arc, which is smooth and stable it is being less expensive,. Argon is better for welding specially aluminium and magnesium alloy. Flow rate of shielding gas is also major parameter affect the weld quality and it is depending upon types of material and thickness of the same.[8].

5) Arc Pulsing

Arc pulsing involves four welding parameters: peak current, background current, pulse width (duty cycle), and pulse frequency. Arc pulsing involves using the welding power supply to alternate the weld current rapidly from a high (peak current) to a low (background current) value. This creates a seam of overlap- ping spot welds. This technique reduces the overall heat input to the base material and also can allow for increases in weld speed. Arc pulsing brings many benefits to the welding procedure, often improving weld quality and repeatability. In some cases, materials and weld joints with poor fit-up that are difficult to weld successfully with a nonplussed arc can be welded easily with a pulsed arc technique. The results are improved weld quality and increased output.[3],[5].

6) Arc Length

The arc length is the distance between the electrode tip and the work-piece. The arc length in GTAW is usually from 2 to 5 mm.[10]. If the arc length increases, the voltage to maintain the arc stability must increase, but the heat input to work-piece decreases due to radiation losses from the column of the arc. Consequently, weld penetration and cross section area of melted material decrease with increasing arc length. [2],[9].

E. Advantages [1-15]

- It gives high quality weld.
- No use of flux hence no danger of flux entrapment when welding critical component of refrigeration.
- Less Post weld finishing is required.
- As the visibility of the arc and the job is much clear, it gives a better control on the welding.
- It is possible to weld in almost any position makes this process much more easy for highly accurate joint.
- It is much more suitable for high quality weld joint of thin materials.
- Adaptable and efficient process for all types of alloy and stainless steel.

F. Disadvantages [1-15]

- TIG equipment capital costs are higher compare to most of other welding equipment.
- If tungsten transfers to molten weld pool, it can contaminate the same. This inclusion is hard to remove.
- Weld metal contamination cause if filler rod end comes out of the inert gas shield.
- Very Limited thickness of material can be weld.

G. Application [1-15]

- It can weld aluminum, copper, nickel, magnesium and their alloys, stainless steel.
- It can weld high temperature and hard surfacing alloys like zirconium, titanium etc.
- It can joint sheet metal and thinner sections too.
- Due to high weld quality it is used to weld expansion bellows, instrument diaphragms and transistor cases.
- TIG is most preferable when it comes to precise weld joint in atomic energy, aircraft and chemical industries.
- When there is a need to achieve a joint which can assured 100 % volumetric inspection then this process is used.

II. EXISTING LITERATURE REVIEW

Bhargav C. Patel [1] et al, in their research paper "Optimizing and analysis of parameter for pipe welding: A literature review" emphasis on the study of the effect of different input parameter of TIG and MIG welding on the weld quality. They studied the effect of various welding parameter by conducting different experiments.

L Suresh Kumar [2] et. al. studied on the mechanical properties of austenitic steel for TIG and MIG process. They used the TIG and MIG process to find out the characteristic of metal after it is welded. The voltage is taken constant and various characteristics such as strength, hardness, ductility, grain structure, modulus of elasticity, breaking point etc. were analysis. They concluded that for austenitic steel TIG welding is more suitable while hardness is more in case of MIG welding.

Javed Kazi, [3] et al, represent a review on various welding techniques in International Journal of Modern Engineering Research publication in 2015. Their prime focus is on fulfillment of objective of Industrial application of welding with producing better quality product at minimum cost and increase productivity. The attempt is made to understand various welding techniques and to find the best welding technique for steel. Special focuses have been put on TIG and MIG welding. For this study they analyzed strength, hardness, modulus of rigidity, ductility, breaking point, % elongation etc. at constant voltage on hardness testing machine and UTM.

Palani.P.K, [4] et al, researched the effect of TIG welding process parameters on welding of Aluminium-65032. Response Surface Methodology was used to conduct the experiments. The parameters selected for controlling the process are welding speed, current and gas flow rate. Strength of welded joints were tested by a UTM.

R.Satish, [5] et al, researched the weld ability and process parameter optimization of dissimilar pipe joints using GTAW. Taguchi method was used to formulate the experimental layout to rank the welding input parameters which affects quality of weld. Results showed that lower heat input resulted in lower tensile strength and too high heat input also resulted in reduced tensile strength.

Jay joshi, [6] et al, researched based on Parametric Optimization of Metal Inert Gas Welding and Tungsten Inert Gas Welding By using Analysis of Variance and Gray Relational Analysis in International Journal of Science and Research publication in 2012. They carried out a design experimental method. With the help of Experimental data, they optimized by the gray relational analysis (GRA) technique, in which input parameters for TIG welding such as current, gas flow and output parameter as in tensile strength is considered. To find percentage contribution of each input parameters for obtaining optimal conditions, Analysis of variance (ANOVA) method was used. By analyzing the GRA the optimum parameters were evaluated.

Matusiak [7] et al, researched arc welding parameters and the emission of welding fume for the stainless steel weldments. The nickel and chromium content materials are welded by using MMA, TIG and MIG. The total amount of chromium are mainly depends on the oxidation content in shielding gasses. The argon mixtures produced less nickel content on the argon shielding gas. The fume emission is higher and mainly depends on the welding current during TIG welding Process covered electrodes produced higher chromium content in the fume.

Arun Kumar [8] et al, analyzed the welding techniques like GTAW and GMAW for the hollow pipes. The pipes are produced by the different combination of the material and the thickness of the pipe is 4mm and the diameter of the tube is 54mm.GMAW used the argon as shielding gas and GTAW uses some amount of CO2 with argon. Tungsten carbide and chromium carbide contribution increased the hardness and tensile strength values.RTR techniques showed some defects like stubs, cracks and holes in the pipe.

Gajendhiran s [9] et al, Make a study on welding parameters on MIG and TIG welding in the International Journal of Recent scientific Research publication in 2016. They concentrate on the selection of manufacturing method should be produced the product with low cost and also increased the productivity. Their focus is on the MIG and TIG welding processes. The process parameters like type of shielding gas, welding current, gas flow rate and welding voltage plays a major role on their mechanical properties of weldments. Center of study surrounded by the welding process parameters that influences on the material mechanical properties of weldments.

S.C. Juang [10] et al, were carried out the selection of the process parameters for TIG welding of stainless steel with the optimal weld pool geometry has been reported. The optimal weld pool geometry has four smaller-the-better quality characteristics, i.e. the front height, front width, back height and back width of the weld pool. The modified Taguchi method is adopted to solve the optimal weld pool geometry with four smaller-the better quality characteristics. Experimental results have shown that the front height, front width, back height and back width of the weld pool in the TIG welding of stainless steel are greatly improved by using this approach.

Raghuvir Singh [11] et al, were carried out investigated the effect of TIG welding parameters like welding speed, current and flux on depth of penetration and width in welding of 304L stainless steel has been studied. From the study it was observed that flux used has the most significant effect on depth of penetration followed by welding current. However Sio2 flux has more significant effect on depth. Optimization was done to maximize penetration and having less bead width.

Naitik s patel [12], et al, represent a review on Parametric Optimization of TIG welding in the International Journal of Computational Engineering Research publication in 2014. They carried out the feature highlighting the TIG as a better prospect for welding then other processes Especially for joining of two dissimilar metal with heating the material or applying the pressure or using the filler material for increasing productivity with less time and cost constrain. They made an attempt to understand the effect of TIG welding parameters such as welding current , gas flow rate ,welding speed ,that are influences on responsive output parameters such as hardness of welding, tensile strength of welding, by using optimization philosophy..

III. Conclusions

After doing the effort of understanding various literatures and making survey based on Influence of process parameters such as Welding current, welding speed, Welding polarity, Arc pulsing, Arc length, types of shielding gas along with their flow rate and aspect ratio on efficiency and output of TIG welding we can conclude that TIG welding is the most widely used arc welding process due to its vast range of advantages over other welding process. It has been observed that TIG welding can be approach to its best output when the above listed parameters are set to its most suitable atmosphere for the specified work. Welding current depends upon the selection on heat dissipation required either on work piece or electrode. Mostly DCEN or DCSP is used. Tungsten electrode Tip is also shaped accordingly. Welding speed depends upon the types of shielding gas used and thickness of material. When it comes to weld Aluminum TIG is best joining process. Flow rate of shielding gas in both pre weld stage and post weld stage plays a major role into the contribution of weld quality.

IV. Future scope

TIG welding parameters and their effect on the weld joint is elaborate in this paper which further useful to understand and chose the proper welding parameters to suit best on the specified working condition. Effect of the quantity of the particular parameters on the weld pool and weld geometry can be more precisely forecast for the best output. Behavior of different parameters on different material can become vast field of research based on the effect of TIG welding parameters on the weld joint and weld quality.

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