

# Review paper on TIG (tungsten inert gas welding) or GTAW(gas tungsten arc welding)

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**Abstract** – Tungsten Inert gas welding or Gas tungsten arc welding is an welding process which require a non consumable Tungsten electrode.(TIG) represents one of the most widely used metal joining process in the manufacturing industry across the globe .many research works have been done in the field of TIG/GTAW welding however these is always a scope for research in any particular field. many research work have been put forward on the basis of changing the process parameter also many have been put forward by the use of optimization techniques etc.

**Keywords**-GTAW(Gas tungsten arc welding) TIG (tungsten arc welding,)process parameter optimization techniques.,

## INTRODUCTION

The basic welding techniques are about as old as metal working itself. Even before the Iron Age started, the ancient gold workers knew how to heat up two pieces of gold and hammer those together. The early process of brazing is found in different gold objects in Egyptian and has been dated to go back as far as 3000 BC. However, the earliest process that is similar to modern day welding where carried out by blacksmiths in the middle ages. The process was to heat up the ends of two pieces of metal, stick them together and hammer it until the two ends together. The second function was to keep slag from forming. Slag is the solidification of unwanted materials that can get trapped inside the weld. The welding techniques remained more or less the same until the end of the 19<sup>th</sup> century [1].

## GAS TUNGSTEN ARC WELDING

A GTAW system consists of a constant current power supply, typically operating from 3 to 300 Amp and 10 to 35 V both direct and alternating current. The GTAW can be manual or semi- automatic. meaning that the filler

metal can be hand-fed into the arc when welding. Alternatively, it can be continually fed. It is possible to weld without filler [3], and then referred to as autogenously welding. This method is used on thin metals, edge joints and flange joints. This unit also contains a gas flow regulator and gas supply. The torches used are lightweight, compared to the other systems. It has a small gas nozzle, a tungsten electrode and a power switch. The only real weight comes from the cables attached to it. The torches come in four basic designs: for automatic welding, for manual welding, air cooled for low current welding and water-cooled for high current welding. A workpiece clamp is needed to complete the welding circuit. Differing from the other systems, the GTAW usually have a “throttle pedal” giving the operator direct control over the current, and in turn direct control over the arc and melting pool. GTAW is the best method to use when welding together different metals. In addition, it creates a very smooth, uniformed surface. When operating manually it requires a highly skilled worker, compared to the other methods. When welding manual GTAW the operator need one hand operating the torch, one hand to feed the filler and a foot to control the current.

## 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 vapour [4]. 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 °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 is shown in figure.1.

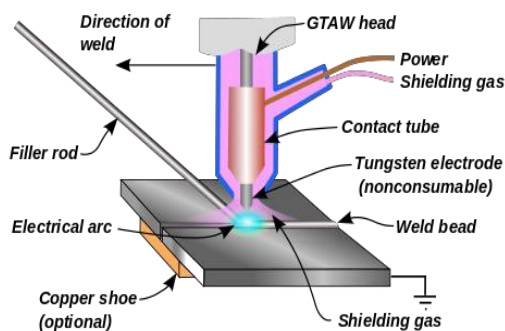


Fig. 1- Principle of TIG welding

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. The power source required to maintain the TIG arc has a drooping or constant current characteristic which provides an essentially constant current output when the arc length is varied over several millimetres. Hence, the natural variations in the arc length which occur in manual welding have little effect on welding current.

The capacity to limit the current to the set value is equally crucial when the electrode is short circuited to the work piece, otherwise excessively high current will flow, damaging the electrode. Open circuit voltage of power source ranges from 60 to 80 V.

## TYPES OF WELDING CURRENT IN TIG WELDING

### 1. 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.

### 2. 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.

### 3. AC (Alternating Current)

It is the preferred welding current for most white metals, e.g. aluminium 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.

### 4. Alternating Current with Square Wave

With the advent of modern electricity AC welding machines can now be produced with a wave form called Square Wave. The square wave has better control and each side of the wave can give a more cleaning half of the welding cycle and more penetration [2].

## APPLICATION OF TIG WELDING

The TIG welding process is best suited for metal plate of thickness around 5-6 mm. Thicker material plate can also be welded by TIG using multi passes which results in high heat inputs, and leading to distortion and reduction in mechanical properties of the base metal. In TIG welding high quality welds can be achieved due to high degree of control in heat input and filler additions separately. TIG welding can be performed in all positions and the process is useful for tube and pipe joint. The TIG welding is a highly controllable and clean process needs very little finishing or sometimes no finishing. This welding process can be used for both manual and automatic operations. The TIG welding process is extensively used in the so-called high-tech industry applications such as

- Nuclear industry
- Aircraft

- Food processing industry
- Maintenance and repair work
- Precision manufacturing industry
- Automobile industry

#### ADVANTAGES OF TIG WELDING

TIG welding process has specific advantages over other arc welding process as follows –

- Makes high quality welds in almost all metals and alloys.
- Almost none post weld clean up required.
- The arc and weld pool are clearly visible to the welder.
- The arc carries no filler, so there is little to none splatter.
- GTAW consumes almost 1/3 of the gas compared to GMAW.
- No slag produced that can be trapped in the weld.
- Welding can be performed in all positions.
- No flux is required because inert gas shields molten metal. So no slag and slag inclusion problems.

#### DISADVANTAGES OF TIG WELDING

- Tungsten inert gas welding is a time-consuming process - They are slower than any other welding process. Low filler deposition rate.
- Safety issue - Welders, are revelation to high intensity of light which can operate eye damage.
- High initial cost.
- It cannot use in thicker sheets of metal.

#### PROCESS PARAMETERS OF TIG WELDING

The parameters that affect the quality and outcome of the TIG welding process are given below.

##### 1. Welding Current

Higher current in TIG welding can lead to splatter and work piece become damage. Again lower current setting in TIG welding lead to sticking of the filler wire. Sometimes larger heat affected area can be found for lower welding current, as high temperatures

need to applied for longer periods of time to deposit the same amount of filling materials. Fixed current mode will vary the voltage in order to maintain a constant arc current.

##### 2. Welding Voltage

Welding Voltage can be fixed or adjustable depending on the TIG welding equipment. A high initial voltage allows for easy arc initiation and a greater range of working tip distance. Too high voltage, can lead to large variable in welding quality.[3]

##### 3. Inert Gases

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. 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. 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, , the use of argon results in good appearance and higher weld quality. Another common shielding gas (helium) is most often used to increase the weld penetration in a joint, welding speed and to weld metals with high heat conductivity such as copper and aluminium. A significant disadvantage is the decreased weld quality associated with a varying arc length and difficulty of striking an arc with helium gas.

##### 4. Welding speed

Welding speed is an important parameter for TIG welding. If the welding speed is increased, power or heat input per unit length of weld is decreases, therefore less weld reinforcement results and penetration of welding decreases. Welding speed or travel speed is primarily control the bead size and penetration of weld. It is interdependent with current. Excessive high welding speed decreases wetting action, increases tendency of undercut, porosity and uneven bead shapes while slower welding speed reduces the tendency to porosity.

##### 5. Electrode

The electrode used in GTAW is made of tungsten or tungsten alloy, because tungsten has the highest melting temperature among pure metals, at 3,400 °C. As a result, the electrode is not consumed during welding although some erosion (called burn-off) can occur. Electrodes can have either a clean finish or a ground finish. Clean finish electrodes have been chemically cleaned, while ground finish electrodes have

been ground to a uniform size and have a polished surface, making them effective for heat conduction. The diameter of the electrode can vary between 0.5 and 6.4 millimetres, and their length can vary from 75 to 610 millimetres. A number of tungsten alloys have been standardized by the International Organization for Standardization and the American Welding Society in code ISO 6848 and AWS A5.12, respectively, for use in GTAW electrodes, and are summarized below. Pure tungsten electrodes (classified as WP or EWP) are for general purpose and have low cost.

### 6. Welding torch

GTAW welding torches are designed for both automatic and manual operation and are equipped with cooling systems using air or water. The automatic and manual torches are similar in construction, but automatic torch normally comes with a mounting rack and the manual torch has a handle. Head angle i.e. the angle between the centerline of the handle and the centerline of the tungsten electrode can be varied on some manual torches according to the preference of the operator. Water cooling is required for high-current welding (up to 600 Amp.), while air cooling systems are most often used for low-current operations (up to about 200Amp.). The torches are connected with cables to the power supply, with hoses to the shielding gas source and where used, with pipe to the water supply. The internal metal parts of a torch are made of copper or brass (of hard alloys) in order to transmit current and heat effectively. The tungsten electrode must be held strongly in the centre of the torch with an appropriately sized collet, and ports around the electrode provide a regular flow of shielding gas. The diameter of the tungsten electrode decides the collet size as it holds the electrode.

### CONCLUSION

It has been found that there is a lot of future scope for research work in the area of welding especially Tungsten Inert gas welding (TIG), by varying the process parameters or by any other optimization techniques. It has a great potential for any research work to be carried out optimally.

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