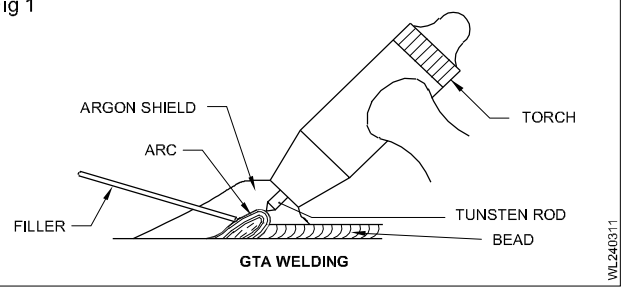
Principles of Gas Tungsten Arc Welding (GTAW), advantages & limitations

Objectives: At the end of this lesson you shall be able to
- **state the principle of GTAW process**
- **state its application**
- **state the advantages and disadvantages of GTAW.**

Process description (Fig.1)

Gas Tungsten Arc Welding (GTAW), also known as tungsten inert gas (TIG) welding is a process that produces an electric arc maintained between a nonconsumable 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 odor and are transparent, permitting the the welder maximum visibility of the arc. In some instances Hydrogen gas may be added to enhance travel speeds.

Fig 1



The GTAW process can produce temperatures of up to 3000° F. The torch contributes heat only to the workpiece. If filler metal is required to make the weld, it may be added manually in the same manner as it is added in the oxy-acetylene welding process, or in other situations may be added using a cold wire feeder.

GTAW is used to weld steel, stainless steel, nickel alloys, 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.

Advantages of GTA welding

- Concentrated Arc - Permits pinpoint control of heat input to the workpiece resulting in a narrow heat-affected zone.
- No Slag - No requirement for flux with this process; therefore no slag to obscure the welder's vision of the molten weld pool.
- No Sparks or Spatter - No transfer of metal across the arc. No molten globules of spatter to contend with and no sparks produced if material being welded is free of contaminants.
- Little Smoke or Fumes - Compared to other arc-welding processes like stick or flux cored welding, few fumes are produced. However, the base metals being welded may contain coatings or elements such as lead, zinc, copper, and nickel that may produce hazardous fumes. Keep your head and helmet out of any fumes rising off the workpiece. Be sure that proper ventilation is supplied, especially in a confined space.
- Welds more metals and metal alloys than any other arc welding process.
- Good for welding thin material.
- Good for welding dissimilar metals together.

Disadvantages of GTA welding

- Slower travel speeds than other processes.
- Lower filler metal deposition rates.
- Hand-eye coordination is a required skill.
- Brighter UV rays than other processes.
- Equipment costs can be higher than with other processes.
- Concentrations of shielding gas may build up and displace oxygen when welding in confined areas - ventilate the area and/or use local forced ventilation at the arc to remove welding fumes and gases. If ventilation is poor, wear an approved air-supplied respirator.

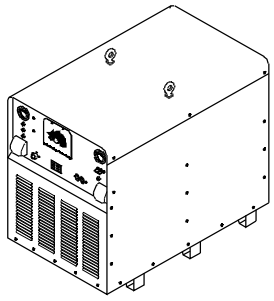
GTAW process brief description

Objective: At the end of this lesson you shall be able to
- **difference between equipments polarities and applications.**

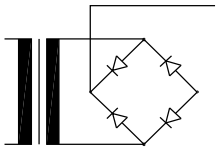
Constructional features of AC/DC welding rectifier: A welding rectifier set is used to convert AC welding supply into DC welding supply. It consists of a step down transformer and a welding current rectifier cell with a cooling fan. (Fig.1) The rectifier cell consists of a supporting plate made of steel or aluminium (Fig.2) which is plated with a thin layer of nickel or bismith, sprayed with SELENIUM or SILICON. It is finally covered with an alloyed film of CADMIUM, BISMITH and TIN.

The coating of nickel or bismuth over the supporting plate serves as one electrode (ANODE) of the rectifying cell. The alloyed film (of cadmium, bismuth and tin) serves as another electrode (CATHODE) of the rectifying cell. The rectifier acts as a non-return valve and allows current to flow on one side of it as it offers very little resistance and on the other side it offers very high resistance to the flow of the current. Hence the current can flow in one direction only.

Fig 1



CONSTRUCTIONAL FEATURE OF A WELDING RECTIFIER SET



SYMBOLIC REPRESENTATION

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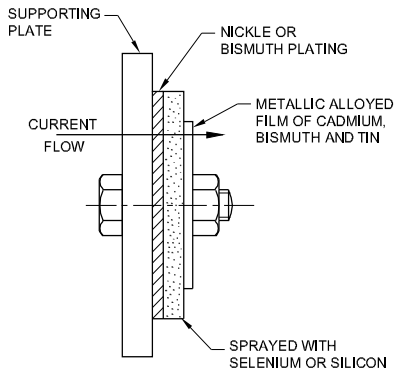
Fig 2



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Working principle: The output of the step down transformer is connected to the rectifier unit, which converts AC to DC. The DC output is connected to positive and negative terminals, from where it is taken for welding purposes through welding cables. It can be designed to provide either AC or DC welding supply by operating a switch provided on the machine.

Care and maintenance of rectifier welding set

Keep all the connections in tight condition.

Lubricate the fan shaft once in 3 months.

Do not adjust the current or operate the AC/DC switch when the welding arc is 'on'.

Keep the rectifier plates clean.

Check and clean the set atleast once in a month.

Keep the air ventilation system in good order.

Never run the machine without the fan.

Advantages and disadvantages of AC and DC welding

Objectives: At the end of this lesson you shall be able to
- **compare the advantages and disadvantages of AC welding**
- **compare the advantages and disadvantages of DC welding.**

Advantages of AC welding

A welding transformer has

– a low initial cost due to simple and easy construction
– a low operating cost due to less power consumption
– no effect of arc blow during welding due to AC
– low maintenance cost due to the absence of rotating parts
– higher working efficiency
– noiseless operation.

Disadvantages of AC welding

It is not suitable for bare and light coated electrodes.

It has more possibility for electrical shock because of higher open circuit voltage.

Welding of thin gauge sheets, cast iron and non-ferrous metals (in certain cases) will be difficult.

It can only be used where electrical mains supply is available.

Advantages of DC welding

Required heat distribution is possible between the electrode and the base metal due to the change of polarity (positive 2/3 and negative 1/3).

It can be used successfully to weld both ferrous and non-ferrous metals.

Bare wires and light coated electrodes can be easily used.

Positional welding is easy due to polarity advantage.

It can be run with the help of diesel or petrol engine where electrical mains supply is not available.

It can be used for welding thin sheet metal, cast iron and non-ferrous metals successfully due to polarity advantage.

It has less possibility for electrical shock because of less open circuit voltage.

It is easy to strike and maintain a stable arc.

Remote control of current adjustment is possible.

Disadvantages of DC welding

DC welding power source has:

- a higher initial cost
- a higher operating cost
- a higher maintenance cost
- trouble of arc blow during welding
- a lower working efficiency
- noisy operation in the case of a welding generator
- occupies more space.

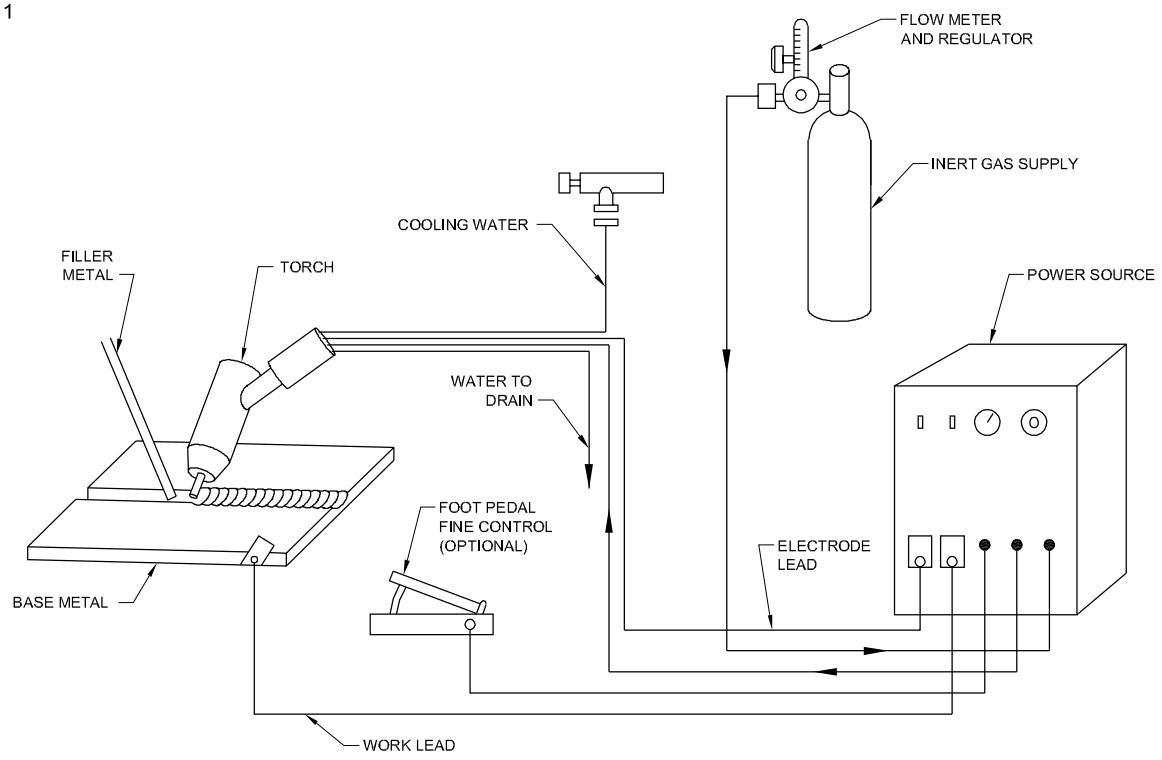
GTAW process and equipment

Objectives: At the end of this lesson you shall be able to
- **identify the GTAW equipment**
- **name the parts of a GTAW equipment**

TIG welding equipment (Fig 1)

– An AC or DC arc welding machine.
– Shielding gas cylinders or facilities to handle liquid gases
– A shielding gas regulator
– A gas flowmeter
– Shielding gas hoses and fittings
– A welding torch (electrode holder)
– Tungsten electrodes
– Welding filler rods
– Optional accessories
– A water cooling system with hoses for heavy duty welding operations
– Foot rheostat (switch)

Fig 1



A DIAGRAMMATIC DRAWING OF A COMPLETE GAS TUNGSTEN ARC WELDING

Various other name of the process (Tig orgamic)

Objectives: At the end of this lesson you shall be able to
- **understand the history and overview of GTAW**
- **state the advantages and applications of GTAW**

History of Gas Tungsten Arc Welding (GTAW)

GTAW welding was, like GMAW developed during 1940 at the start of the Second World War.

GMAW's development came about to help in the welding of difficult types of material, eg aluminium and magnesium. The use of GMAW today has spread to a variety of metals like stainless mild and high tensile steels.

GTAW is most commonly called TIG (Tungsten Inert Gas welding).

The development of TIG welding has added a lot in the ability to make products, that before the 1940's were only thought of.

Like other forms of welding, TIG power sources have, over the years, gone from basic transformer types to the highly electronic power source of the world today.

Overview

TIG welding is a welding process that uses a power source, a shielding gas and a TIG torches. The power is fed out of the power source, down the TIG torches and is delivered to a tungsten electrode which is fitted into the torches. An electric arc is then created between the tungsten electrode and the workpiece. The tungsten and the welding zone is protected from the surrounding air by a gas shield (inert gas). The electric arc can produce temperatures of up to 3000^0C and this heat can be very focused local heat.

The weldpool can be used to join the base metal with or without filler material.

The TIG process has the advantages of -

1 Narrow concentrated arc
2 Able to weld ferrous and non-ferrous metals
3 Does not use flux or leave a slag
4 Uses a shielding gas to protect the weldpool and tungsten
5 A TIG weld should no spatter
6 TIG produces no fumes but can produce ozone

The TIG process is a highly controllable process that leaves a clean weld which usually needs little or no finishing. TIG welding can be used for both manual and automatic operations.

The TIG welding process is so good that it is wisely used in the so-called high-tech industry applications such as

1 Nuclear industry
2 Aircraft
3 Food industry
4 Maintenance and repair work
5 Some manufacturing areas
6 The off shore industry
7 Combined heat and power plants
8 Petro chemical industry.
9 Chemical industry.

GTAW power sources

Objectives: At the end of this lesson you shall be able to
- **state the necessity of a suitable power sources**
- **state the different types of power sources used**
- **state the application of different power sources**
- **state the care and maintainance of GTAW machine.**

Power sources

TIG welding power sources have come a long way from the basic transformer types of power sources which were used with add-on units to enable the power source to be used as a TIG unit, eg high frequency unit and/or DC rectifying units.

The basics of TIG welding has almost remained the same, but the advent of technology TIG welding power sources have made the TIG processes more controllable and more portable.

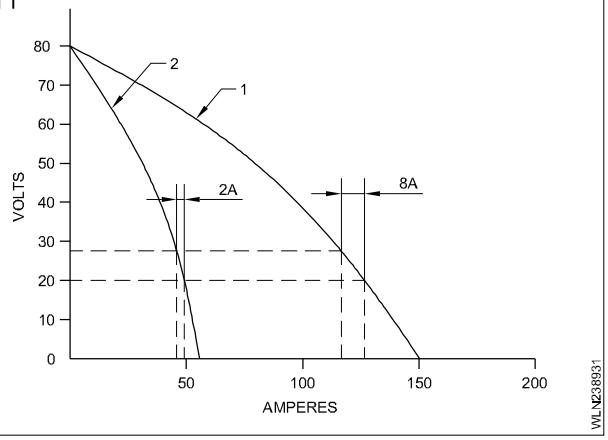
The one thing that all TIGs have in common is that they are CC (Constant Current) type power sources. This means only output adjustment will control the power source amps. The voltage will be up or down depending on the resistance of the welding arc.

Characteristerics of power fource :The output slope or voltampere curve A, a change from 20 volts to 25 volts will result in a decrease in amperage from 135 amps to 126 amps. With a change of 25 percent in voltage, only a 6.7 percent change occurs in the welding current in curve A. Thus if the welder varies the length of the arc, causing a change in voltage, there will be very little change in the current and the weld quality will be maintained. The current in this machine, even though it varies slightly is considered constant (Fig 1).

This is called drooping characteristic power source. Also called Constant Current (CC)power source.

This type of power source is used in SMAW & GTAW process.

Fig 1



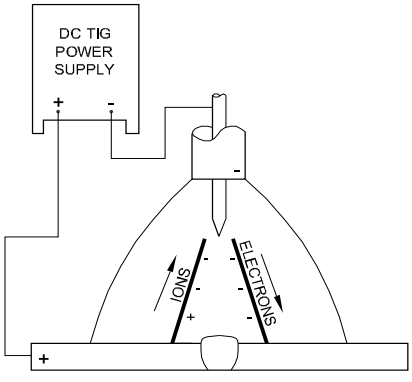
Types of welding current used for GTAW

When TIG welding, there are three choices of welding current. They are: Direct Current Straight Polarity, Direct Current Reverse Polarity, and Alternating Current with High Frequency stabilisation. Each of these has its applications, advantages, and disadvantages. A look at each type and its uses will help the operator select the best current type for the job. The type of current used will have a great effect on the penetration pattern as well as the bead configuration. The diagrams below, show arc characteristics of each current polarity type.

DCSP - Direct Current Straight Polarity (Fig 2): (The tungsten electrode is connected to the negative terminal). This type of connection is the most widely used in the DC type welding current connections. With the tungsten being connected to the negative terminal it will only receive 30% of the welding energy (heat). This means the tungsten will run a lot cooler than DCRP. The resulting weld will have good penetration and a narrow profile.

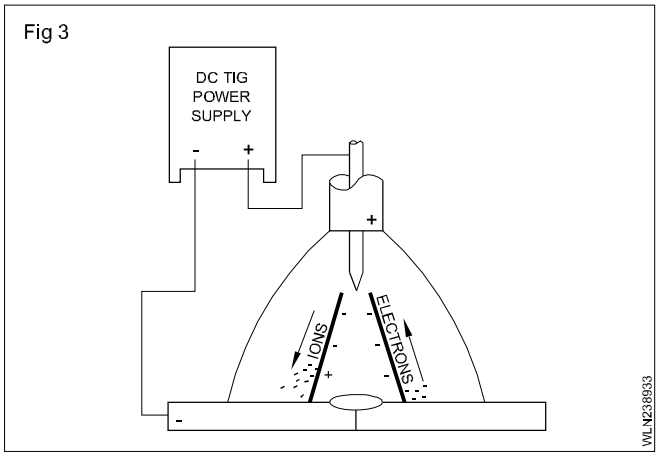
Current type	DCSP
Electrode Polarity	Electrode Negative
Oxide Cleaning Action	No
Heat Balance in the Arc	70% at work end 30% at electrode end
Penetration Profile	Deep, narrow
Electrode Capacity	Excellent

Fig 2



DCRP - Direct Current Reverse Polarity (Fig 3): (the tungsten electrode is connected to the positive terminal). This type of connection is used very rarely because most heat is on the tungsten, thus the tungsten can easily ove heat and burn away. DCRP produces a shallow, wide profile and is mainly used on very light material at low amps.

Fig 3



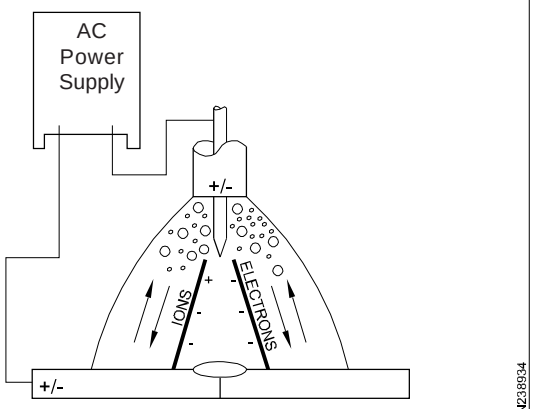
Cueent type	DCRP
Electrode Polarity	Electrode Positive
Oxide Cleaning Action	Yes
Heat Balance in the Arc	30% at work end 70% at electrode end
Penetration Profile	Shallow, wide
Electrode Capacity	Poor

Current type	ACHF
Electrode Polarity	Alternating
Oxide Cleaning Action	Yes (once every half cycle)
Heat Balance in the Arc	50% at work end 50% at electrode end
Penetration Profile	Medium
Electrode Capacity	Good

AC - Alternating Current (Fig 4) is the preferred welding current for most white metals, eg 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 is positive electron welding current 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 becomes negative the electrons (welding current) will flow from the welding tungsten to the base material. This side of the cycle is called the penetration half of the AC wave form.

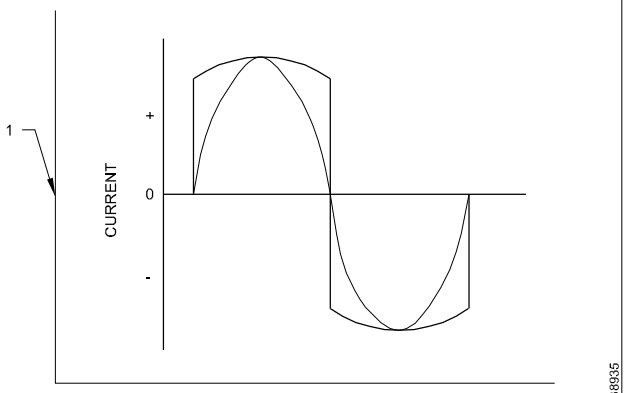
Fig 4



Because the AC cycle passes through a zero point the arc goes out. This can be seen with fast film photography. At this point the arc would stay out if it wasn't for the introduction of HF (high frequency). High frequency has very little to do with the welding process; its job is the re-ignition of the welding current as it passes through zero. HF is also often used for starting the welding arc initially without the tungsten touching the workpiece. This helps on materials that are sensitive to impurities. HF start can also be used on DC welding current to initially start the welding current without the tungsten touching the workpiece.

AC - Alternating Current - Square Wave (Fig 5)

Fig 5



1. SQUAREWAVE IMPOSED OVER SINE 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 the benefit of a lot more control and each side of the wave can be, in some cases, controlled to give a more cleaning half of the welding cycle, or more penetration.

Once the welding current gets above a certain amperage (often depends on the machine) the HF can be turned off, allowing the welding to be carried on with the HF interfering with anything in the surrounding area.

Extended Balance Control (Fig 5 ,6 & 7)

AC balance control allows the operator to adjust the balance between the penetration (EN) and cleaning action (EP) portions of the cycle. Some inverters have adjustable EN as great as 30 percent to 99 percent for control and fine-tuning of the cleaning action.

For instance, if the operator sets EN at 60 percent, it means that 70 percent of the AC cycle is putting energy into the work, while 40 percent of the cycle is cleaning.

Fig 6

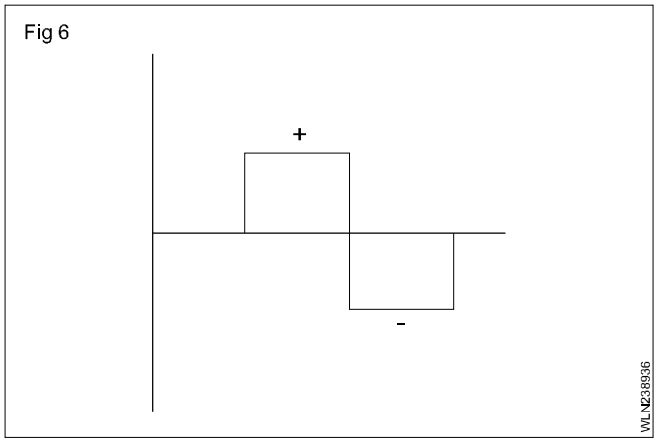


Fig 7

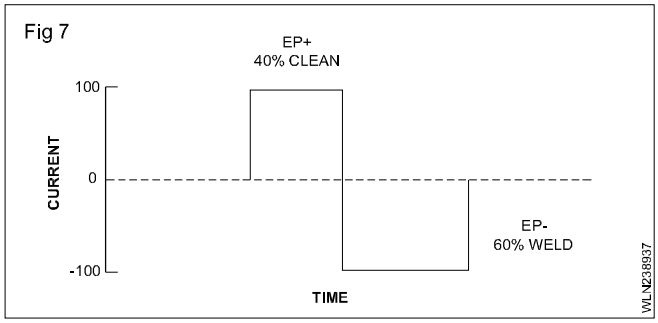
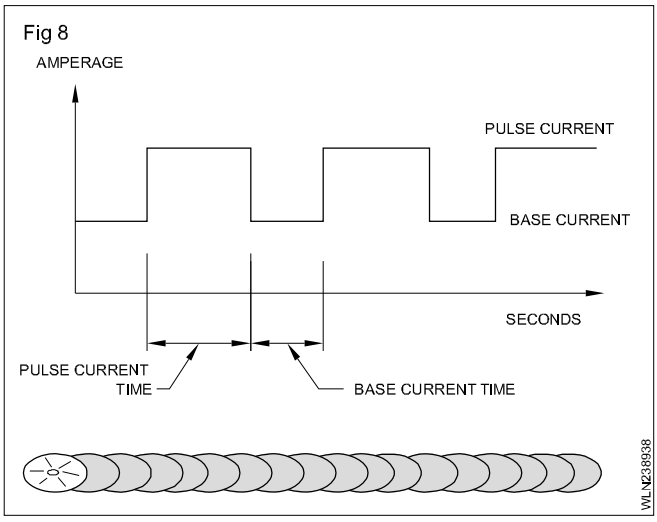


Fig 8



Pulsed TIG (Fig 8)

In this type of power source, the supply current is not constant and it is being fluctuated from low level to high level. This causes low heat input to the metal and hence distortion effect will be less.

Pulsed TIG has the advantages of

1 better penetration with less heat
2 less distortion
3 better control when welding out of position
4 easy to use on thin materials

The down side is - more set-up cost and more operator training.

Pulsed TIG consists of

Peak current - This is set up higher than for non-pulsed TIG.

Background current - This is set lower than peak current and is the bottom current the pulse will drop to, but must be enough to keep the arc alive.

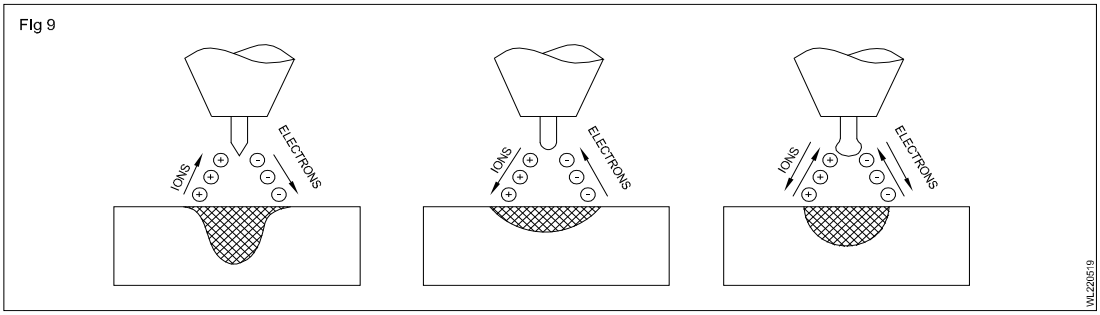
Pulses per second - This is the number of times per second that weld current reaches peak current.

% on Time - This is the pulse peak duration as a percentage of the total time, which controls how long the peak current is on for before dropping to the background current.

The pulse and base current periods are also controllable.

When welding is done with pulsing welding mode the weld is in principle a row of spot welds overlapping to a lerger or smaller extent depending on the welding speed.

Many double-current machines are equipped with a control function which makes it possible to modify the curve of the alternating current in balance between thew positive and the negative semi-periods.

Current Type	DCEN	DCEP	AC (Balanced)
Electrode Polarity	Negative	Positive	
Electron and ion flow Penetration Charateristics	Flg 9 		
Oxide Cleaning Action	No	Yes	Yes-once every Half Cycle
Heat Balance in the arc (approx.)	70% at work end 30% at electrode end	30 % at work end 70% at electrode end	50 % at work end 50 % at electrode end
Penetration	Deep Narrow	Shallow Wide	Medium
Electrode Capacity	Excellent e.g., 1/8 in. (3.2 mm) 400 A	Poor e.g. 1/4 in. (6.4 mm) 120 A	Good e.g. 1/8 in. (3.2 mm) 225 A