Presentation on

Plasma arc welding and plasma arc cutting

Introduction

- What is plasma?

Plasma is one of the four fundamental states of matter, it consists of a gas of ions – atoms which have some of their orbital electrons removed –and free electrons. Plasma can be artificially generated by heating a neutral gas or subjecting it to a strong electromagnetic field to the point where an ionized gaseous substance becomes increasingly electrically conductive.

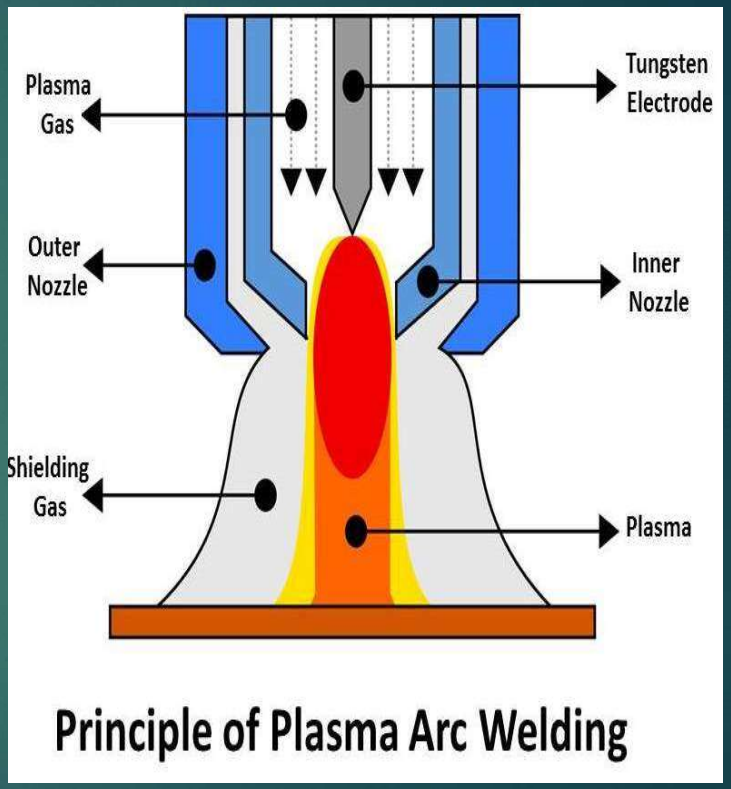
- What is plasma arc welding?

Plasma arc welding (paw) is an arc welding process very similar to TIG welding as the arc is formed between a pointed tungsten electrode and the workpiece. However, by positioning the electrode within the body of the torch, the plasma arc can be separated from the shielding gas envelope. Plasma is then forced through a fine-bore copper nozzle which constricts the arc.

Working principle of PAW

- A plasma is a gas which is heated to an extremely high temperature and ionized so that it becomes electrically conductive. Similar to GTAW, the plasma arc welding process uses this plasma to transfer an electric arc to a work piece. The metal to be welded is melted by the intense heat of the arc and fuses together.

- In the plasma welding torch a Tungsten electrode is located within a copper nozzle having a small opening at the tip. A pilot arc is initiated between the torch electrode and nozzle tip. This arc is then transferred to the metal to be welded.



Principle of Plasma Arc Welding

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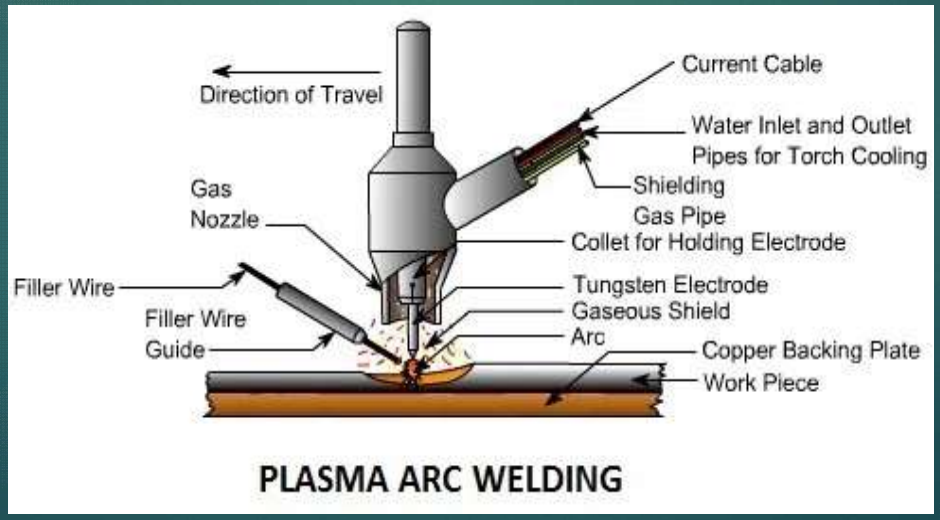
- By forcing the plasma gas and arc through a constricted orifice, the torch delivers a high concentration of heat to a small area. With high performance welding equipment, the plasma process produces exceptionally high quality welds.
- Plasma gases are normally argon. The torch also uses a secondary gas, argon, argon/hydrogen or helium which assists in shielding the molten weld puddle thus minimizing oxidation of the weld.



PLASMA ARC WELDING

Welding parameters

- Current 50 to 350 amps
- Voltage 17 to 31 volts
- Gas flow rate 2 to 40 liters/min
- Temperature of gas (28000°C)

Modes in PAW

1) Micro-plasma welding : welding current from 0.1A to 15A, use for welding thin sheet and wire.
2) Medium plasma welding: welding current from 15A to 100A
3) Keyhole welding: welding current above 100A, where the plasma arc penetrates the wall thickness, use for high-quality joint in aircraft, chemical industry to weld thicker material in single pass.

Variants in PAW

1) **Transferred PAW:**

The transferred PAW method uses direct polarity DC current. And in this method, the tungsten electrode can be allied to the -ve terminal and the metal can be allied to the +ve terminal. The arc produces among tungsten electrode as well as work portion. In this kind of method, both arc and plasma moved toward the work portion, which will enhance the heating capacity of the method. This type of PAW can be used to join solid sheets.

2) **Non-transferred PAW:**

The Non-transferred PAW method used direct polarity DC current. And in this method the tungsten electrode can be connected to the –ve and the nozzle can be connected to the +ve pole. The arc generates among the nozzle as well as tungsten electrode within the torch, which will enhance the ionization of the gas within the torch. And the torch will transfer the ionized gas for further procedure. This type of PAW can be used to join thin sheets.

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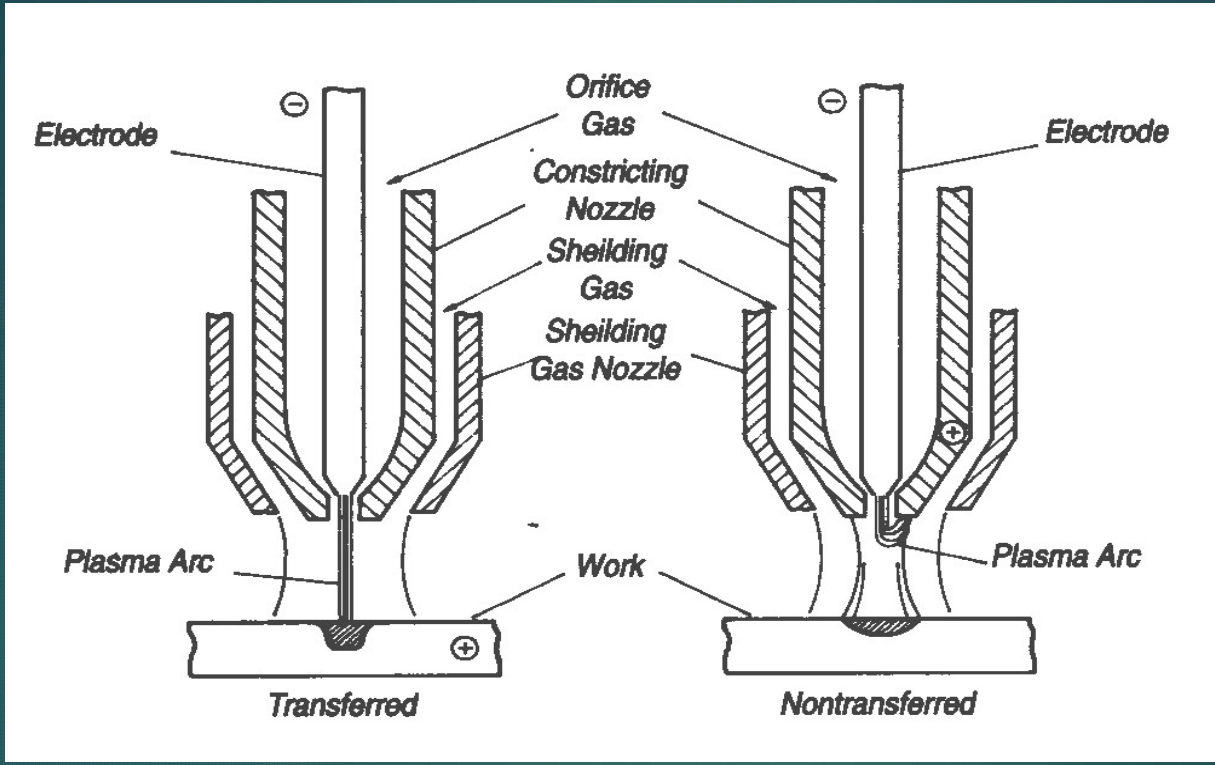
Electrode
Orifice Gas
Constricting Nozzle
Sheilding Gas
Sheilding Gas Nozzle
Plasma Arc
Work
Transferred
Electrode
Plasma Arc
Nontransferred

Equipment

Main equipment used in PAW are listed below:

1) **Power supply:** A DC power source with a drooping characteristics and open circuit's voltage of 70 volts or above is very much suitable for plasma arc welding.
2) **High frequency generator and current limiting resistors:** These both are used for arc ignition.
3) **Plasma torch:** The torch has an electrode and water cooling system which saves the life of the nozzle and the electrode from melting due to excessive heat produced while welding.
4) **Fixture:** It is required to avoid atmospheric contamination of the molten metal under bead.
5) **Shielding gas:** An inert gas, either Argon, helium, or a mixture, is used for shielding the arc area from the atmosphere. argon is more common because it is heavier and provides better shielding at lower flow rates.

Advantages and disadvantages

The advantages of PAW mainly include the following:

- Power consumption is low
- Welding speed is high, so it can simply utilize to join thick and hard workpieces.
- Penetration rate and strong arc are high.
- It can function at little amperage.
- The arc arrangement doesn't affect by the distance among tool as well as the workpiece.
- By using this method, the more steady arc can be produced.

The disadvantages of PAW mainly include the following.

- The process is noisy.
- Equipment cost is high.
- High expertise labor required.
- Radiation is more.

Application of PAW

- PAW can be used in industries like aerospace as well as marine
- PAW is used to join stainless tubes and pipes
- This type of welding is mostly applicable for electronic industries.
- PAW is mainly used to fix tools, mold and die.
- PAW is used to coating otherwise welding on the turbine blade.

Plasma arc cutting (PAC)

Plasma cutting (plasma arc cutting) is a melting process in which a jet of ionised gas at temperatures above 20,000°C is used to melt and expel material from the cut. During the process, an electric arc is struck between an electrode (cathode) and the workpiece (anode). The electrode is recessed in a water- or air-cooled gas nozzle which constricts the arc causing the narrow, high temperature, high velocity plasma jet to form.

Working principle:

- The basic plasma cutting process involves creating an electrical channel of superheated, electrically ionized gas i.e. plasma from the plasma cutter itself, through the work piece to be cut, thus forming a completed electric circuit back to the plasma cutter through a grounding clamp.
- This is accomplished by a compressed gas (oxygen, air, inert and others depending on material being cut) which is blown through a focused nozzle at high speed toward the work piece.

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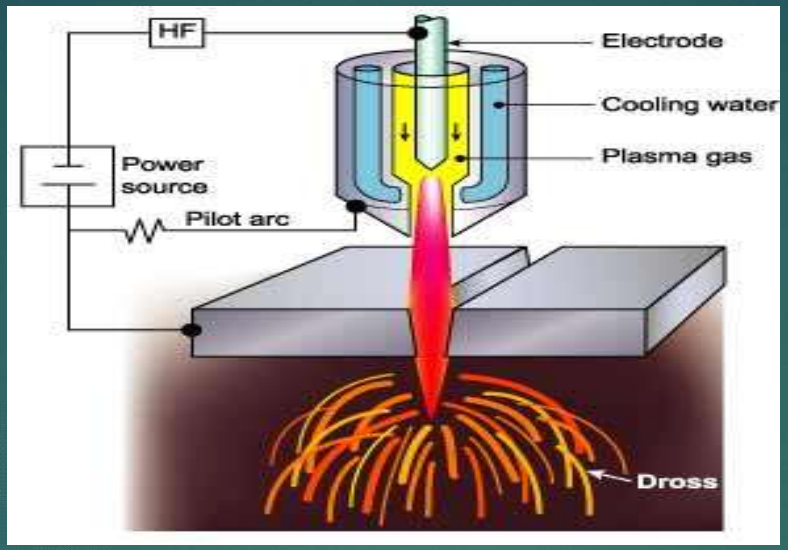

- An electrical arc is then formed within the gas, between an electrode near or integrated into the gas nozzle and the work piece itself. The electrical arc ionizes some of the gas, thereby creating an electrically conductive channel of plasma.
- As electricity from the cutter torch travels down this plasma it delivers sufficient heat to melt through the work piece. At the same time, much of the high velocity plasma and compressed gas blow the hot molten metal away, thereby separating, i.e. cutting through, the work piece.

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- Plasma cutting is an effective way of cutting thin and thick materials alike. Hand-held torches can usually cut up to 38 mm (1.5 in) thick steel plate, and stronger computer-controlled torches can cut steel up to 150 mm (6 in) thick.
- The arcs are generated in a three step process:

1) A high voltage spark briefly ionizes the air within the torch head. This makes the air conductive and allows the "pilot arc" to form. The pilot arc forms within the torch head, with current flowing from the electrode to the nozzle inside the torch head. The pilot arc burns up the nozzle, a consumable part, while in this phase.
2) The air then blows the plasma out the nozzle towards the work, providing a current path from the electrode to the work. When the control system senses current flowing from the electrode to the work, it cuts the electrical connection to the nozzle.
3) Current then flows from the electrode to the work, and the arc forms outside the nozzle. Cutting can then proceed, without burning up the nozzle. Nozzle life is limited by the number of arc starts, not cutting time.

Advantages and disadvantages

PAC have following advantages:

- cutting of all electrically conductive materials
- cutting of high-alloy steel and aluminium materials in medium and large thicknesses
- excellent performance in small and medium mild steel thicknesses
- cutting of high-strength structural steel with lower heat input
- high cutting speeds (up to 10 times higher than with oxyfuel)
- plasma cutting guarantees automation
- plasma cutting under water allows very low heat exposure and low noise level at the workplace

PAC have following dis-advantages:

- restriction of use of up to 160 mm (180 mm) for dry cutting and 120 mm for underwater cutting
- a slightly wider kerf
- relatively high power consumption
- lasers offer an even higher cutting quality
- more expensive than oxyacetylene cutting systems
- noise development possible with dry cutting

Thank you