Plasma Arc Welding (PAW)

It is a fusion welding process wherein the coalescence is produced by heating the work with a constricted arc established between a non consumable tungsten electrode and work piece or between a non consumable electrode and constricted nozzle. The shielding of the weld pool is obtained by the hot ionized gas produced by passing inert gas through the arc and constricted nozzle. Filler material may or may not be applied.

Principles of Operation:
In the PAW process, the workpiece is cleaned and edges are prepared. An arc is established between a non consumable tungsten electrode and workpiece or between a non consumable electrode and constricted nozzle. An inert gas is passed through the inner orifice surrounding the tungsten electrode and subsequently the gas is ionized and conducts electricity. This state of ionized gas is known as plasma. The plasma arc is allowed to pass through the constricted nozzle causing high energy and current density. Subsequently high concentrate heat and very high temperatures are reached.

Plasma arc welding is of two types: Non-transferred plasma arc welding process and transferred arc welding process. In the former, the arc is established between the electrode and the nozzle and in the latter process the arc is established between the electrode and the workpiece. The low flow rate (0.25 to 5 l/min) of the orifice gas is maintained as excessive flow rate may cause turbulence in the weld pool. However the orifice gas at this flow rate is insufficient to shield the weld pool effectively. Therefore inert gas at higher flow rate (10-30 l/min) is required to pass through outer gas nozzle surrounding the inner gas nozzle to protect the weld pool. A typical\ manual torch used in PAW is as shown in Fig. below.

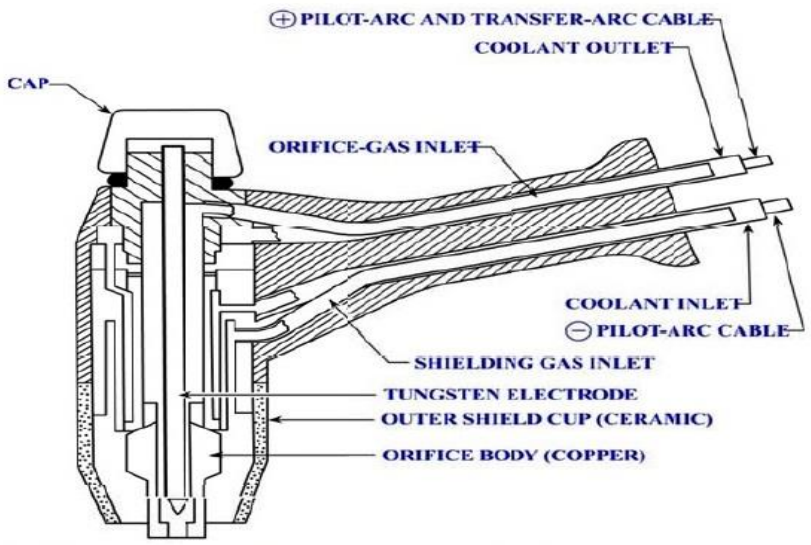

Fig. Manual torch used in PAW

Plasma arc welding is of two types: Non-transferred plasma arc welding process and transferred arc welding process. In the former, the arc is established between the electrode and the nozzle and in the latter process the arc is established between the electrode and the workpiece. The differences between these two processes are presented in the Table below.

Table: Difference between the transferred and non-transferred arc welding processes

Transferred plasma arc welding process	Non-transferred plasma arc welding process
Arc is established between electrode and workpiece	Arc is established between electrode and nozzle.
The work piece is part of the electrical circuit and heat is obtained from the anode spot and the plasma jet. Therefore, higher amount of energy is transferred to work. This is useful for welding.	The work piece is not part of the electrical circuit and heat is obtained from the plasma jet. Therefore, less energy is transferred to work. This is useful in cutting.
Higher penetration is obtained, so thicker sheets can be welded.	Less penetration is obtained, so thin sheets can be welded.
Higher process efficiency.	Less process efficiency.

PAW Operation:

In the PAW process, arc can not be initiated by touching the work piece as electrode is recessed in the inner constricted nozzle. Therefore, a low current pilot arc is established in the constricted inner nozzle and electrode. The pilot arc is generally initiated by the use of high frequency AC or high voltage DC pulse superimposed on the main welding current. It causes the ionization of the orifice gas and high temperature which contributes to easy initiation of the main arc between the electrode and work piece. After the initiation of the main arc, the pilot arc may be extinguished. This is followed by adding the filler material as in TIG welding process. Next, the welding torch is moved manually or automatically in the direction of welding. There are two techniques: (i) Key hole technique and (ii) Non key hole technique. In the key hole technique, due to constricted

inner nozzle and electrode. The pilot arc is generally initiated by the use of high frequency AC or high voltage DC pulse superimposed on the main welding current. It causes the ionization of the orifice gas and high temperature which contributes to easy initiation of the main arc between the electrode and work piece. After the initiation of the main arc, the pilot arc may be extinguished. This is followed by adding the filler material as in TIG welding process. Next, the welding torch is moved manually or automatically in the direction of welding. There are two techniques: (i) Key hole technique and (ii) Non key hole technique. In the key hole technique, due to constricted arc, high temperature and high gas flow; small weld pool with high penetration (up to 100%) to width is obtained, resulting in complete melting of the base material beneath the arc. As the arc moves forward, the material is melted and fills the hole produced due to arc force. The power supply and gas flow rate are turned off once the key hole is filled appropriately in the end of welding. The workpiece is suitably cleaned after cooling.

Equipment and Consumables:

Power source: A conventional DC current power supply with drooping V-I characteristics is required. Both rectifier or generator type power source may be used; however, rectifier type power source is preferred. The general range of the open-circuit voltage and current is 60-80V and 50-300A respectively.

Plasma torch: It consists of non consumable tungsten electrode, inner nozzle (constricting nozzle) and outer gas nozzle. The torch is water cooled to avoid heating of the nozzle. It is of two types: transferred arc and non transferred arc welding torch.

Filler material and shielding gases:

Filler material used in this process is the same as those used in the TIG and MIG welding processes. The selection of the gases depends upon the martial to be welded. The orifice gas must be an inert gas to avoid contamination of the electrode material. Active gas can be used for shielding provided it does not affect the weld quality. In general, the orifice gas is the same as the shielding gas.

Applications of PAW:

This process is comparatively new and hence the potential of the process is yet to be understood/ accepted. This process can be used to join all the materials those can be welded by welding TIG process. Present applications of the process include:

1) Piping and tubing of stainless and titanium,

2) Submarine, aeronautical industry and jet engine manufacturing,
3) Electronic components.

Advantages of PAW:

1) Welding speed is higher.

2) Penetration is more.

3) Higher arc stability.

4) The distance between torch and workpiece does not affect heat concentration on the work up to some extent.

5) Addition of filler material is easier than that of TIG welding process.

6) Thicker job can be welded.

7) Higher depth to width ratio is obtained resulting in less distortion.

Disadvantages of PAW:

1) Higher radiations.

2) Noise during welding.

3) Process is complicated and requires skilled manpower.

4) Gas consumption is high.

5) Higher equipment and running cost.

6) Higher open circuit voltage requiring higher safety measures to take.

References:

Books:

1. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.

2. Manufacturing Technology, vol. II by P.N. Rao, Tata McGraw Hill, New Delhi

Web Links:

1. https://nptel.ac.in/courses/112105212/

2. https://nptel.ac.in/courses/112/103/112103244/