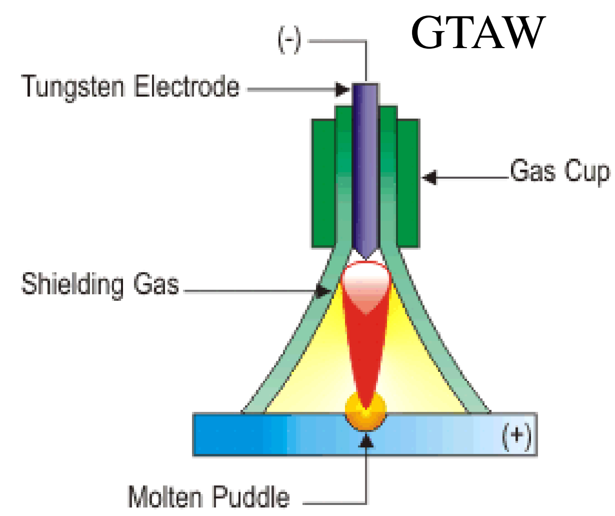
Plasma Arc Welding (PAW)

PAW: Introduced in 1957.

Similar to Gas Tungsten Arc Welding (GTAW) :

Electric Arc formed between an tungsten electrode and work piece.



Key difference from GTAW:

PAW-Electrode placed within the body of the torch

Plasma Arc separated from shielding gas,

Plasma forced through a fine-bore copper nozzle $\Rightarrow$ Constricts the arc and the plasma exits the orifice at high velocities and high temperature ~ 20,000 °C.

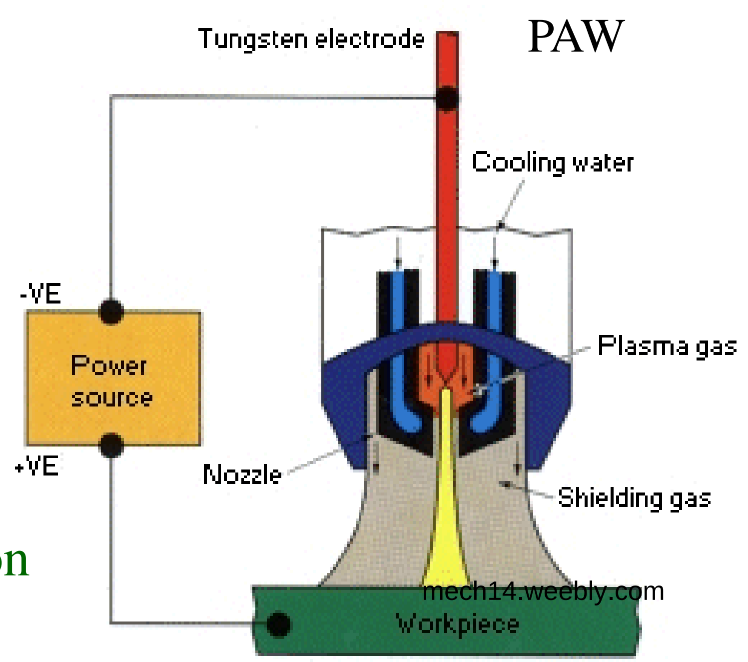
Plasma transfers the electric arc to the work piece.

Metal to be welded is melted by the intense heat of the arc and fuses together.

Higher energy concentration $\Rightarrow$ Deeper and narrower welds, Increased welding speed.

Plasma gas: Normally argon.

Secondary gas also used in torch: Argon, Argon/hydrogen or helium $\Rightarrow$ shielding the molten weld puddle from atmosphere to minimize oxidation



Three operating modes (Current ranges) can be produced by varying nozzle bore diameter and plasma gas flow rate:

Micro-plasma: 0.1 to 15A.

PAW was first developed for low current welding of thin materials since TIG could not provide stable arc at low currents.

Micro-plasma arc can be operated at very low welding currents.

Medium current: 15 to 200A.

Process characteristics of the plasma arc are similar to the TIG arc, however because plasma is constricted, arc is more concentrated, thus is capable to weld faster & better than TIG .

Keyhole plasma: over 100A.

At high welding current and plasma gas flow, a very powerful plasma beam is created which can create a keyhole and achieve full penetration in a material, as in laser or electron beam welding.

During welding, the hole progressively cuts through the metal with the molten weld pool flowing behind to form the weld bead under gravity, surface tension and gas pressure of shielding gases. This process can weld thicker material (up to 8mm of Steel, 10mm Tungsten) in a single pass without any preparation (V-groove) of the work-piece.

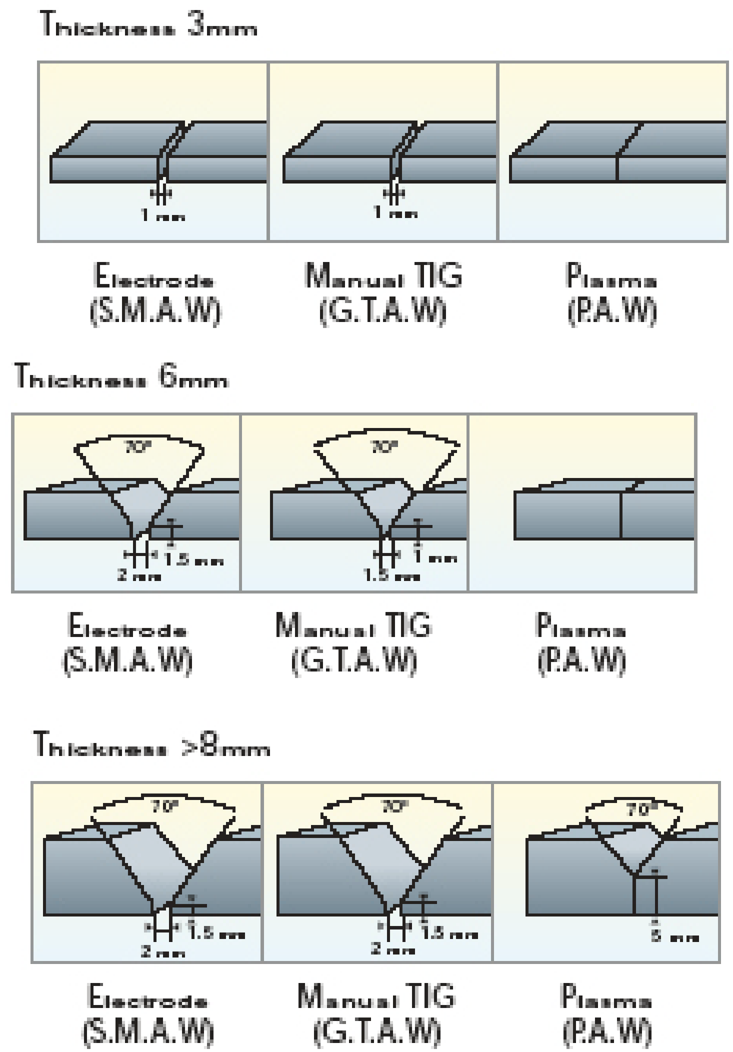
Advantages of the Plasma-keyhole technique:

* Welding of simple I-butt joints (without edge preparation) of thick sections in one single run

* Improved welding efficiency.

* Limited distortion due to the even distribution of heat through the plate thickness.

Joint preparation for different welding processes



Key process variables:

Current Type and Electrode Polarity: Standard – DC source with Electrode as cathode

AC square-wave - For aluminum and magnesium

Welding current and pulsing - Vary from 0.5 A to 1200 A; Current – DC or modulated at frequencies up to 20 kHz

Gas flow rate: Critical variable, must be carefully controlled based upon the current, orifice diameter and shape, gas mixture, and the base material and thickness.

Filler material feed rate

Advantages of Plasma Welding:

- ✓ Better stability: Less sensitivity to changes in Arc length.
- ✓ Recessed electrode reduces the possibility of tungsten inclusions in the weld and increases electrode life.
- ✓ Weld in a single pass up to 6 mm plates in square butt position and 10 mm plates in only two passes.
- ✓ Keyhole mode of welding gives smaller heat affected zone
- ✓ Reduced weld time results in better weld quality
- ✓ Less filler metal required in keyhole mode significantly reduces porosity.

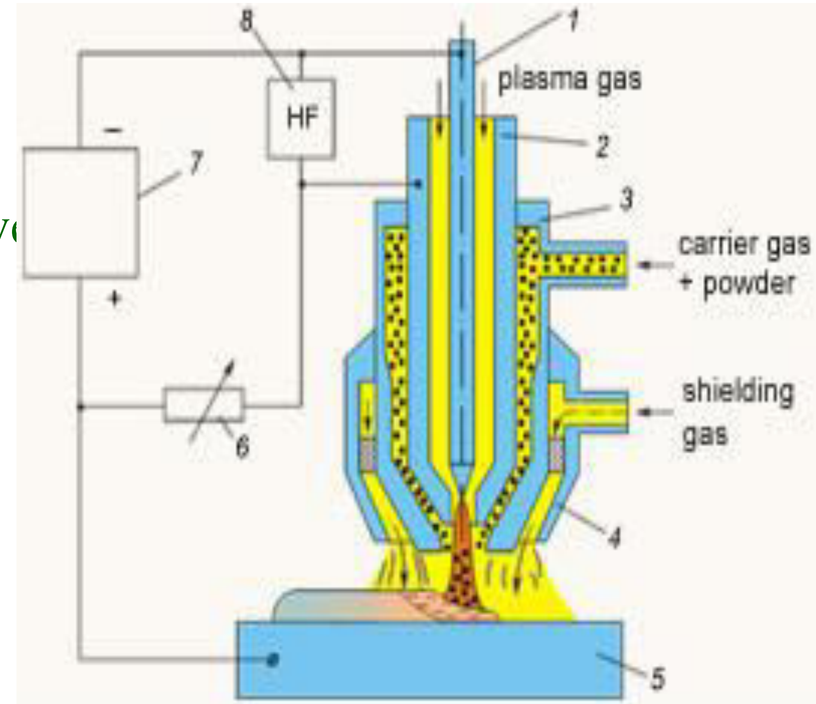
Applications: Welding of different types of steels, Nickel, Copper, Titanium, Zircon and Their Alloys and Special Materials

Plasma Arc Surfacing

* **Plasma transferred arc (PTA) surfacing-**

  To coat functional areas with special materials, which are resistant against intensive wear, corrosion, thermal and percussive loading.

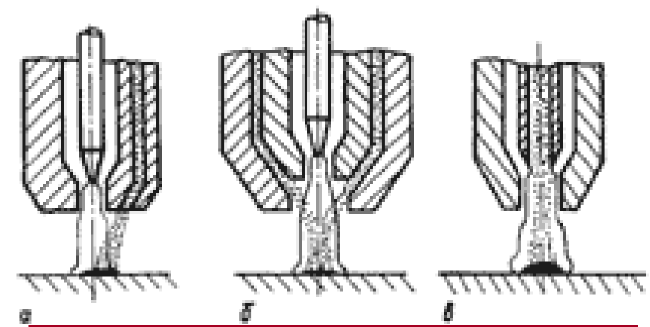
  1. Electrode
  2. Plasma nozzle
  3. Focusing nozzle
  4. Shielding nozzle
  5. Work piece
  6. Ballast resistance
  7. Power source
  8. High Frequency unit



* Additive powder is fed into the arc column.

* Process parameters to be controlled for minimum dilution and good metallurgical bond between cladding layer and base material

* Argon gas used for plasma arc and also for carrying power & shielding



Schemes of feeding of additive powder in arc: a - external; b - internal; c - through sleeve cathode

Comparing with conventional arc surfacing technologies
PTA offers:

- ✓ High deposition rate up to 10 kg/h
- ✓ High quality of deposited metal
- ✓ Minimum penetration/ dilution into base metal (< 5%)
- ✓ Minimum losses of filler material
- ✓ Deposits between 0,5 - 5,0 mm thickness and 3,0 - 50,0 mm width can be produced rapidly in a single pass
- ✓ Fe-, Ni-, Co-, Cu- base alloys as well as composite materials can be clad

In comparison to the laser surfacing the PTA technology could offer much more high productivity, comparable high quality of deposits and significantly lower costs.

Typical application areas of the PTA technology

- Extruding machine screws

- Valves of internal combustion engines (motorcar, marine, locomotive etc.)

- Cutting tools (milling cutters, broaches, knifes)

- Quid roll fittings, accessories for ships, petroleum chemistry and power generation, hydro-transport, pump plungers etc.