

# Plasma Arc Welding & Cutting

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# INTRODUCTION

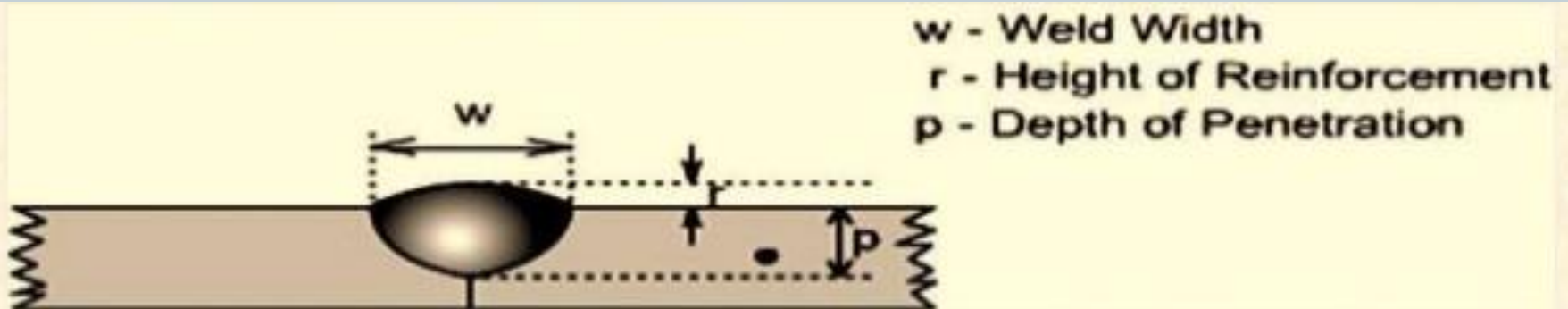


- Arc plasma is a temporary state of gas.
- The gas get ionized after the passage of electricity current through it and it becomes a conductor of electricity.
- In ionized state gas atoms break into electron (-) and ions (+) and the system contains a mixture of ions, electrons and highly excited atoms.
- The energy of the plasma jet and thus the temperature is dependent upon the electrical power employed to create arc plasma.
- A typical value of temperature obtained in a plasma jet torch may be of the order of  $16500^{\circ}\text{C}$ .

# KEYWORDS



- **Plasma** : A gas heated to a very high temperature and ionized so that it becomes conductive.
- **Pilot arc** : First arc between electrode & constricting nozzle.
- **Keyhole** : A welding technique in which a concentrated heat source penetrates the WP forming a hole at the leading edge of the molten weld metal.
- **Sinter** : Integrate into a solid or porous mass by means of heating.
- **Weld Bead Geometry** :

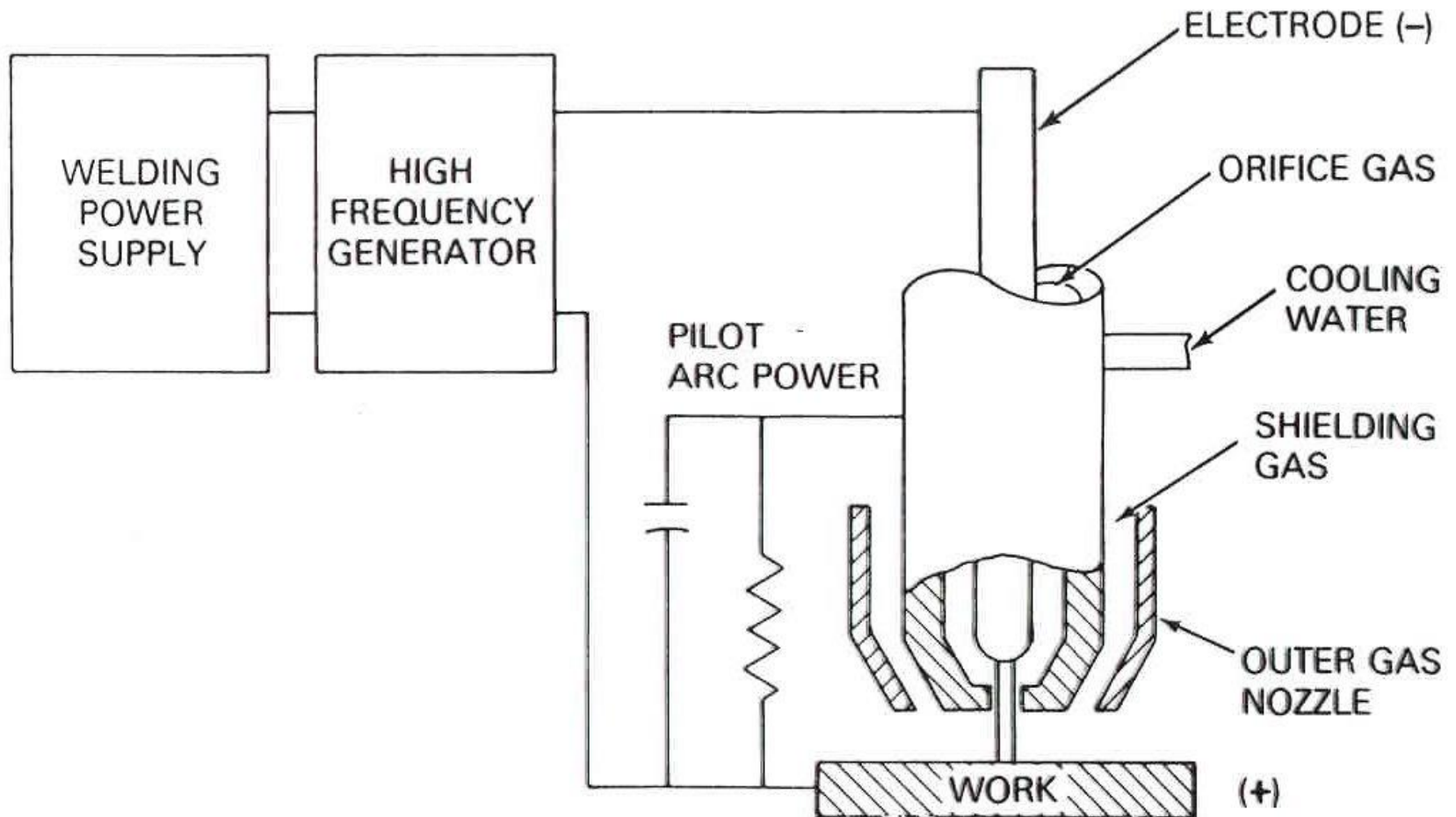


# EQUIPMENT



- Power source : open circuit voltage of 80 volts
- Current : 50 – 350A
- A DC welding current is required
- High frequency generator
- A cooling system : water recirculation
- Plasma welding torch
- Plasma gas
- Shielding gas : Argon, Argon/Hydrogen or Helium

# Plasma Welding Equipment

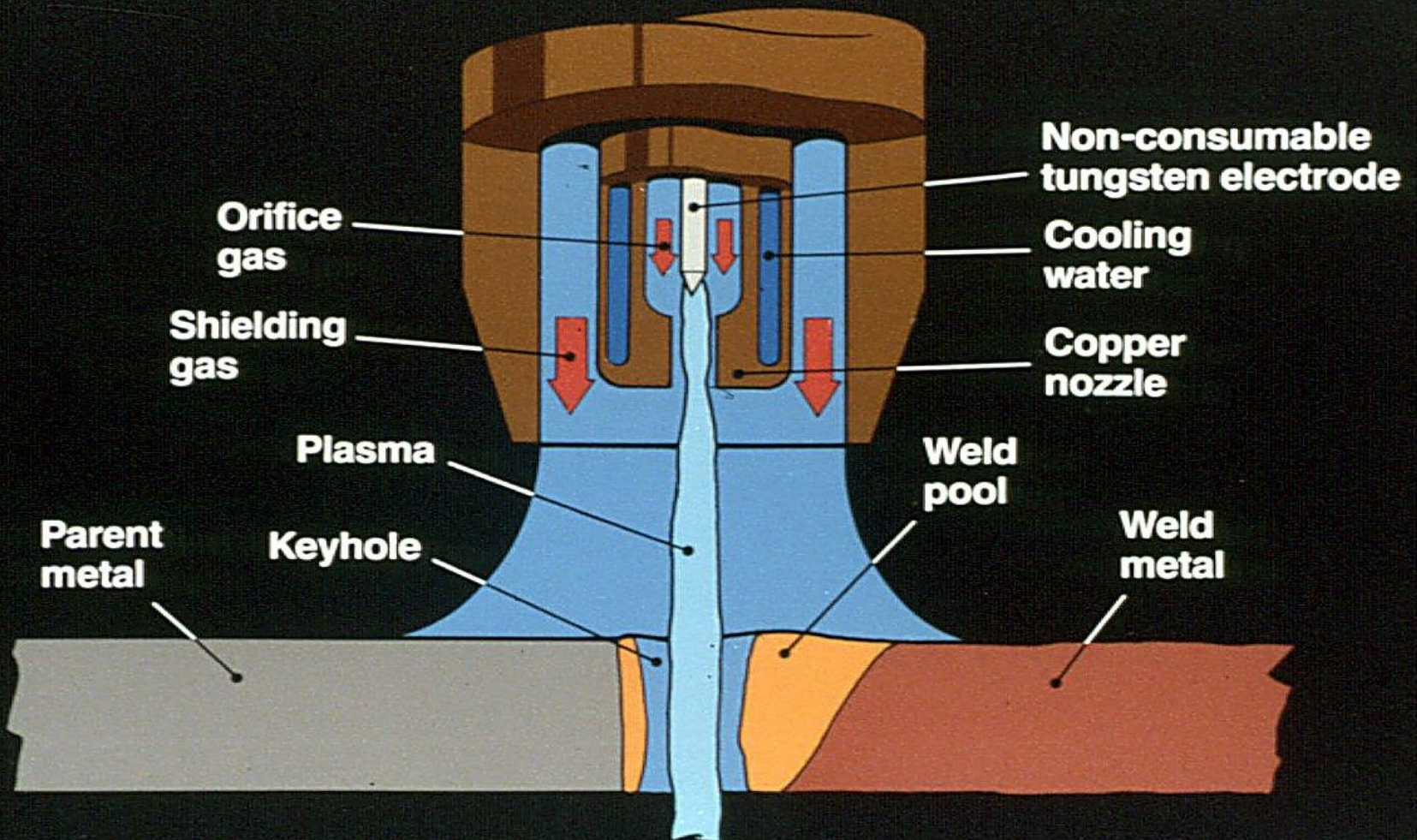


# PRINCIPLE



- Plasma arc welding is process where a coalescence is produced by the heat which is developed from a special setup between a tungsten alloy electrode and the water cooled nozzle (Non transferred ARC ) or between a tungsten alloy electrode and the job (transferred ARC) .
- This process employs two different gases for two different purposes –
  - 1) One gas is used to form the Arc plasma.
  - 2) Second gas is used to shield the arc plasma.

# PRINCIPLE





# WORKING



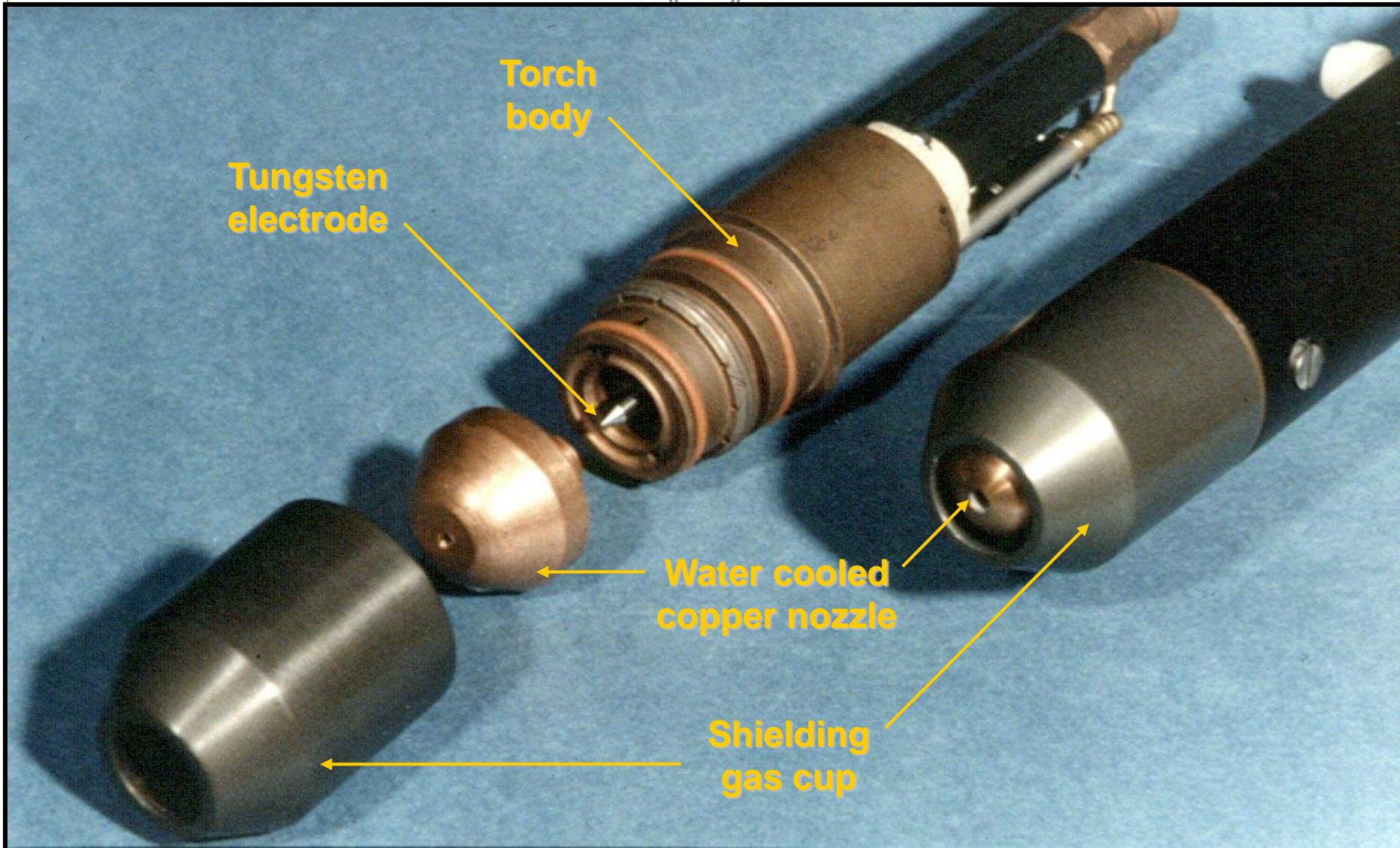
- The plasma arc welding process is normally compared to the gas tungsten arc process :
  - 1) The plasma torch contains an electrode made out of tungsten fixed in a nozzle which is made of copper . The arc is started between the electrode and the tip of nozzle. Then the arc or flame is transferred to the material to be welded.
  - 2) The small opening forces the gas to travel through a constricted opening or orifice. This concentrates the heat to smaller area. This ability allows welder to produce a very high quality weld .
  - 3) The result is a process that gives higher welds speed ,less distortion, more consistent welds ,less spatter and more control on the weld area.

# WORKING

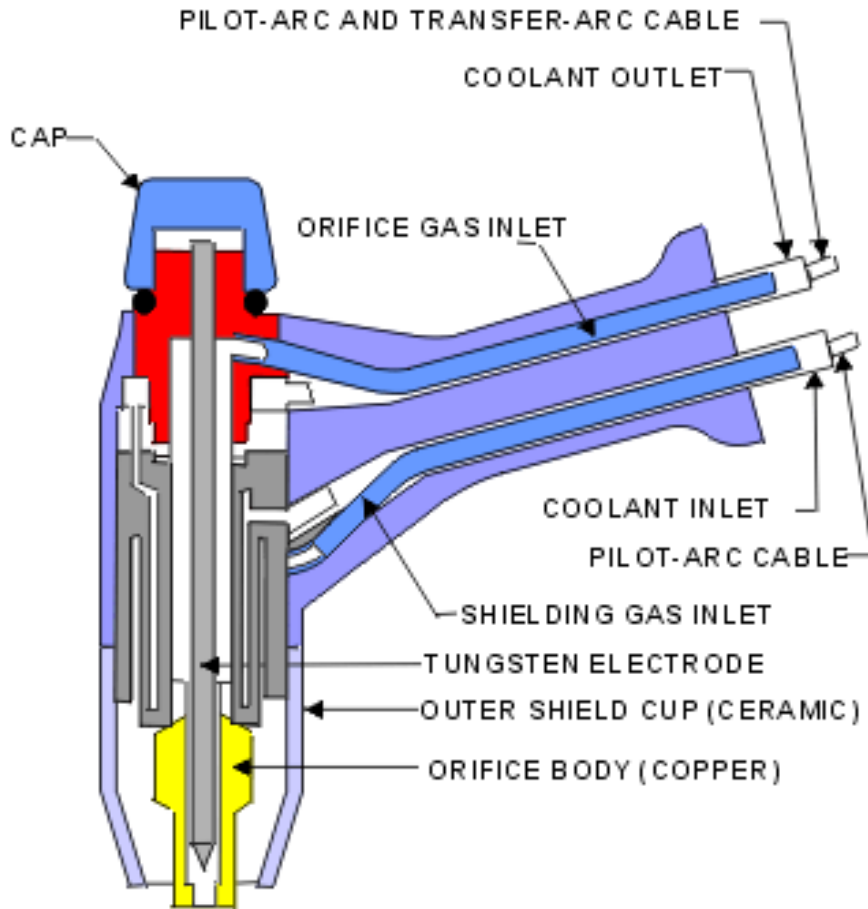


## Working Principle of Plasma Arc Machining (PAM)

# Plasma Welding Torch



# Plasma Welding Torch

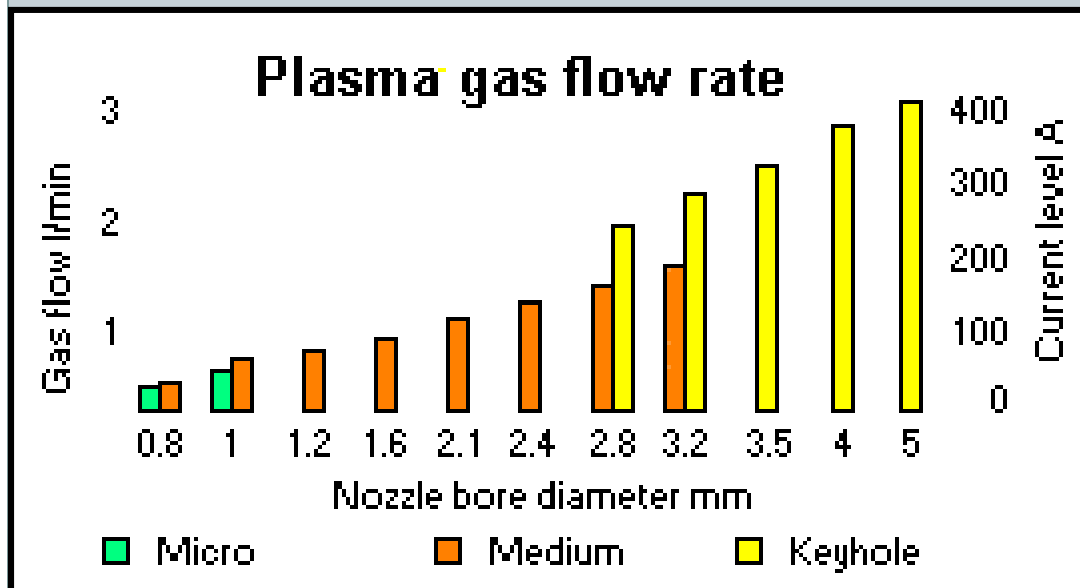


- Operates at very high temperatures so, cooling is mandatory.
- Heavy and bulky
- Limitations on hand held torches
- Alignment, setting, concentricity of tungsten electrode needs precision

# Gases For Plasma Welding

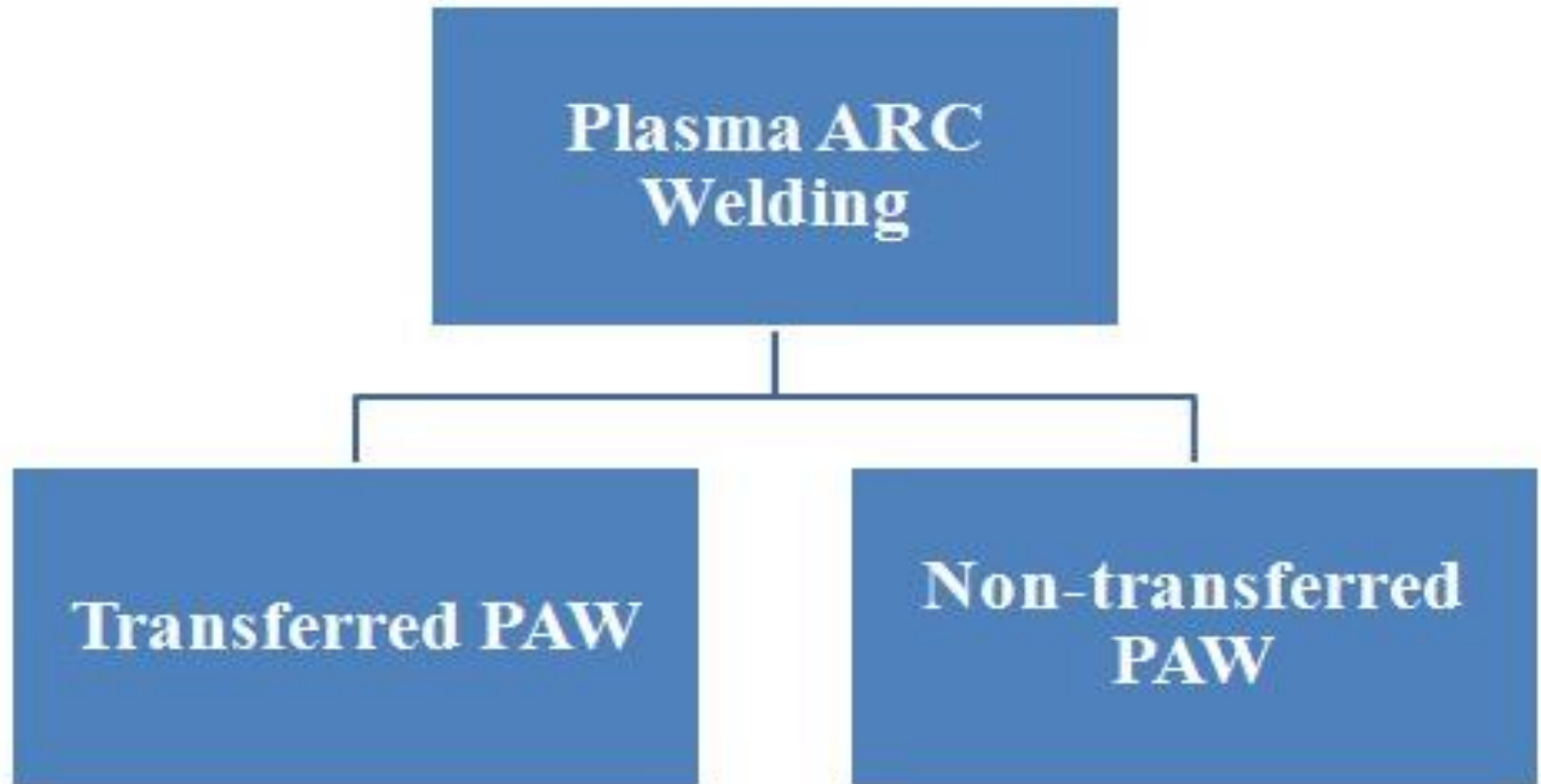


- Argon for carbon steel, titanium, zirconium, etc.
- Argon + (5-15%) Hydrogen for stainless steel, Nickel alloys, Copper alloys
- Argon + Helium mixtures (min 40%) give a hotter arc but reduces torch life

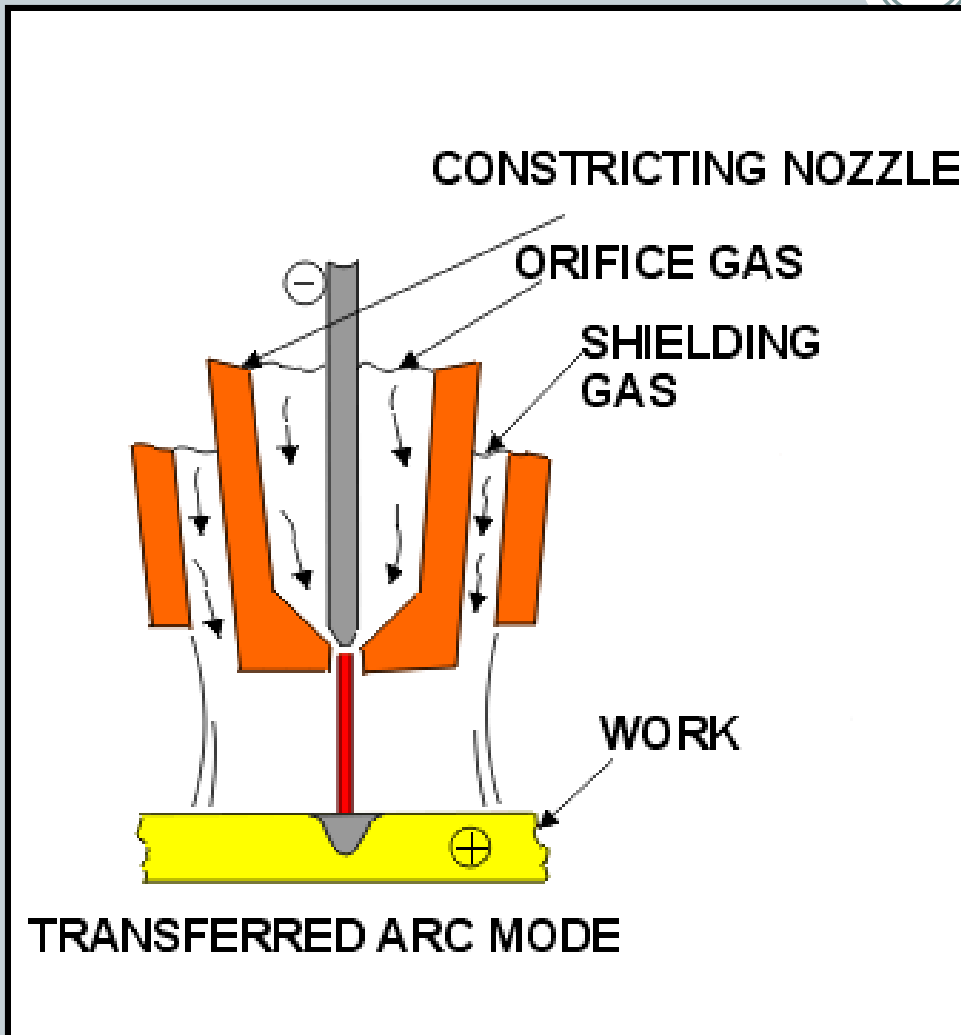


- Shielding gases as for TIG
- Shielding gas flow rate 10-30 l/min
- Back purge as for TIG (also for keyhole)

# Types of Plasma Arc Welding



# Transferred Arc Mode



- Arc is struck between the electrode (-) and the work piece (+)
- Generally used for high speed welding
- Work is part of electrical circuit
- Heat is obtained from anode spot and from plasma jet
- Greater energy transfer to the work
- Higher penetration is obtained, so thicker sheets can be welded
- Used to weld ceramics, steels & aluminium, copper, titanium, nickel alloys

# Non – Transferred Arc Mode

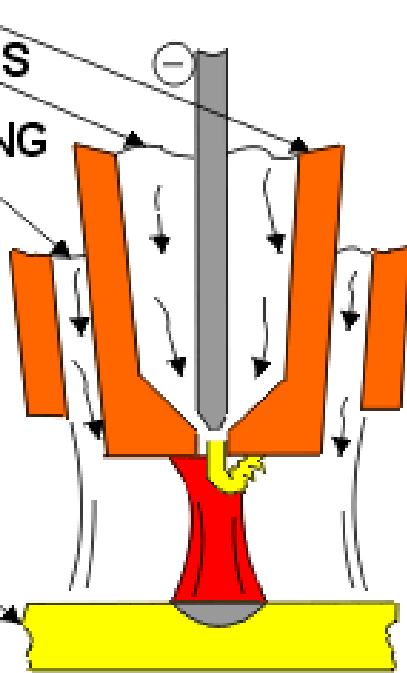
CONSTRICTING NOZZLE

ORIFICE GAS

SHIELDING  
GAS

WORK

NONTRANSFERRED ARC MODE



- Arc is struck between the electrode (-) and the nozzle (+)
- Work is not part of electrical circuit
- Heat is obtained from plasma jet only
- Less energy transfer to the work
- Less penetration is obtained, so thin sheets can be welded
- Used for cutting and joining non-conductive work piece



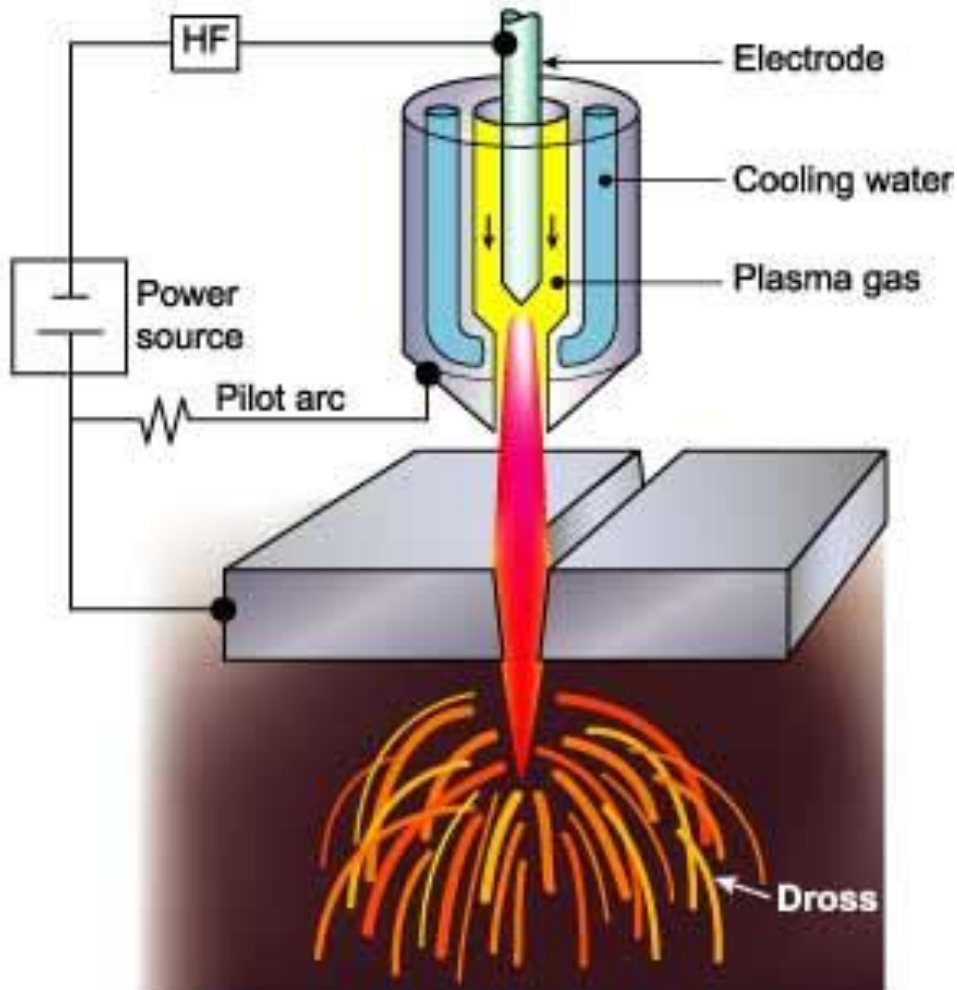
# Plasma Arc Cutting Introduction



## What we can do with plasma arc cutting :-

- Accurate cuts can be made in stainless steel and non-ferrous metals such as aluminium by plasma arc cutting.
- The cuts are made by a high temperature, high velocity gas jet generated by constricting an arc between a tungsten electrode and the component.
- The heat from the arc melts the metal and the gas jet removes the molten metal from the cut.
- The arc operates in an inert inner shield, whilst an outer shield provides protection for the cut surface.
- Argon, helium, nitrogen and mixtures of these gases are used for both the inner and outer shields.
- Plasma arc cutting is characterised by fast cutting speeds and is mainly used in mechanised systems.
- The cutting is accompanied by a high noise level which can be reduced by operating the torch under water.

# Plasma Cutting



- No need to promote oxidation -no preheat
- Works by melting and blowing and/or vaporisation
- Gases: air, Ar, N<sub>2</sub>, O<sub>2</sub>, mix of Ar + H<sub>2</sub>, N<sub>2</sub> + H<sub>2</sub>
- Air plasma promotes oxidation - increased speed but special electrodes need
- Shielding gas – optional
- Applications: stainless steels, aluminium and thin sheet carbon steel

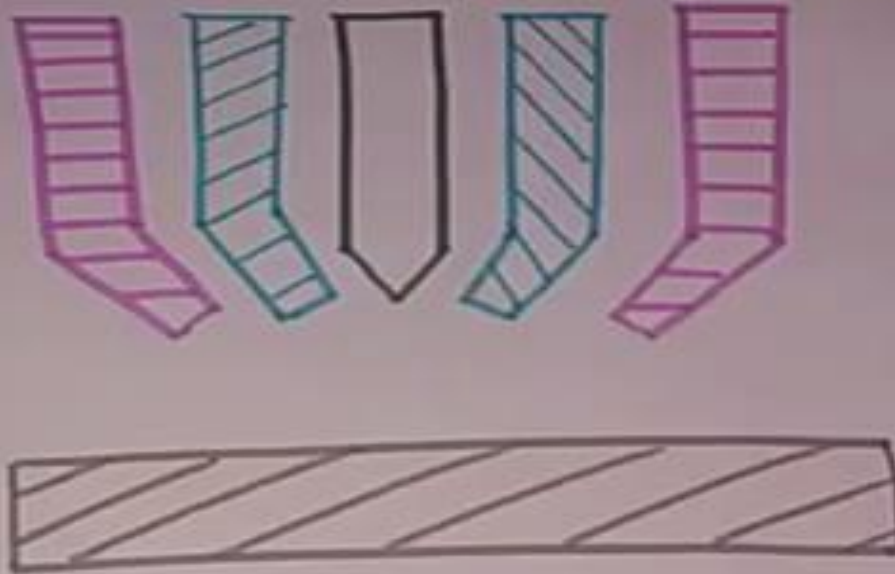
# Plasma Cutting



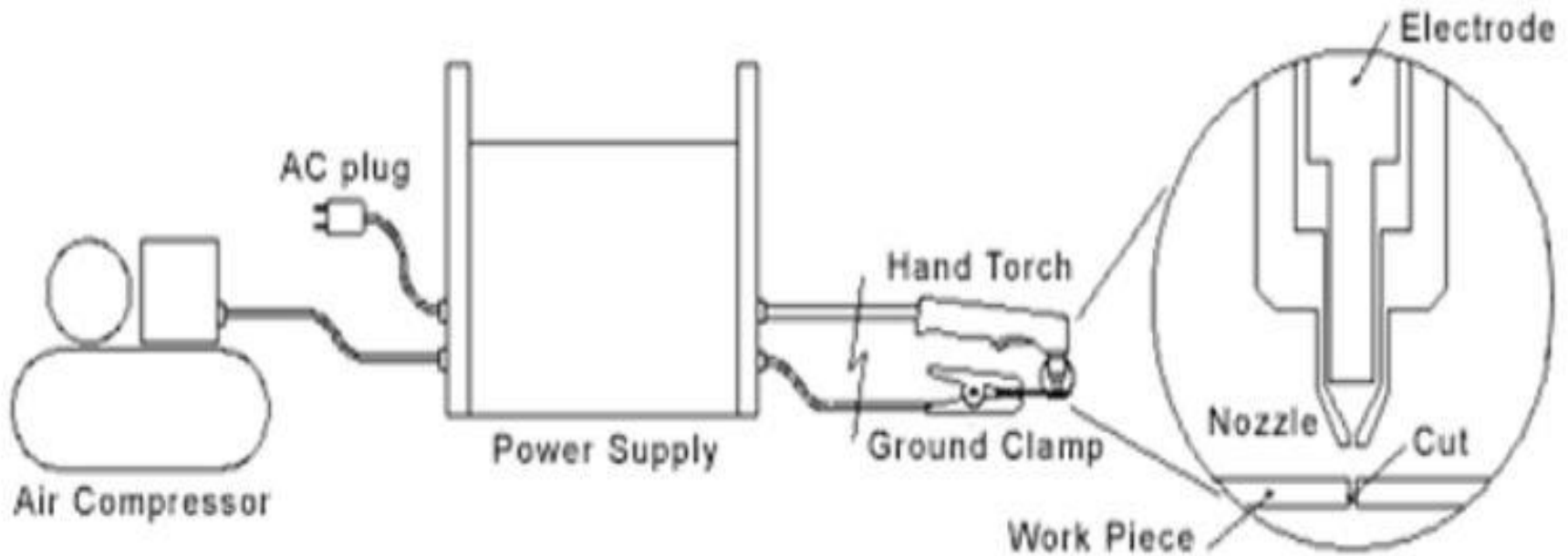
LEARN  
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PLASMA ARC CUTTING  
(BASIC PRINCIPLE)

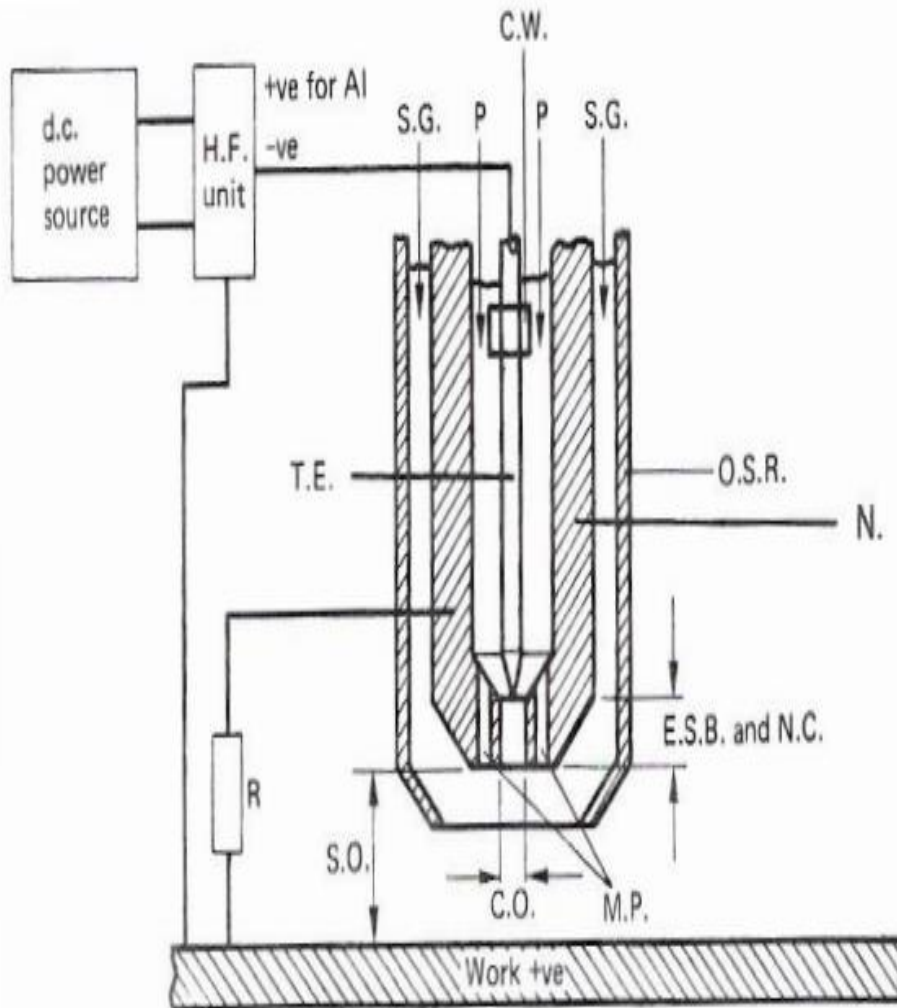
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# Plasma Arc Cutting System



# Component Parts of a Plasma Arc Torch



- C.W. = Cooling water, nozzle and electrode
- P = Plasma gas varies with different materials
- S.G. = Auxiliary shielding gas
- T.E. = Tungsten electrode
- O.S.R. = Outer shielding ceramic to prevent double arcing
- R = Resistance limiting pilot arc current
- E.S.B. = Electrode set back distance
- N.C. = Nozzle construction
- C.O. = Orifice construction improves velocity
- S.O. = Stand-off distance approx. 6 mm
- M.P. = Multi-ports shape the arc plasma

H.P. = High frequency discharge ignites the arc

N = Copper nozzle

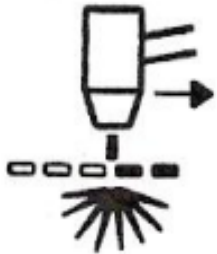
# Cutting Speeds for Plasma Arc Cutting



Material	Thickness mm	Current amps	Cutting speed Mm/min	Gas
Aluminium	1.5	40	1200	A/H <sub>2</sub>
	5.0	50	1500	A/H <sub>2</sub>
	12.0	400	3750	A/H <sub>2</sub>
	25.0	400	1250	A/H <sub>2</sub>
Stainless steel 18/8	2	50	1600	A/H <sub>2</sub>
	5	100	2000	A/H <sub>2</sub>
	12	380	1500	A/H <sub>2</sub>
	25	500	625	A/H <sub>2</sub>

# Generic Settings for Plasma Arc Cutting

## Mode Switch



Use to cut expanded metal. Automatically reinitiates pilot.



Use to cut plate/sheet metal. Optimum consumable life.



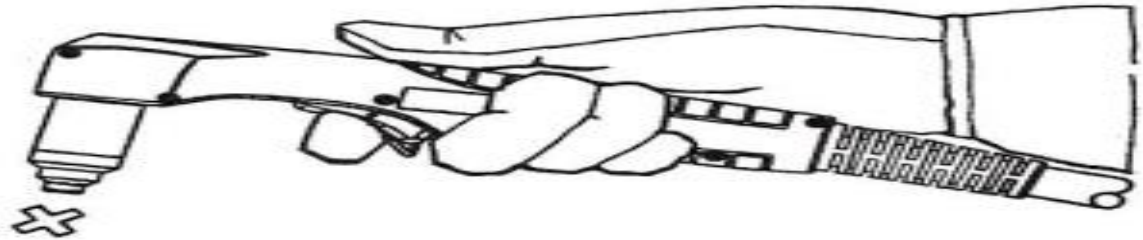
Use to gouge, or for non-transferred-arc operation.

# Operation of Hand Torch for Plasma Arc Cutting

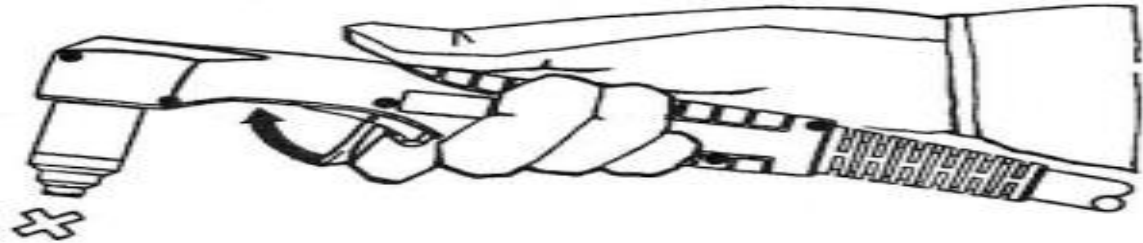


## Safety Trigger Operation:

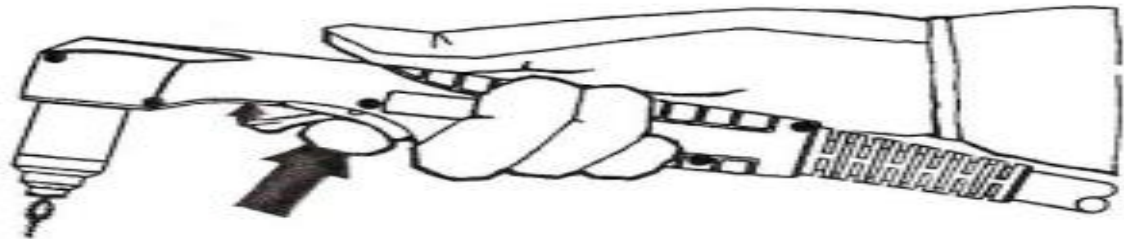
1.



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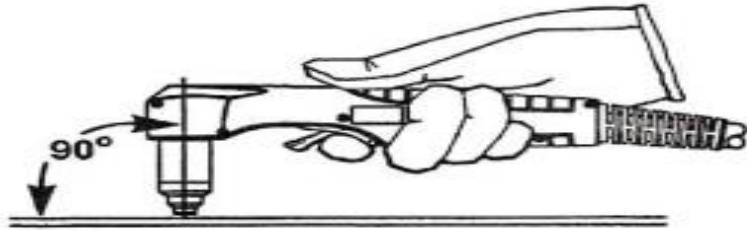


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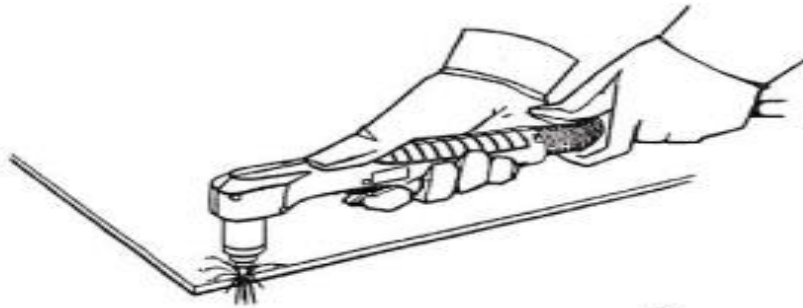




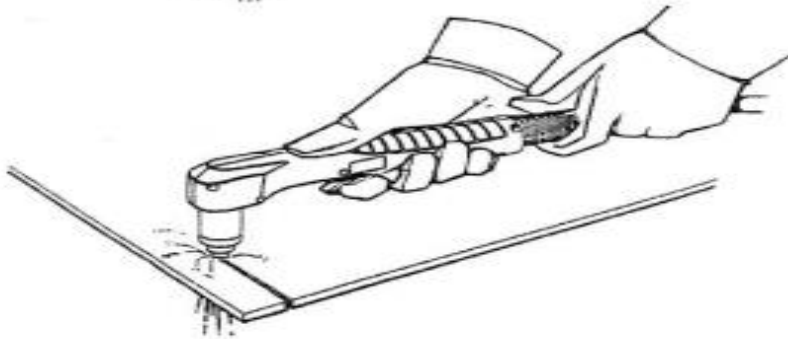
# Hand Torch Operation: Starting a Cut from the Edge of a Work Piece



Hold the torch nozzle vertical at the edge of the workpiece.



Start cutting from the edge of the workpiece. Pause at the edge until the arc has completely cut through the workpiece.

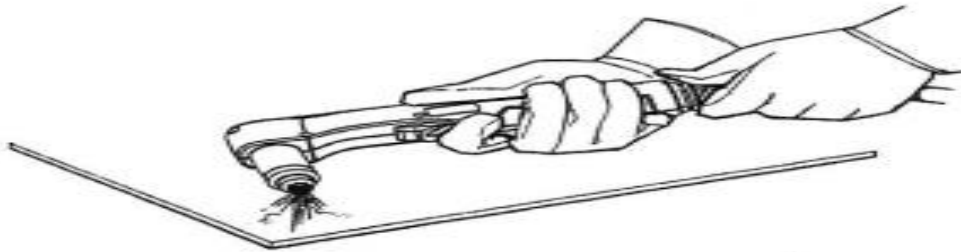


Then, proceed with the cut.

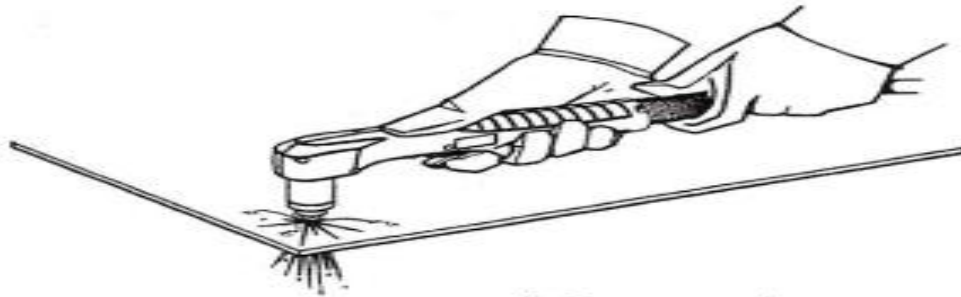
# Hand Torch Operation: Piercing Technique



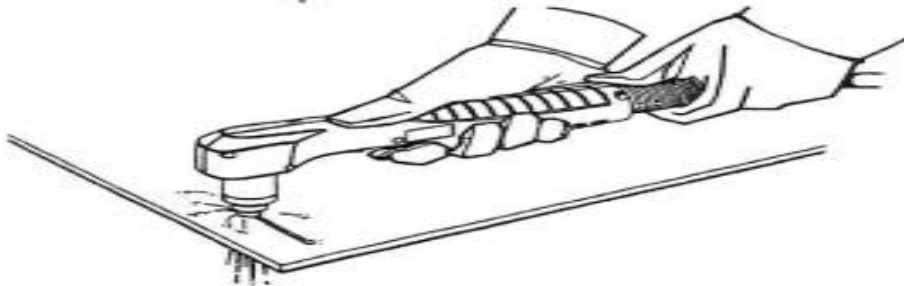
Hold the torch so that the nozzle is within  $\frac{1}{8}$  inch (3 mm) from the workpiece before firing the torch.



Fire the torch at an angle to the workpiece, and then slowly rotate it to an upright position.



When sparks are exiting from the bottom of the workpiece, the arc has pierced through the material.

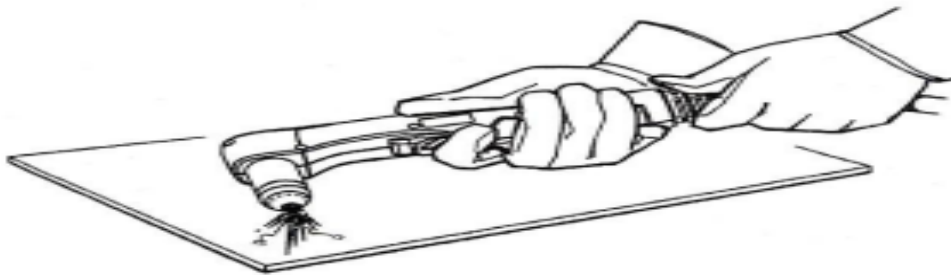


When the pierce is complete, proceed with the cut.

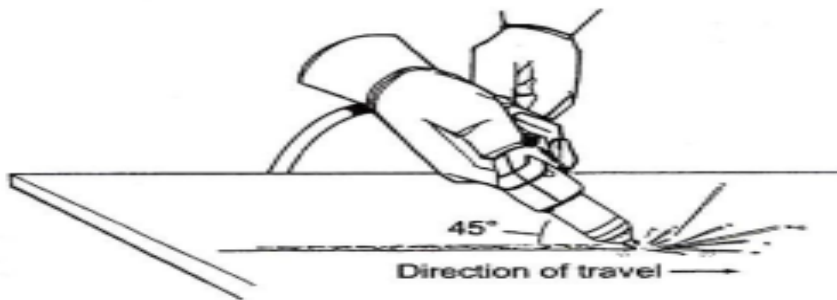
# Hand Torch Operation: Gouging Technique



Hold the torch so that the nozzle is within 1.5 mm from the workpiece before firing the torch.



Hold the torch at a 45 degree angle to the work piece. Pull the trigger to obtain a pilot arc. Transfer the arc to the work piece.

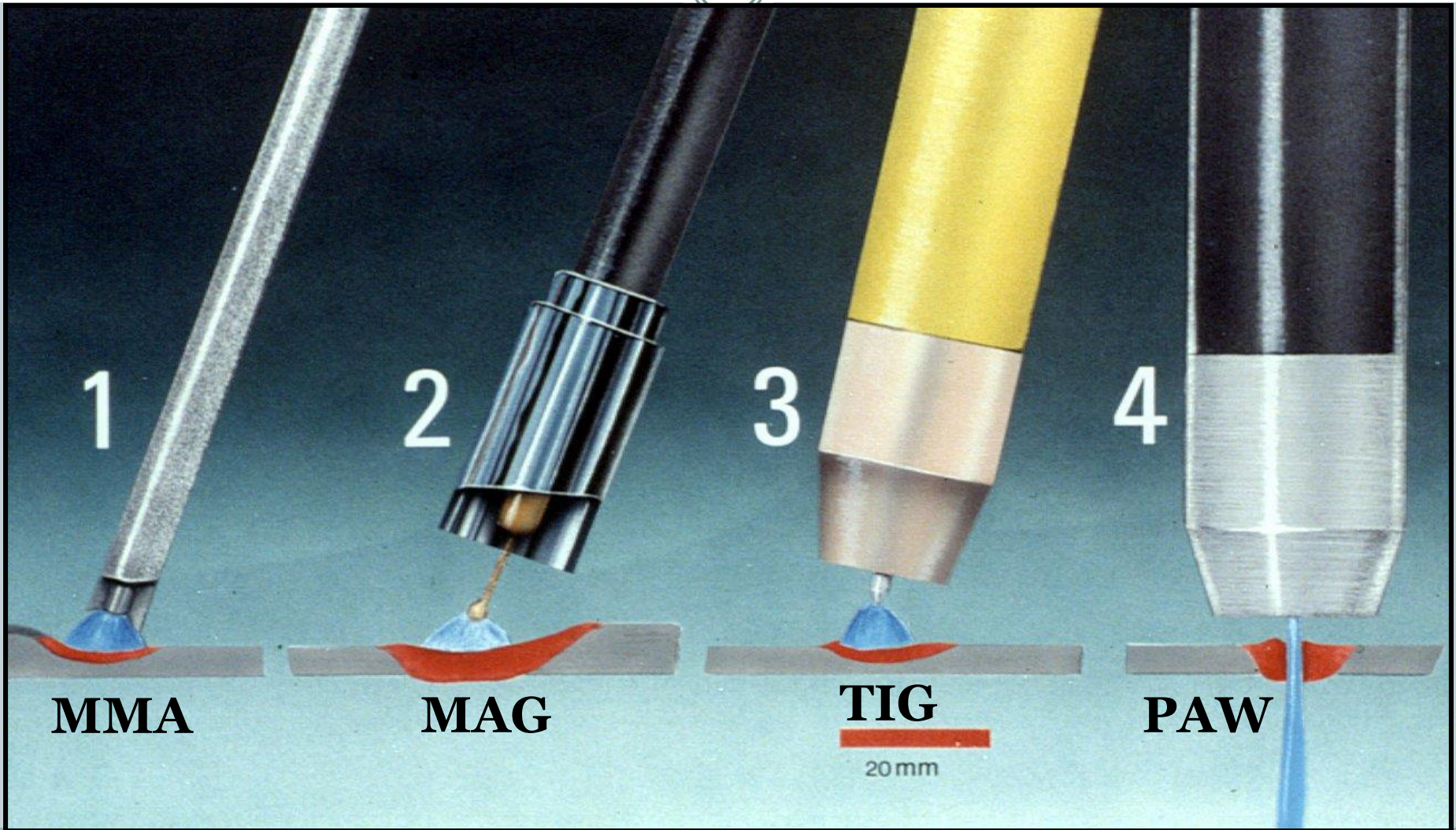


Maintain a 45° angle, approximately from the workpiece.

Feed into the gouge.

**Note:** A heat shield is available for added hand and torch protection.

# Plasma Process Techniques



# Operating Modes



- Three operating modes can be produced by varying bore diameter and plasma gas flow rate:
  - 1) **Micro plasma** : 0.1 to 15A.
  - 2) **Medium current** : 15 to 200A.
  - 3) **Keyhole plasma** : over 100A.

# ADVANTAGES



- High welding speed.
- High energy available for welding. It can be easily used to weld hard and thick work pieces.
- The distance between tool and work piece does not effects the arc formation.
- Low power consumption for same size weld.
- More stable arc produced by PAW method.
- High intense arc or high penetration rate.
- It can work at low amperage.

# DISADVANTAGES



- Higher equipment cost.
- Noisy operation.
- More radiation.
- High skill labour required.
- High maintenance cost.

# APPLICATIONS



- Aerospace Industries
- Cryogenics
- Foodstuff and Chemical Industries
- Machine and Plant Construction
- Automobiles and **Railways**
- Ship Construction
- Tank Equipment and Pipeline Construction etc.



# Applications in Railways



- To cut particularly those non-ferrous and stainless metals that cannot be cut usual oxidation induced by ordinary flame torches.
- For stock cutting, plate beveling, shape cutting and piercing.
- For removing gates and risers in foundry.
- For manufacturing railroad components, etc.

Thank  
you

