SNS COLLEGE OF TECHNOLOGY

(An autonomous institution)

Department of Mechanical Engineering

Unit – III

III

Topic

Welding

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Welding

The AWS definition for a welding process is

“A materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone and with or without the use of filler material".

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Welding

Classification of welding process:

1. Fusion welding
2. Plastic welding.

Fusion welding: The metal at the joint is heated to a molten state and then it is allowed to solidify. Pressure is not applied during the process and hence it is called “non pressure welding”. Filler material is required for this welding.

Plastic welding: The metal parts are heated to a plastic state and are pressed together to make the joint. It is called as “pressure welding”. No filler material is required

Terms used

Alloy → is an element added to a metal.

Arc → is what is between the end of the electrode and the base metal. The resistance causes heat.

Bead → the deposited filler metal on and in the work surface when the wire or electrode is melted and fused into the steel.

Welding

Electrode → Electrodes come either covered with flux, or just bare wire. In the field an electrode is called a "rod" in stick welding, and "wire" for MIG and Flux Cored Arc Welding.

Electrode Holder → A hand clamp that holds a welding rod and conducts electricity out of the rod in DCEN, or into the rod in DCEP.

Filler Metal → This is metal added to the weld pool. A weld can be made with or without filler metal. Thin gauge metal is sometimes welded by melting the two base metals together.

Welding

- **Nozzle →** A brass attachment that is about three inches long and shaped as an open cylinder. It is put over and insulator and seals at the top giving the shielding gas one direction to go out over the weld.

- **Penetration →** Is the FUSION or depth into the PARENT METAL from its surface, or the amount of FUSION through an open faced joint.

- **Shielding Gas →** Gases such as argon or helium are inert, meaning they will not combine with other elements. This makes them good for keeping atmospheric contaminants out of the WELD POOL.

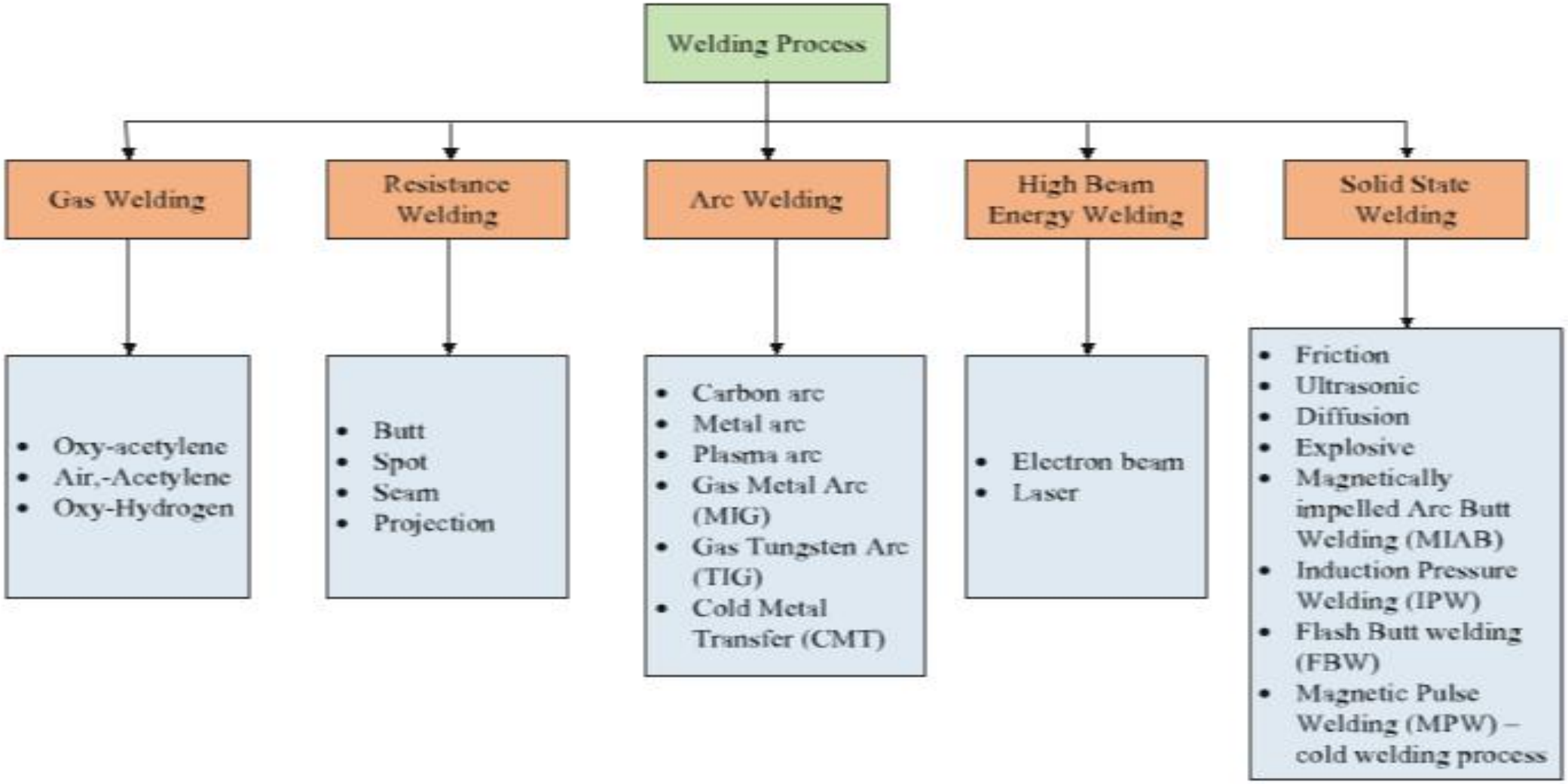
Welding

Depth of Fusion → How deep your filler metal penetrates into the metal from the surface.

Flux → Cleans the surface and when burned makes a Shielding gas that protects the weld pool, or puddle from atmospheric contaminants that cause defects.

Slag → when the FLUX on a welding ROD melts it produces the SHEILDING GAS to protect the weld, and then forms a hardened protective coating over the weld. This has to be chipped off and thoroughly cleaned, usually by brushing.

Types of Welding



Electric Arc Welding

The process of **welding in which heat is produced by creating an electric arc** to join metal workpieces is known as electric arc welding.

Electric arc welding is a type of welding that uses a welding power supply to create an electric arc between a metal stick, called electrode, and the workpiece to melt the metals at the point of contact.

Electric arc welding can use **either DC supply or AC supply** and a consumable or non-consumable electrode.

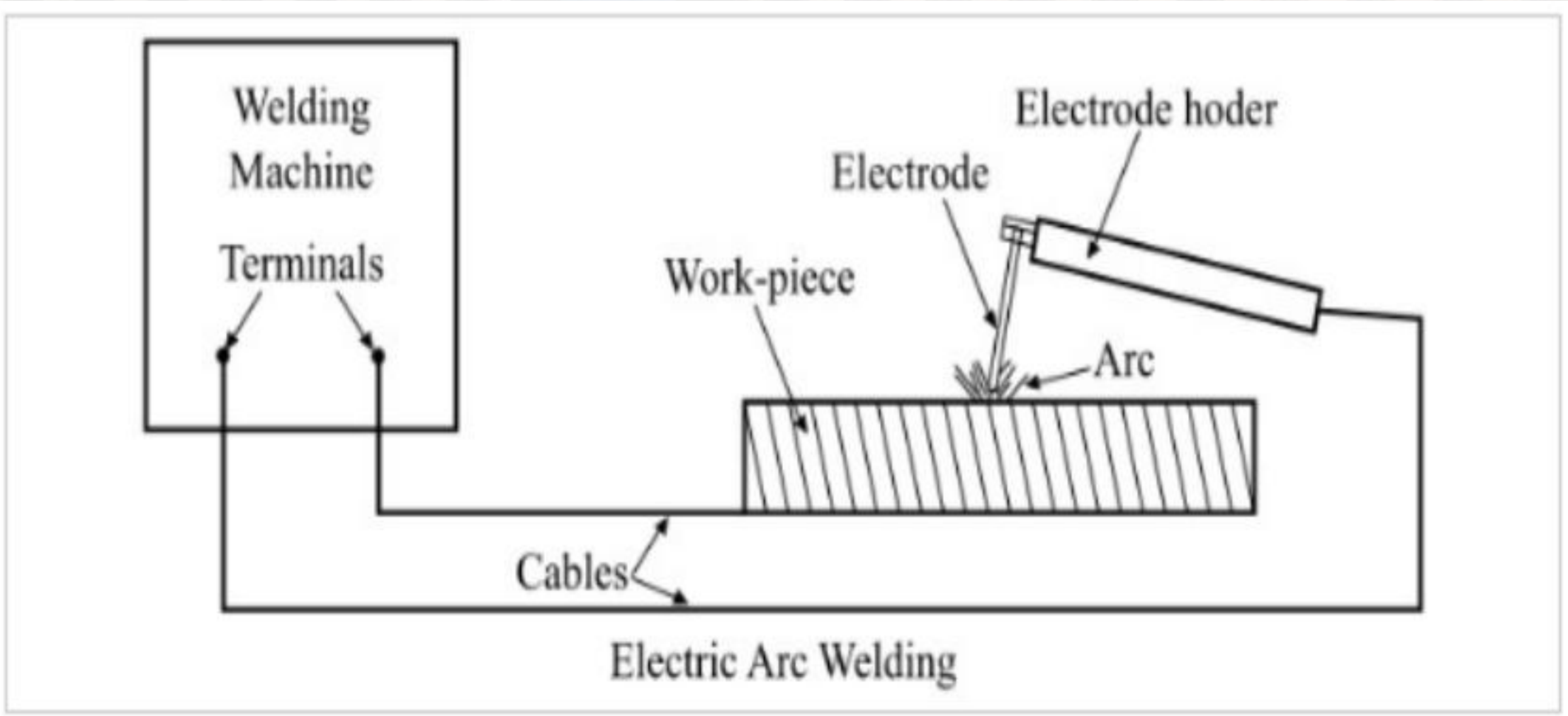
Electric Arc Welding Equipments

ARC WELDING EQUIPMENTS:

The equipments used in arc welding are

1) Welding generator DC or Transformer AC
2) Electrode
3) Electrode holder
4) Two cables, one for work and other for electrode
5) Gloves
6) Protective shield
7) Apron
8) Wire brush
9) Chipping hammer
10) Safety goggles

Electric Arc Welding



Electric Arc Welding

Working Principle of Electric Arc Welding

- The process of electric arc welding is based on the principle that, when electric current is passed through an air gap from one electric conductor to another, then an electric arc is produced which generates a very intense and concentrated heat.
- The temperature of the arc between two conductors is approximately **3500 °C to 4000 °C.**
- This high temperature generates **intense heat** in the arc at the point of welding, which melts a small portion of metal in the work-piece.
- The electric arc keeps this molten metal pool agitated and the base metal is thoroughly mixed with melted electrode metal, after that the metal pool cools down under a protective cover of slag left by the electrode.
- On cooling, **a strong weld join** is formed between the two metal pieces.

Welding

- In electric arc welding, **either AC or DC current** is obtained from a welding power supply. Here, one terminal is connected to the electrode mounted on an electrode holder, which is held by the welder, while the other terminal is connected to the workpiece and the circuit is completed through an air gap between the electrode and the work-piece.
- The length of the air gap (i.e., distance between electrode tip and the surface of the work-piece) is about **3 mm to 6 mm.**
- The welding is done by creating an electric arc between the electrode and the workpiece. The temperature of the arc is very high (about 3500 °C to 4000 °C) and the metal in contact with the arc becomes molten which enables a weld to be melt.
- The electrode is then moved slowly in the desired direction to complete the weld.

Welding

Advantages of Arc Welding

- ✓ Some of the chief advantages of the electric arc welding are given as follows –
- ✓ The electric arc welding is the suitable welding process for **high speed welds.**
- ✓ Apparatus required for arc welding is very **simple and portable**.
- ✓ The electric arc welding gives **superior temperature** at the point of welding.
- ✓ Electric arc welding can work on **both AC and DC supply.**
- ✓ It is **inexpensive t**o install.

Welding

Disadvantages of Electric Arc Welding

- ✓ The disadvantages of electric arc welding are as follows −
- ✓ The welding process with electric arc welding **requires skilled operators**.
- ✓ Electric arc welding cannot be used for welding of **reactive metals such as aluminium, titanium, etc.**
- ✓ Electric arc welding is **not suitable for welding thin metals.**

Welding

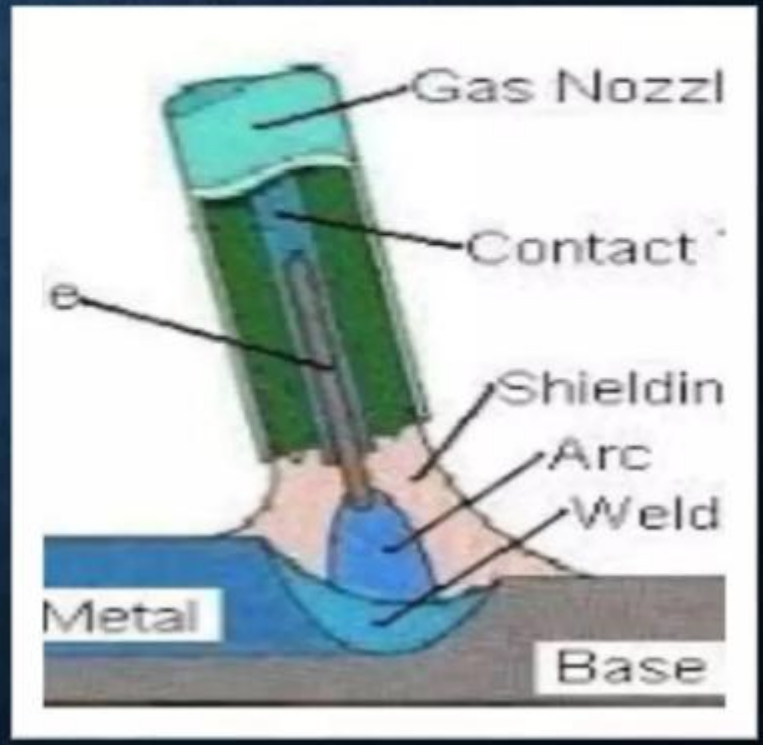
Applications of Electric Arc Welding

- ✓ The important applications of electric arc welding are as follows –
- ✓ Electric arc welding is used in **repairing of broken parts of machines**.
- ✓ It is used for welding of **cast iron or steel housings and frames.**
- ✓ Electric arc welding is used in various industries such as **automotive industries, construction industries, mechanical industries, etc.**
- ✓ Electric welding is also used for welding process in **shipbuilding.**

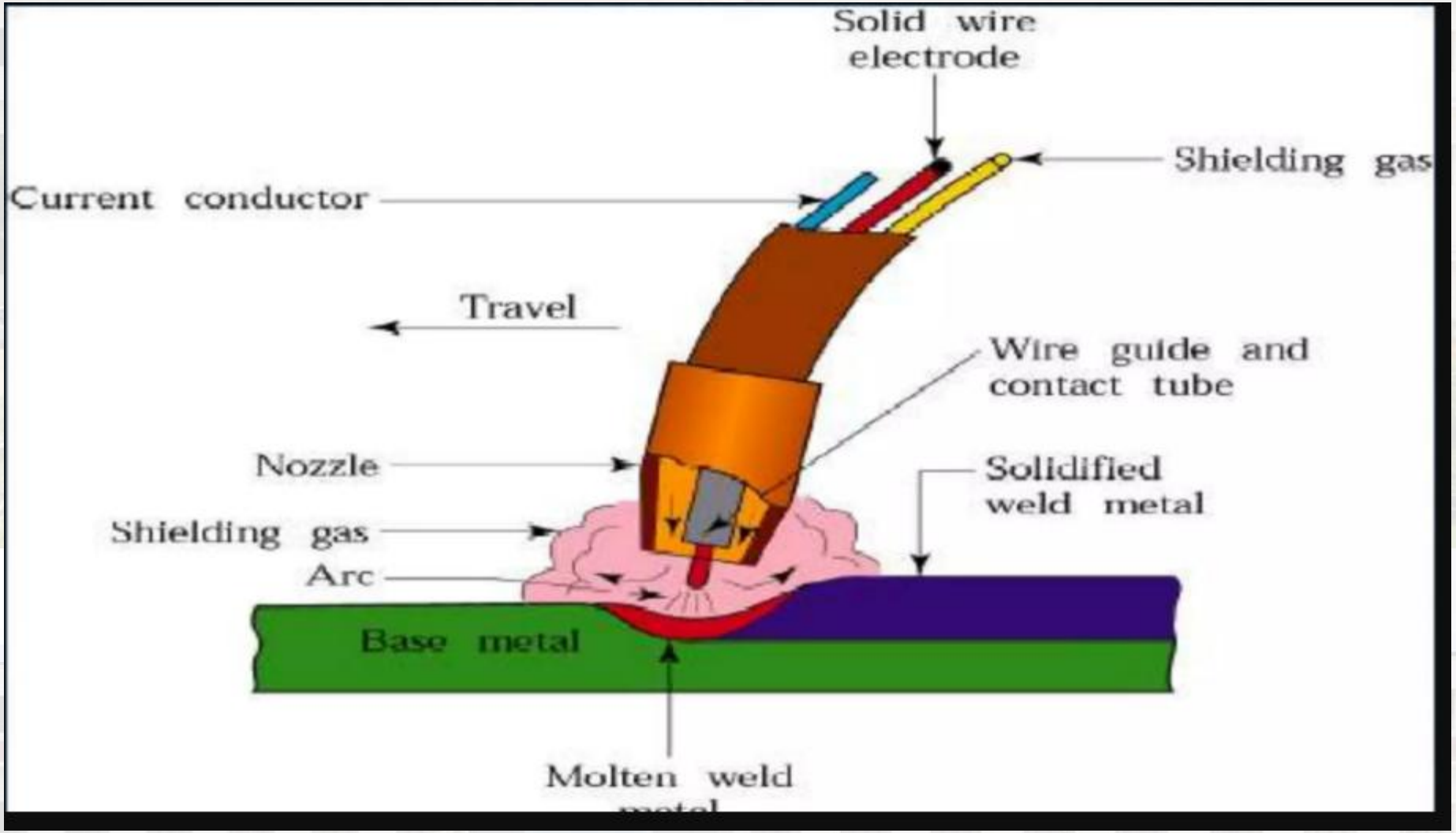
MIG Welding

METAL INERT GAS WELDING MIG/MAG
WORKING PRINCIPLE:

It is an arc welding process that uses an arc between a consumable electrode and the welding pool with a shielding from externally supplied gas without any application of pressure. Which heat the work piece metal and causing them to melt and joined.



MIG Welding


Solid wire electrode
Shielding gas
Current conductor
Travel
Wire guide and contact tube
Nozzle
Solidified weld metal
Shielding gas
Arc
Base metal
Molten weld

MIG Welding

MIG/MAG EQUIPMENT

- Shielded gas system
- Power source
- Wire feed unit
- Welding torch

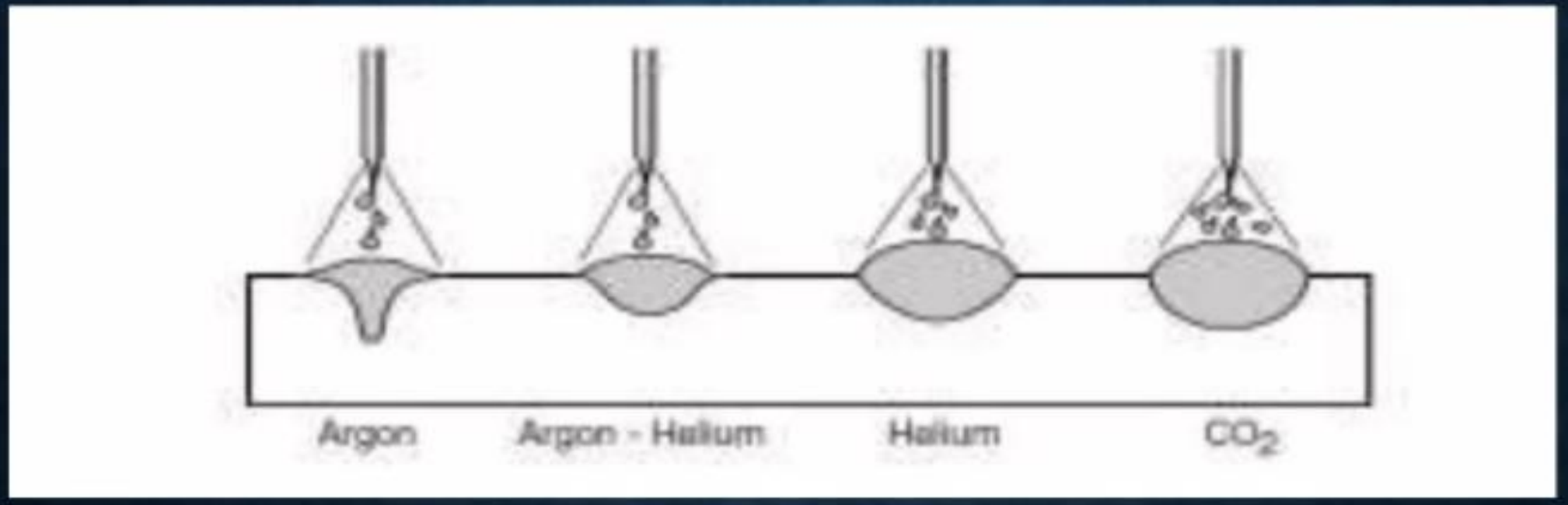
MIG Welding

SHIELDED GAS SYSTEM

- Purpose of shielding gas is to protect the weld area from the contaminants in the atmosphere.
- Gas can be inert, reactive or mixtures of both
- For MIG welding inert shielding gases are used (Argon and Helium)
- For MAG welding reactive shielding gases are used (Oxygen, Nitrogen, Carbon dioxide, Hydrogen)
- The pressure of shielding gas is up to 150 kp/cm2.

MIG Welding

BEAD CONTOUR AND PENETRATION PATTERN OF VARIOUS SHIELDING GASES



MIG Welding

POWER SOURCE

- MIG is operated with direct current power source.
- Flat characteristic power source is used for MIG welding.
- For MIG the output characteristics fall into two main categories

i. constant current

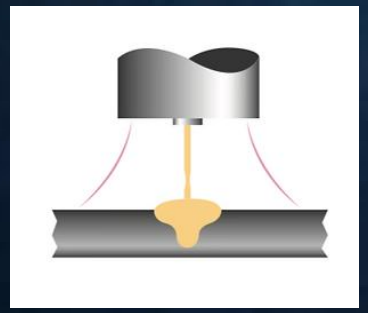
ii. Constant voltage

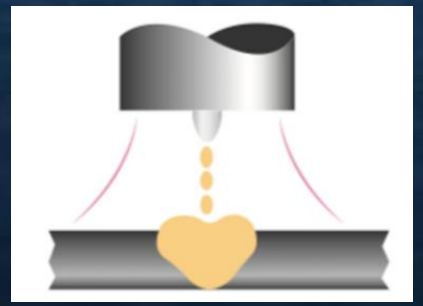
- A wide range of power sources are available

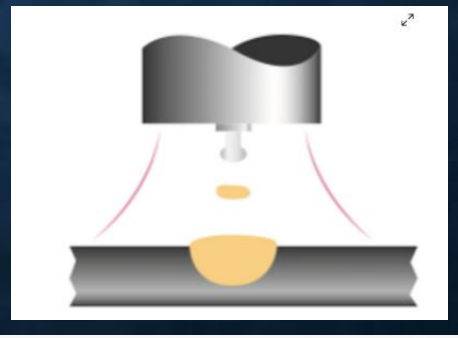
i. Dip

ii. Spray

iii. pulsed







MIG Welding

FEED WIRE SYSTEM

- The performance of the wire feed system can be crucial to the stability and reproducibility of MIG welding. There are three types of feeding system.

i. Push system

ii. Pull system

iii. Push-pull system

MIG Welding

PUSH SYSTEM

The wire is pushed forward by the wire drive unit through the wire guide liner to the torch.

Pull system

The wire is pulled forward to the torch by a wire feed unit in the torch. Both the wire feed unit and the wire rolls are placed inside the welding torch.

Push-pull system

The wire is pushed forward by a wire feed unit in the welding machine and at the same time it is pulled through the wire liner by a wire feed unit in the welding torch the so called push-pull system.

MIG Welding

WELDING TORCH

- The welding torch feeds the wire and directs inert gas to the weld area with the help of gas nozzle.
- The selection of the proper MIG torch, commonly called a MIG gun, depends upon the following factors.

i. Type of welding (semiautomatic, hard automation or robotic automation)

ii. Level of current required by the welding application and capacity of the torch.

iii. Shielding gas selected

iv. Duty cycle of the torch

v. Preference of an air cooled or water cooled torch.

MIG Welding

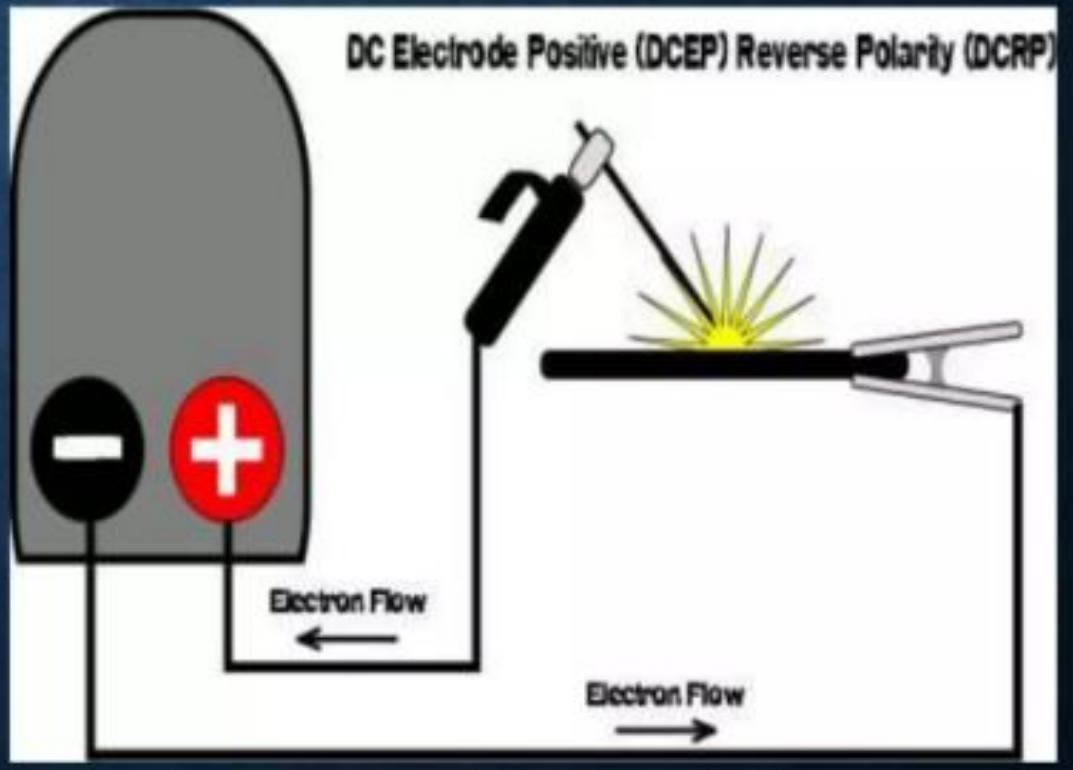
MIG WELDING PARAMETERS

1. Welding Current (I)
2. Arc Voltage (V)
3. Polarity
4. Electrode
5. Gas Flow Rate
6. Length Of Stick Out
7. Shielding Gas Composition

MIG Welding

1.WELDING CURRENT

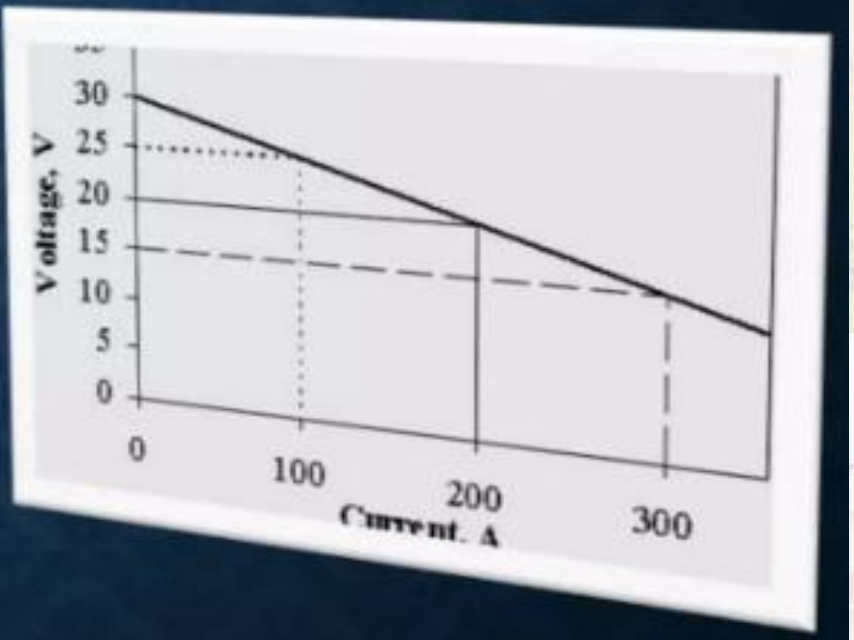
- Welding current depends upon welded metal thickness and metal transfer mode required according to the parent metal properties
- For metal thickness
- T<6mm=100-200amps
- T6-8mm=200-450amps
- T>8mm=450-700amps



MIG Welding

2.ARC VOLTAGE

- In MIG welding process we generally use constant voltage is used .
- This produce self regulation of arc length.
- For current range 150-200amp it is kept in between 25-30V for mild steel workpiece .



MIG Welding

MIG WELDING PARAMETERS

3. Polarity

- In MIG we use **DCEP** (Direct Current Electrode polarity)or Reverse Polarity
- Positive terminal to electrode wire negative terminal to weld fixture.
- **DC** ensures elimination of arc blow .

4.Electrode Dia

- Dia of electrode is dependent on welding current, with higher current Día also large and vice versa.
- It ranges from **0.7-2.4mm** depending upon current. For current **100-200**amps(**Dia 0.8-1.2mm**) is used.
- Electrode is made of same metal as parent metal coated with deoxidizing agents (copper)it also prevent impurities.

MIG Welding

MIG WELDING PARAMETERS

5. Gas Flow Rate

- For different applications different flow rate is chosen.
- The four primary variation of GMAW have differing shielding gas flow requirements-for small weld pools of the short circuiting and pulsed spray modes ,about 10L/min is preferred, while for globular transfer ,around 15L/min is preferred.

6. Length Of Stick Out

- Length of stick out is generally kept between 10-12mm.
- For stable arc should not larger.
- It is controlled by self regulation characteristic of MIG.

MIG Welding

6. SHIELDING GASES

- Shielding gases are necessary for GMAW to protect the welding area from atmospheric gases such as nitrogen and oxygen which can cause fusion defects ,porosity ,and weld metal embrittlement if they come in contact with electrode ,the arc ,or the welding metal.
- The mostly commonly used Argon mixed with CO2.
- Pure Argon doesn`t provide much penetration with ferrous metals .
- Whereas pure CO2 causes oxide formation.
- As a result ,argon and CO2 Are frequently mixed in a 75%/25% to 90%/10% mixture.

MIG Welding

WELDABLE MATERIALS

The material used to weld different types of metals are

- Carbon steel
- Stainless steel
- Aluminium
- Magnesium
- Copper
- Nickel
- Silicon bronze and other alloys

MIG Welding

IMPORTANCE OF MIG WELDING

- Why MIG welding is used in manufacturing?
- High productivity can lead to high profits.
- Welding speed of MIG welding is high.
- It is much quicker than the traditional welding.
- More over the high productivity can also be achieved by using MIG welding for its clean welds
- It is highly economic.

MIG Welding

APPLICATIONS

- Automotive repair
- Rebuilding equipment
- Overlay of wear resistant coating
- Welding pipes
- Can also be used to reinforce the surface of a warn out railroad track

MIG Welding

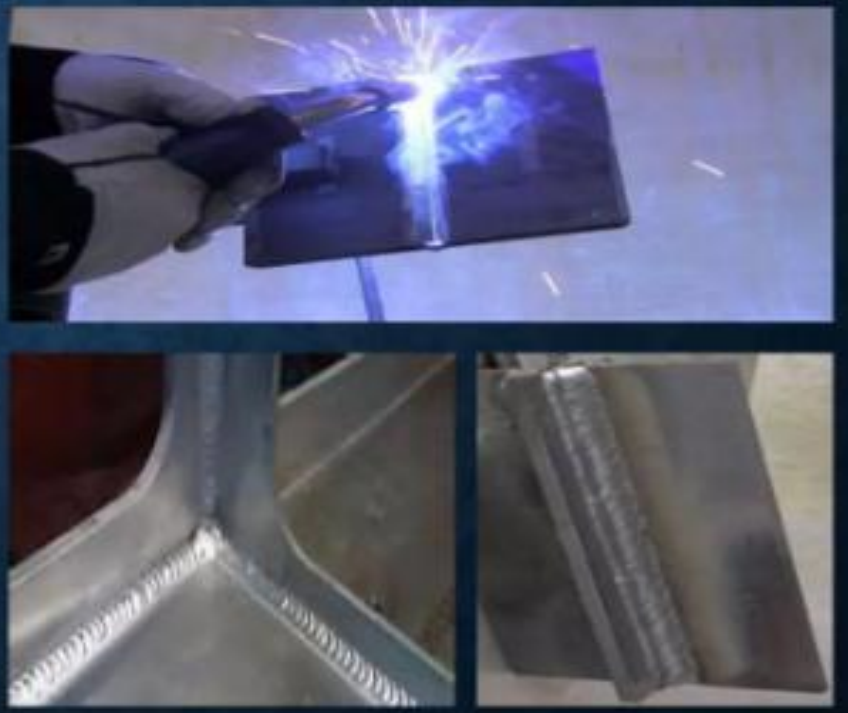
Merits of MIG welding

Good visibility

- Its weld visibility is generally good because there is no fumes and smoke.

Deep penetration and less time

- Less time is needed for weld joints and it also gives deep penetration which permits use of small welds for equal strength.



MIG Welding

Use for ferrous and non ferrous metals

- MIG welding is used for both ferrous and non ferrous metals by change the wire and shielding gas.

Low cost consumables

- Out of all process consumables of MIG welding of low cost.

Low level of spatter

- By adjusting right mod of metal transfer low spattering can be achieved.

MIG Welding

High productivity

- This process gives high productivity because of continuously fed electrode also it reduces cleaning time.

Large metal and low hydrogen deposition

- Large metal deposition rate is achieved by MIG welding while hydrogen deposition rate is low because solid does not pick up moisture.

Slag removal is not required

Increase corrosion resistance

MIG Welding

Demerits of MIG welding

- **Complex process**

MIG welding is complex process because number of variables are required to be controlled for achieving good results.

- **Less portable equipment**

Welding equipment are more costly, more complex and non portable.

- **Not for out door use**

It is not used for out door applications

MIG Welding

- **Higher cooling rate**

  Cooling rate of weld metal is higher that deposit slag on metal.

- **Expensive shielding gas**

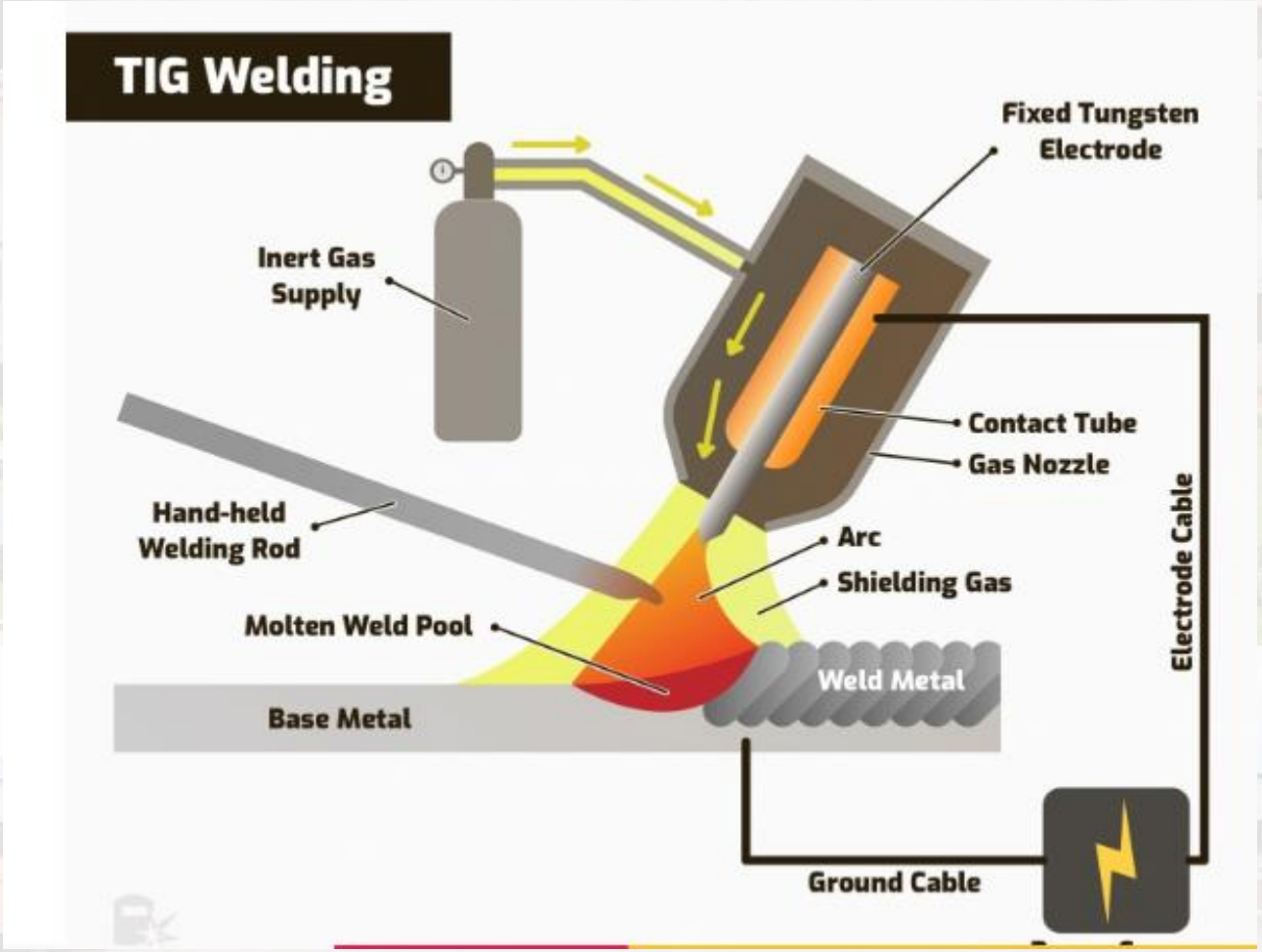
  The use of argon gas in spray and pulsed transfer modes are more expensive than carbon dioxide.

- **Difficulty getting into tight places**

  The gun is hard to get in tight places.

TIG Welding

TIG welding is a stable arc welding process that uses a **non-consumable tungsten electrode** and an inert gas in the welding arc to create high-quality welds. It became a groundbreaking success during the 1940s when it was first used for welding together aluminium and magnesium alloys in the aerospace industry.



TIG Welding

What Is TIG Welding?

- Tungsten inert gas welding, also known as **gas tungsten arc welding (GTAW)**, is a welding process that joins pieces of metal together through a welding current.
- An inert gas is supplied to the welding torch that flows along the welding arc to **protect the metals from oxidation** and from forming small circular gaps.
- A tungsten electrode is assembled within the welding torch, which has a higher melting point than most metals.

TIG Welding

Major Equipments

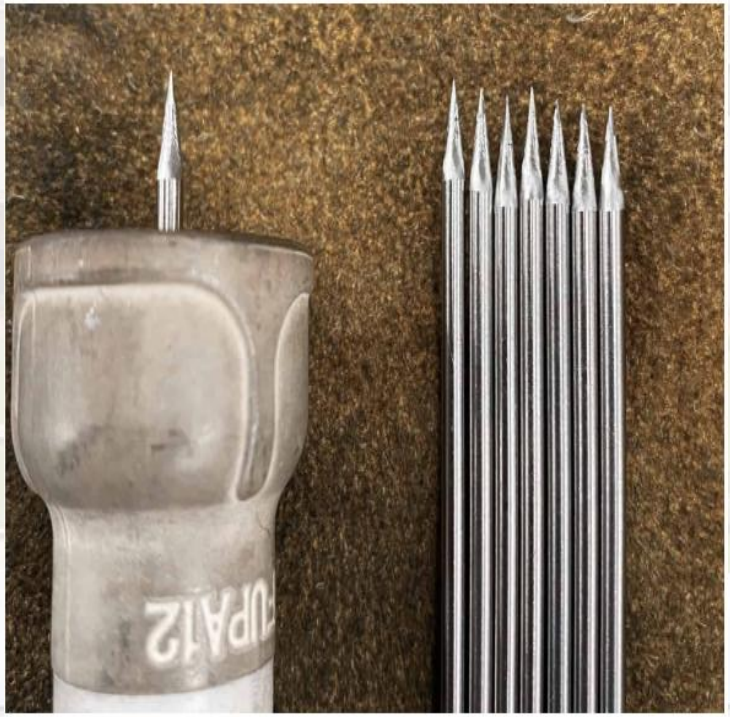
- Non consumable Tungsten Electrode
- Power Source
- Sheilding gas
- Welding Torch

TIG Welding

Non-Consumable Tungsten Electrode

TIG welding tungsten electrodes

- Tungsten is used in this process since this rare, metallic element intrinsically has a **high melting temperature (3422°C)** when compared to other metals (e.g. stainless steel has a melting point from 1400 to 1530°C).
- Tungsten offers excellent **electrical conductivity** without being consumed. Though, erosion can still occur on the tip during the shielded metal arc welding procedure.



Tungsten electrodes can also be alloyed to improve their properties depending on the weld type. Here are some common examples:

Pure tungsten electrode (green) – They offer **good arc stability** when using AC current. Used for **light metals** since they keep a clean, balled end. These are also the cheapest and applied for general purpose work.

TIG Welding

Thoriated electrodes (1% thorium yellow; 2% red; 3% purple) –

- Quite common in the welding scene as they were the first to beat pure tungsten electrodes in DC welding arc performance.
- They have a **high current carrying capacity** and they maintain the **shape of the tip longer**.
- However, **thorium emits alpha radiation**, which can harm the respiratory system.
- A **dust extraction system** is required for collecting the dust during tip grinding.

Lanthaned electrodes (1% lanthanium black, 1.5% gold, 2% blue) –

- **Non-radioactive electrode** alloyed with lanthanum oxide.
- Characterised by **excellent arc stability properties with low erosion rate.**
- A bit **less efficient** than thoriated electrodes.

Ceriated electrodes (2% cerium grey) –

- **Non-radioactive electrode** alloyed with cerium oxide.
- These electrodes have great arc starting but less current capacity than lanthaned electrodes.

TIG Welding

Zirconiated electrodes (0.7-0.9% zirconium white, 0.15-0.5% brown) –

- These electrodes combine tungsten with zirconium oxide.
- This alloy has a **high resistance to contamination and longer electrode life.**
- Produces an extremely stable arc, thus it is used when the highest quality is needed.

Cerium lanthanium electrodes (pink) –

- A combination of ceriated and lanthaned electrodes offering **simplified arc ignition with a long life span.**

TIG Welding

Inert Gas

- Inert shielding gas is fed to the TIG torch to keep the **weld pool free from contamination** while the current is supplied to the welding arc.
- The shielding gas flow is essential in **protecting the weld puddle from oxidation** and impurities from the atmosphere while the metals are melted and fused along with the filler rod.

- The most common shielding gas used for this process is **argon.**
- Other combinations of **hydrogen and argon and a mixture of helium and argon** are used when other factors are considered (e.g. metals to be welded, welding speed, material penetration etc).

TIG Welding

Welding Torch
TIG welding gun

A welding torch is a mechanical tool specialised in melting and fusing metals.
It has several types depending on its use:

Air-cooled TIG torches only have one gas input and are more prone to overheating, unlike water-cooled TIG torches.
The primary use of these torches is for **thin-walled metals and minor projects.**

Water-cooled TIG torches have a gas input while having an input and output for water lines.
This is an advantage for **larger projects** that need rapid cooling.
This comes with its price though, as a water cooler system has to be installed.

TIG Welding

Power Source

The source of the current in gas tungsten arc welding should be drooping and constant.

This allows for stable and consistent heat input. You can also **switch between alternating current (AC) to direct current (DC) power source** depending on the material type and weld output you desire.

AC vs DC power

There are three options available for the welding current along with its own respective uses:

AC welding uses an alternating current between the positive and negative polarities, maintaining the heat without overheating the base material. Commonly used materials are aluminium and magnesium.

TIG Welding

DC power electrode negative uses the negative polarity on the torch to pinpoint the energy flow to the material, much like a hose spraying water on a targeted area. This makes it more appealing to all metals, **excluding aluminium and magnesium.**

DC power electrode positive is hardly used in TIG welding since the current is flowing towards the electrode, making it ball up from the rapid heat input. The only plus side in DCEP is the presence of a “cleaning action” wherein the oxides in the weld pool’s surface give off a shiny appearance.

Another factor to keep in mind is the applied frequency Hz. Lower frequencies create a wider bead with decent penetration, whereas higher frequencies allow for more control and penetration in the weld area.

TIG Welding

Working of TIG

- First, a low voltage high current supply supplied by the power source to the welding electrode or tungsten electrode.
- Mostly, **the electrode is connected to the negative terminal** of power source and **work piece to positive terminal.**
- This current supplied **form a spark** between tungsten electrode and work piece.
- Tungsten is a non –consumable electrode, which give a highly intense arc.
- This arc produced heat which melts the base metals to form welding joint.
- The shielded gases like **argon, helium** is supplied through pressure valve and regulating valve to the welding torch.
- These gases **form a shield** which does not allow any oxygen and other reactive gases into the weld zone.
- These gases also create plasma which increases heat capacity of electric arc thus increases welding ability.

TIG Welding

Advantages of TIG Welding

- TIG welding can be performed on a wide array of different metals and alloys.
- A TIG welder has many customisable functions, perfect for specific operations.
- Applicable to varying types of metal thicknesses and complex metal welding. Although for really thick metals, MIG or stick welding is preferred.
- A non-consumable electrode and a stable arc allow for greater control and create high-quality TIG welds.
- Safe gases are used in this gas metal arc welding process, as a result, it has fewer weld defects.
- TIG welding can be performed at awkward angles. An example would be its application in welding overhangs, where the welding torch has to be in a unique position.
- It is easy to view the workpiece since the shielding gas is colourless with minimal smoke formed.

TIG Welding

Disadvantages of TIG Welding

TIG welding requires a lot of skill from the operator.

Welding time is noticeably longer compared to other welding techniques.

Using the wrong polarity can easily contaminate the weld bead.

The overall weld strength diminishes when exhibiting a lack of control over the heat input. This also negatively affects the microstructure of the metals.

Without a controlled environment, mainly a wind-free environment, it might be difficult to keep a constant gas flow over the weld area.

Compared to other welding techniques, the equipment and inert gases are more pricey.

TIG Welding

Important Points To Remember

- TIG welding offers accurate and good-looking weld beads with good penetration.
- It is the preferred method for welding aluminium and magnesium alloys, along with many other metals including stainless steel.
- It is a bit more expensive and slower method when compared to some other types of welding but it is irreplaceable when creating higher quality welds.
- Its consistency and versatility allow it to be highly attractive across almost all industries, from professionals to hobbyists alike.
- Although TIG process can be automated with the use of welding robots, the manual welding process still has quite a steep learning curve and to achieve the best results, it is most often performed by experienced welders.

TIG Welding

Materials in Gas Tungsten Arc Welding

TIG welders can utilise an array of materials. Some of the base materials listed for tungsten inert gas arc welding are:

- Aluminium
- Brass
- Bronze
- Carbon steel
- Copper
- Gold
- Magnesium
- Mild Steel
- Nickel
- Stainless steel
- Titanium steel
- Different alloys

MIG VS TIG Welding

S.NO	MIG	TIG
	Metal inert gas (MIG) welding utilizes a consumable electrode that is continuously fed into the welding zone from a wire pool.	Tungsten inert gas (TIG) welding utilizes a non-consumable electrode (so it remains static and intact during welding).
	The electrode itself melts down to supply necessary filler metal required to fill the root gap between base metals. So electrode acts as filler metal (no additional filler is required).	If required, filler metal is supplied additionally by feeding a small diameter filler rod into the arc. So filler metal is supplied separately.
	Composition of electrode metal is selected based on parent metal. Usually, metallurgical composition of electrode metal is similar to that of base metal.	Electrode is always made of tungsten with small proportion of other alloying elements (like thorium).
	It is suitable for homogeneous welding. It cannot be carried out in autogenous mode welding as filler is applied inherently.	It is particularly suitable for autogenous mode welding. However, it can also be employed for homogeneous or heterogeneous mode by supplying additional filler.

MIG VS TIG Welding

S.NO	MIG	TIG
	The electrode-cum-filler for MIG welding comes in the form of a small diameter (0.5 – 2 mm) and very long (several hundred meters) wire that is wound in a wire-pool.	TIG welding filler typically comes in the form of small diameter (1 – 3 mm) and short length (60 – 180 mm) rod.
	Due to very large length, the filler electrode can be fed for a longer duration without replacement.	Due to short length, frequent replacement of filler is required. This interrupts the welding process unintentionally.
	MIG welding is commonly carried out either in AC or in DCEP polarity so that electrode can be melted and deposited at a faster rate.	TIG welding is commonly carried out either in AC or DCEN polarity to increase electrode life.
	Filler deposition rate is very high, so the process is highly productive.	Filler deposition rate is low. In this sense, it is not very productive.

MIG VS TIG Welding

S.NO	MIG	TIG
	MIG welding usually produce spatter. This causes loss of costly filler metal.	TIG welding is mostly free from spatter.
	Quality and appearance of weld bead are not very good.	It can easily produce defect-free reliable joint with good appearance.
	It does not lead to tungsten inclusion defect.	TIG welding sometimes leads to tungsten inclusion defect (occurred when a melted/broken part of the tungsten electrode gets embedded into weld bead).

Thankyou