Introduction to Welding

Welding is a fabrication process that involves heating and fusing two or more pieces of metal to join them together. There are several types of welding processes, including electric arc welding, gas welding, resistance welding, and more. The choice of welding process depends on the materials being joined, the desired quality of the weld, and the production rate.

Welding is widely used in various industries such as construction, automotive, aerospace, and manufacturing. It provides several benefits, including strong and permanent joints, improved efficiency in the manufacturing process, and the ability to join dissimilar metals.

Classification of Welding

Welding classification can be done based on the following aspect

- Depending upon the source of heat
- Depending upon the application of pressure
- Depending upon the different phases of base and filler material
- Depending upon the composition of the joint
- Depending upon the mechanism

Different welding techniques name (depending on source of heat)

(i). Arc welding

- Carbon arc (CAW)
- Metal arc (SMAW)
- Tungsten inert gas(TIG/GTAW)
- Metal inert gas (MIG/GMAW)
- Plasma arc (PAW)
- Submerged arc (SAW)
- Electro-slag (ESW)
- Electro gas(ESW)

(ii). Gas Welding

- Oxy-acetylene
- Air-acetylene
- Oxy-hydrogen
- Pressure gas

(iii). Resistance Welding

- Butt
- Spot
- Seam
- Projection
- Percussion
- Flash Butt

(iv) Thermo-chemical welding process

- Thermit welding
- Atomic hydrogen welding

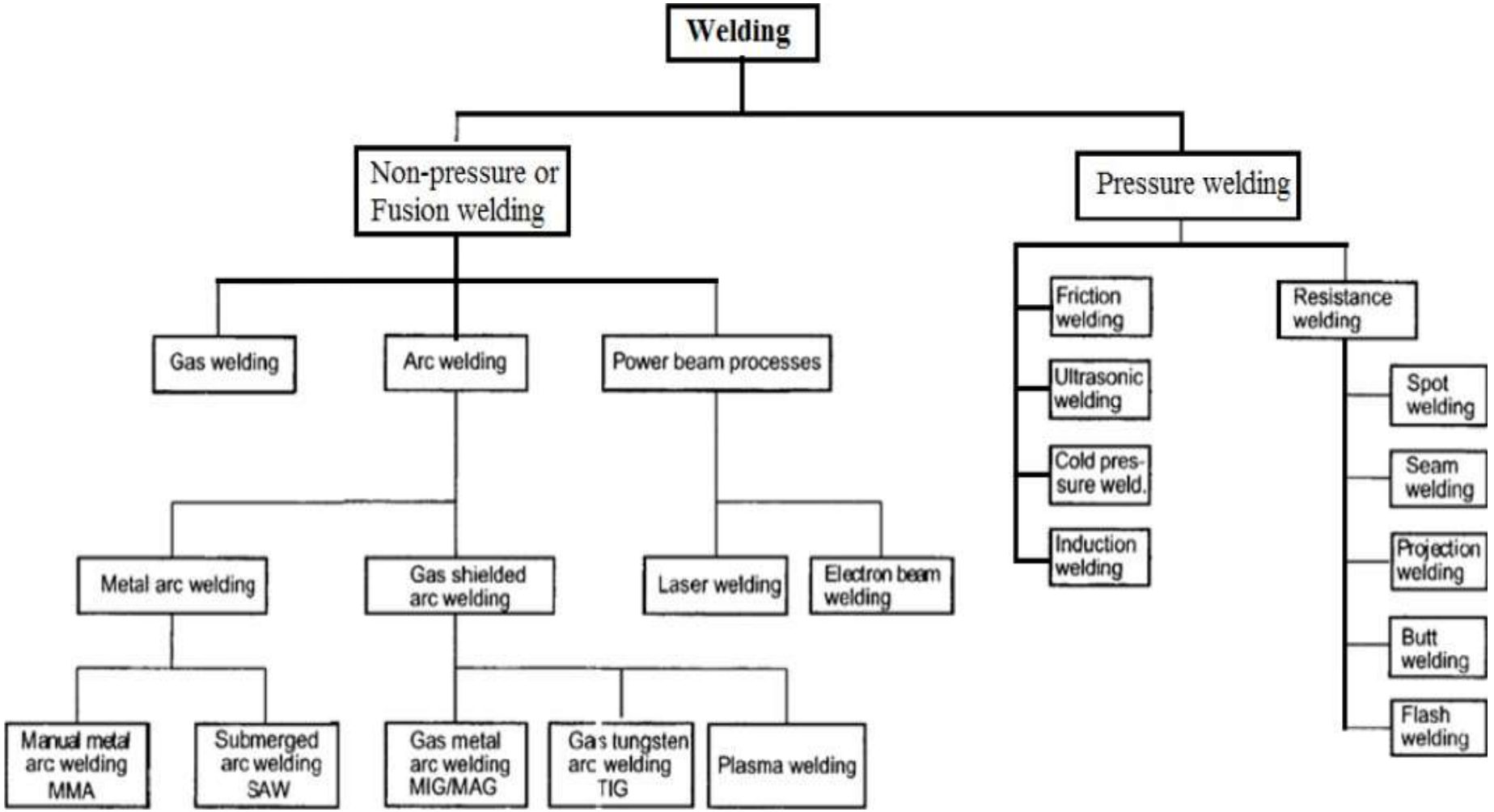
(v) Mechanical energy welding process

- Friction
- Ultrasonic
- Diffusion
- Forge
- Roll
- Explosive

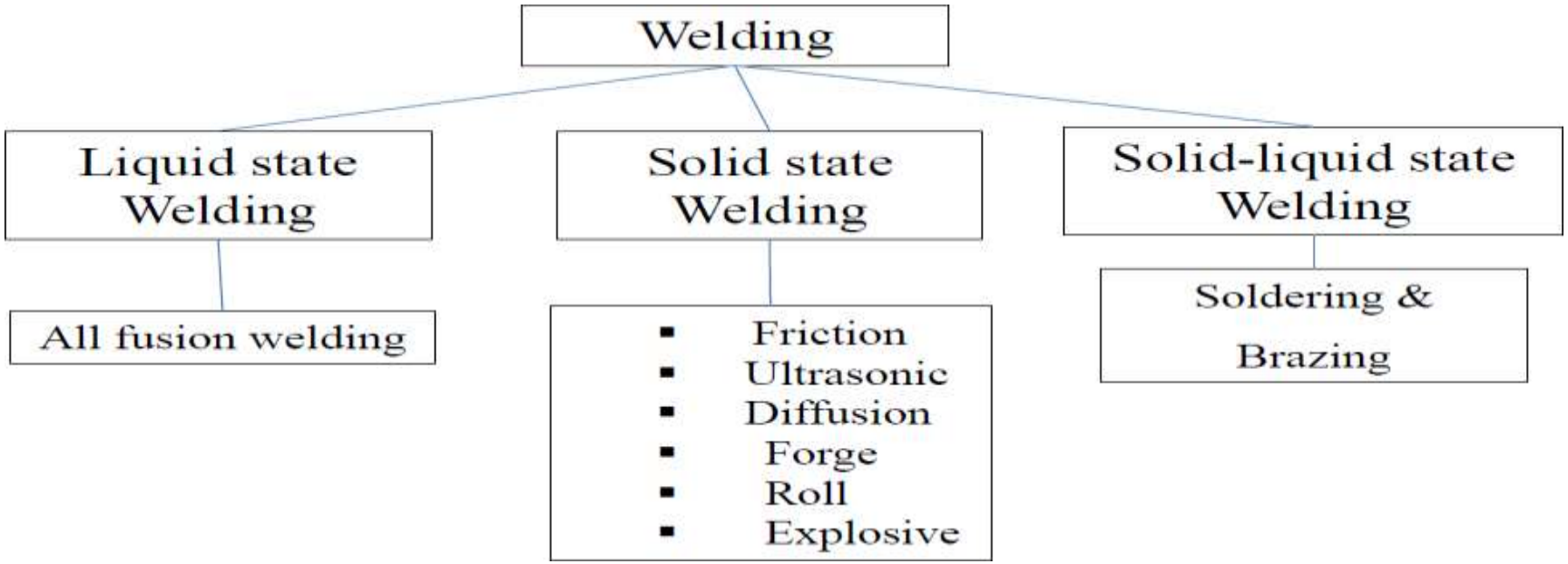
(vi) Radiant energy welding process

- Electron-beam (EBW)
- Laser (LBM)

2.Depending upon the application of pressure



3.Depending upon the different phases of base and filler material



4.Depending upon the composition of the joint

- **Autogenous welding:** No filler material is added during this joining. **Ex.:** All type of solid phase welding, resistance welding and non-consumable welding.
- **Homogeneous welding:** The composition of filler material used during this joining is same as the parent material. **Ex.:** Arc, Gas and Thermit welding.
- **Heterogeneous welding:** The composition of filler material used during this joining is different as the parent material. **Ex.:** Soldering and Brazing.

5. Depending upon the mechanism

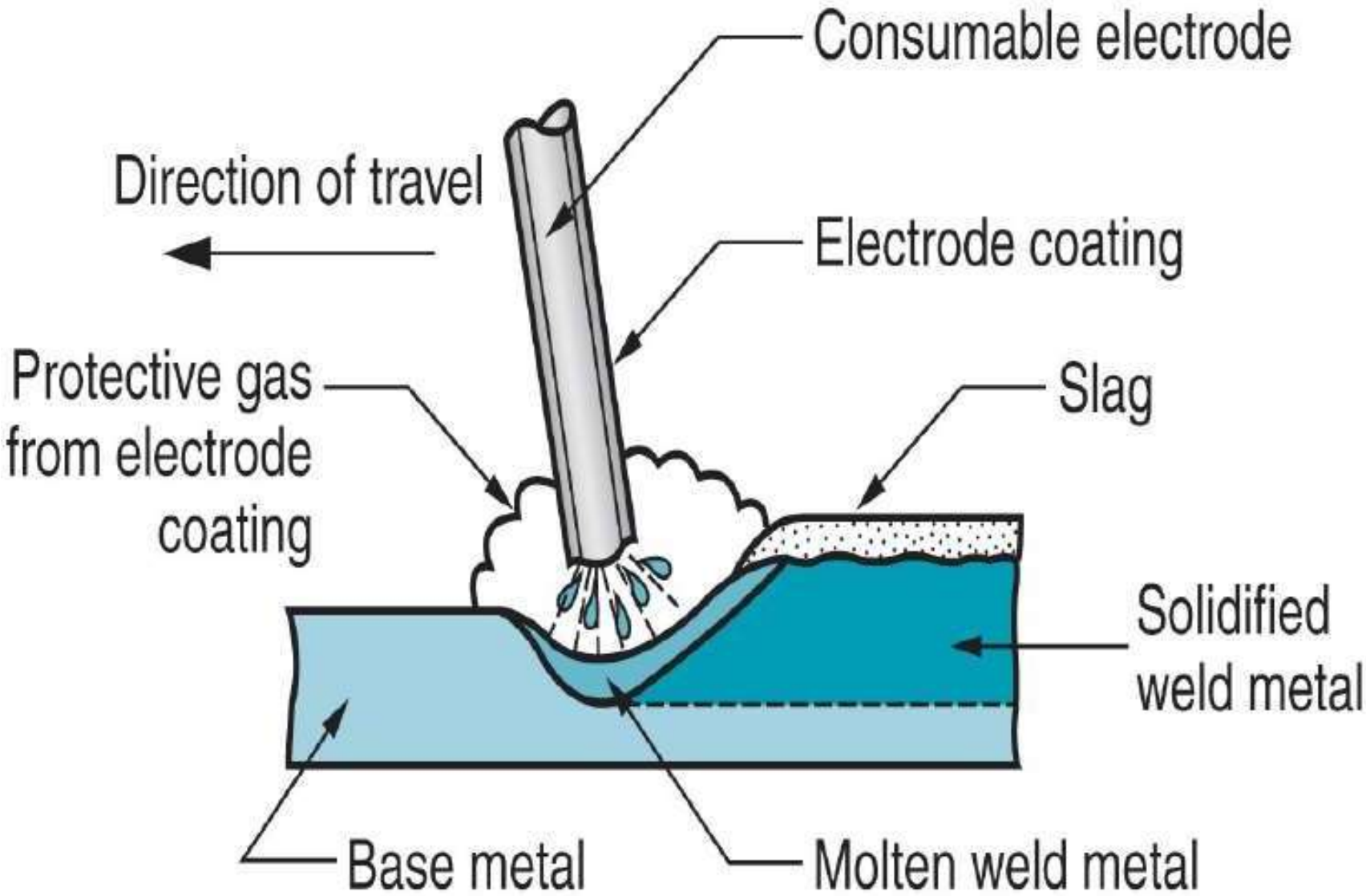
- **Manual Welding:** In manual welding both feeding of filler material and welding speed are controlled manually. Example: SMAW.
- **Semi-automatic:** In this welding either feeding of filler material or welding speed is controlled automatically. Example: MIG, TIG etc.
- **Fully automatic:** In this welding both feeding of filler material and welding speed is controlled automatically. Example: SAW, Laser, EB etc.

Arc Welding

Arc welding is a welding process where in coalescence is produced by heating with an electric arc. Mostly arc welding is done without pressure and with or without filler metal depending upon plate thickness. The electric arc heats the metal to its melting point, and the molten metal fuses the base material together. The molten metal is then cooled and solidified to form a weld joint.

Arc is generated by electrons flowing from negative (-ive) to positive (+ ve) terminal and electrical energy is changed in the arc into heat and light approximately 2/3 of the heat is generated near the positive (+ ive) terminal which burns into the form of a creater. Temperature range form 2700 ° C to 5500 ° C. While remaining 1/3 is generated near negative (-ive) terminal as electrode connected with positive (+ve) terminal.

Shielded Metal Arc Welding (SMAW)



Welding Stick in SMAW

- Composition of filler metal (aluminium ,tin or lead)usually close to base metal
- Coating: powdered cellulose mixed with oxides and carbonates, and held together by a silicate binder
- Welding stick is clamped in electrode holder connected to power source
- Disadvantages of stick welding:
  - Sticks must be periodically changed
  - High current levels may melt coating prematurely

Some common terms used in EAW:

- **Electrode -** A metal rod or wire that serves as both the filler material and the electrode in the welding process.
- **Electrode Coatings -** The material coating on the electrode that affects the type of weld and the shielding from the environment.
- **Filler Material -** The material that is added to the weld pool to fill the gap between the base materials.
- **Weld Pool -** The area where the melted metal is present during the welding process.
- **Weld Bead -** The finished weld that results from the welding process.
- **Weld joint:** the point at which two or more pieces of metal are joined together.
- **Shielding Gas -** A gas used to protect the weld pool from the air, which can cause oxidation and porosity in the weld.

- **Arc:** the electrical discharge between the electrode and the workpiece that creates heat and melts the metal.
- **Arc Length -** The distance between the electrode tip and the weld pool.
- **Welding Voltage -** The electrical potential difference between the electrode and the workpiece.
- **Welding Current -** The electrical current that flows through the electrode and into the weld pool, providing the heat to melt the metal.
- **Weld penetration:** the depth of the weld bead in relation to the base metal.

Two Basic Types of Arc Welding (Based on Electrodes)

1. Consumable electrodes

Consumed during welding process

Added to weld joint as filler metal in the form of rods or spools of wire

2. Non-consumable electrodes

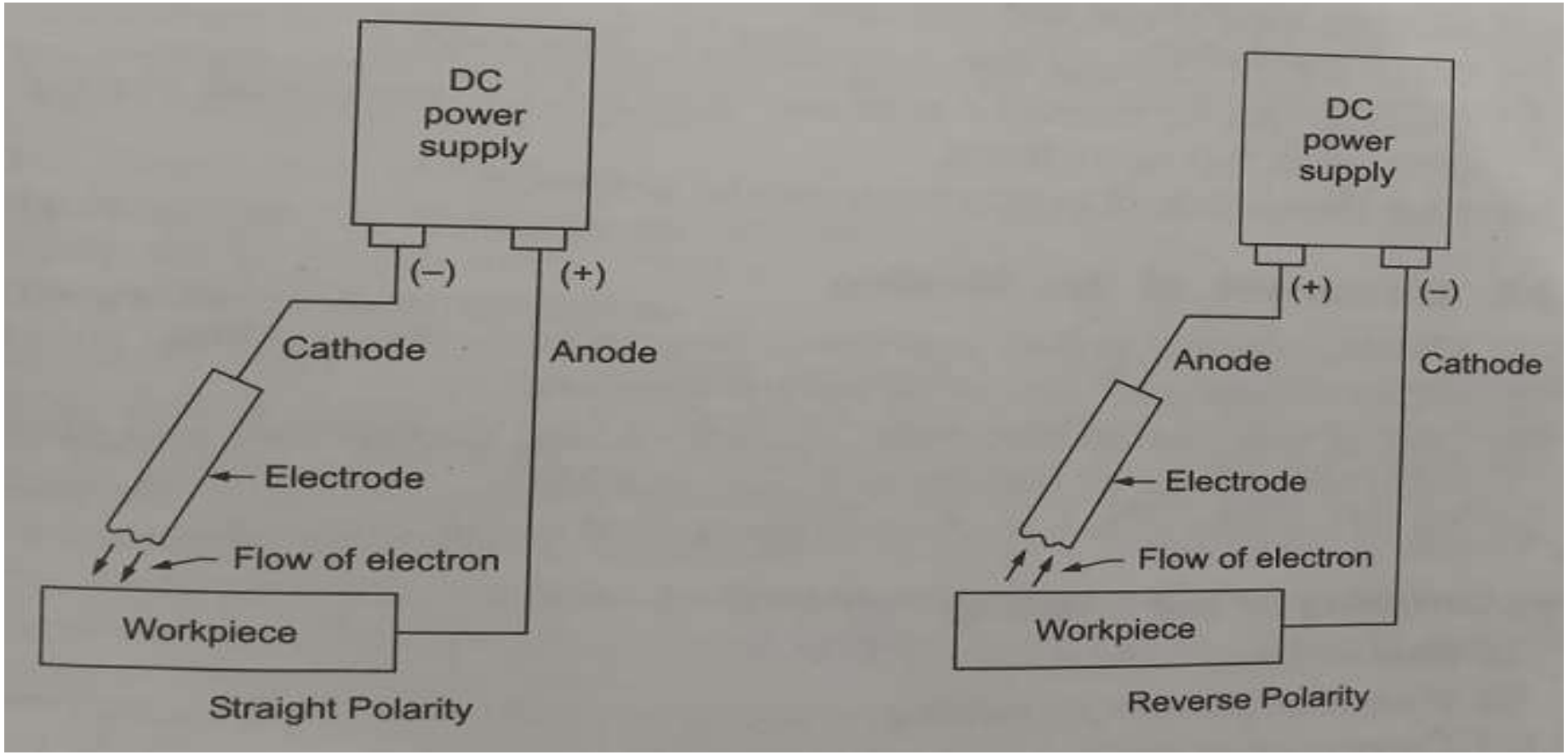
Not consumed during welding process but does get gradually eroded

filler metal must be added separately if it is added

Basic Steps of Arc Welding

- Prepare the base materials: remove paint and rust.
- Choose the right welding process.
- Choose the right filler material.
- Assess and comply with safety requirements.
- Use proper welding techniques and be sure to protect the molten puddle from contaminants in the air.
- Inspect the weld.

Polarity in Arc Welding



Difference Between AC and DC Welding

AC Welding

- Striking of arc with electrode is relatively difficult
- No problem of arc blow in AC arc welding
- Arc is never stable.
- No polarity change possible.
- Bare electrode cannot be used.
- Distribution of heat in arc is equal at electrode and job.

DC Welding

- Developing an arc is easier
- Problem of arc blow in DC welding
- Arc is more stable
- Polarity (DCSP or DCRP) can be changed
- Bare and coated electrode can be used
- Most of heat (up to 66.67 %) is liberated in the positive side of arc

Advantages of arc welding

1. Simple welding equipment
2. Portable
3. Inexpensive power source
4. Relatively inexpensive equipment
5. Welders use standard domestic current.
6. Process is fast and reliable
7. Equipment can be used for multiple functions
8. Used for maintenance, repair, and field construction

SMAW Applications

- Used for steels, stainless steels, cast irons, and certain nonferrous alloys.
- Not used or rarely used aluminium and its alloys, copper alloys, and titanium.
- Can be used in windy weather.
- Can be used on dirty metals (i.e. painted or rusted surfaces).
- Good for repair work.
- Makes thick welds.

Safety and environmental factors

Welding also has some associated hazards, such as the emission of harmful fumes and ultraviolet radiation, and the risk of fire and explosion. It is important to follow proper safety procedures and use the appropriate personal protective equipment to minimize these risks.

The operator is normally protected by means of protective clothing, local screening and ventilation whilst additional protection may be required to protect other workers in adjacent areas. These measures may be costly in themselves as well as having an effect on the overall efficiency of the production operation.

Advances in welding processes may be justified if they offer the following

- Increased deposition rate;
- Reduced cycle time;
- Improved process control;
- Reduced repair rates;
- Reduced joint preparation time;
- Removal of the operator from hazardous area;
- Reduced weld size;
- Reduction in post-weld operations;
- Improved operating factor;
- Reduction in potential safety hazards;
- Simplified equipment setting.

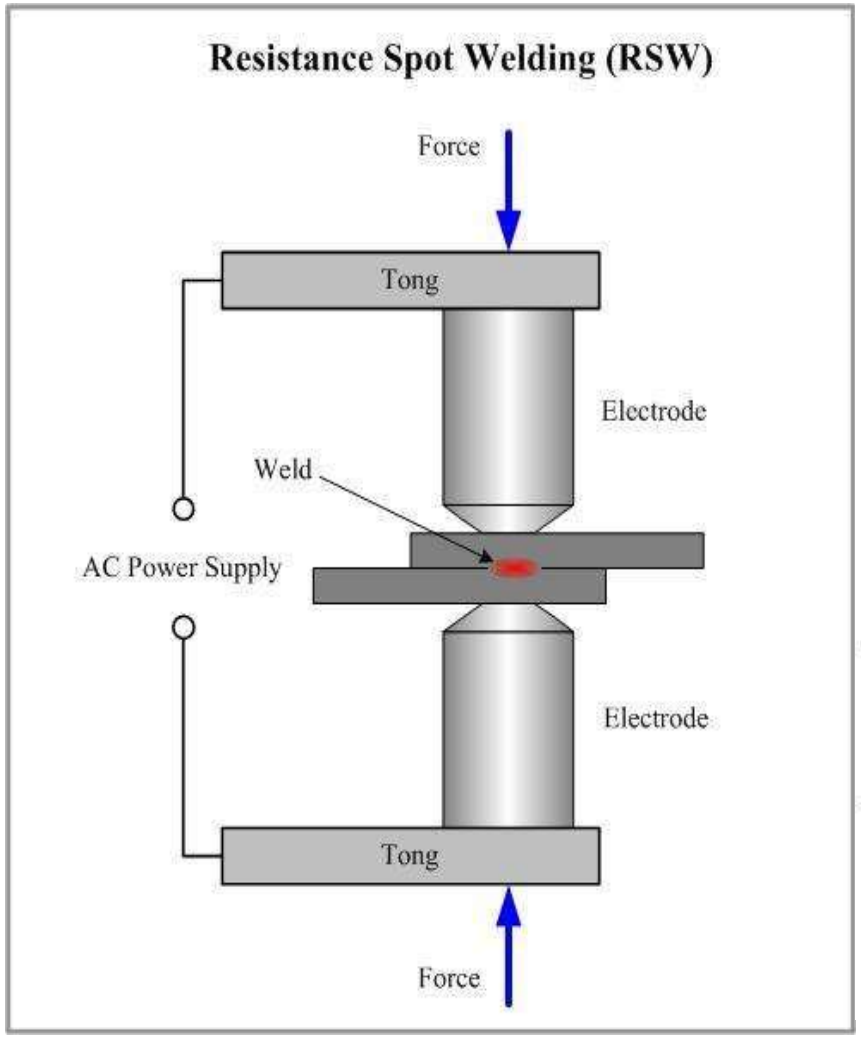
Resistance Welding

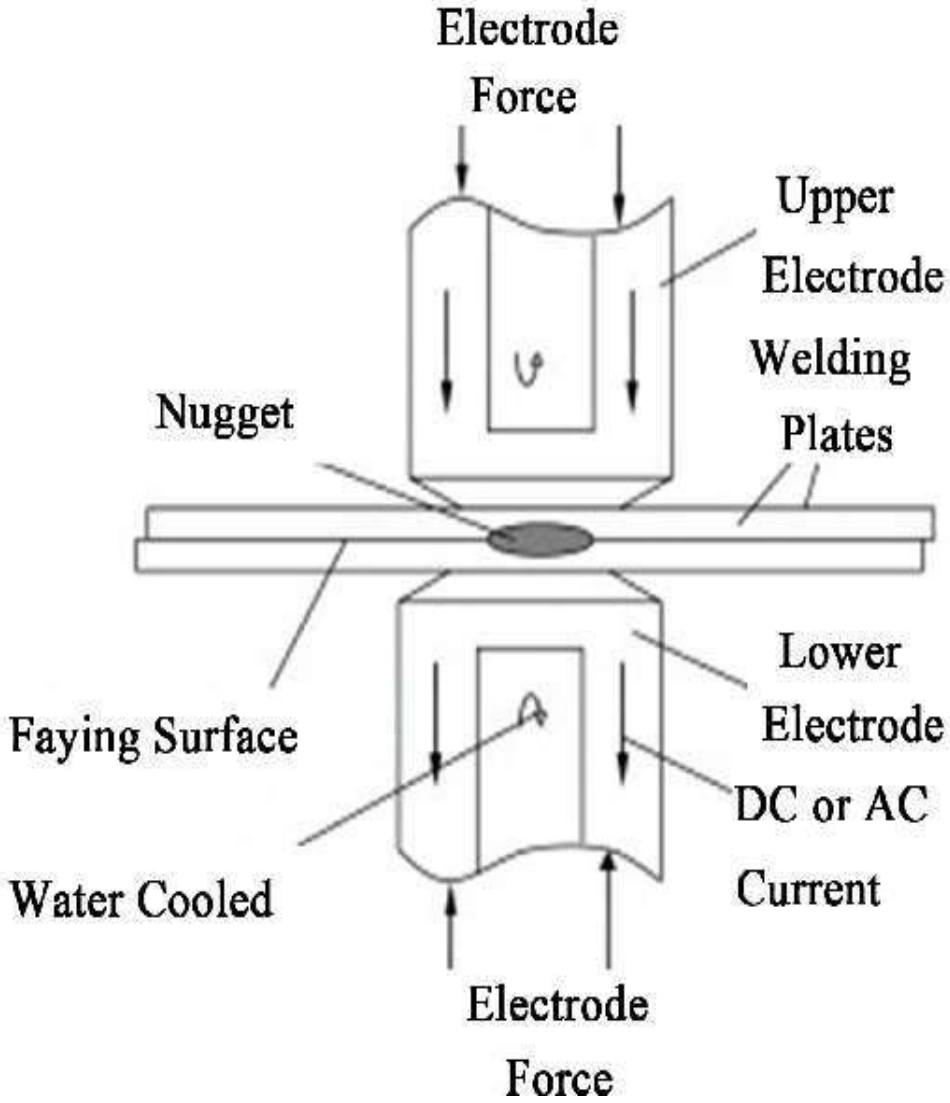
- **Resistance Welding** is a welding process, in which work pieces are welded due to a combination of a pressure applied to them and a localized heat generated by a high electric current flowing through the contact area of the weld.
- Resistance welding processes are a fast and reliable means of joining thin sheets of metal together. The weld is created by first applying pressure on the two parts to be joined. Once the correct amount of pressure is applied, current is passed between the two (or more) overlapped sheets. Resistive heating results in melting and the formation of a “weld nugget” or a “weld seam”.

Types of resistance welding

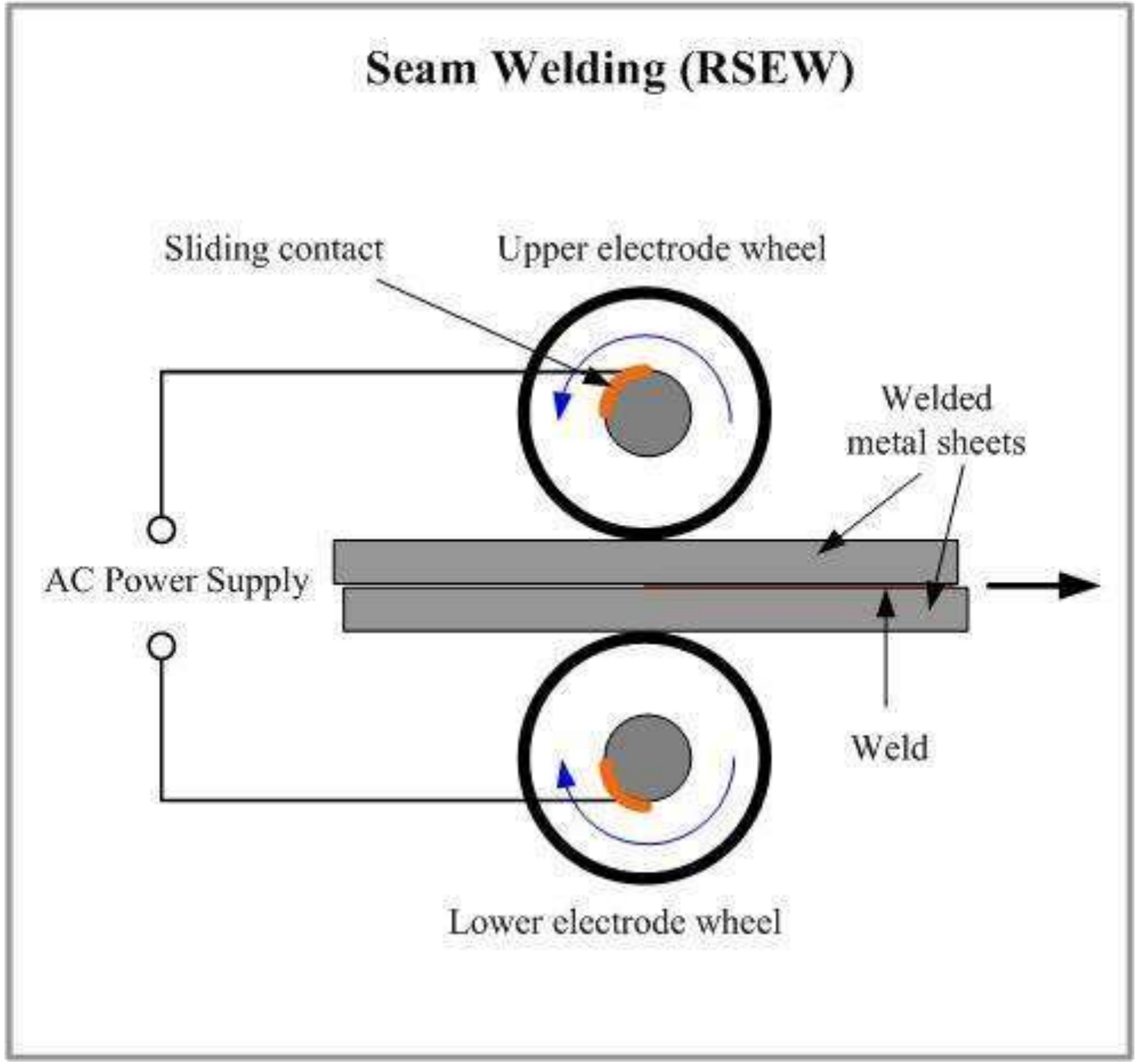
- **Spot welding:** This is a type of resistance welding in which two or more metal sheets are joined together at a single point or spot.
- **Projection welding:** This process is used for welding small and intricate parts, such as electrical components, where a specific projection on one part is welded to a corresponding flat surface on the other part.
- **Seam welding:** This is a continuous process of welding two metal sheets or edges together in a linear fashion.
- **Butt welding:** This process is used for welding two metal sheets or rods end-to-end.

Spot welding





Seam Welding (RSEW)



Difference Between Spot and Seam Welding

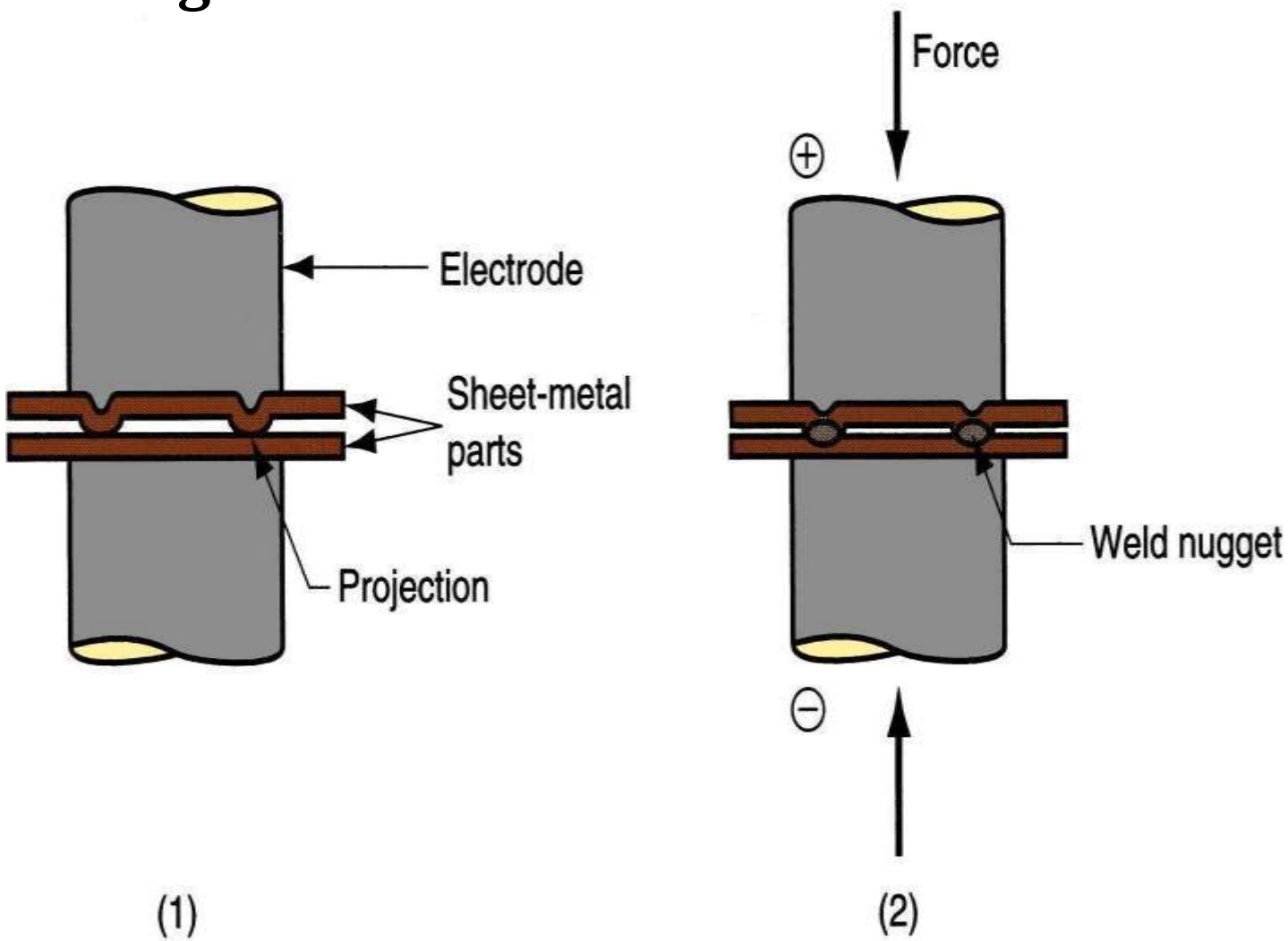
Spot

- The electrodes are a pair of copper rods between which the sheets to be welded are positioned
- The welding takes place at discrete intervals
- It is used for components such as flat sheets , panels as in car bodies.

Seam

- Electrodes are a pair of rotating copper rolls between which sheets to be welded are passed
- The seam weld joints are continuous
- It is used to weld components such as a fuel tank shells & other application which require the joint to be leak proof.

Projection Welding

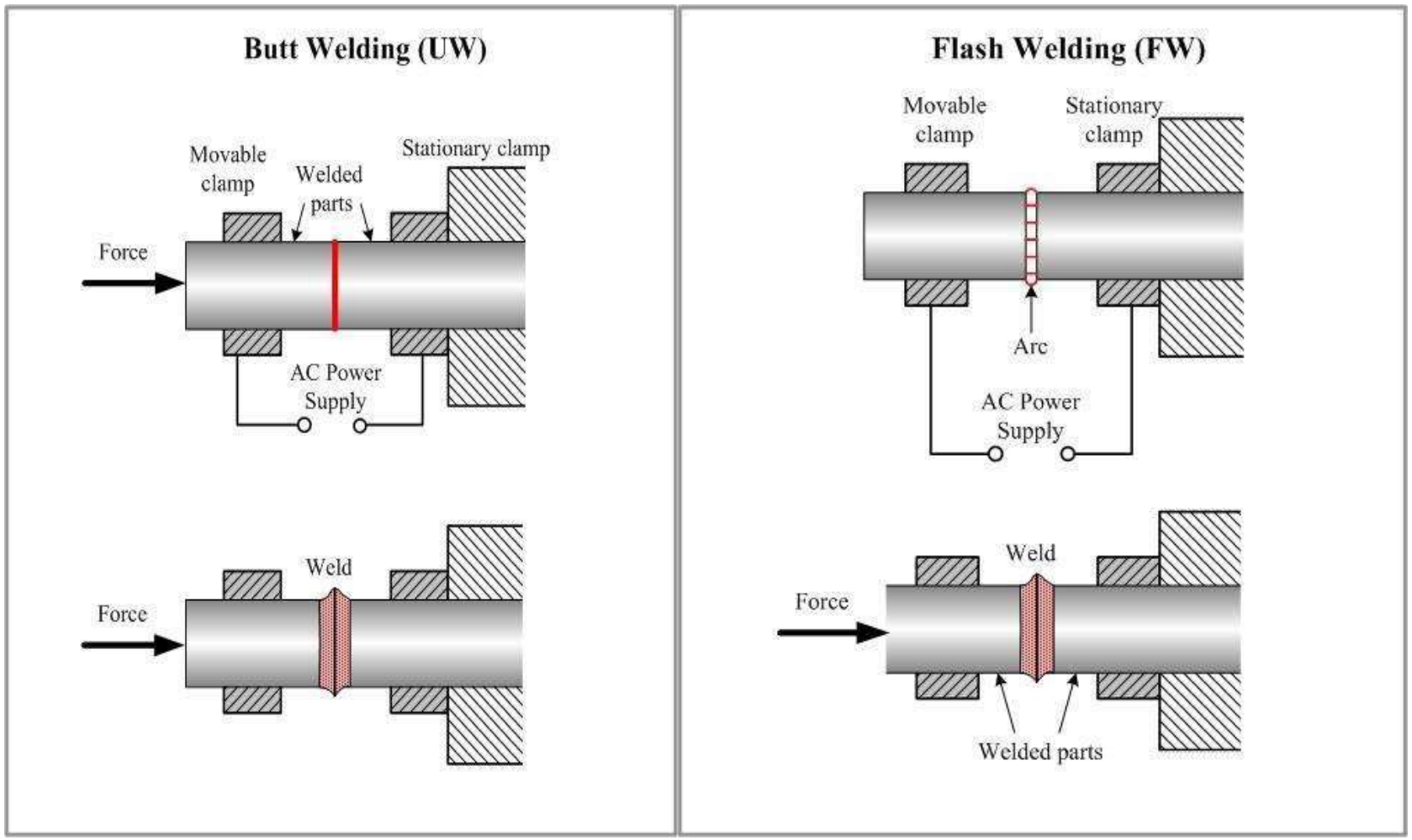


Resistance Butt Welding

Upset Welding: In upset butt welding , the parts are clamped and brought in solid contact and current is applied so that the heat is generated through the contact areas of the parts.

Flash welding: It is similar to upset welding except that the heat is obtained by means of an arc than the simple resistance heating. The two parts are brought together and the power supply is switched on. As the parts are moved closer , flashing or arcing raises the temperature of the parts to a welding temperature. Now power is switched off and two parts are rapidly pressed (forced) together causing a small upset. This squeezes out liquid metal and oxides ,formed on the joint surfaces and the two parts are welded together.

Resistance Butt Welding



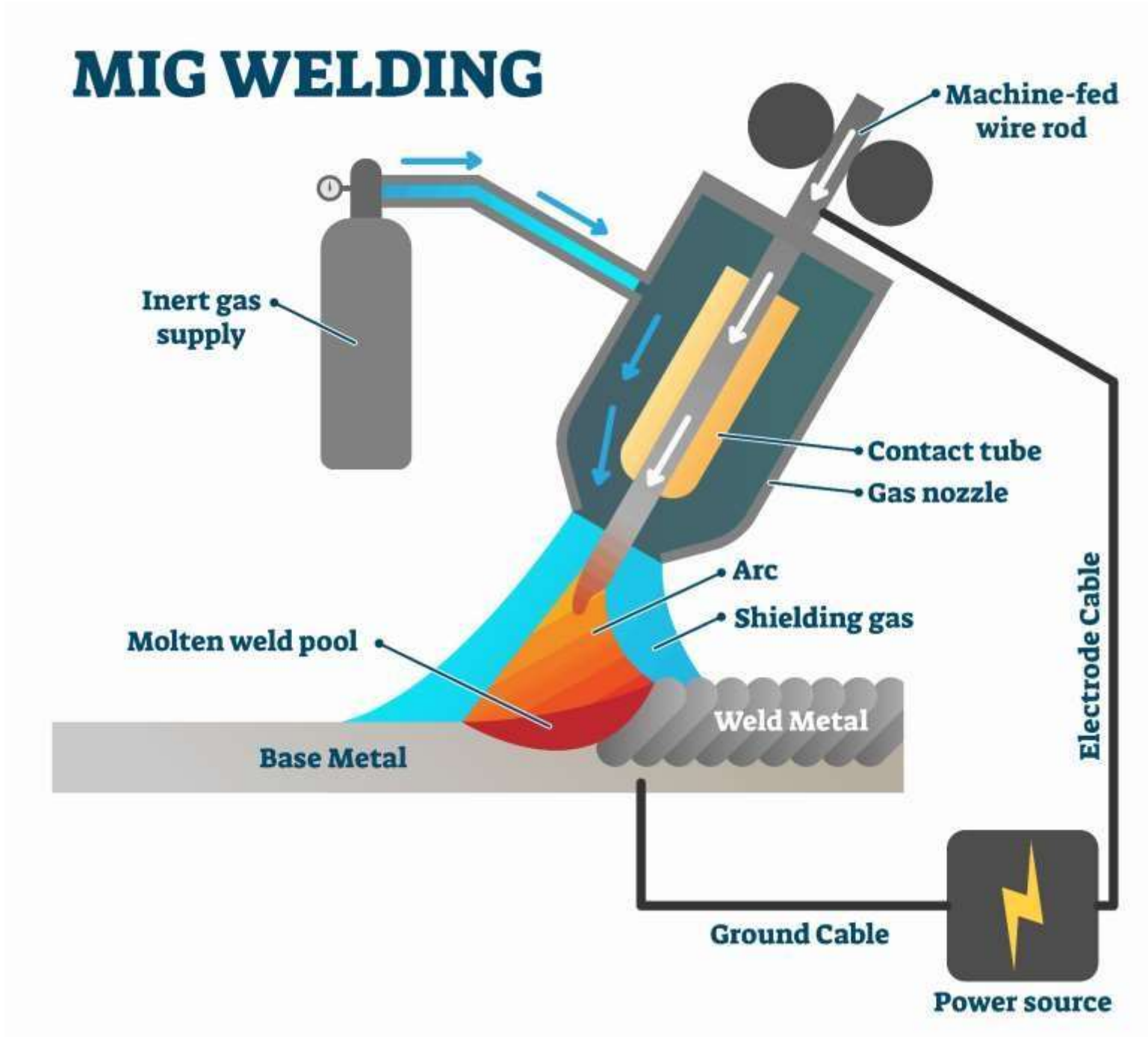
Resistance welding application

- This type of welding can be widely used within Automotive Industries, making of nut as well as a bolt.
- Seam welding can be utilized to generate leak prove joint necessary within little tanks, boilers, etc.
- Flash welding can be used for welding tubes and pipes.

Metal Inert Gas (MIG) Welding

Metal inert gas welding or gas metal arc welding (GMAW) is a group of arc welding process in which the work pieces are joined by the heat obtained from an electric arc struck between a bare (uncoated) consumable electrode and the work piece in the presence of an inert gas atmosphere. The consumable electrode acts as a filler metal to fill the gap between the two work pieces.

The two base materials are melted together forming a join. The gun feeds a shielding gas alongside the electrode helping protect the weld pool from airborne contaminants.


MIG WELDING
Machine-fed wire rod
Inert gas supply
Contact tube
Gas nozzle
Arc
Shielding gas
Molten weld pool
Weld Metal
Base Metal
Electrode Cable
Ground Cable
Power source

Advantages

- MIG welding is fast and economical.
- The electrode and inert gas are automatically fed, and this makes the operator easy and to concentrate on the arc.
- Weld deposition rate is high due to the continuous wire feed
- No flux is used. Hence, no slag formation. This results in clean welds.
- Thin and thick metals can be welded.
- Process can be automated

Disadvantages

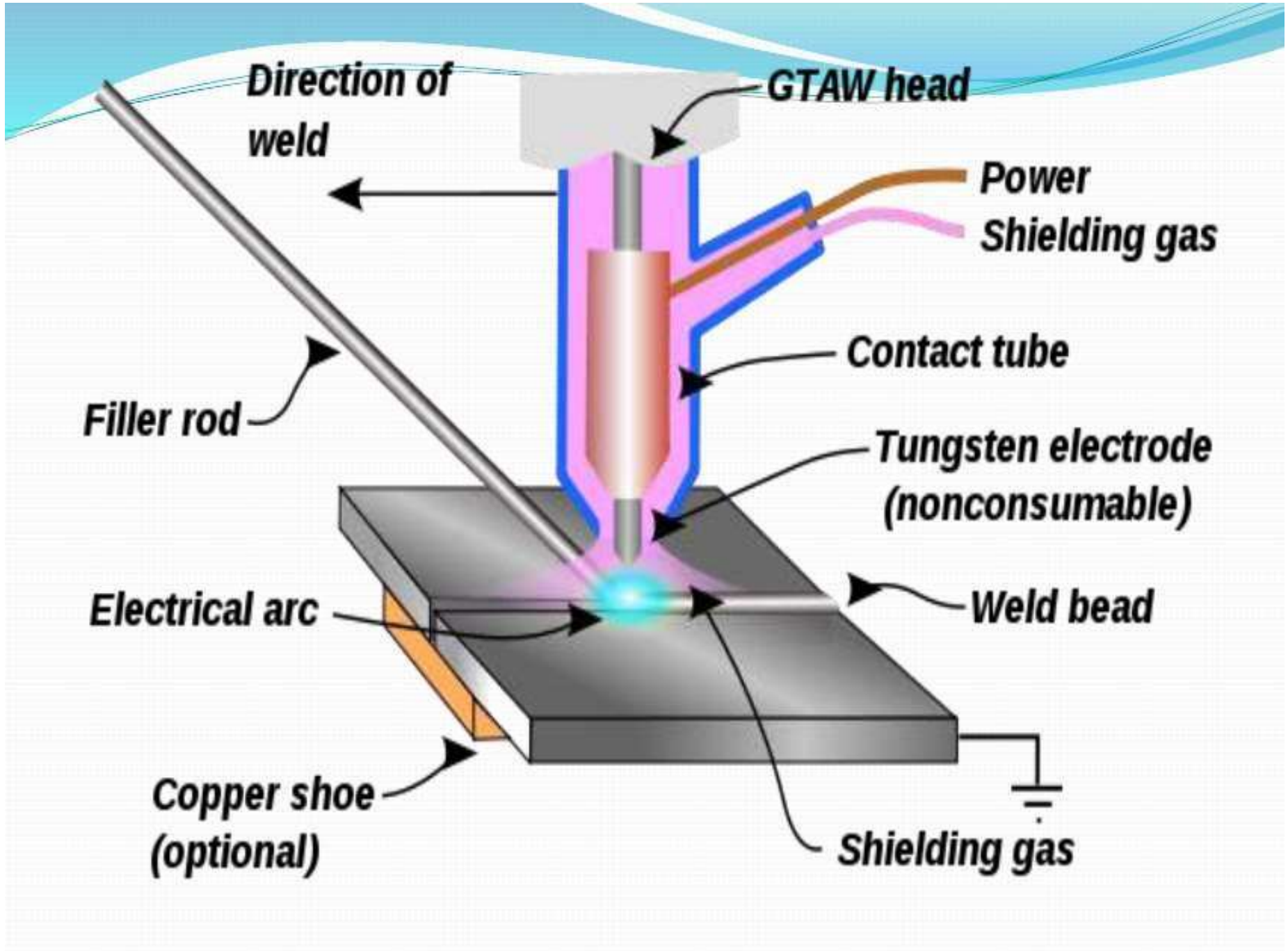
- Equipment is costlier
- Porosity (gas entrapment in weld pool) is the most common quality problem in this process. However, extensive edge preparation can eliminate this defect.

Tungsten Inert Gas(TIG) Welding

It is one of the type of arc welding process where in coalescence is produced by heating the job with an electric arc struck between a non-consumable tungsten electrode and the job. A shielding gas(argon , helium or both) is used to avoid the atmospheric contamination of the molten metal weld pool. A filler metal may be added if required, during the welding process.

Equipment used in GTAW

- Welding torch
- Tungsten electrode
- Welding power source
- Inert gas cylinder
- Cooling water supply


Direction of weld
GTAW head
Power
Shielding gas
Contact tube
Filler rod
Tungsten electrode (nonconsumable)
Electrical arc
Weld bead
Copper shoe (optional)
Shielding gas

Advantage

- Suitable for thin metals.
- Clear visibility of the arc provides the operator to have a greater control over the weld.
- Strong and high quality joints are obtained.
- No flux is used. Hence, no slag formation. This results in clean weld joints.
- Deeper penetration can be achieve through this process.

Disadvantage

- TIG is the most difficult process compared to all the other welding processes. The welder must maintain short arc length, avoid contact between electrode and the work-piece and manually feed the filler metal with one hand while manipulating the torch with the other hand.
- Skilled operator is required.
- Process is slower.
- Not suitable for thick metals.

Difference between TIG and MIG

TIG	MIG
1. In TIG welding a non-consumable (permanent) tungsten electrode is used.	1. MIG uses a copper coated wire of same chemical composition as the parent metal being welded.
2. TIG welding electrode, serve the purpose of producing the are only filler rod needed if any.	2.MIG welding wire servers both the purpose of producing the arc as well as of filler metal.
3. TIG welding process is not so faster as MIG welding process separately a filler rod is added.	3. MIG is faster process as compared to TIG because no filler rod is added separately.
4. TIG welding requires a skill operator.	4. Not so much skilled operator is needed.
5. TIG welding torch may be watercool.	5. MIG welding torch are not watercool.
6. Penetration is not so much deeper as compared to MIG.	6. Deeper penetration can be achieved very easily.

Application

Both MIG and TIG welding can be used on a wide range of metals, with MIG welding more suitable for thick materials and TIG more appropriate for thin materials. Typical weld materials include aluminium, carbon steel, and stainless steel.