WELDING

- Welding is a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure and with or without the use of filler material.

- It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

The five basic joints used in welding are :-

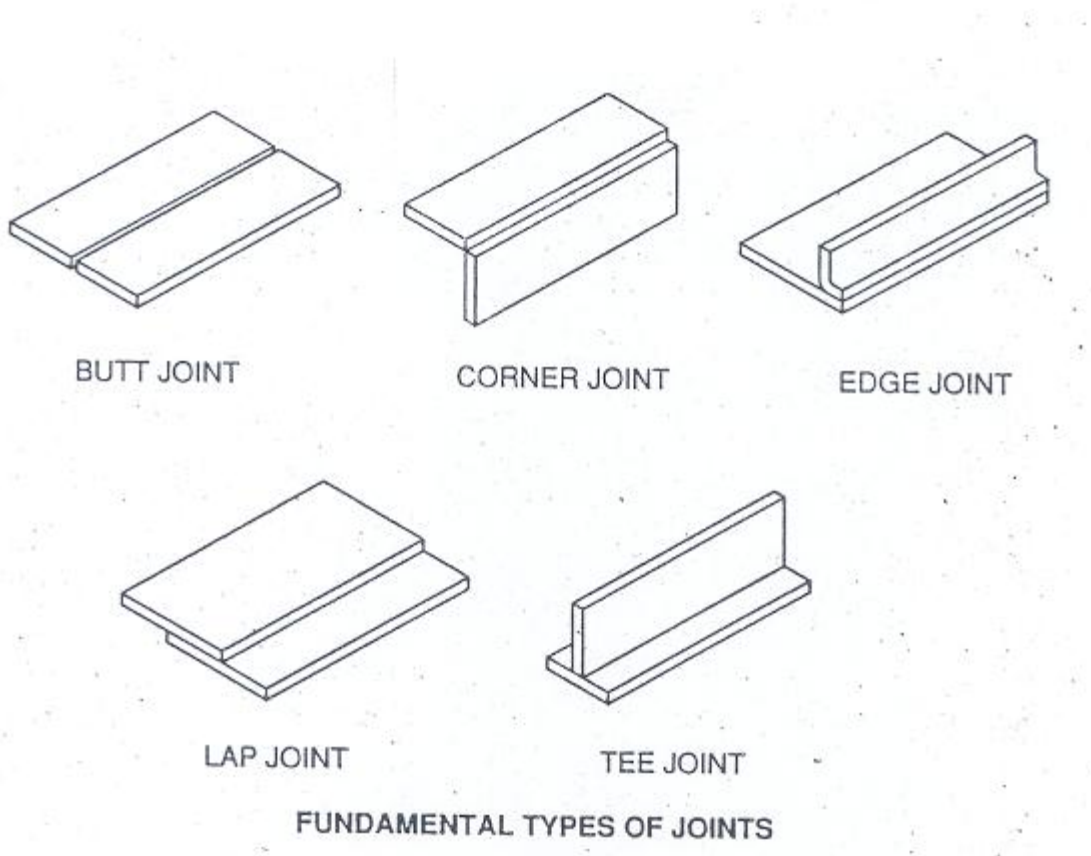


Figure 12 : Basic types of joints

The general function of welding

1. Provides a permanent joint

2. One of the most economical ways to join parts in terms of material usage and fabrication costs

Mechanical fastening usually requires additional hardware (e.g., screws) and geometric alterations of the assembled parts (e.g., holes)

3. Not restricted to a factory environment

Welding can be accomplished "in the field"

Limitations and Drawbacks of Welding

1. Most welding operations are performed manually and are expensive in terms of labor cost.
2. Most welding processes utilize high energy and are dangerous.
3. Welded joints do not allow for convenient disassembly.
4. Welded joints can have quality defects that are difficult to detect.

TYPES

- **Pressure Welding**

  The piece of metal to be joined are heated to a plastic state and forced together by external pressure

  (Ex) Resistance welding

- **Fusion Welding or Non-Pressure Welding**

  The material at the joint is heated to a molten state and allowed to solidify

  (Ex) Arc welding

Classification of welding processes:

(i). **Arc welding**

- Shielded metal arc welding (SMAW)
- Gas tungsten arc welding (GTAW)
- Flux-cored arc welding (FCAW)
- Submerged arc welding
- Stud welding

(ii). **Gas Welding**

- Oxy-acetylene

(iii). **Resistance Welding**

- Spot
- Seam
- Projection

Arc welding

Equipments:

- A welding generator (D.C.) or Transformer (A.C.)
- Two cables- one for work and one for electrode
- Electrode holder
- Electrode
- Gloves
- Wire brush
- Chipping hammer (welding slag
- Goggles

Fig. 3.1 Electrode Holder

Fig. 3.2 Earth Clamp

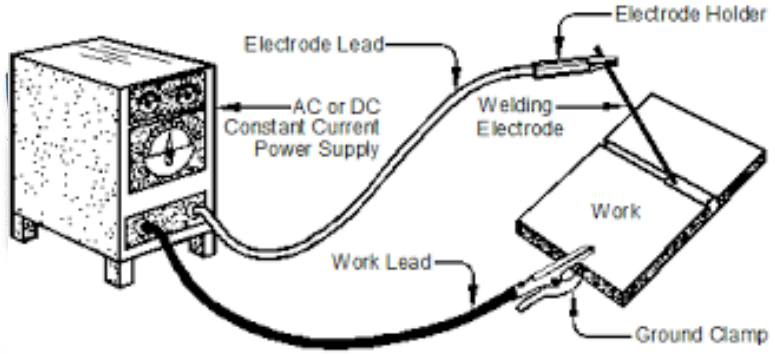


Fig. 3.5 Scriber

Fig. 3.6 Chipping Hammer

Fig. 3.7 Wire Brush

Two Basic Types of Arc Welding (Based on Electrodes)

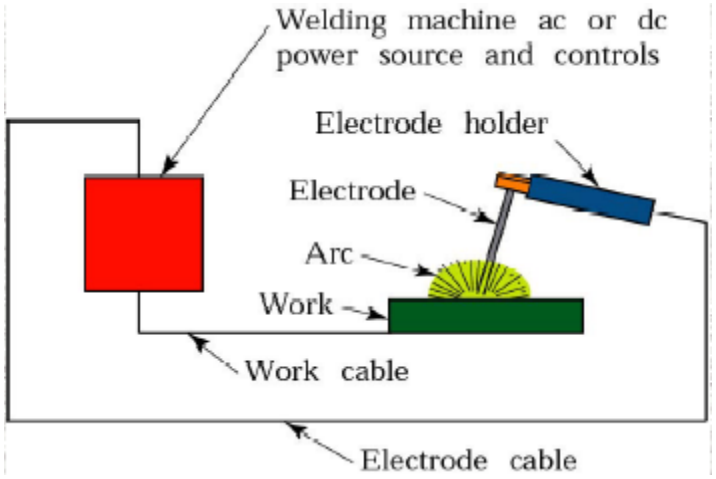
1. Consumable electrodes
   - ❑ consumed during welding process
   - ❑ added to weld joint as filler metal
   - ❑ in the form of rods or spools of wire

- SMAW – Shielded Metal Arc Welding
- SAW – Submerged Arc Welding

1. Non-consumable electrodes
   - ❑ not consumed during welding process but does get gradually eroded
   - ❑ filler metal must be added separately if it is added

- GTAW – Gas Tungsten Arc Welding
- Stud welding

Arc Welding



Briefly, the process takes place in the following manner :-

•The work to be welded is connected to one side of an electric circuit, and a metal electrode is connected to the other side. These two parts of the circuit are brought together and the separated slightly. The electric current jumps the gap and causes a continuous spark called an *arc.*

•The high temperature of this arc melts the metal to be welded, forming a molten puddle. The electrode also melts and adds metal to the puddle. As the *arc* is moved, the metal solidifies. The metal fuses into one piece as it solidifies.

Arc Shielding

1. At high temperatures in AW, metals are chemically reactive to oxygen, nitrogen, and hydrogen in air

   - Mechanical properties of joint can be degraded by these reactions
   - Arc must be shielded from surrounding air in AW processes to prevent reaction

2. Arc shielding is accomplished by
   - Shielding gases, e.g., argon, helium, CO_2
   - Flux

Comparison of A.C. and D.C. arc welding

Alternating Current (from Transformer)

More efficiency

Power consumption less

Cost of equipment is less

Higher voltage – hence not safe

Not suitable for welding non ferrous metals

Not preferred for welding thin sections

Any terminal can be connected to the work or electrode

Comparison of A.C. and D.C. arc welding

Direct Current (from Generator)

Less efficiency

Power consumption more

Cost of equipment is more

Low voltage – safer operation

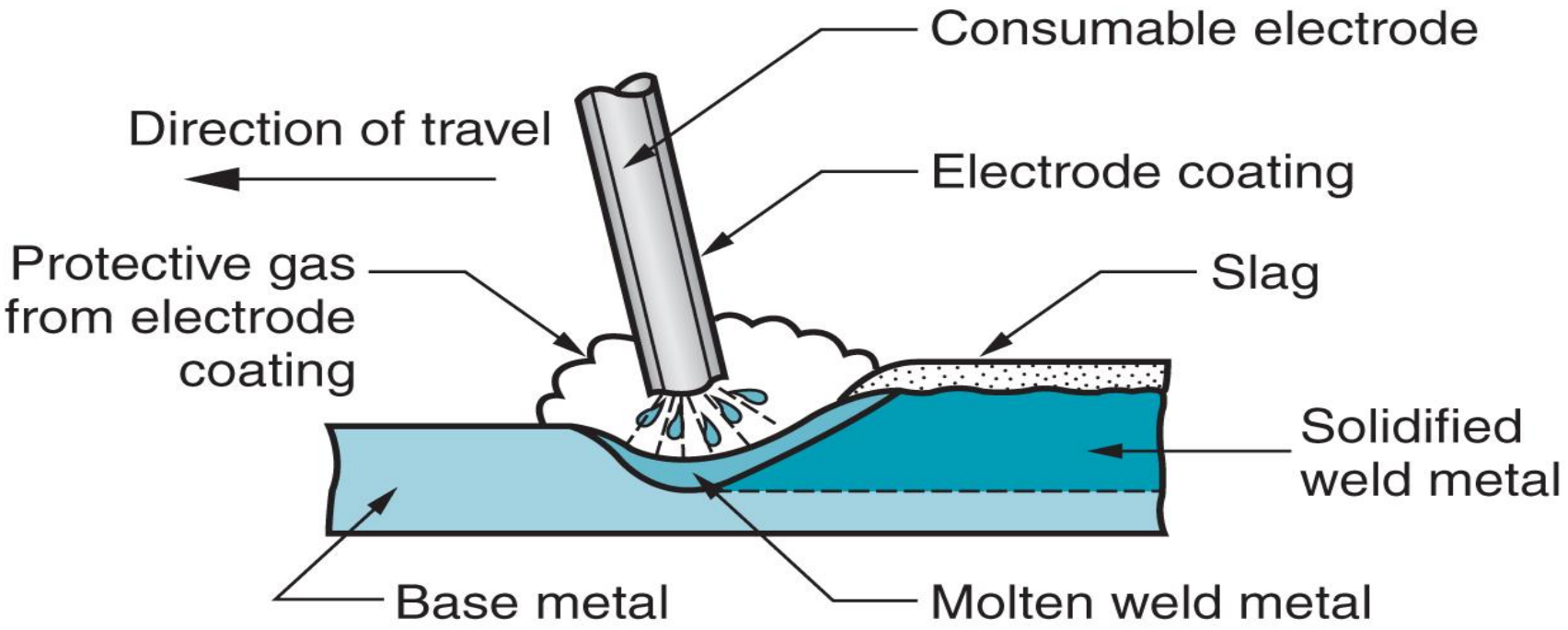
suitable for both ferrous non ferrous metals

preferred for welding thin sections

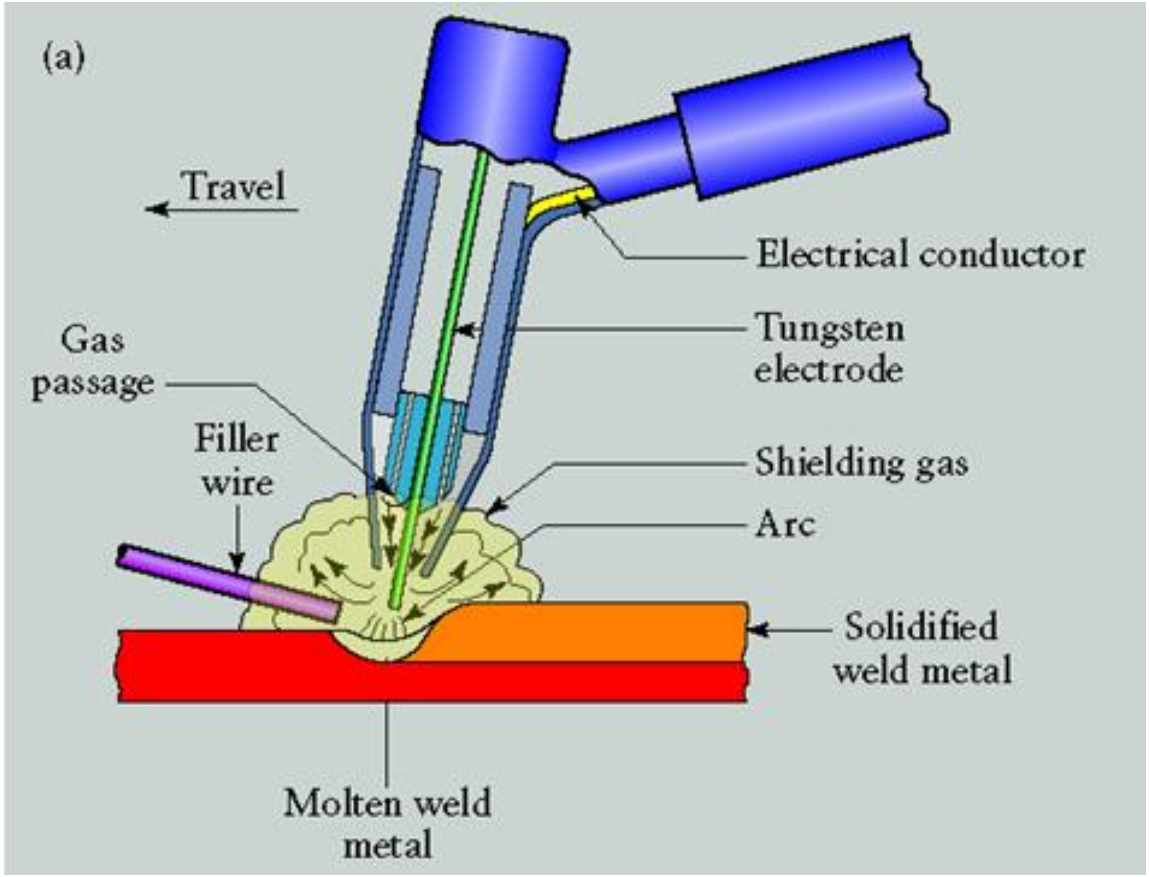
Positive terminal connected to the work

Negative terminal connected to the electrode

Shielded Metal Arc Welding (SMAW)



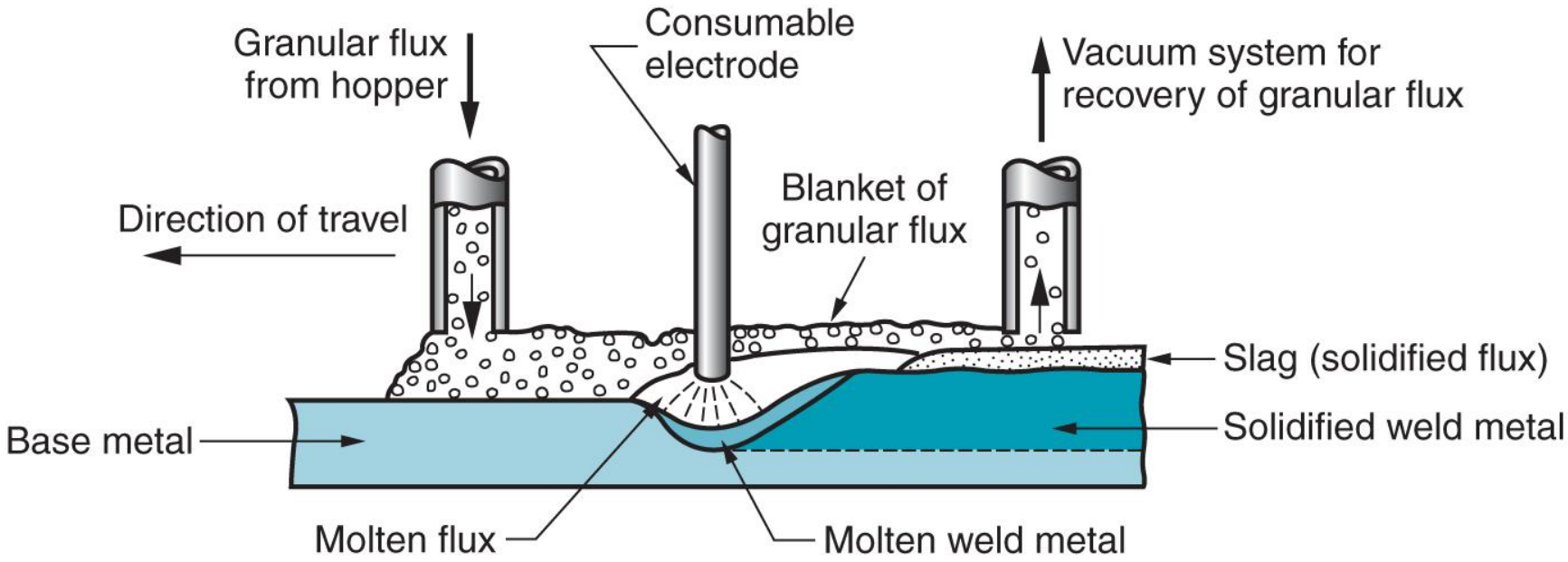
- Uses a consumable electrode consisting of a filler metal rod and coating around rod.
- Coating composed of chemicals that provide flux and shielding.
- Slag keeps oxygen off weld bead during cooling
- Low cost welding system.



GTAW – Gas Tungsten Arc Welding (TIG): non-consumable electrode

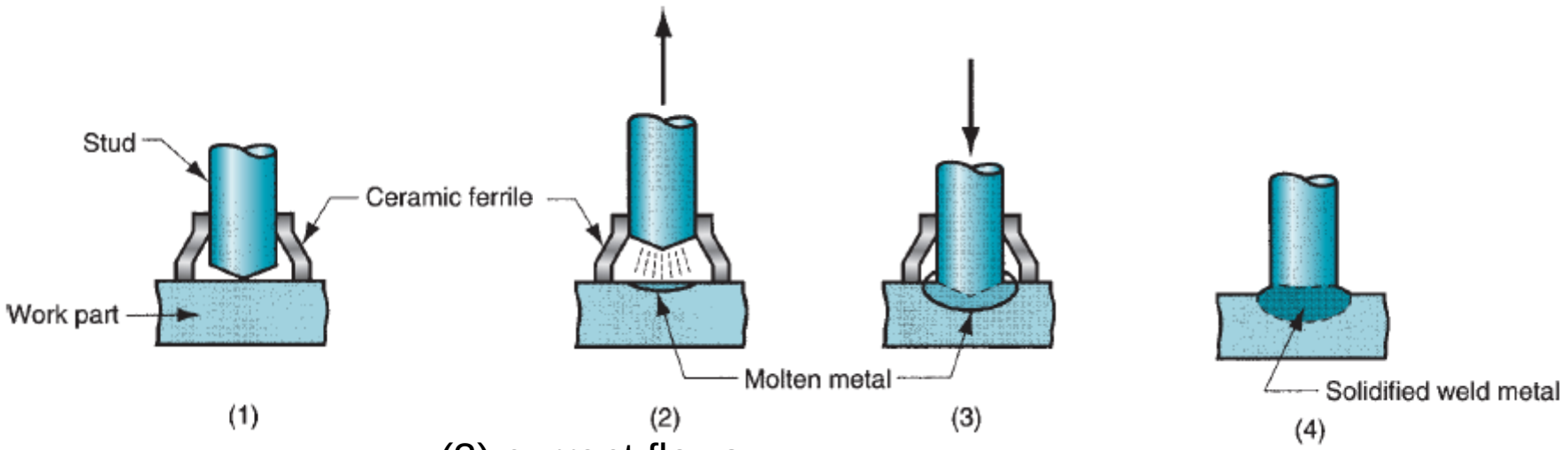
Gas tungsten arc welding (GTAW) is an AW process that uses a nonconsumable tungsten electrode and an inert gas for arc shielding. GTAW can be implemented with or without a filler metal. When a filler metal is used, it is added to the weld pool from a separate rod or wire, being melted by the heat of the arc. Tungsten is a good electrode material due to its high melting point of 3410C (6170F). Typical shielding gases include argon, helium, or a mixture of these gas elements.

Submerged Arc Welding



- Consumable wire electrode
- Shielding provided by flux granules
- Flux acts as thermal insulator (lime, silica, manganese oxide, calcium fluoride)
- High speed & quality
- Suitable for thick plates

Stud Welding



(1)Stud is chucked in specific weld gun and stud is positioned

(2) current flows from the gun, and stud is pulled from base to establish arc and create a molten pool

(3) stud is plunged into molten pool

(4) ceramic ferrule is removed after solidification.

Shielding is obtained by the use of ceramic ferrule.

Oxyacetylene Welding

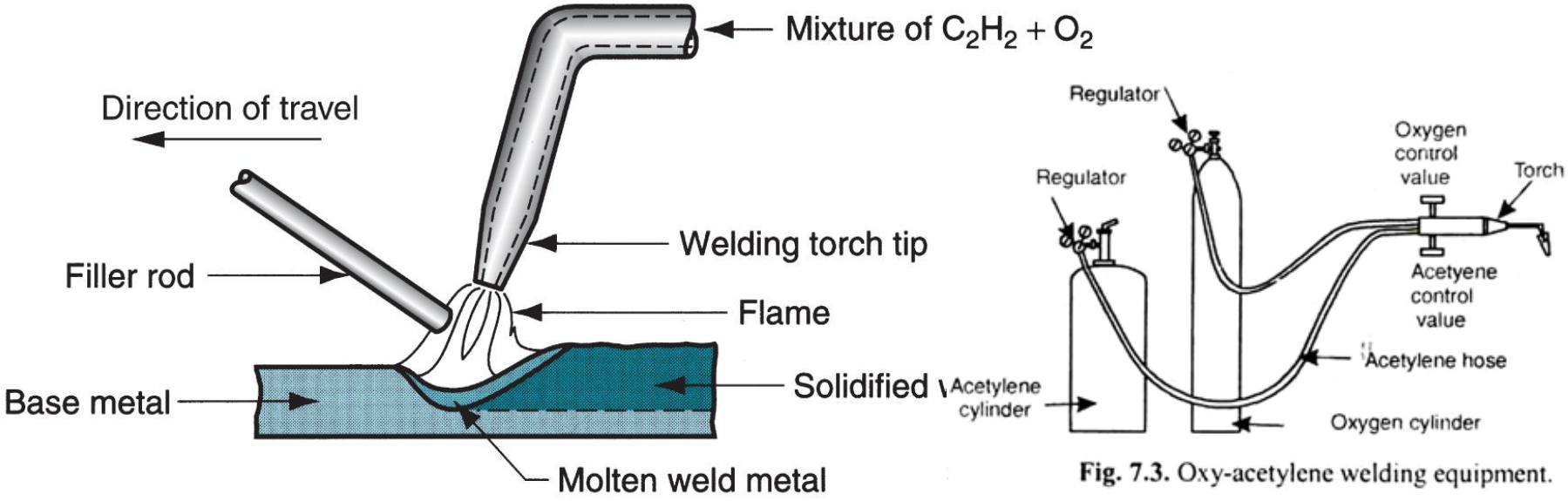


Fig. 7.3. Oxy-acetylene welding equipment.

In oxyacetylene welding, one of the gas welding processes, the metal is heated by the hot flame of a gas-fed torch.

The metal melts and fuses together to produce the weld.

In many cases, additional metal from a welding rod is melted into the joint which becomes as strong as the base metal. Filler rod often coated with *flux* to prevent oxidation

WELDING TECHNIQUE

- In forehand welding the welding rod comes before torch.
- In backhand welding the torch comes before the rod.

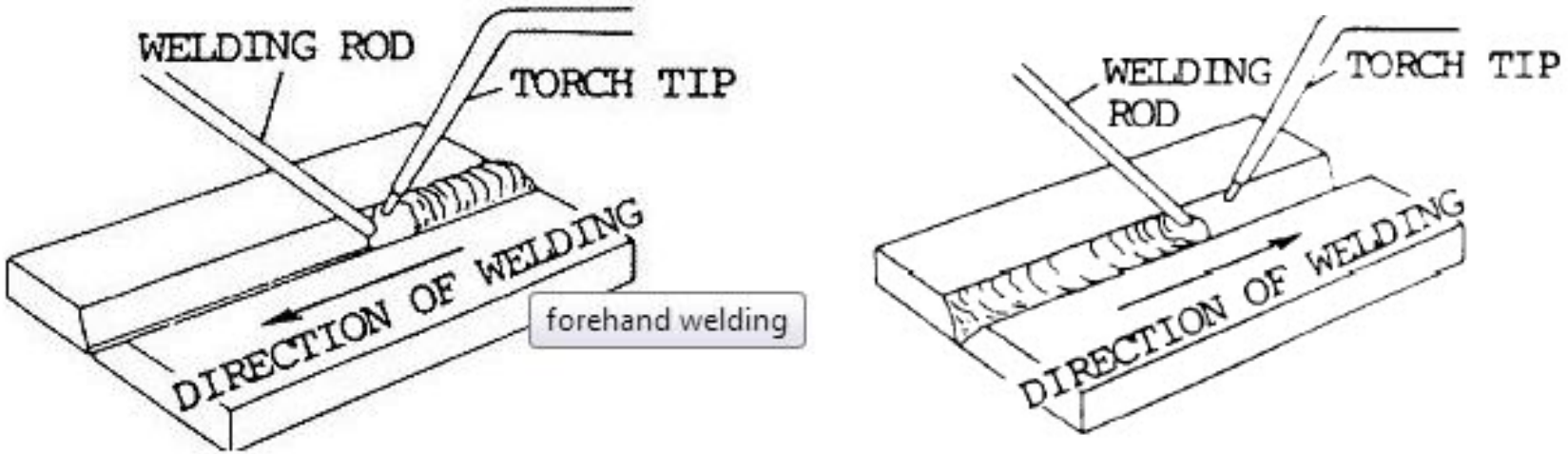
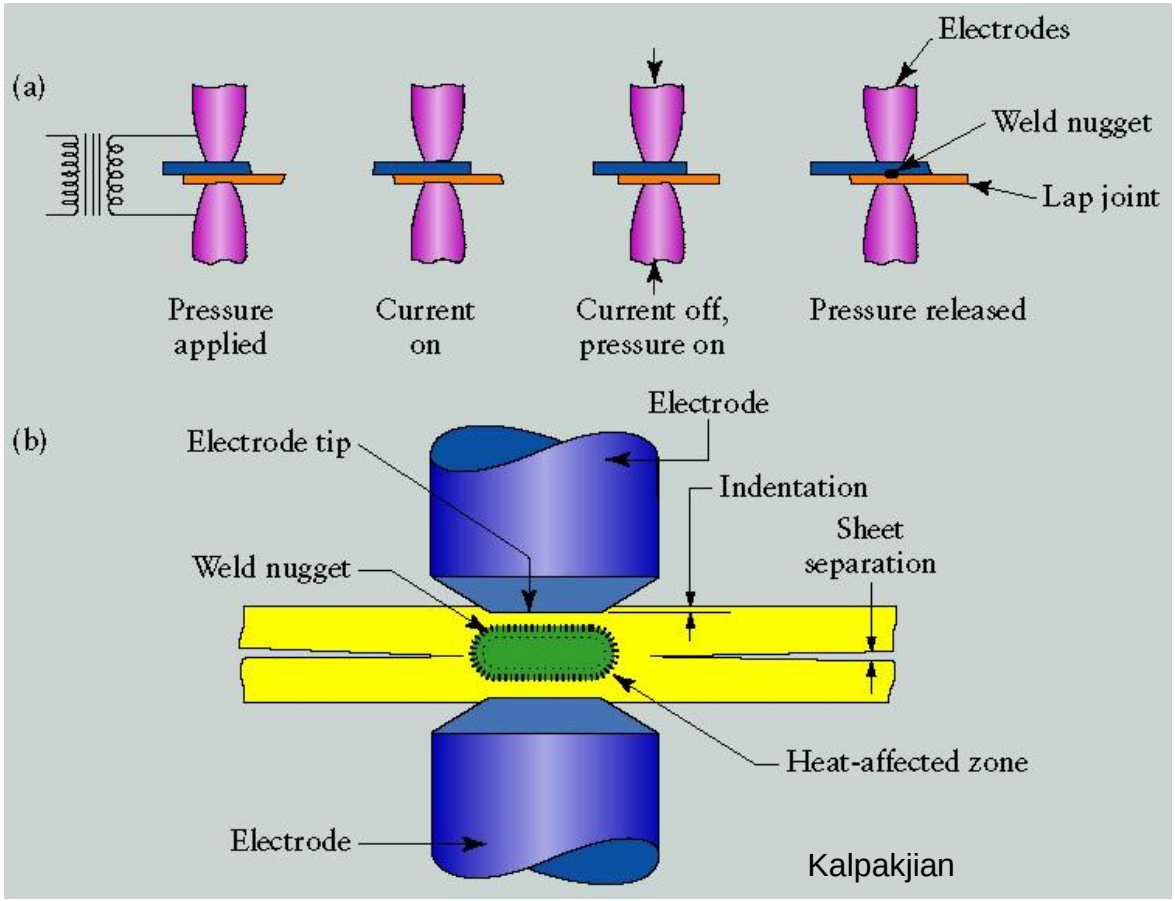


Figure 8 : Welding Technique : (a) Forehead, (b) Backhand

Resistance Spot Welding (RSW): "*Spot* Welding"

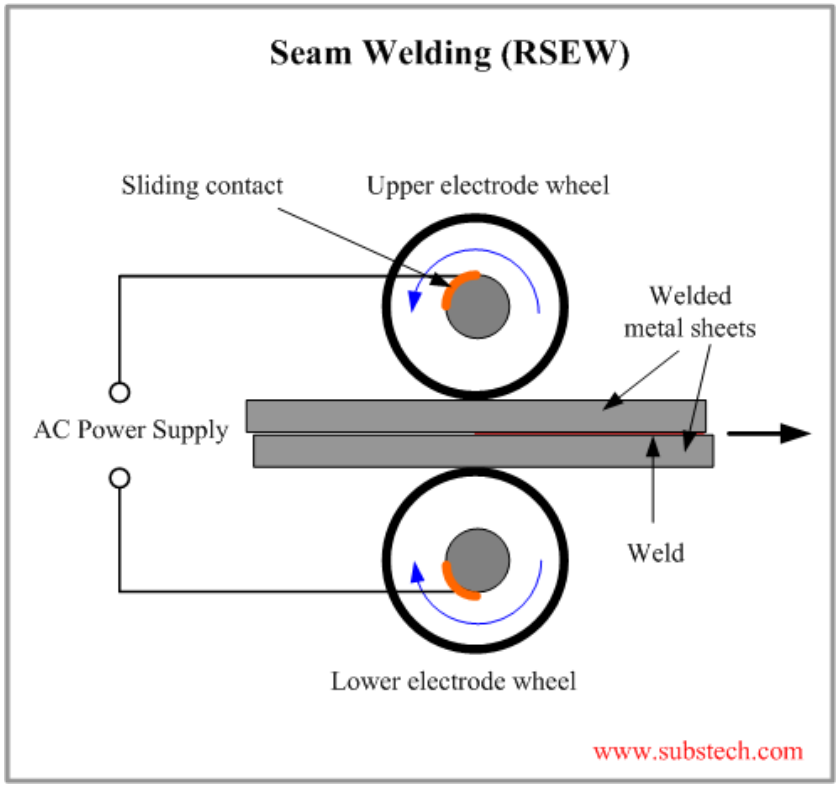
• Resistance welding processes are pressure welding processes in which heavy current is passed for short time through the area of interface of metals to be joined.

•Because of the resistance, heat is generated in the air gap within the contact points. The metal gets melted and then become solid and thus the joint is formed.



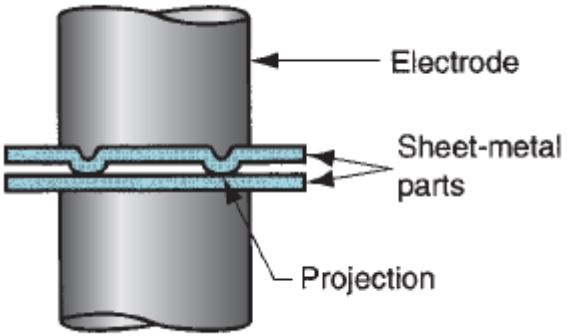
Seam Welding

- Unlike spot welding the disc shaped electrodes are not separated after each weld, but maintain continues pressure over the work pieces.

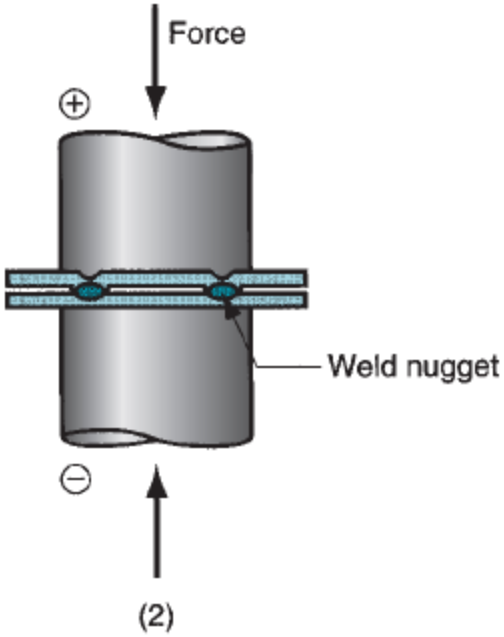


Projection Welding

- Resistance projection welding is an resistance welding process in which coalescence occurs at one or more relatively small contact points on the parts. These contact points are determined by the design of the parts to be joined, and may consist of projections, embossments, or localized intersections of the parts.



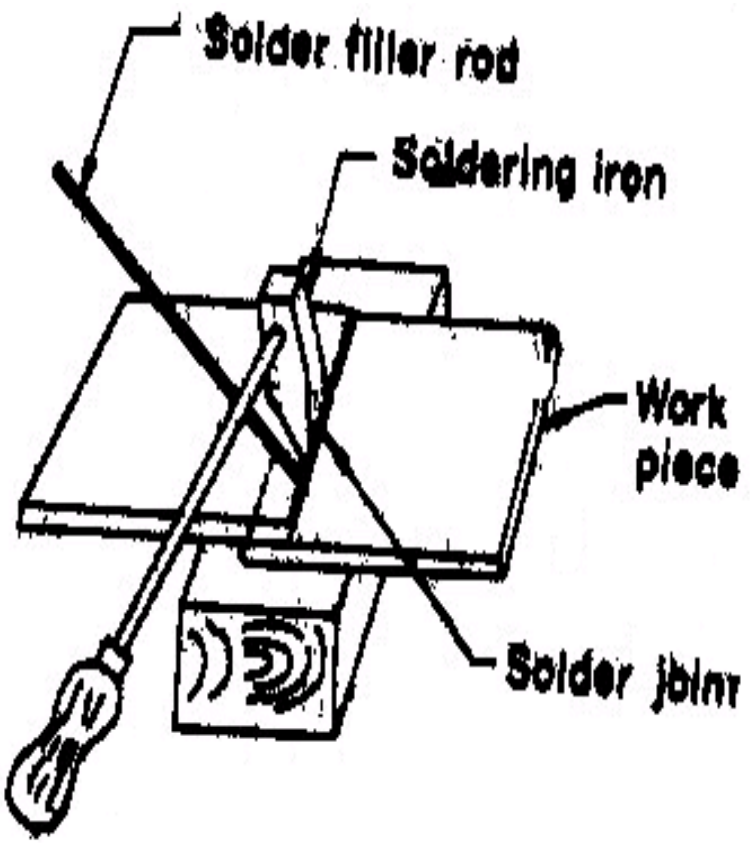
At start of operation, contact between parts is at projections



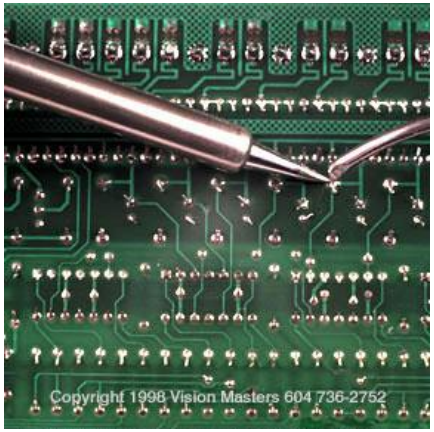
When current is applied, weld nuggets similar to those in spot welding are formed at the projections

Soldering

- It is a low temperature joining process. It is performed at temperatures below 840ºF for joining.
- Soldering is used for,
    - Sealing, as in automotive radiators or tin cans
    - Electrical Connections
    - Joining thermally sensitive components
    - Joining dissimilar metals



Soldering & Brazing



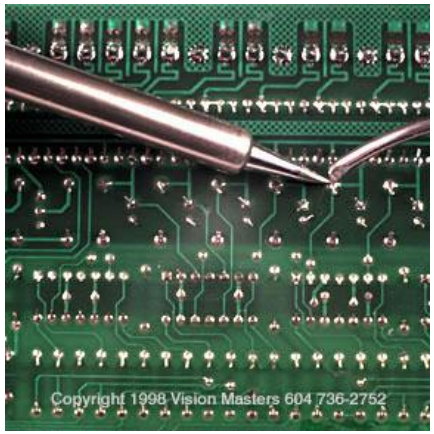
- Only filler metal is melted, not base metal
- Lower temperatures than welding
- Filler metal distributed by capillary action
- Metallurgical bond formed between filler & base metals
- Strength of joint typically
  - stronger than filler metal itself
  - weaker than base metal
  - gap at joint important (0.001 – 0.010”)

- Pros & Cons
  - Can join dissimilar metals
  - Less heat - can join thinner sections (relative to welding)
  - Excessive heat during service can weaken joint

Soldering

Solder = Filler metal

- Alloys of Tin (silver, bismuth, lead)
- Melt point typically below 840 F



Flux used to clean joint & prevent oxidation

- separate or in core of wire (rosin-core)

Tinning = pre-coating with thin layer of solder

Applications:

- Printed Circuit Board (PCB) manufacture
- Pipe joining (copper pipe)
- Jewelry manufacture
- Typically non-load bearing

Easy to solder: copper, silver, gold

Difficult to solder: aluminum, stainless steels

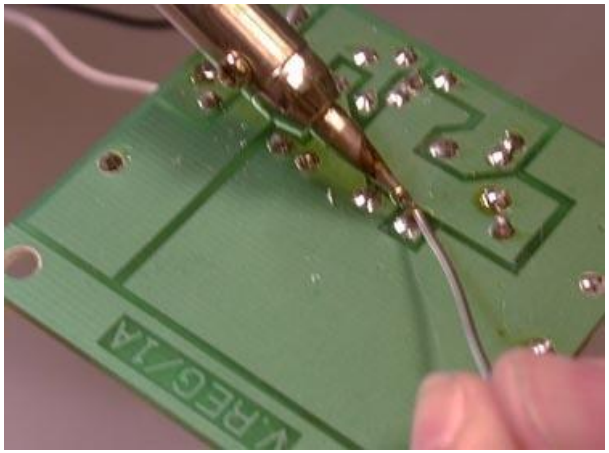
(can pre-plate difficult to solder metals to aid process)

Manual PCB Soldering

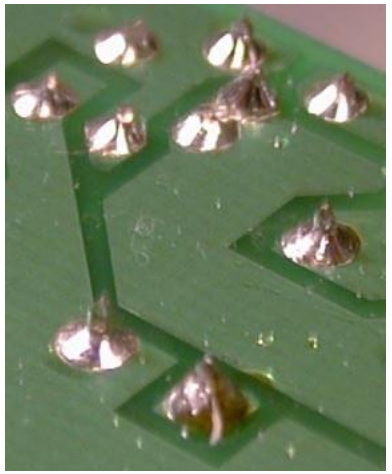
PTH - Pin-Through-Hole connectors

• Soldering Iron & Solder Wire

• Heating lead & placing solder



• Heat for 2-3 sec. & place wire opposite iron



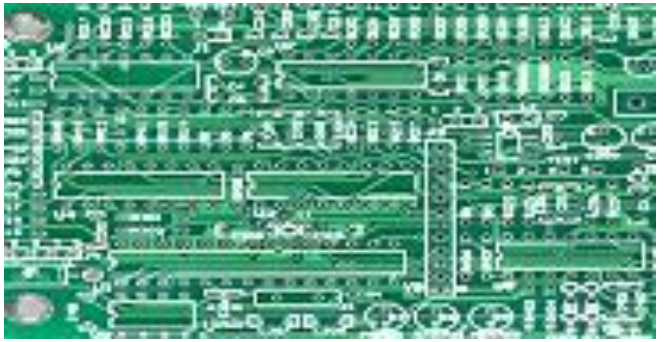
• Trim excess lead

Automated Reflow Soldering

SMT = Surface Mount Technology

• Solder/Flux paste mixture applied to PCB using screen print or similar transfer method

• Solder Paste serves the following functions:
  – supply solder material to the soldering spot,
  – hold the components in place prior to soldering,
  – clean the solder lands and component leads
  – prevent further oxidation of the solder lands.



Printed solder paste on a printed circuit board (PCB)

• PCB assembly then heated in “Reflow” oven to melt solder and secure connection

Brazing

Use of low melt point filler metal to fill thin gap between mating surfaces to be joined utilizing capillary action

- Filler metals include Al, Mg & Cu alloys (melt point typically above 840 F)
- Flux also used
- Types of brazing classified by heating method:
  - Torch, Furnace, Resistance

Applications:

- Automotive - joining tubes
- Pipe/Tubing joining (HVAC)
- Electrical equipment - joining wires
- Jewelry Making
- Joint can possess significant strength

Figure 7. Typical brazed pipe/tube applications. (Photo courtesy of Handy & Harman)

Figure 11. Typical brazing filler metal preforms. (Photo courtesy of Handy & Harman)

Brazing and Soldering

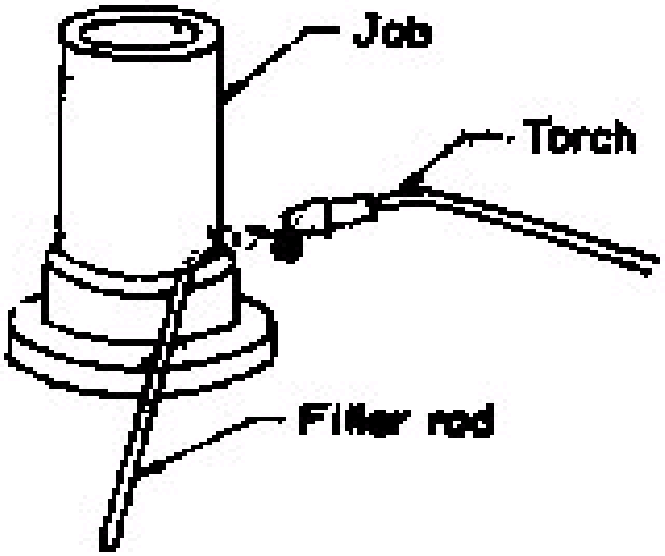
- **Brazing**

It is a low temperature joining process. It is performed at temperatures above 840º F and it generally affords strengths comparable to those of the metal which it joins. It is low temperature in that it is done below the melting point of the base metal. It is achieved by diffusion without fusion (melting) of the base

Brazing can be classified as

Torch brazing
Dip brazing
Furnace brazing
Induction brazing

Brazing



BRAZING