

METAL JOINING PROCESSES

- Joining includes welding, brazing, soldering, adhesive bonding of materials.
- They produce permanent joint between the parts to be assembled.
- They cannot be separated easily by application of forces.
- They are mainly used to assemble many parts to make a system.
- Welding is a metal joining process in which two or more parts are joined or coalesced at their contacting surfaces by suitable application of heat or/and pressure.
- Some times, welding is done just by applying heat alone, with no pressure applied
- In some cases, both heat and pressure are applied; and in other cases only pressure is applied, without any external heat.
- In some welding processes a filler material is added to facilitate coalescence(Joining)

Joining Processes: Welding, Brazing, Soldering

1. Brazing and Soldering: Melting of filler rod only

- Brazing: higher temperature, ~brass filler, strong
- Soldering: lower temp, ~tin-lead filler, weak

2. Welding: Melting of filler rod and base metals



Advantages of welding:

- Welding provides a permanent joint.
- Welded joint can be stronger than the parent materials if a proper filler metal is used that has strength properties better than that of parent base material and if defect less welding is done.
- It is the economical way to join components in terms of material usage and fabrication costs. Other methods of assembly require, for example, drilling of holes and usage of rivets or bolts which will produce a heavier structure.

Disadvantages of welding:

- Labour costs are more since manual welding is done mostly.
- Dangerous to use because of presence of high heat and pressure.
- Disassembly is not possible as welding produces strong joints.
- Some of the welding defects cannot be identified which will reduce the strength.

Classification of Welding processes

- Arc Welding

- 1) Gas tungsten arc welding(TIG) or (GTAW)
- 2) Gas metal arc welding(MIG) or (GMAW)
- 3) Shielded metal arc welding(SMAW)
- 4) Submerged arc welding
- 5) Plasma arc welding
- 6) Flux cored arc welding(FCAW)

- Resistance welding 1) Spot welding 2) seam welding 3) Projection welding 4) Resistance butt welding

- Gas welding

- 1) Oxy-acetylene welding
- 2) Oxy-hydrogen welding
- 3) Air - acetylene welding
- 4) Pressure Gas welding

- Thermo chemical welding
Process

- 1) Thermit welding
- 2) Atomic hydrogen welding

- Radiant energy welding Process

- 1) Electron beam welding
- 2) Laser beam welding.

Types of welding:

Welding processes can be broadly classified into

(i) fusion(non-pressure) welding, and (ii) solid state welding(pressure welding)

Fusion welding:

In fusion-welding processes, heat is applied to melt the base metals. In many fusion welding processes, a filler metal is added to the molten pool during welding to facilitate the process and provide strength to the welded joint.

When no filler metal is used, that fusion welding operation is referred to as Autogenous weld.

Types: Arc welding, Resistance welding, Gas welding, electron beam welding, laser welding

Solid State Welding:

- In this method, joining is done by application of pressure only or a combination of heat and pressure.
- Even if heat is used, the temperature in the process is less than the melting point of the metals being welded (**unlike in fusion welding**).
- No filler metal is utilized.

Diffusion welding: Two part surfaces are held together under pressure at elevated temperature and the parts join by solid state diffusion.

Friction welding/Stir welding: Joining occurs by the heat of friction and plastic deformation between two surfaces.

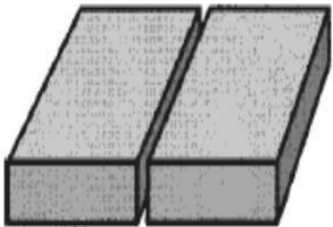
Ultrasonic welding: Moderate pressure is applied between the two parts and an oscillating motion at ultrasonic frequencies is used in a direction parallel to the contacting surfaces

Arc welding processes with consumable electrodes

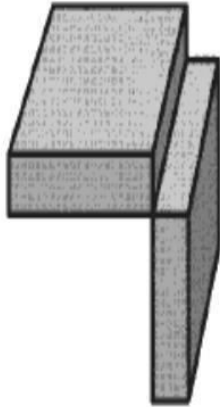
• **Shielded metal arc welding (SMAW):**

- In this process, a consumable electrode consisting of a filler metal rod which is coated with chemicals that provide flux and shielding, is used.
- Generally the filler metal has chemical composition very close to base metal.
- **Filler rod coating:** Coating consists of powdered cellulose (cotton and wood powders) mixed with oxides, carbonates, combined using a silicate binder.
- This coating provides protective layer to the weld pool and stabilizes the arc.
- current: < 300 A; Voltage: 15 – 45 V.
- **Applications:** ship building, construction, machine structures etc.
- **Materials:** grades of steel, stainless steel etc. are welded. Al, Cu, Ti alloys are not welding using SMAW.
- **Disadvantages:** repeated change of electrodes, current maintained in typical range

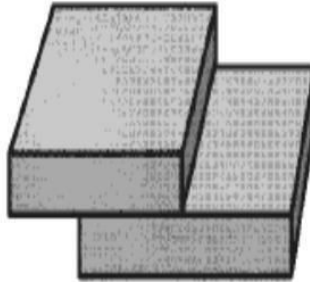
Types of Weld joint



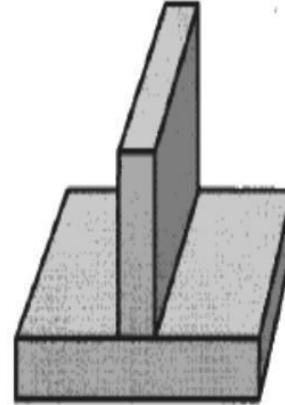
Butt joint



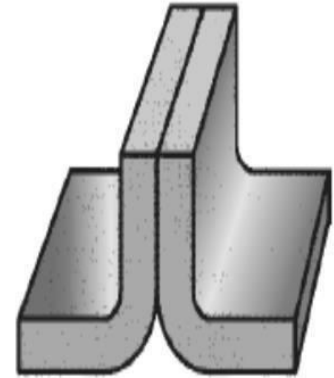
Corner joint



Lap joint



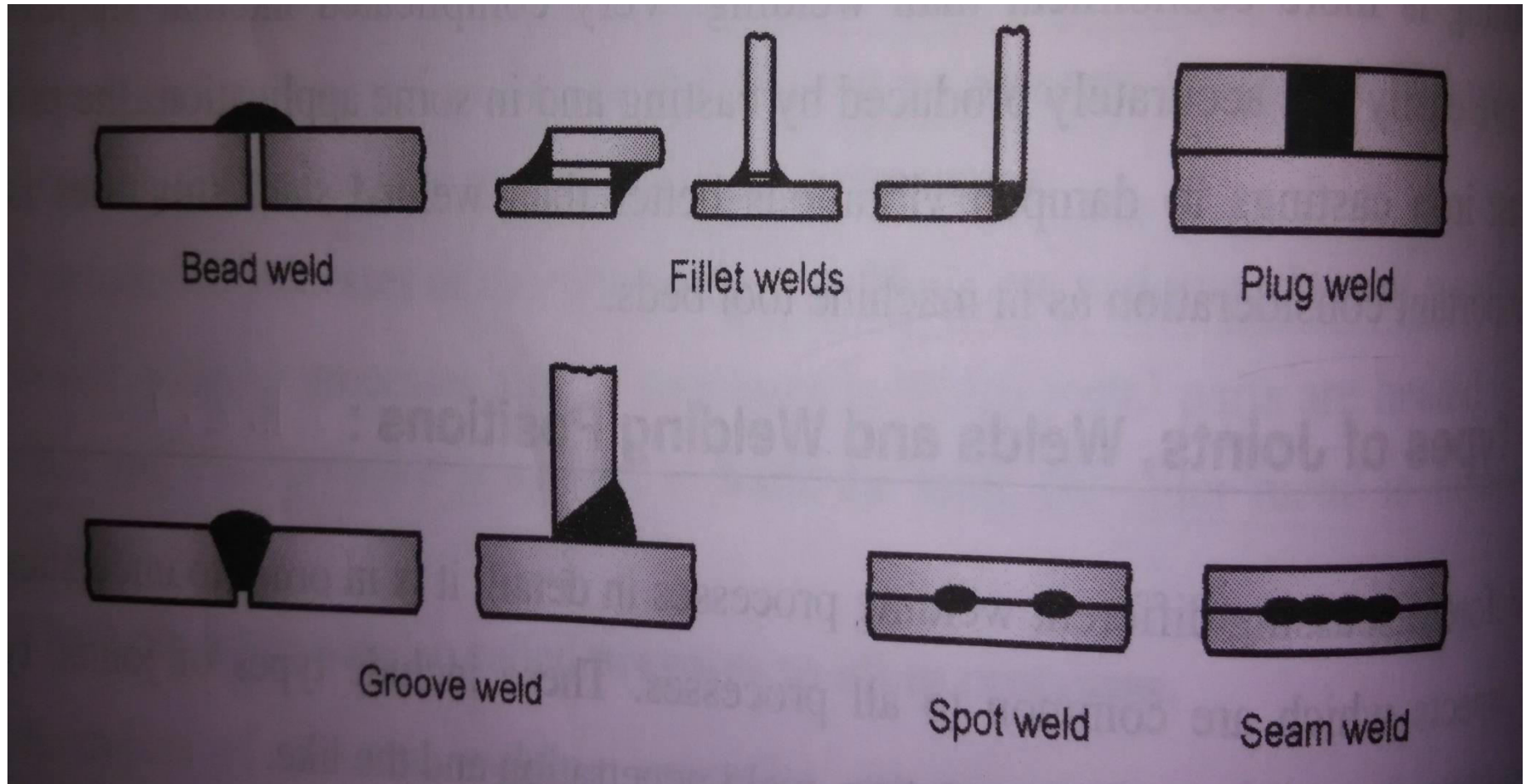
Tee joint

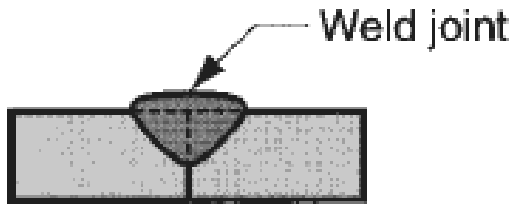


Edge joint

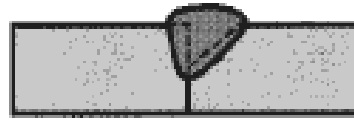
Types of Welds

- The type of weld depends on the joint.
- As shown in fig. weld may be a bead weld, fillet weld, plug weld, groove weld, spot weld or seam weld

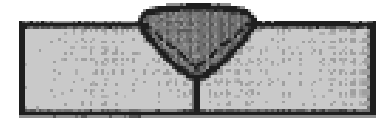




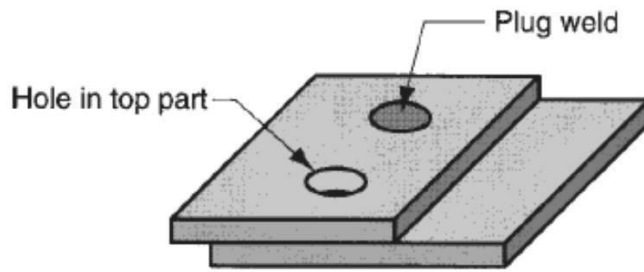
square groove weld one side



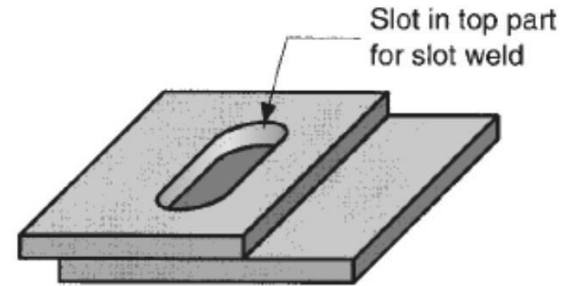
single bevel groove weld



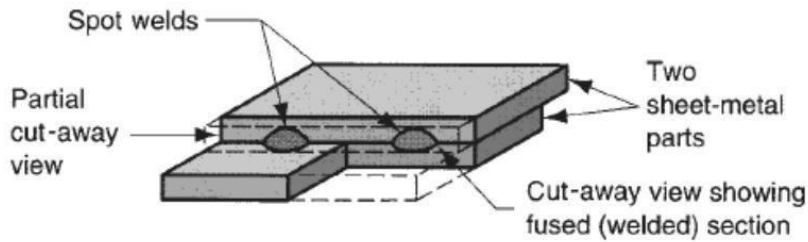
single V-groove weld



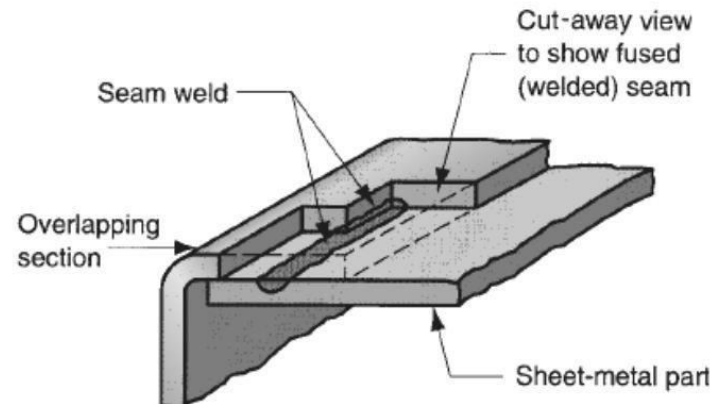
Plug weld



Slot weld

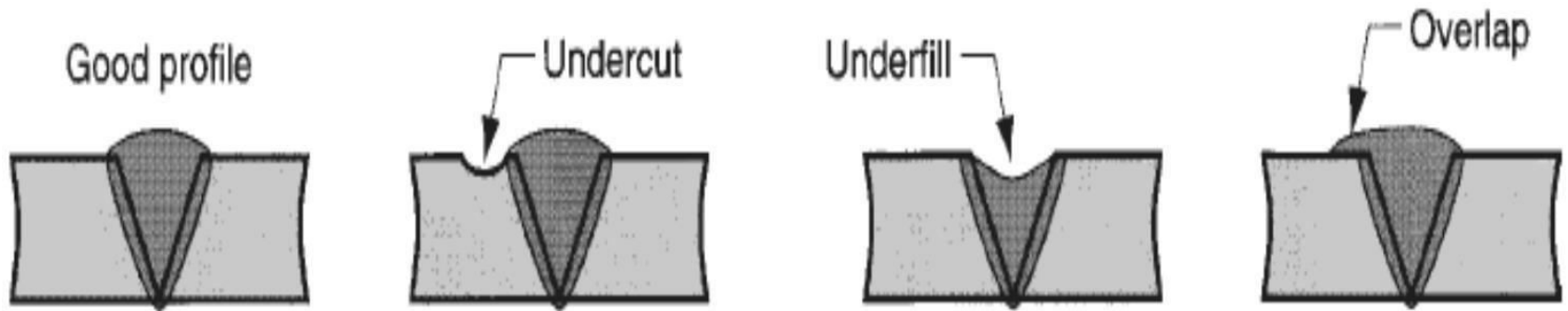


Spot weld

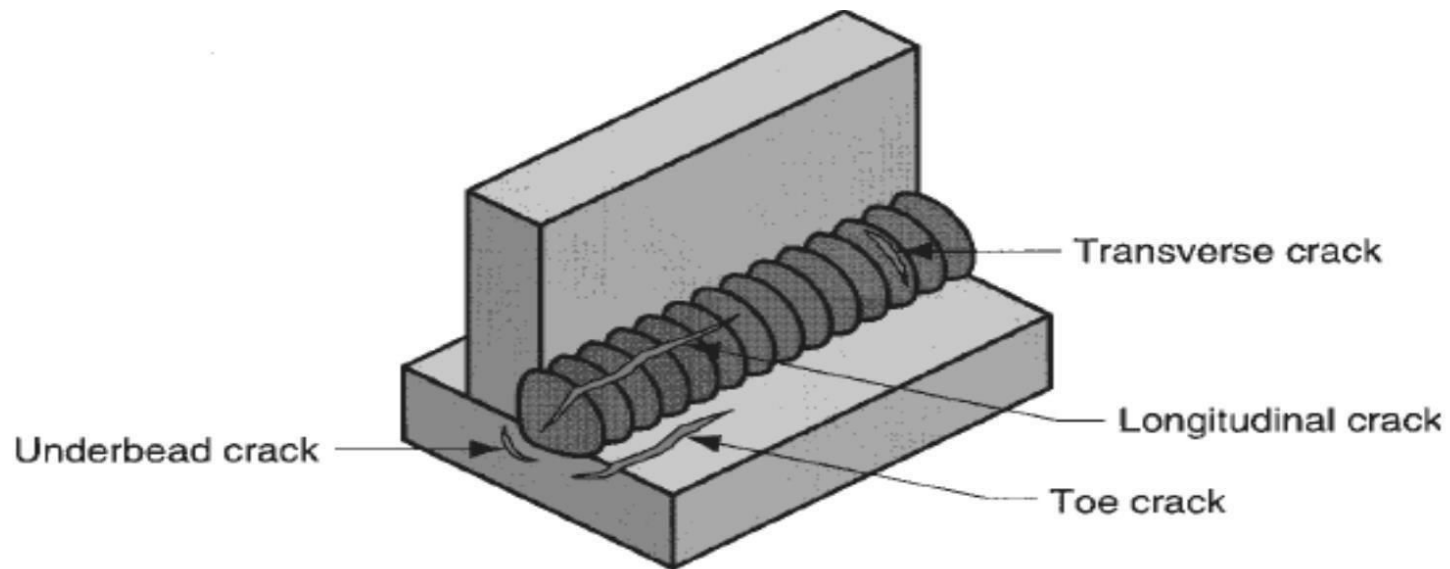


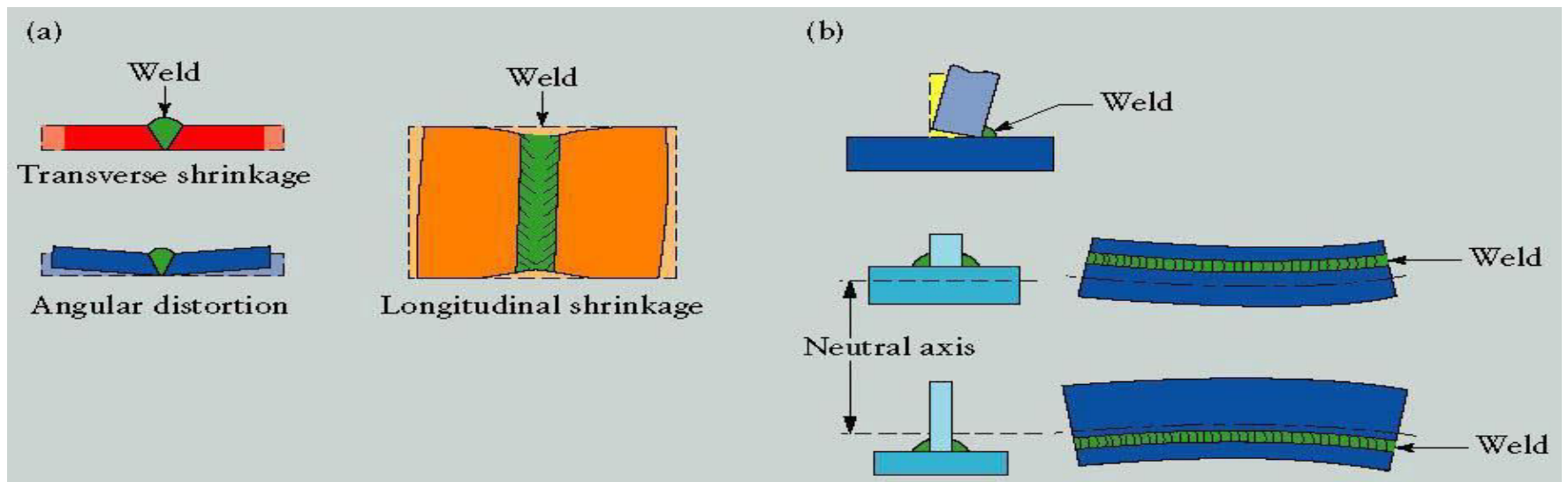
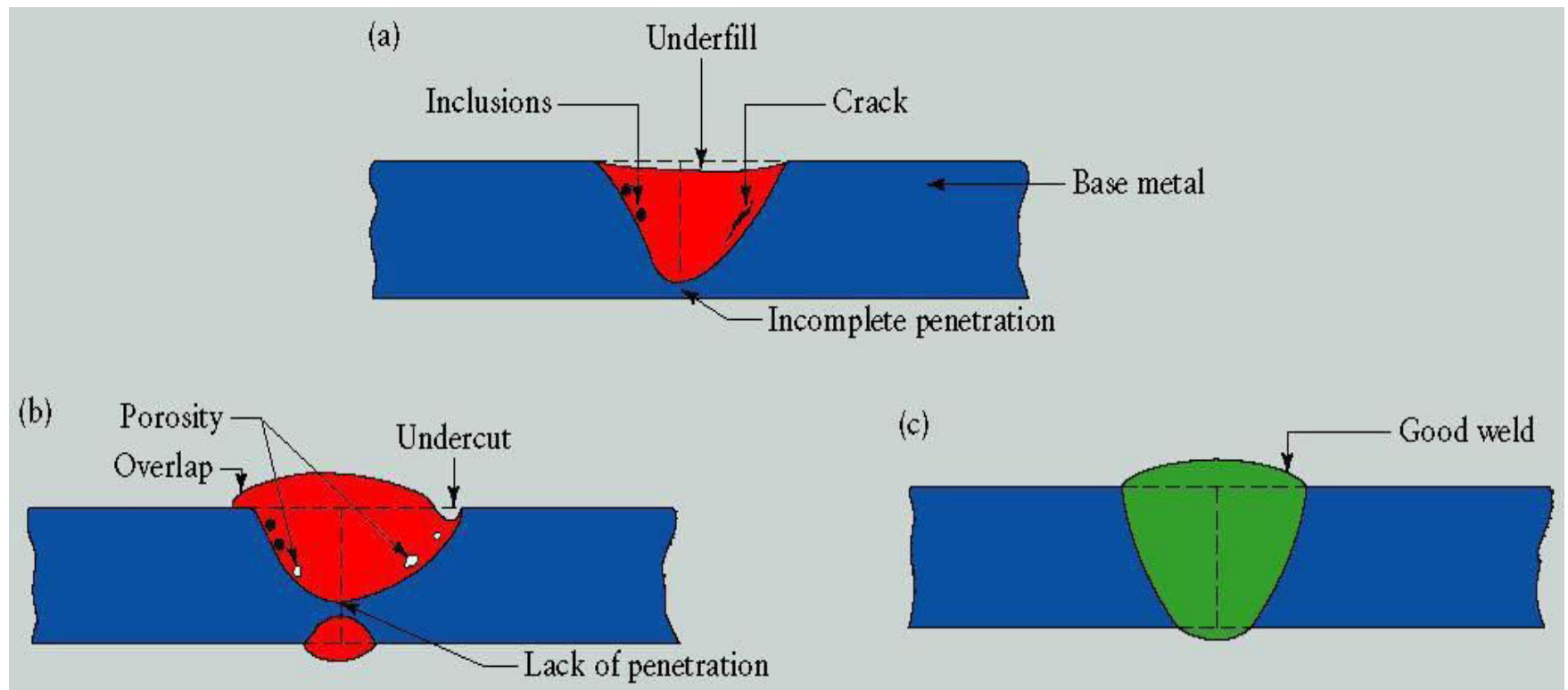
Seam weld

Improper weld profile:



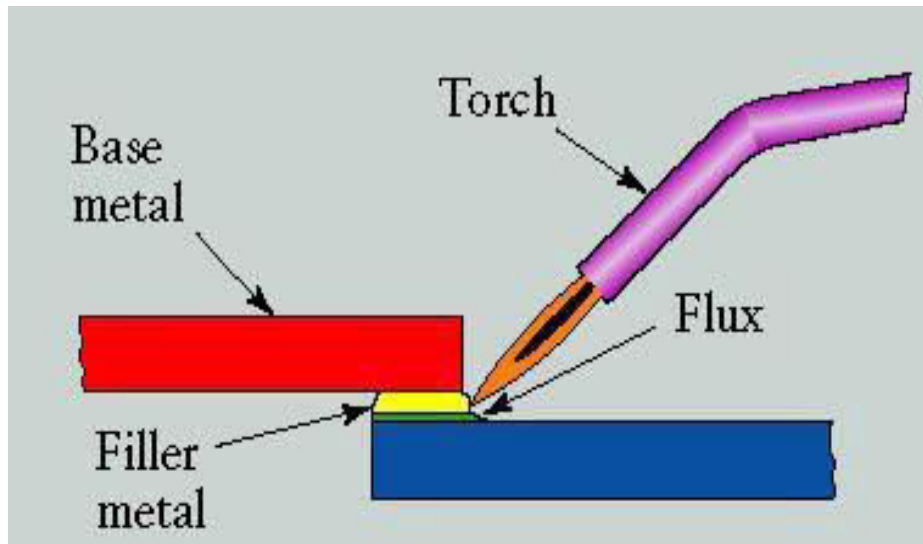
Weld cracks:





Brazing

- It is a joining process in which a filler metal is melted and distributed by capillary action between the faying (contact) surfaces of the metal parts being joined.
- In brazing, the filler metal has a melting temperature above 450°C , but below the melting point of base metals to be joined.
- Join produced by this welding is stronger than soldering.
- This process offers better corrosion resistance.
- Filler used in brazing include Cu and Cu alloys, silver alloys and Al alloys.
- In this process heating is done by torch, furnace, induction, resistance, bath dipping infrared techniques.



Advantages of brazing

- Brazing can be used to join a large variety of dissimilar metals.
- Pieces of different thickness can be easily joined by brazing
- Thin-walled tubes & light gauge sheet metal assemblies not joinable by welding can be joined by brazing.
- Complex & multi-component assemblies can be economically fabricated with the help of brazing.
- Inaccessible joint areas which could not be welded by gas metal or gas tungsten arc spot or seam welding can be formed by brazing.

- **Applications:**

- 1) Automobile – Joining Tubes
- 2) Pipe/Tubing joining (HVAC)
- 3) Electrical equipment - joining wires
- 4) Jewelry Making

SOLDERING

- Soldering is similar to brazing and can be defined as a joining process in which a filler metal with melting point not exceeding 450°C is melted and distributed by capillary action between the faying surfaces of the metal parts being joined.
- As in brazing, no melting of the base metals occurs, but the filler metal wets and combines with the base metal to form a metallurgical bond.
- Filler metal, called Solder, is added to the joint, which distributes itself between the closely fitting parts.
- Strength of the joint is weak
- Corrosion resistance is less

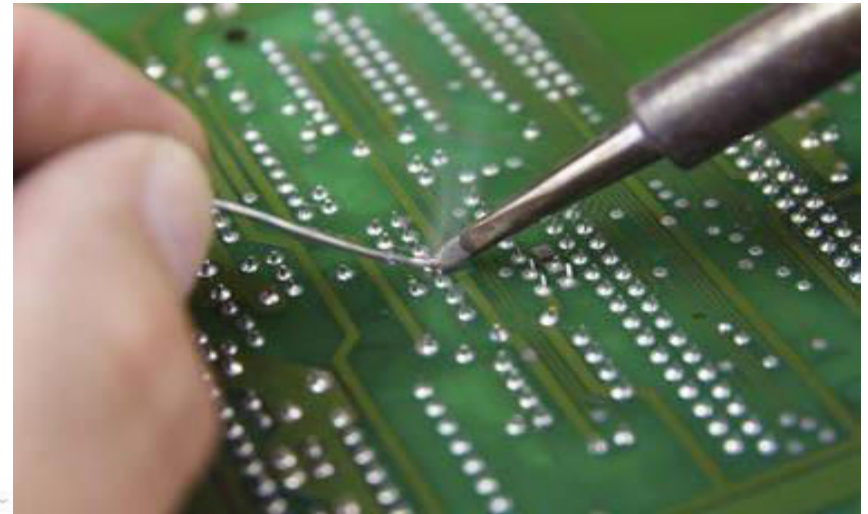
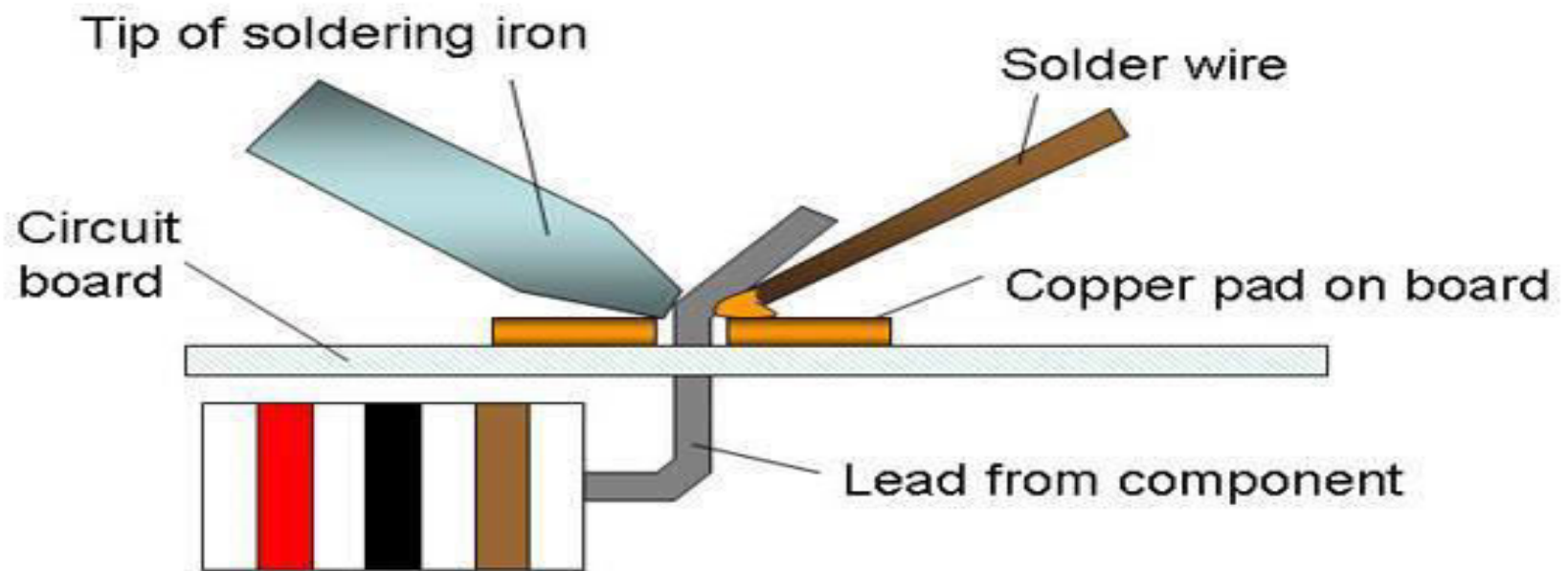
SOLDER: Alloys of Tin and Lead. Tin is chemically active at soldering temperatures and promotes the wetting action required for successful joining.

Applications:

- 1) Printed Circuit Board (PCB) manufacture
- 2) Pipe joining (copper pipe)

Easy to solder: copper, silver, gold

Difficult to solder: aluminum, stainless steels



Comparison between Welding,soldering and brazing

Sl. No.	Welding	Soldering	Brazing
1.	These are the strongest joints used to bear the load. Strength of a welded joint may be more than the strength of base metal.	These are weakest joint out of three. Not meant to bear the load. Use to make electrical contacts generally.	These are stronger than soldering but weaker than welding. These can be used to bear the load upto some extent.
2.	Temperature required is upto 3800°C of welding zone.	Temperature requirement is upto 450°C.	It may go to 600°C in brazing.
3.	Workpiece to be joined need to be heated till their melting point.	No need to heat the workpieces.	Workpieces are heated but below their melting point.

4.	Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible.
5.	Heat cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and skill required are in between others two.
6.	Heat treatment is generally required to eliminate undesirable effects of welding.	No heat treatment is required.	No heat treatment is required after brazing.
7.	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating of workpieces before soldering is good for making good quality joint.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.