JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTER

Year & Sem. – I Year & I SEM

Subject –Basic Mechanical Engineering (1FY3-07)

Unit– 5

Presented by – Nitin Chhabra (Assistant Professor)

VISION AND MISSION OF INSTITUTE

VISION OF INSTITUTE

To became a renowned centre of outcome based learning and work towards academic professional ,cultur al and social enrichment of the lives of individuals and communities .

MISSION OF INSTITUTE

Focus on evaluation of learning ,outcomes and motivate students to research aptitude by project based learning.

- Identify based on informed perception of Indian ,regional and global needs ,the area of focus and prov ide platform to gain knowledge and solutions.
-
- Offer opportunities for interaction between academic and industry .
- Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted lea ders may emerge.

VISION AND MISSION OF DEPARTMENT

Vision

The Mechanical Engineering Department strives to be recognized globally for excellent technical knowledge and to produce quality human resource, who can manage the advance technologies and contribute to society through entrepreneurship and leadership.

Mission

1) To impart highest quality technical knowledge to the learners to make them globally competitive mechanical engineers.
2) To provide the learners ethical guidelines along with excellent academic environment for a long productive career.
3)To promote industry-institute linkage.

Course Outcomes of BME

- To describe the importance of mechanical engineering in any industry and to apply the various concepts in thermal based industry.
- To understand the various machines and power transmission related to it and also the effect of parameters on a job.
- To relate the industrial issues with the environment and to consider key concepts in in engineeri ng materials.
- To come across new practices and researches going in mechanical engineering line CAD, CAM etc.

Contents of UNIT-5

- Introduction to Foundry.
- Pattern.
- Furnaces for Casting Processes.
- Metal Joining Process.
- Metal Forming Process.

Introduction to Foundary

What is a Foundry?

A foundry is:

a factory that pours molten metal into molds, producing cast metal objects.

- Casting is one of the oldest industrial processes
- There are different casting processes.
  The fo s: “GREEN SAND” CASTING

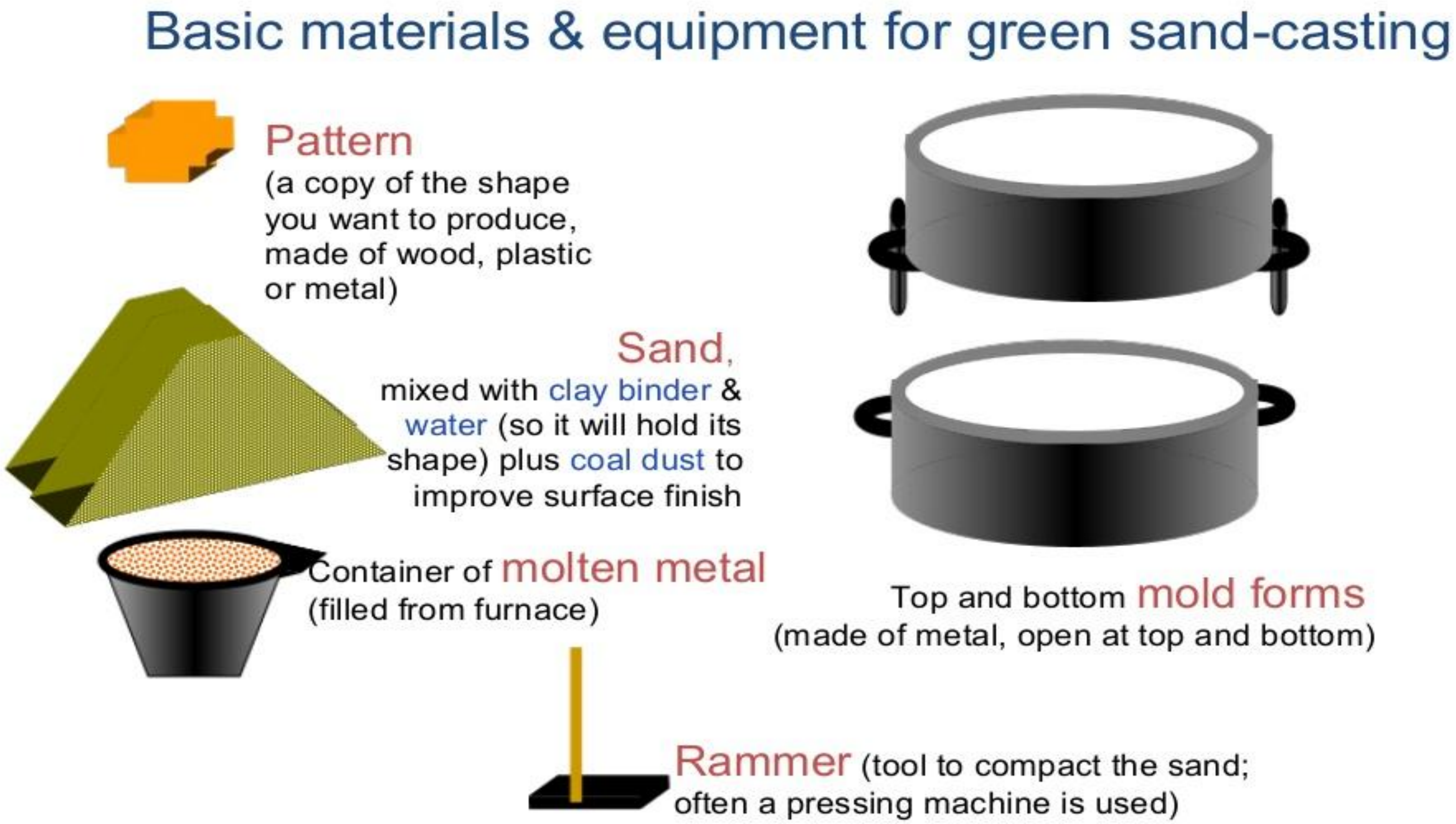
Some typical cast metal objects:

Aluminum pots

Engine blocks, axles

Turbine blades in jet engines

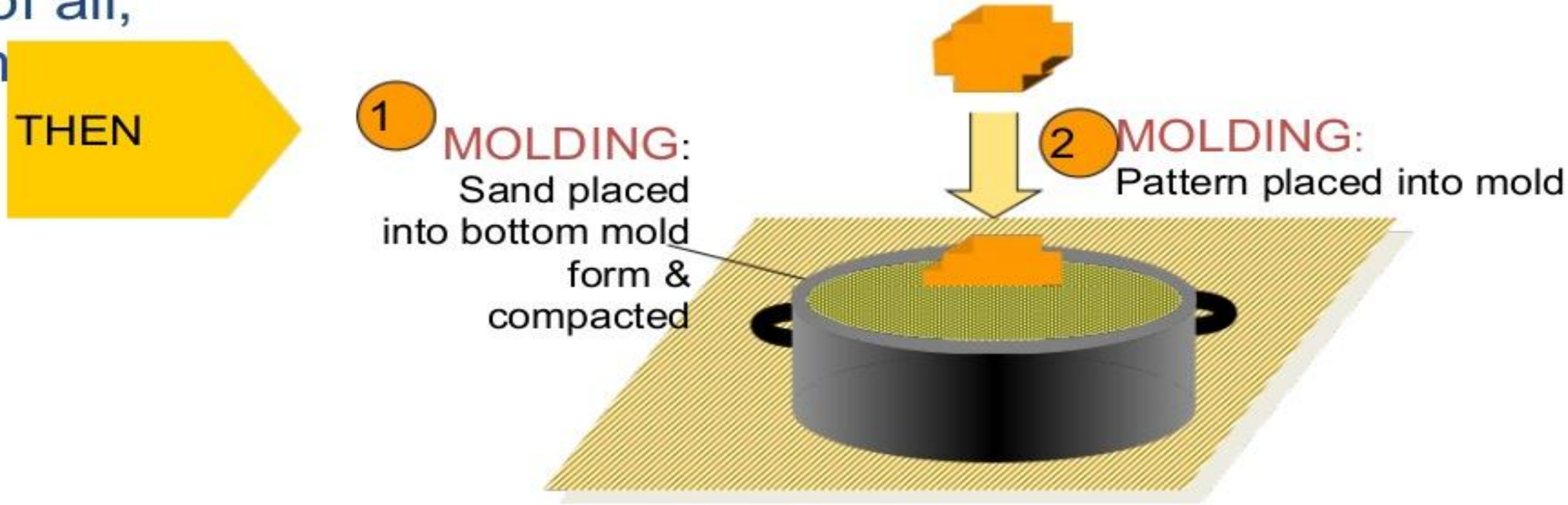
SAND-CASTING



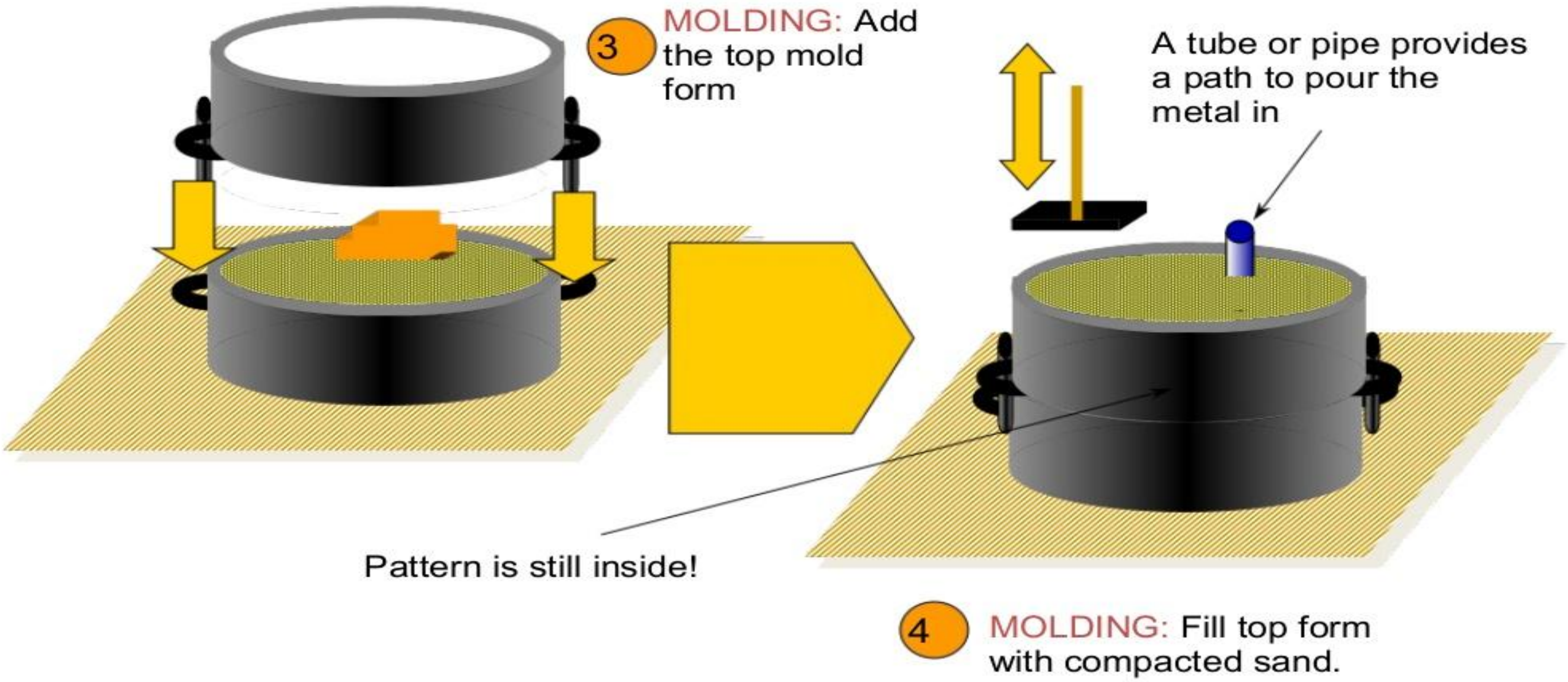
SAND-CASTING

A very basic summary of the sand casting process. . .

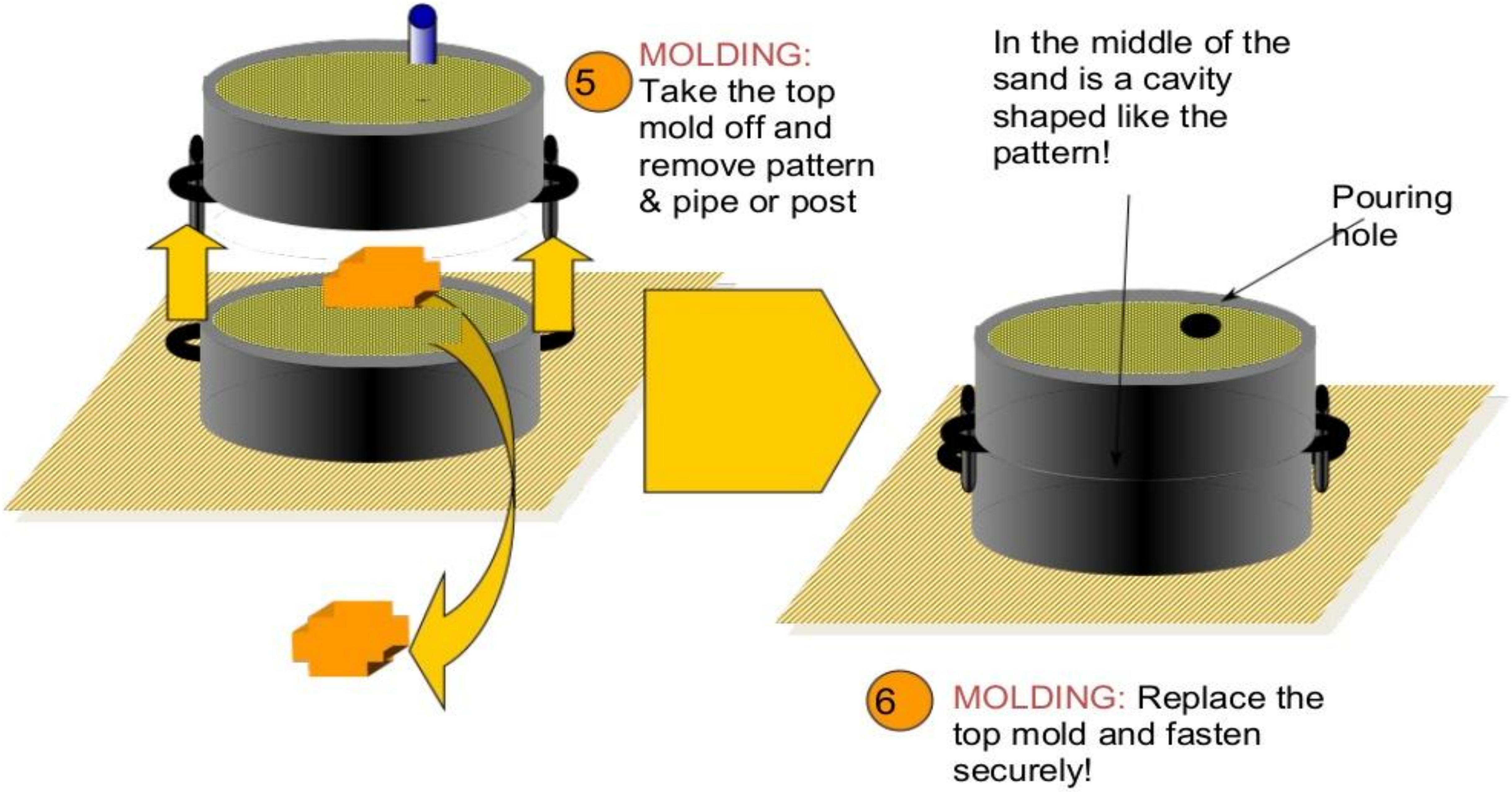
First of all,
mix th



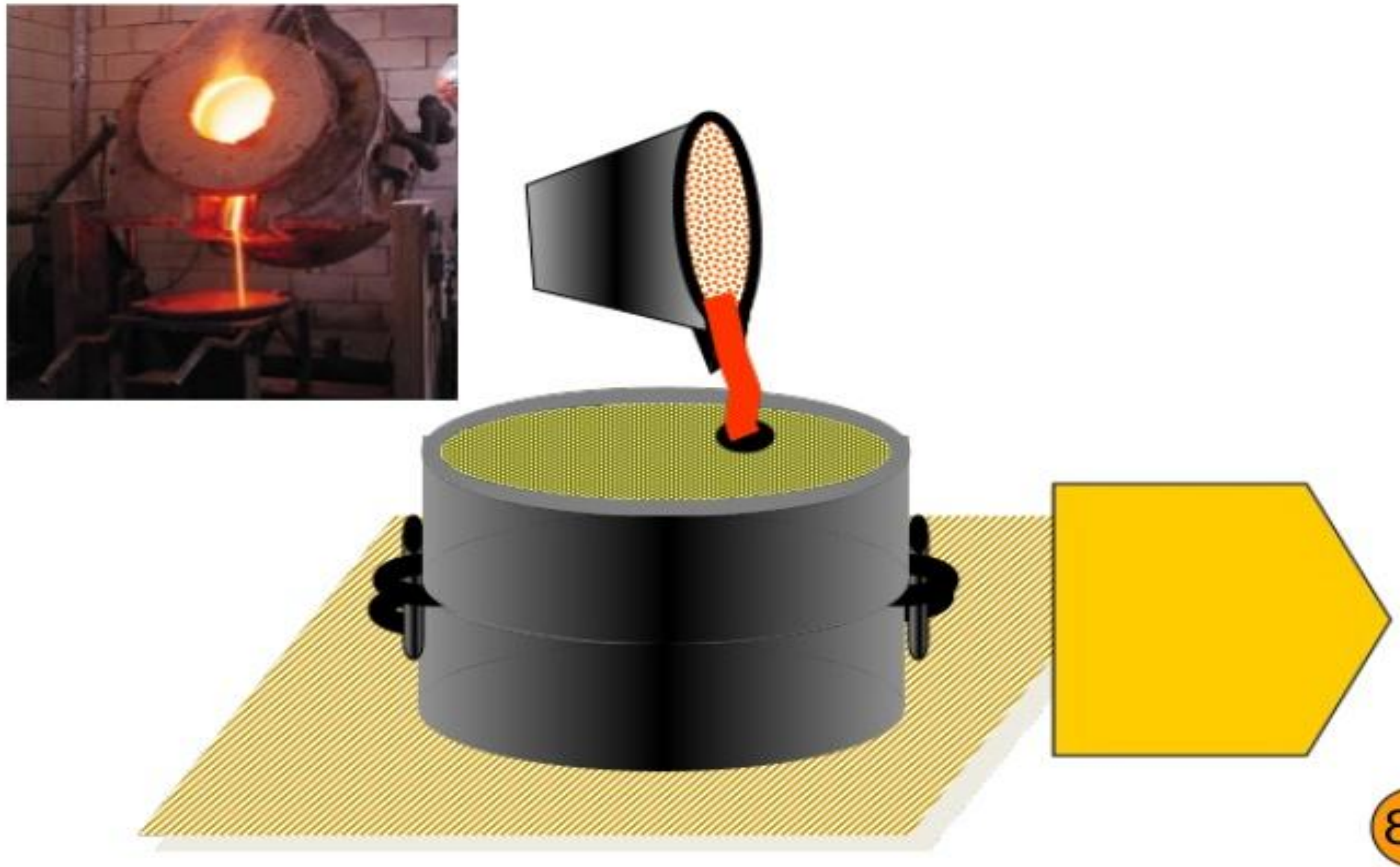
SAND-CASTING

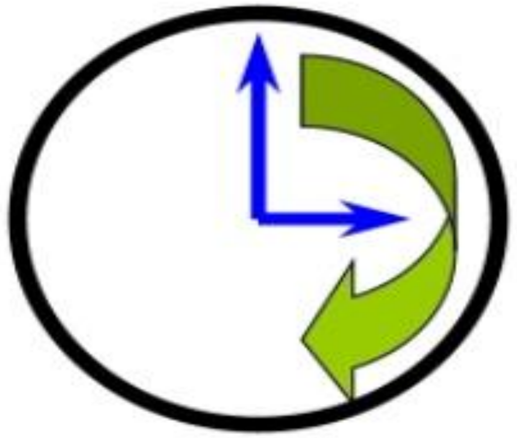


SAND-CASTING



SAND-CASTING

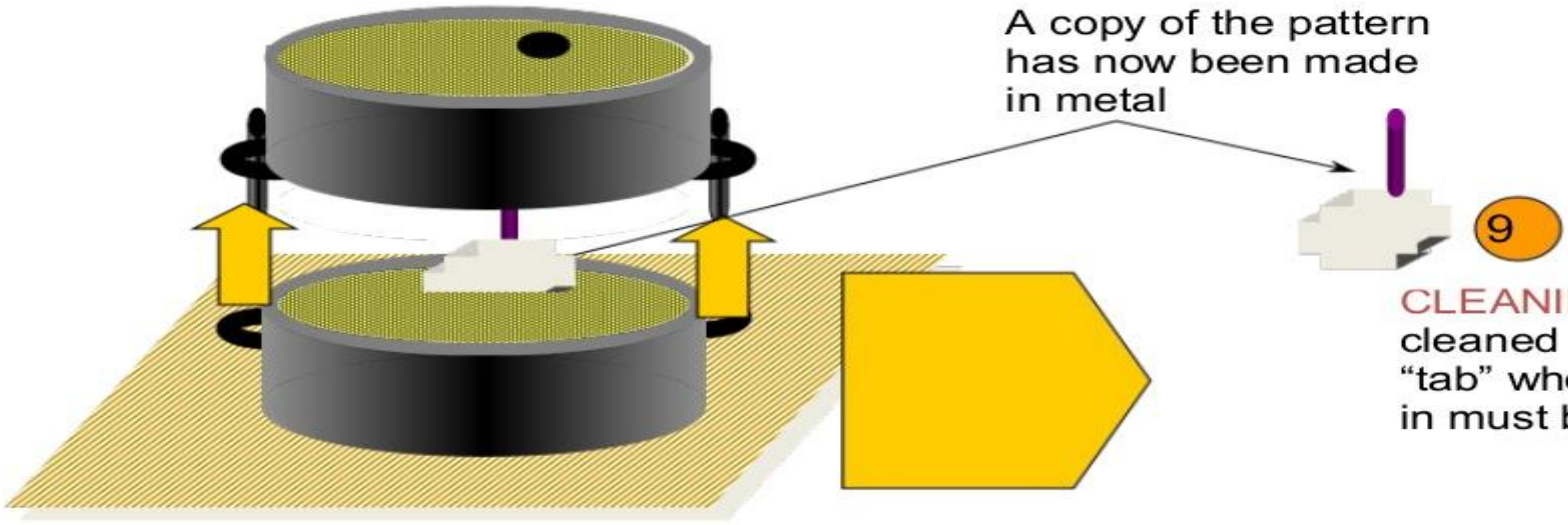




7 CASTING:
Pour the metal (container is filled from furnace immediately before you are ready to pour)

8 Wait for the metal to cool (minutes to days, depending on the size of the casting)

SAND-CASTING



CLEANING. Sand is cleaned off the part, the "tab" where metal flowed in must be removed.

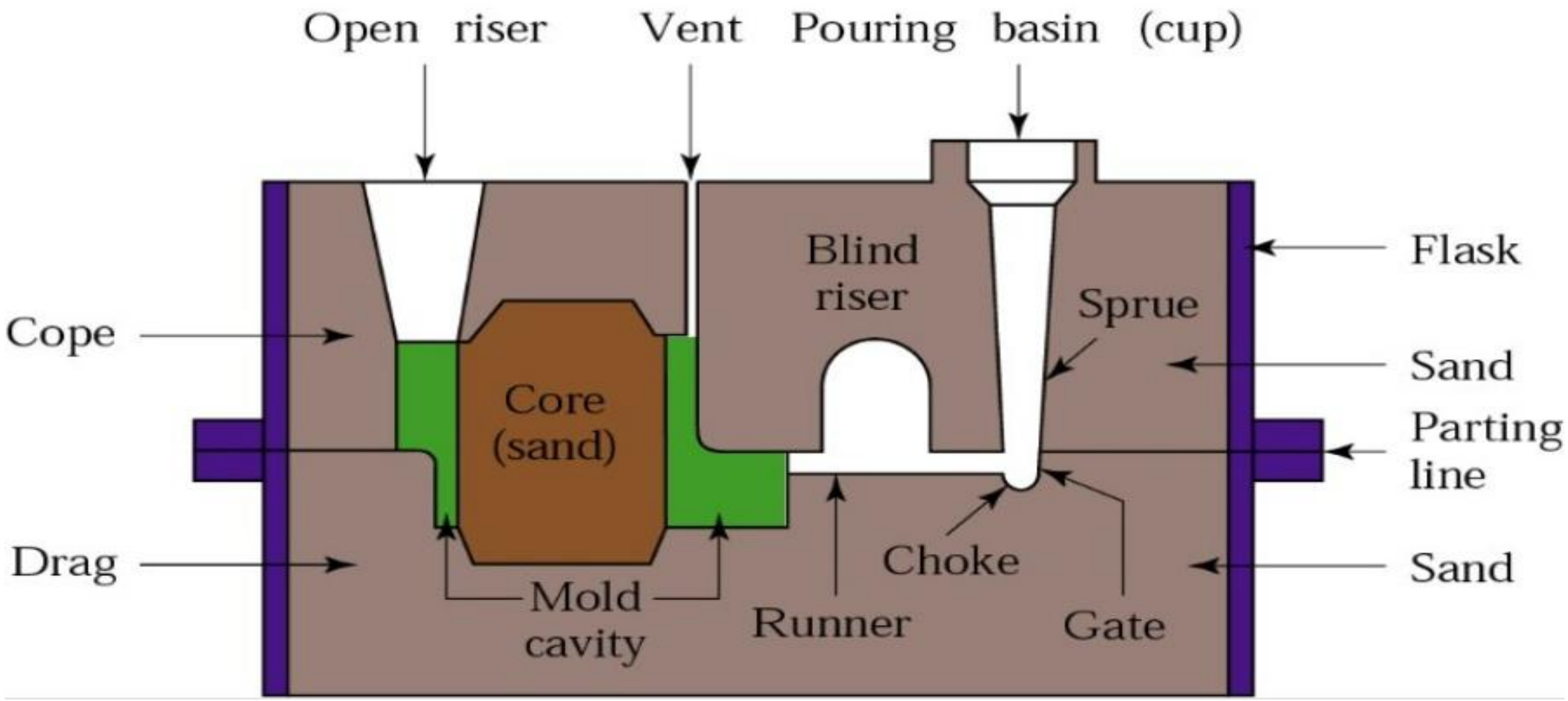
8 SHAKE OUT: Break apart the two halves of the mold & take out the part—usually requires vibrating or striking the mold to break apart the sand

10 Mold forms are reused

11 Sand is broken up, screened to remove debris and clumps, and sent for remixing

Sand Casting: Parts of a Sand Mold (expendable mold)

Key terms:
Flask, Cope, Drag, Sprue, Runner, Gate, Riser, Mold Cavity, Core, Parting Line, Draft (not shown).



Desirable Mold Properties and Characteristics

- *Strength* - to maintain shape and resist erosion
- *Permeability* - to allow hot air and gases to pass through voids in sand
- *Thermal stability* - to resist cracking on contact with molten metal
- *Collapsibility* - ability to give way and allow casting to shrink without cracking the casting
- *Reusability* - can sand from broken mold be reused to make other molds?

Binders Used with Foundry Sands

- Sand is held together by a mixture of water and bonding clay
  - Typical mix: 90% sand, 3% water, and 7% clay
- Other bonding agents also used in sand molds:
  - Organic resins (e g , phenolic resins)
  - Inorganic binders (e g , sodium silicate and phosphate)
- Additives are sometimes combined with the mixture to enhance strength and/or permeability

Patterns

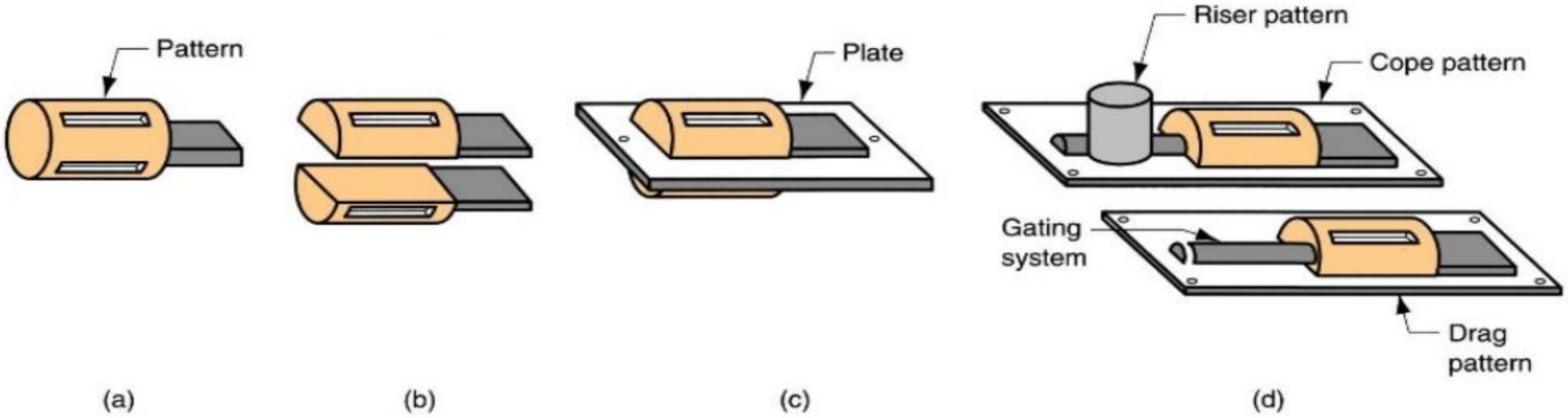
What is pattern?

- Approximate duplicate of product

- Patterns are made in the shape of the casting
- Pattern Materials: Wood, Plastic or metal.
- One piece or multiple piece pattern

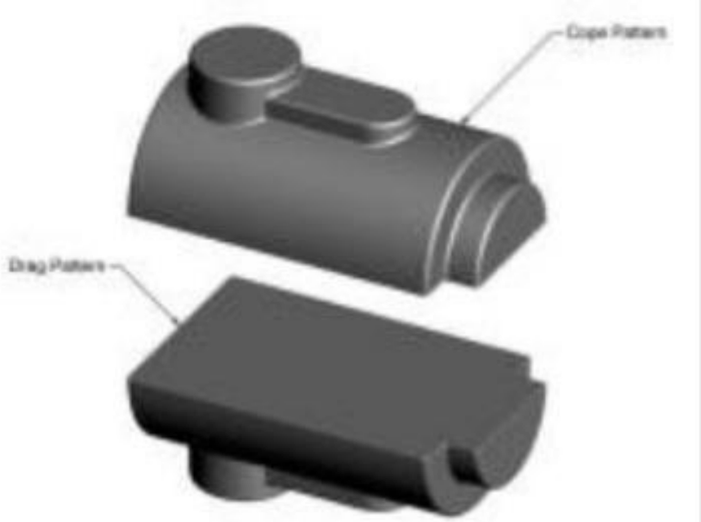
Types of Patterns

Types of patterns used in sand casting:
(a) solid pattern
(b) split pattern
(c) match-plate pattern
(d) cope and drag pattern

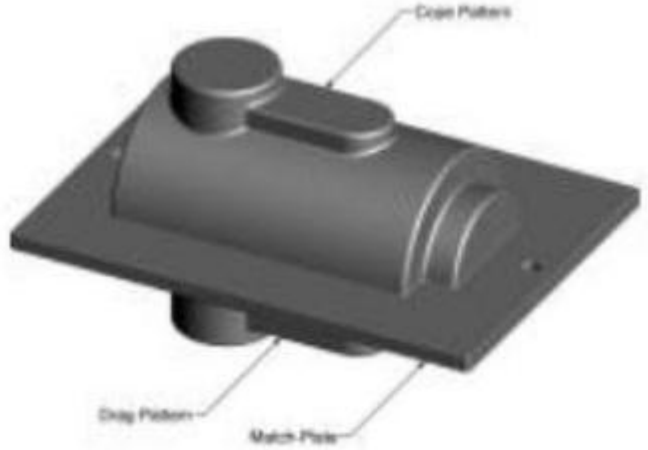


Pattern Making

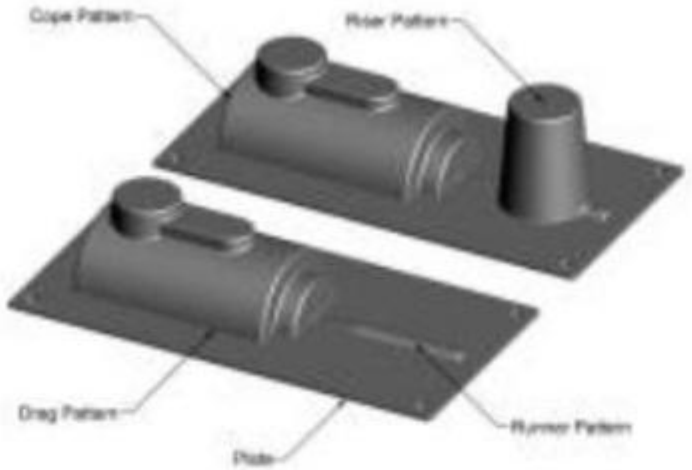
One piece or Solid Pattern



Split Pattern



Match Plate Pattern



Cope & Drag Pattern

Pattern Allowances

Shrinkage Allowance

Patterns are made larger than the casting to compensate contraction of the liquid while freezing.

For internal cavities the allowances should be negative.

Machining Allowance

Allowance required to remove the rough cast surface. 2 to 25 mm (0.1 to 1')

Draft Allowance

To facilitate ease of removal, usually ½ to 2 deg.

Shrinkage allowance

Normal shrinkage: Cast iron 0.83 to 1.3%

Aluminum - 1.3%

Casting Quality

•There are numerous opportunities for things to go wrong in a casting operation, resulting in quality defects in the product

•The defects can be classified as follows:

□Defects common to all casting processes

□Defects related to sand casting process

Casting Defects

Misrun

A casting that has solidified before completely filling mold cavity

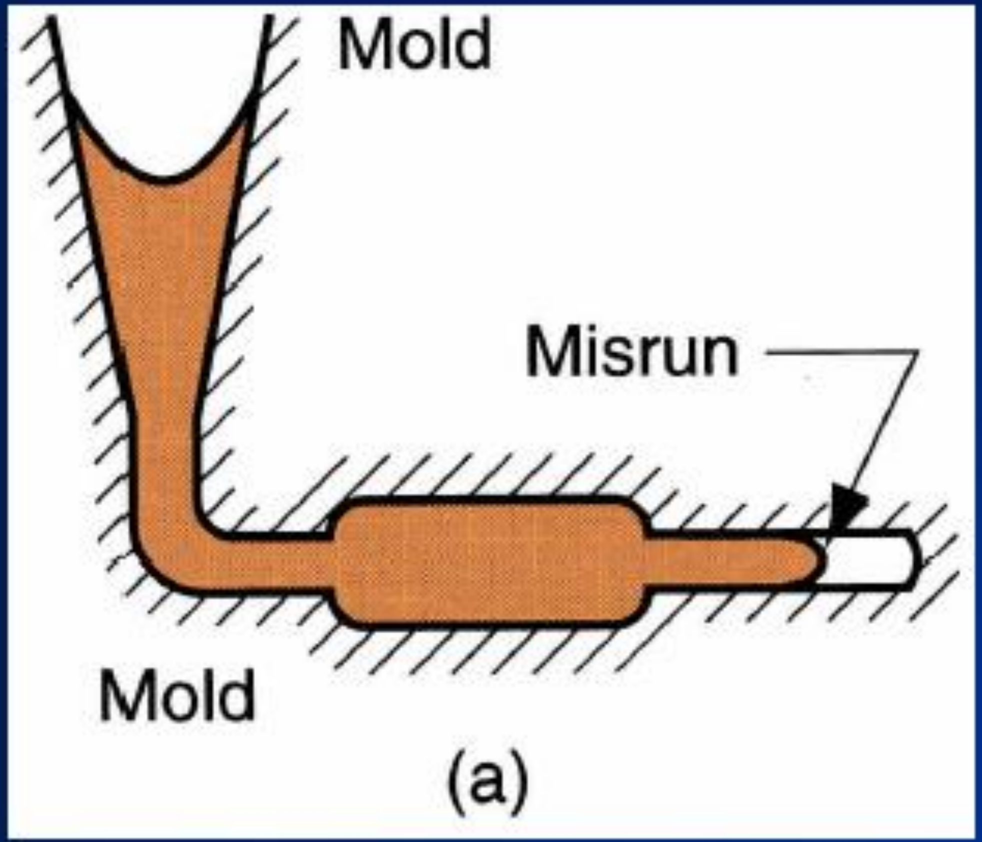


Figure 11.22 - Some common defects in castings: (a) misrun

Casting Defects

Cold Shut

Two portions of metal flow together but there is a lack of fusion due to premature freezing

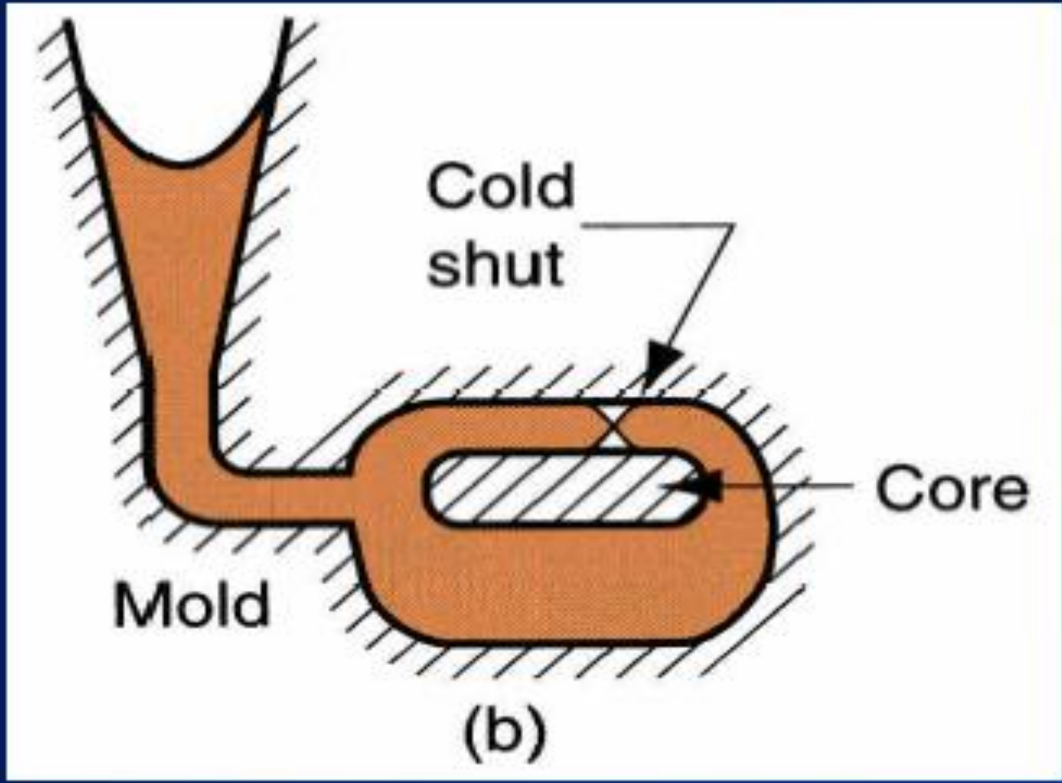


Figure 11.22 - Some common defects in castings: (b) cold shut

Casting Defects

Cold Shot

Metal splatters during pouring and solid globules form and become entrapped in casting

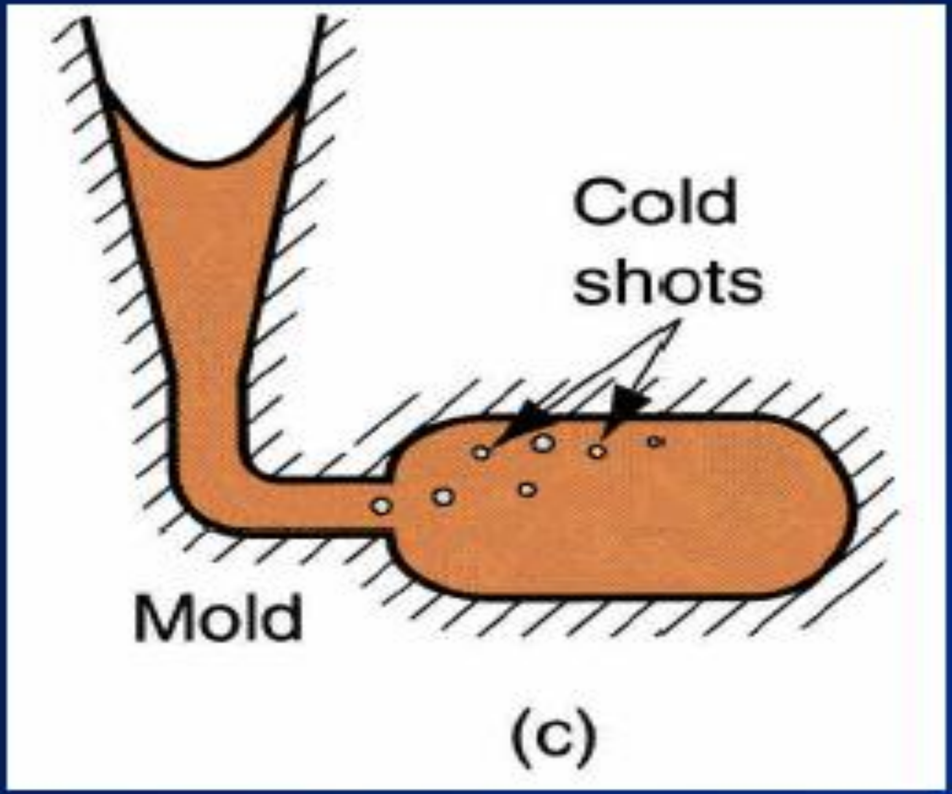


Figure 11.22 - Some common defects in castings: (c) cold shot

Casting Defects

Shrinkage Cavity

Depression in surface or internal void caused by solidification shrinkage that restricts amount of molten metal available in last region to freeze

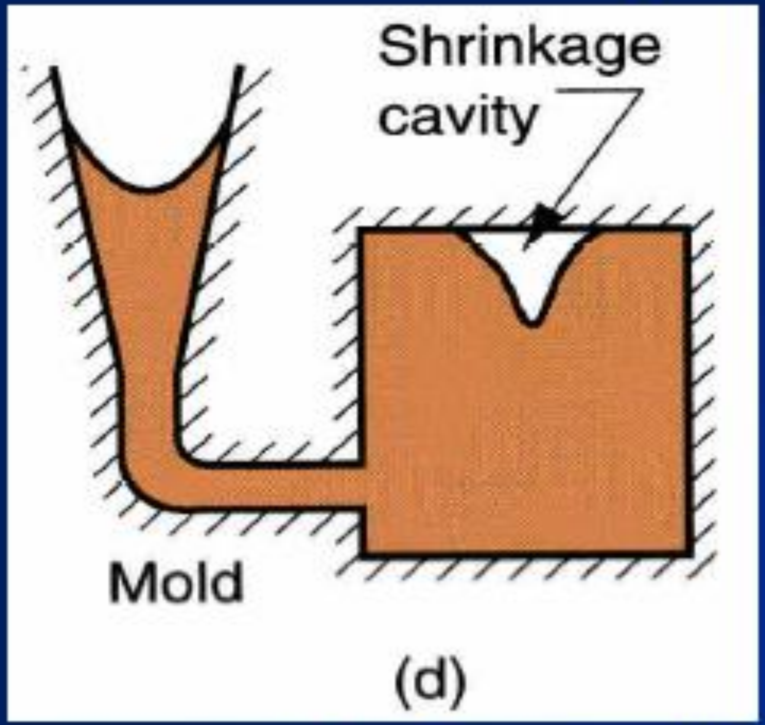


Figure 11.22 - Some common defects in castings: (d) shrinkage cavity

Casting Defects

Sand Blow

Balloon-shaped gas cavity caused by release of mold gases during pouring

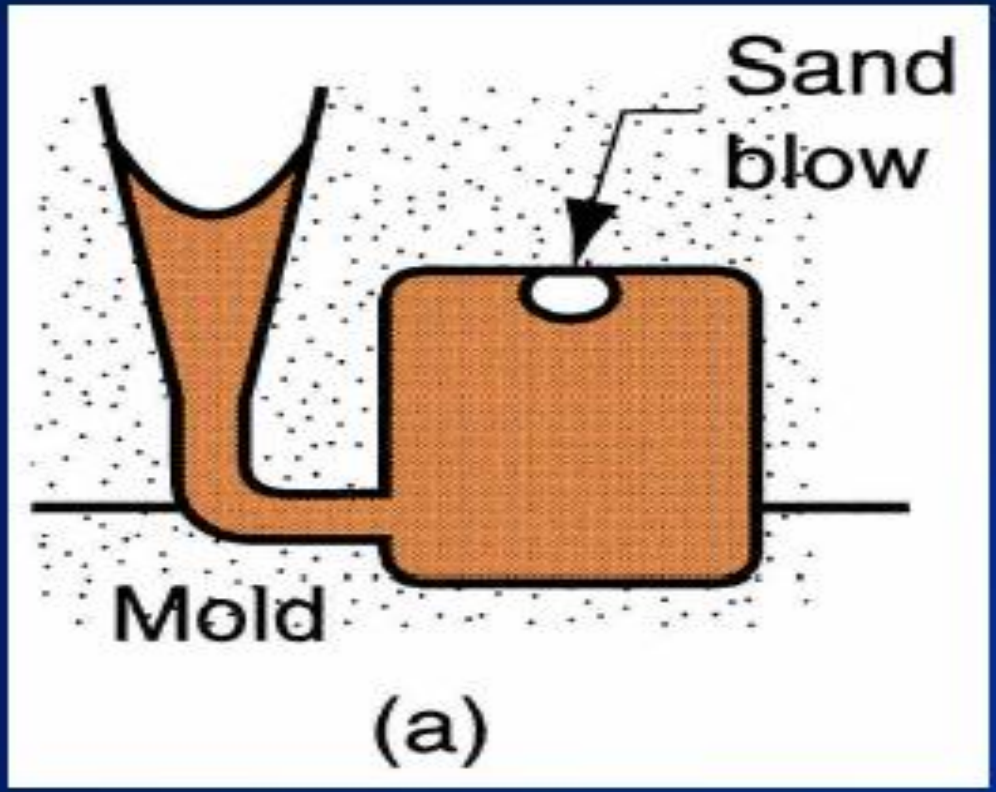


Figure 11.23 - Common defects in sand castings: (a) sand blow

Casting Defects

Pin Holes

Formation of many small gas cavities at or slightly below surface of casting

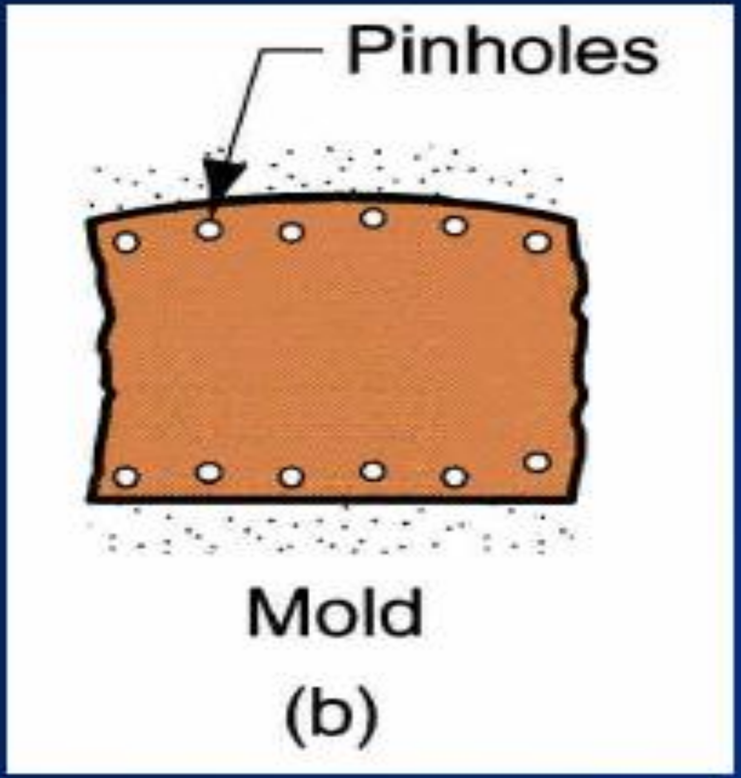


Figure 11.23 - Common defects in sand castings: (b) pin holes

Casting Defects

Penetration

When fluidity of liquid metal is high, it may penetrate into sand mold or sand core, causing casting surface to consist of a mixture of sand grains and metal

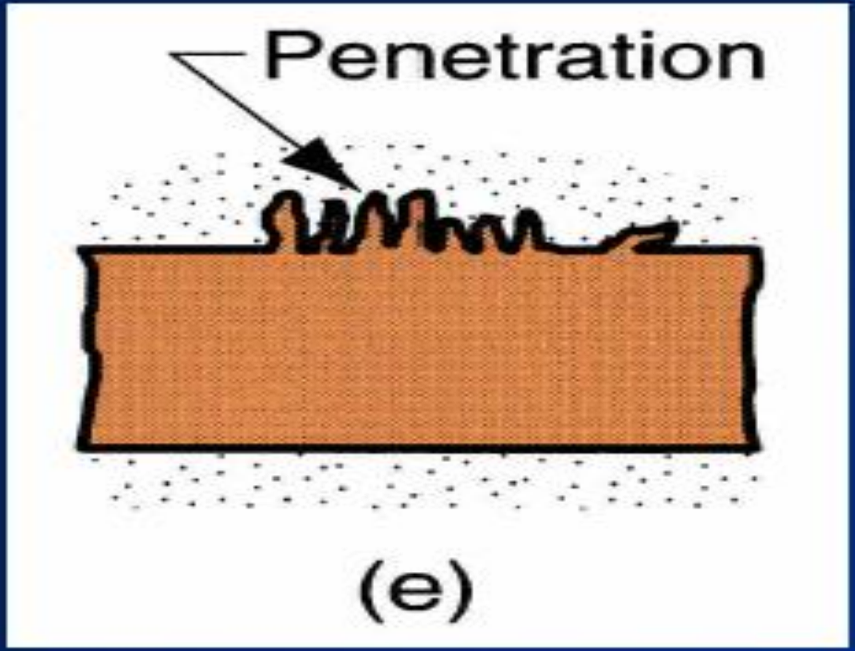


Figure 11.23 - Common defects in sand castings: (e) penetration

Casting Defects

Mold Shift

A step in cast product at parting line caused by sidewise relative displacement of cope and drag

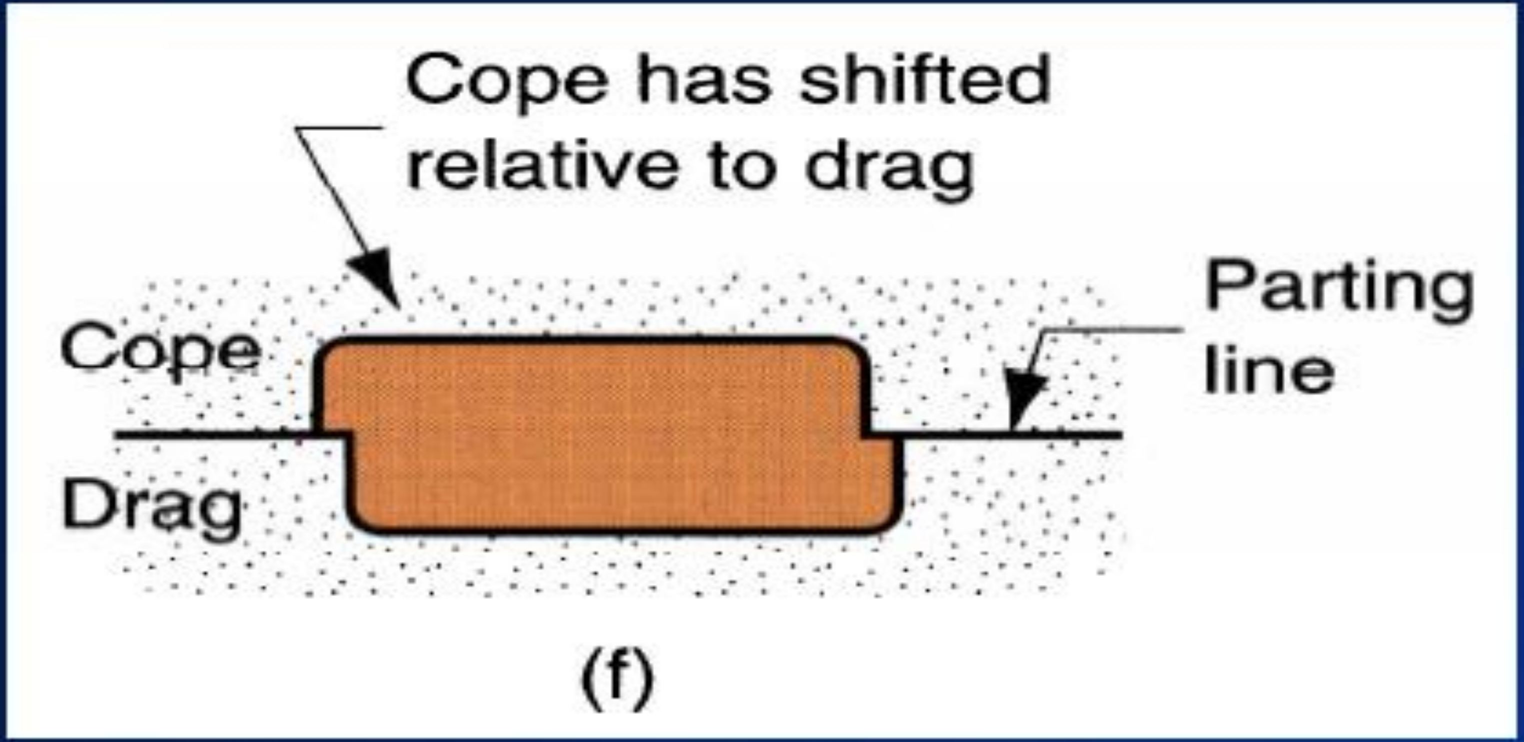


Figure 11.23 - Common defects in sand castings: (f) mold shift

Furnaces for Casting Processes

- Furnaces most commonly used in foundries:
  - Cupolas
  - Direct fuel-fired furnaces
  - Crucible furnaces
  - Electric-arc furnaces
  - Induction furnaces

Cupolas

Vertical cylindrical furnace equipped with tapping spout near base

- Used only for cast irons, and although other furnaces are also used, largest tonnage of cast iron is melted in cupolas
- The "charge," consisting of iron, coke, flux, and possible alloying elements, is loaded through a charging door located less than halfway up height of cupola

Direct Fuel-Fired Furnaces

Small open-hearth in which charge is heated by natural gas fuel burners located on side of furnace

- Furnace roof assists heating action by reflecting flame down against charge
- At bottom of hearth is a tap hole to release molten metal
- Generally used for nonferrous metals such as copper-base alloys and aluminum

Crucible Furnaces

Metal is melted without direct contact with burning fuel mixture

- Sometimes called *indirect fuel-fired furnaces*
- Container (crucible) is made of refractory material or high-temperature steel alloy
- Used for nonferrous metals such as bronze, brass, and alloys of zinc and aluminum
- Three types used in foundries: (a) lift-out type, (b) stationary, (c) tilting

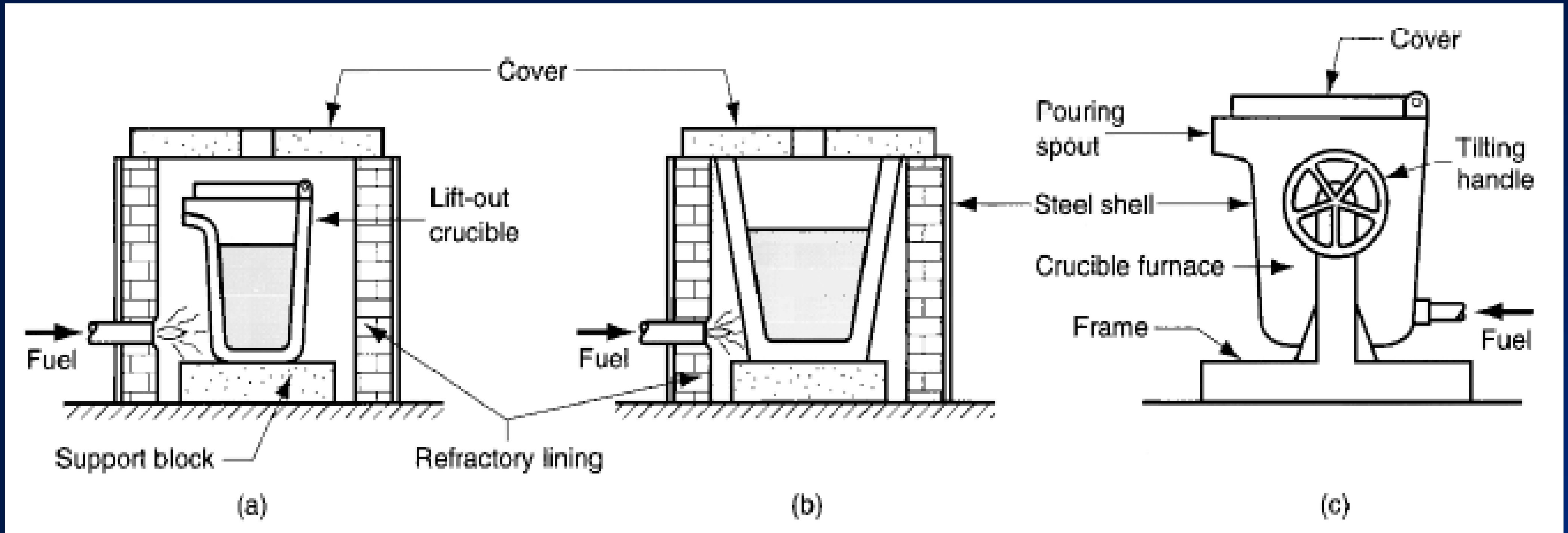


Figure 11.19 - Three types of crucible furnaces:

(a) lift-out crucible,

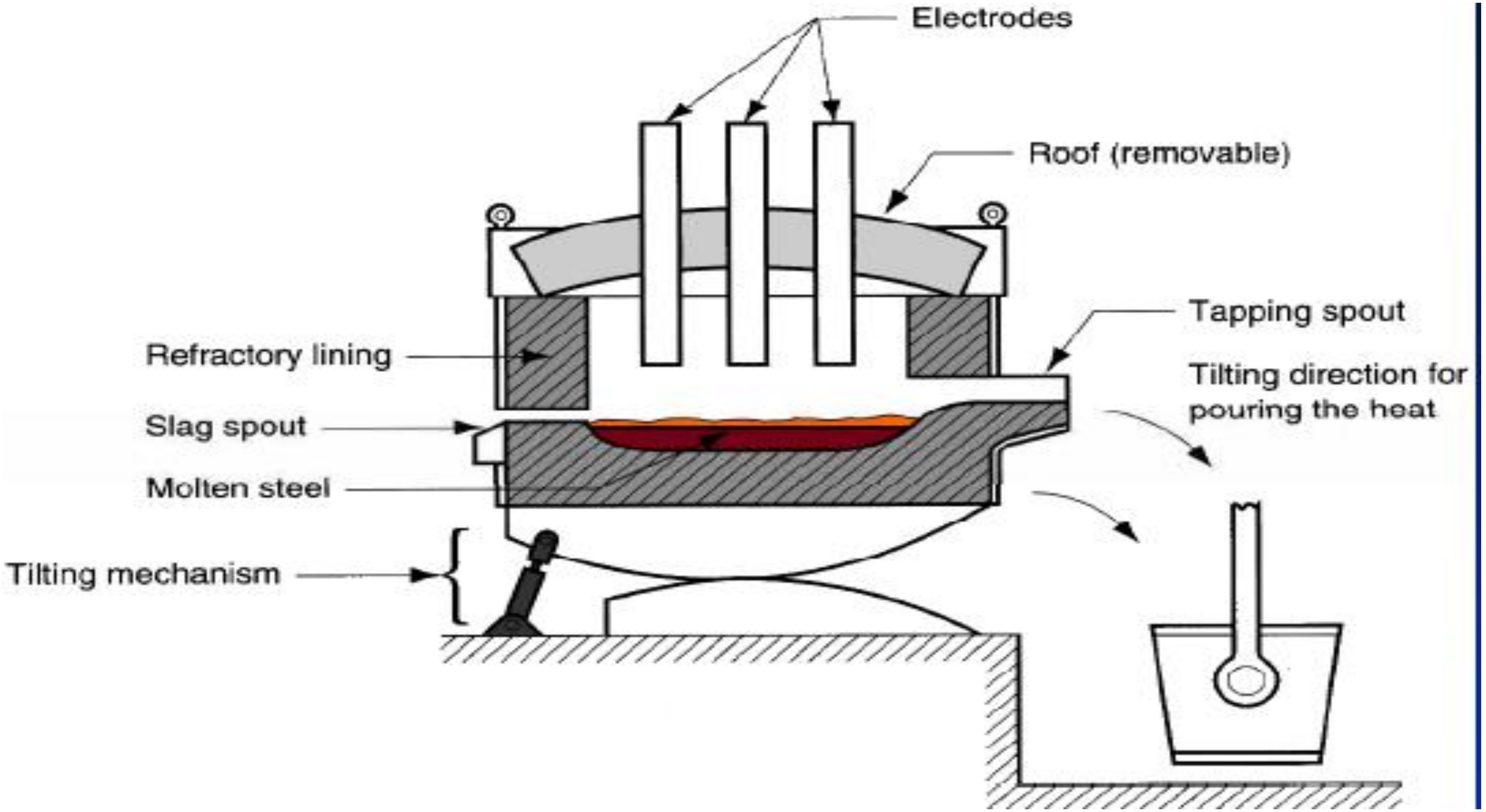
(b) stationary pot, from which molten metal must be ladled, and

(c) tilting-pot furnace

Electric-Arc Furnaces

Charge is melted by heat generated from an electric arc

- High power consumption, but electric-arc furnaces can be designed for high melting capacity
- Used primarily for melting steel

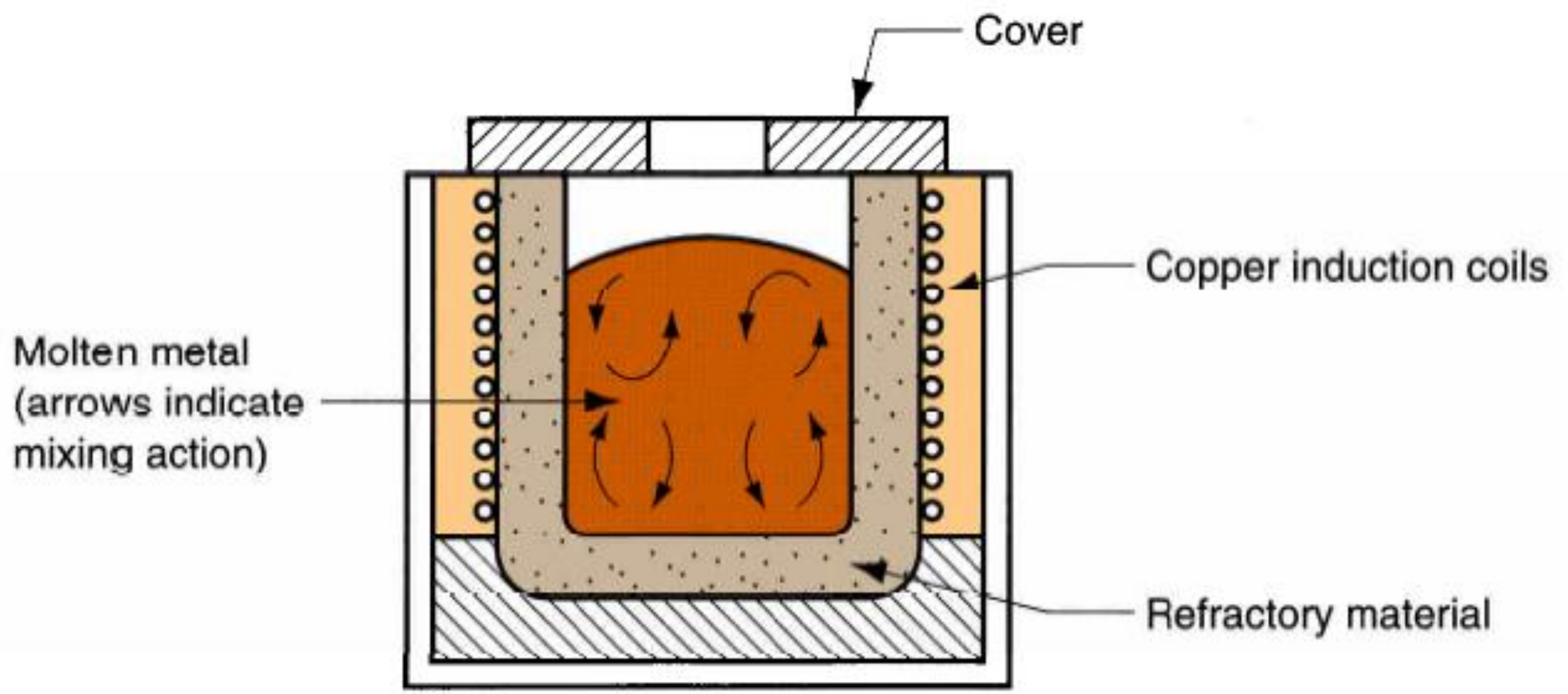


Electric arc furnace for steelmaking

Induction Furnaces

Uses alternating current passing through a coil to develop magnetic field in metal

- Induced current causes rapid heating and melting
- Electromagnetic force field also causes mixing action in liquid metal
- Since metal does not contact heating elements, the environment can be closely controlled, which results in molten metals of high quality and purity
- Melting steel, cast iron, and aluminum alloys are common applications in foundry work



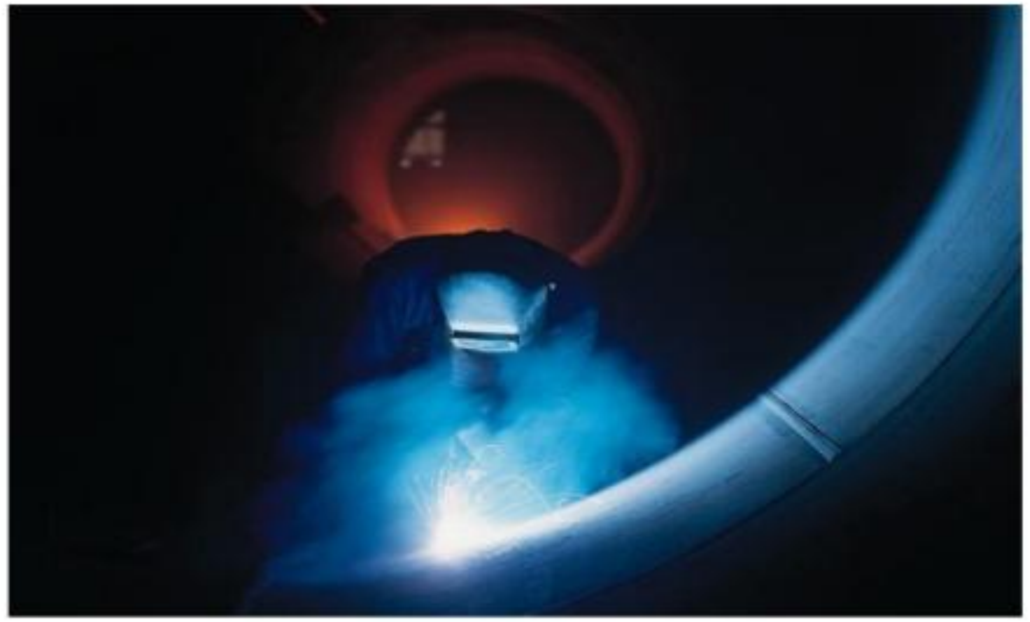
Induction furnace

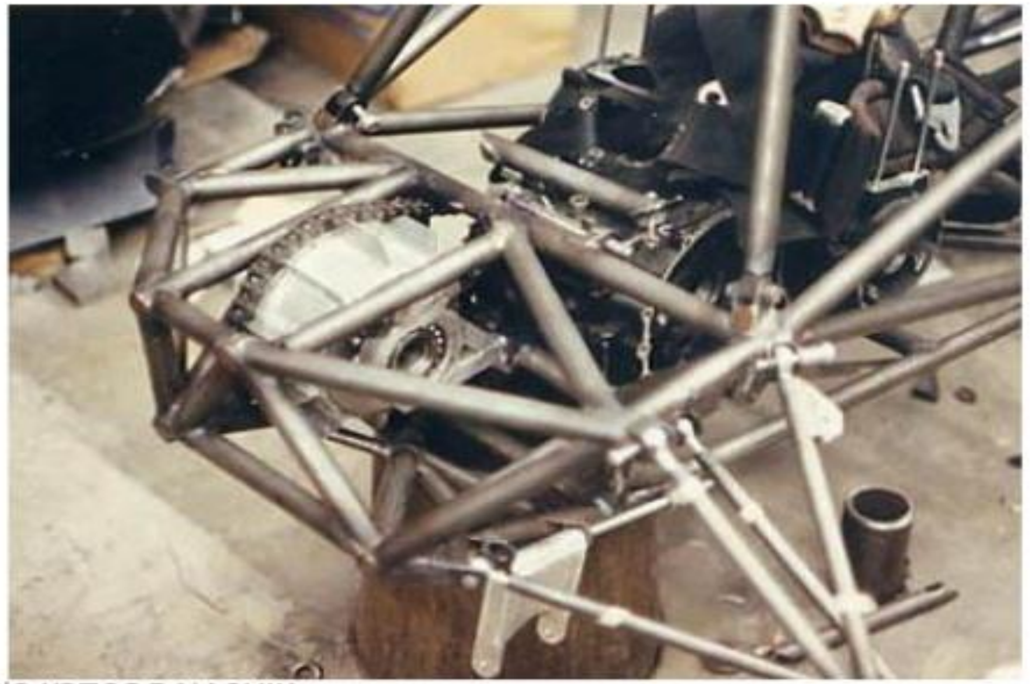
JOINING PROCESSES

- 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:

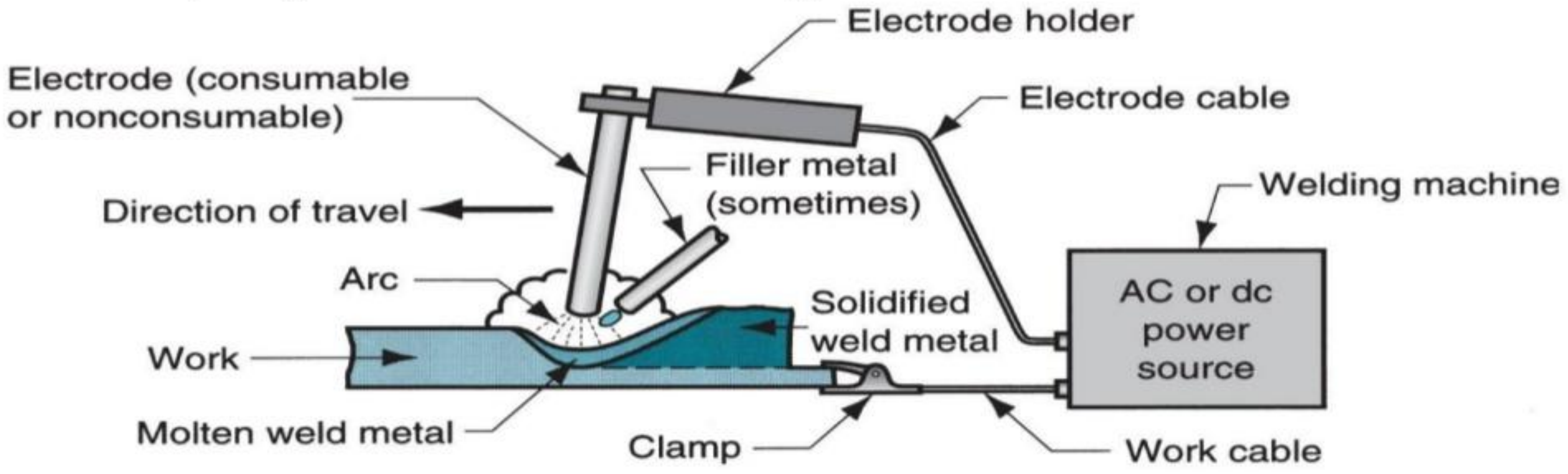
- Labour costs are more since manual welding is done mostly.
- Dangerous to use because of presence of high heat and pressure.
- Disassembly is not possible as welding produces strong joints.
- Some of the welding defects cannot be identified which will reduce the strength.

Arc welding Process

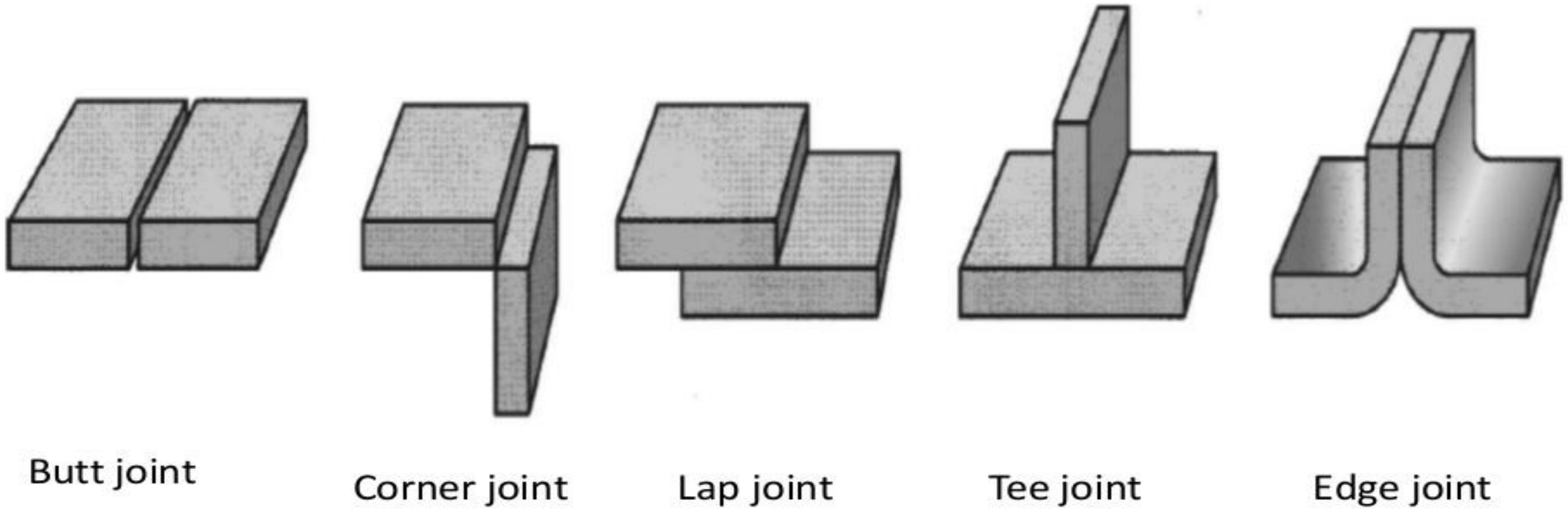
It is a fusion welding process in which the melting and joining of metals is done by the heat energy generated by the arc between the work and electrode.

An electric arc is generated when the electrode contacts the work and then quickly separated to maintain the gap. A temperature of 5500°C is generated by this arc.

This temperature is sufficient to melt most of the metals. The molten metal, consisting of base metal and filler, solidifies in the weld region. In order to have seam weld, the power source moves along the weld line.



Types of Weld joint



Electrodes

- Two types of electrodes are used: **consumable and non-consumable**
- **Consumable electrodes:**

Present in rod or wire form with 200 to 450 mm length and less than 10 mm diameter. This is the source of filler rod in arc welding.

The electrode is consumed by the arc during the welding process and added to the weld joint as filler metal.

The consumable electrodes will be changed periodically as it is consumed for each welding trials. This becomes a disadvantage for welder and reduces the production rate.

- **Non-Consumable electrodes:**

The electrodes are not consumed during arc welding. Though this is the case, some depletion occurs because of vaporization.

Filler metal must be supplied by means of a separate wire that is fed into the weld pool.

Gas welding / Oxyfuel gas welding

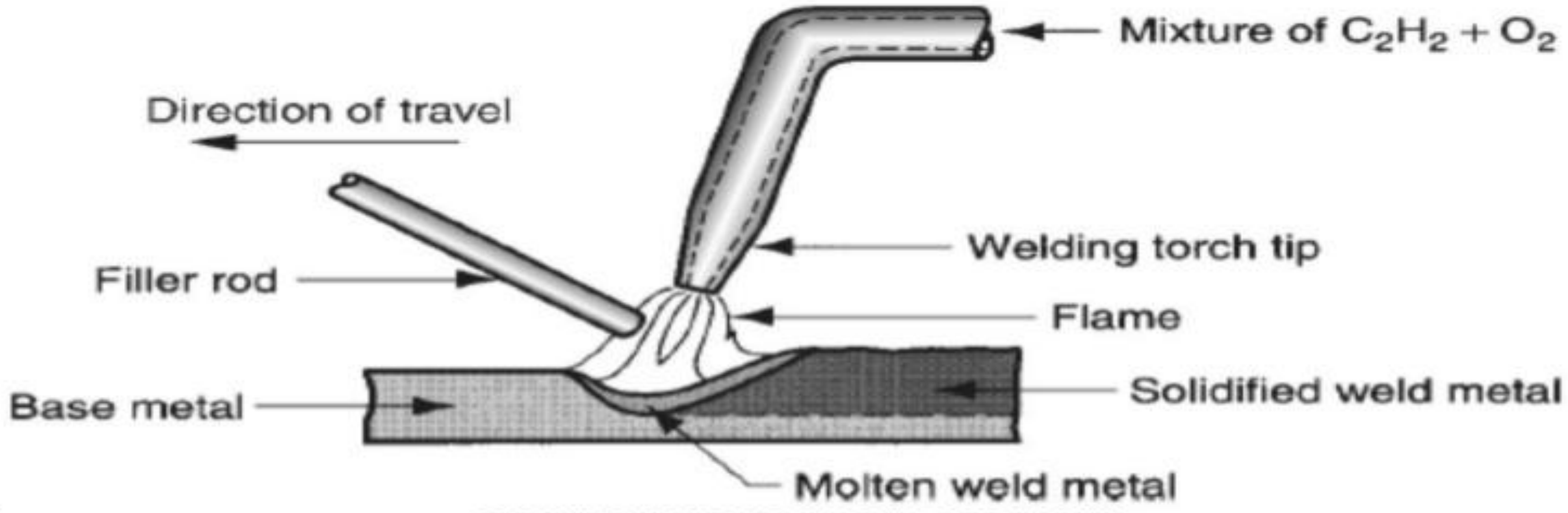
-In this process, various fuels are mixed with oxygen and burnt to perform welding. Eg: Oxyacetylene welding

➢Oxyacetylene welding (OAW):

In this case, welding is performed by a flame formed by the combustion of oxygen and acetylene. The flame comes from a torch.

A filler rod coated with flux is used sometimes which prevents oxidation, creating a better joint.

Acetylene is a famous fuel because it is capable of generating a temperature of 3500°C.



The chemical reaction between oxygen and acetylene happens at two stages as given below.

$$C_2H_2 + O_2 = 2CO + H_2 + HEAT$$ (First stage; inner core)

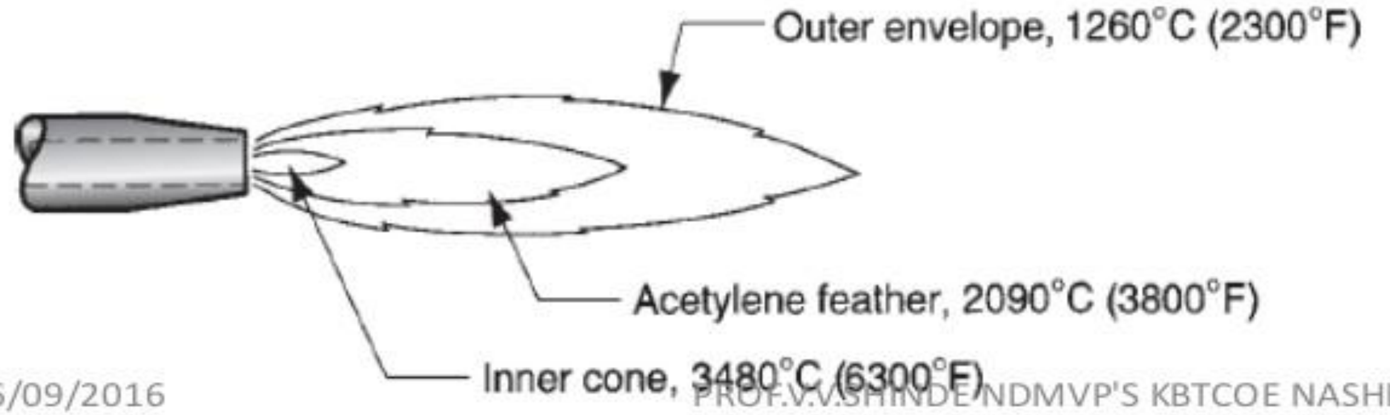
The products of first reaction are combustible and second reaction occurs as,

$$2CO + H_2 + 1.5O_2 = 2CO_2 + H_2O + Heat$$ (second stage; outer envelope)

When both oxygen and acetylene are mixed in ratio of 1:1, then neutral flame is seen as shown in figure. The outer envelope delivers a temperature of 1260°C and inner core has app. 3500°C.

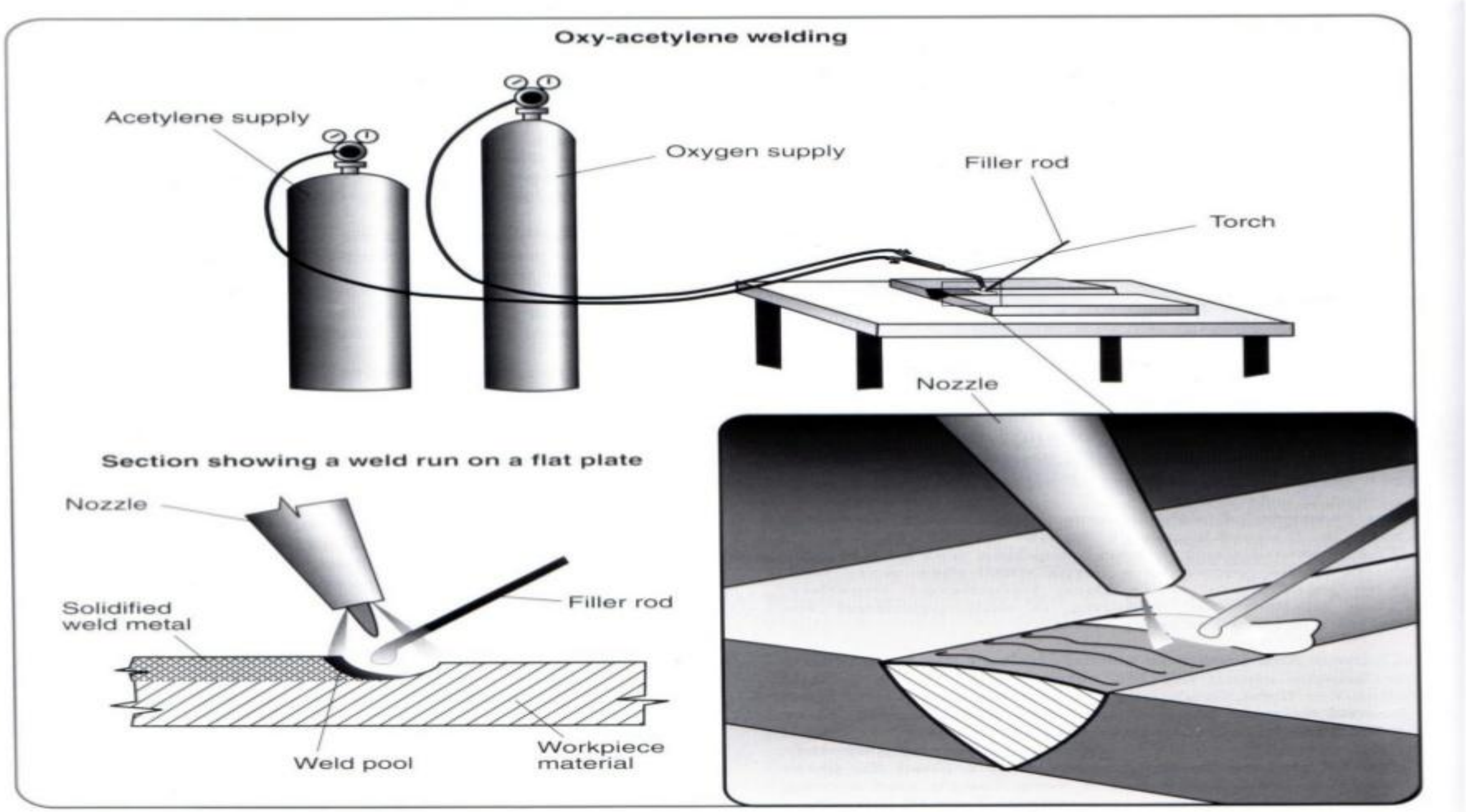
The first stage reaction is seen as the inner cone of the flame (bright white colour), while the second stage reaction is seen in the outer envelope (colorless but with tinges ranging from blue to orange). The temperature is very high at the inner core which is app. 3500°C.

Total heat liberated during the two stages of combustion is 55×10^6 J/m^3 of acetylene. But the heat transfer factor in OAW is 0.1 to 0.3 as the flame spreads over large region.



Neutral flame in oxyacetylene welding

Gas Welding



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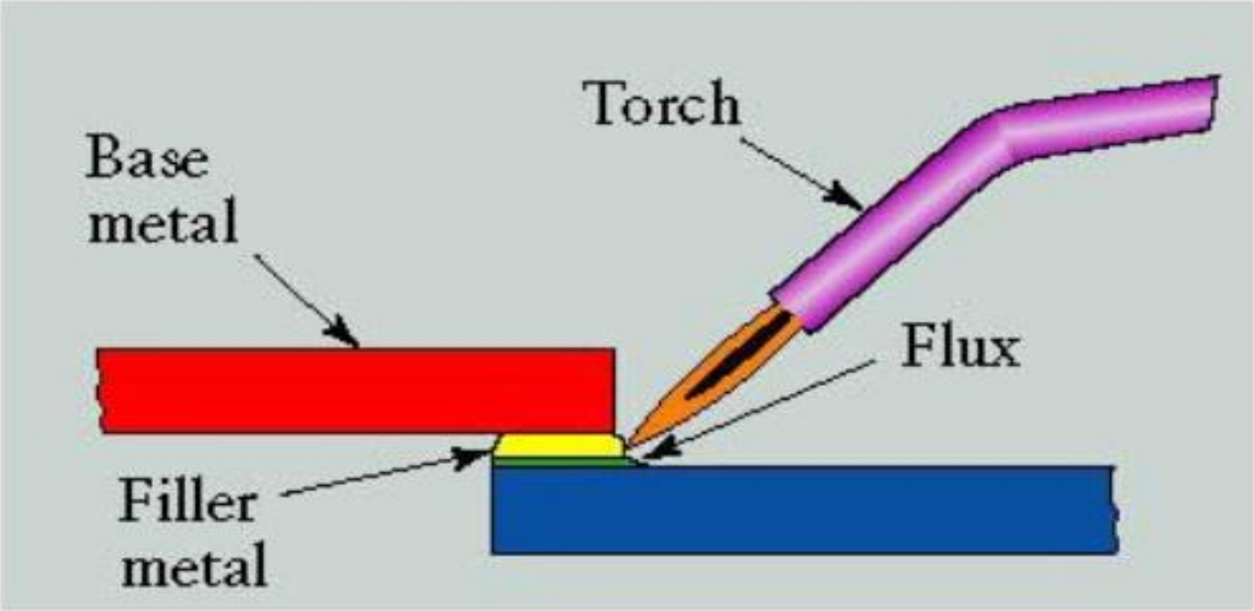
Brazing

- 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.

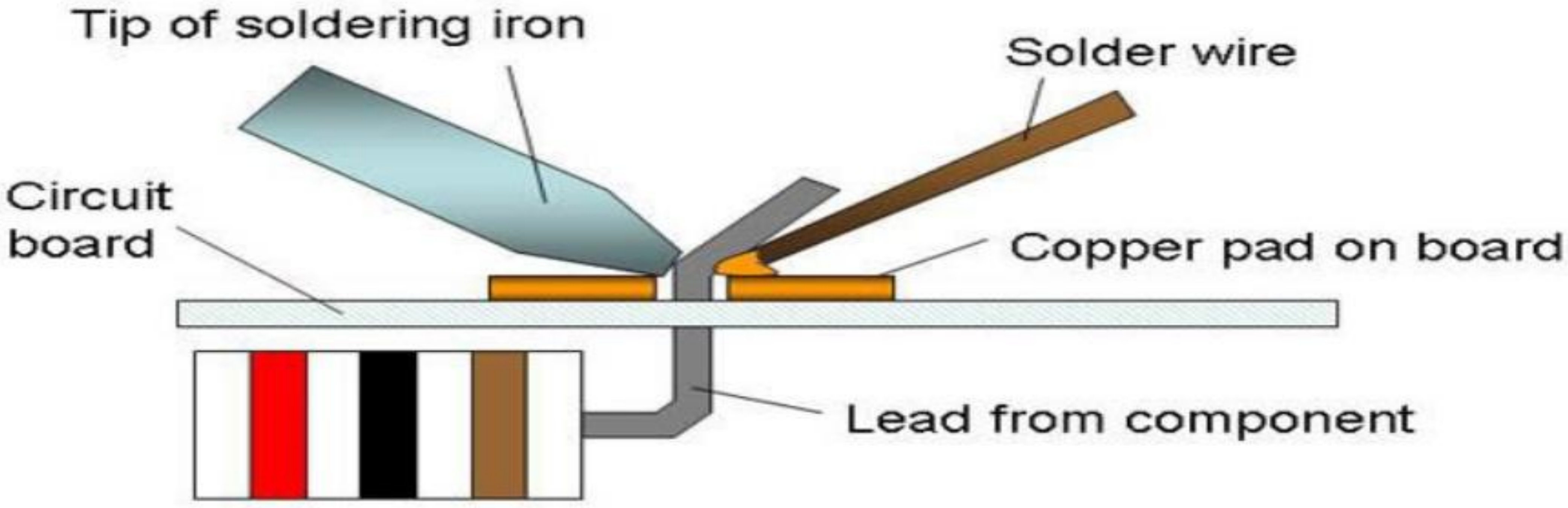
Applications:

1) Printed Circuit Board (PCB) manufacture

2) Pipe joining (copper pipe)

Easy to solder: copper, silver, gold

Difficult to solder: aluminum, stainless steels


Tip of soldering iron
Solder wire
Circuit board
Copper pad on board
Lead from component

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.

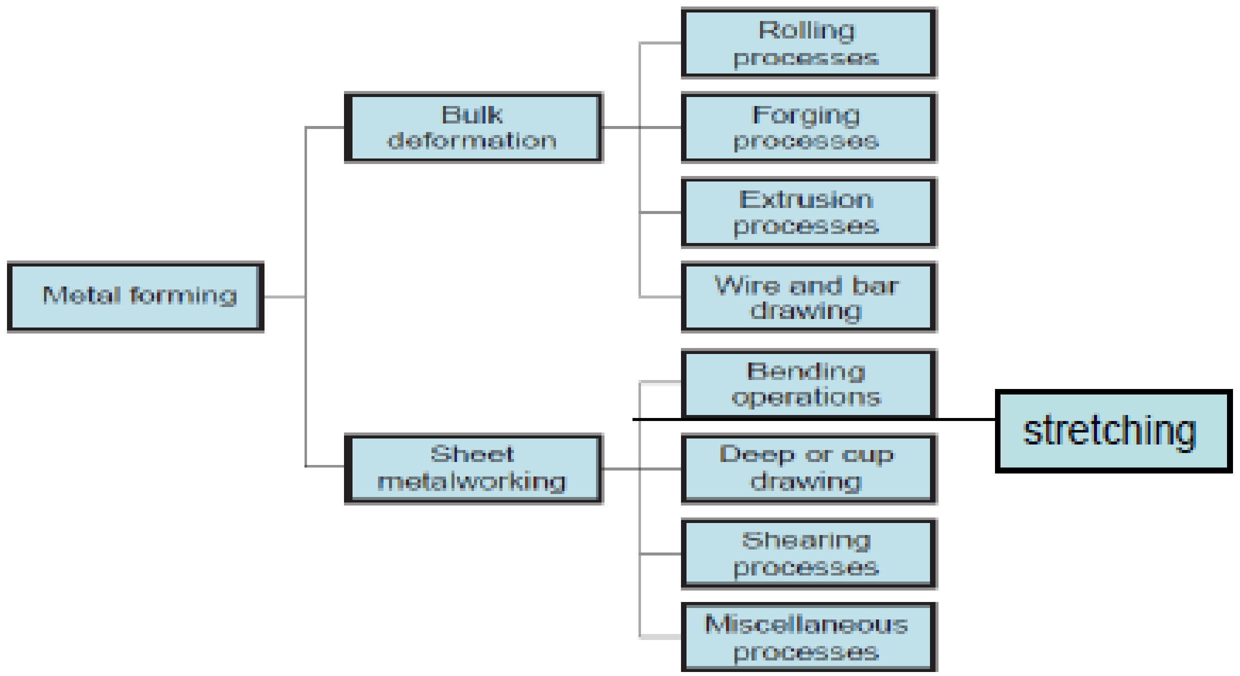
4.	Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible.
5.	Heat cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and sill 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.

Metal forming processes

Metal forming: Large set of manufacturing processes in which the material is deformed plastically to take the shape of the die geometry. The tools used for such deformation are called die, punch etc. depending on the type of process.

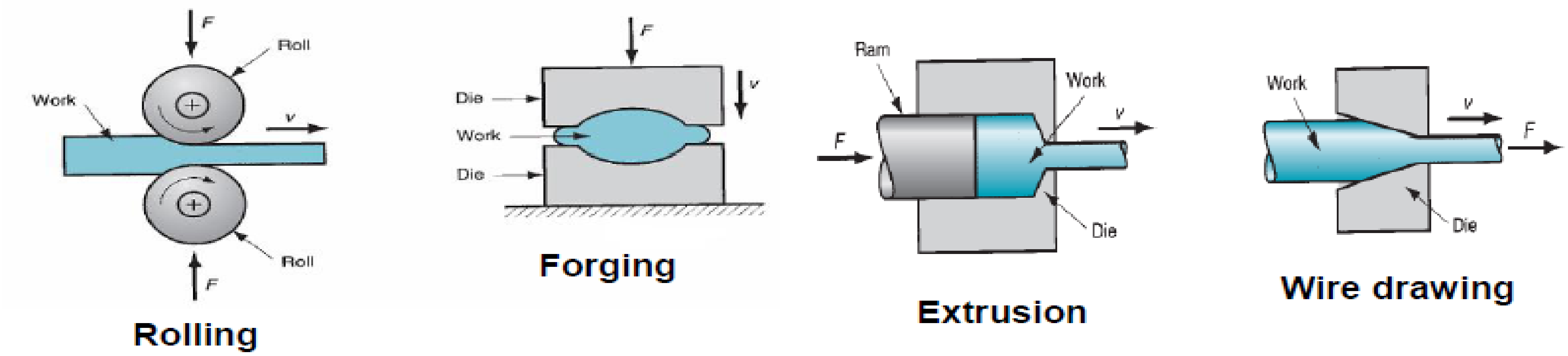
Plastic deformation: Stresses beyond yield strength of the workpiece material is required.

Categories: Bulk metal forming, Sheet metal forming



General classification of metal forming processes

Classification of basic bulk forming processes



Bulk forming: It is a severe deformation process resulting in massive shape change. The surface area-to-volume of the work is relatively small. Mostly done in hot working conditions.

Rolling: In this process, the workpiece in the form of slab or plate is compressed between two rotating rolls in the thickness direction, so that the thickness is reduced. The rotating rolls draw the slab into the gap and compresses it. The final product is in the form of sheet.

Forging: The workpiece is compressed between two dies containing shaped contours. The die shapes are imparted into the final part.

Extrusion: In this, the workpiece is compressed or pushed into the die opening to take the shape of the die hole as its cross section.

Wire or rod drawing: similar to extrusion, except that the workpiece is pulled through the die opening to take the cross-section. R. Ganesh Narayanan, IITG

Cold working, warm working, hot working

Cold working: Generally done at room temperature or slightly above RT.

Advantages compared to hot forming:
(1) closer tolerances can be achieved; (2) good surface finish; (3) because of strain hardening, higher strength and hardness is seen in part; (4) grain flow during deformation provides the opportunity for desirable directional properties; (5) since no heating of the work is involved, furnace, fuel, electricity costs are minimized, (6) Machining requirements are minimum resulting in possibility of near net shaped forming.
Disadvantages: (1) higher forces and power are required; (2) strain hardening of the work metal limit the amount of forming that can be done, (3) sometimes cold forming-annealing-cold forming cycle should be followed, (4) the work piece is not ductile enough to be cold worked.

Warm working: In this case, forming is performed at temperatures just above room temperature but below the recrystallization temperature. The working temperature is taken to be 0.3 T_m where T_m is the melting point of the workpiece.
Advantages: (1) enhanced plastic deformation properties, (2) lower forces required, (3) intricate work geometries possible, (4) annealing stages can be reduced.

Hot working: Involves deformation above recrystallization temperature, between $0.5T_m$ to $0.75T_m$.

Advantages: (1) significant plastic deformation can be given to the sample, (2) significant change in workpiece shape, (3) lower forces are required, (4) materials with premature failure can be hot formed, (5) absence of strengthening due to work hardening.

Disadvantages: (1) shorter tool life, (2) poor surface finish, (3) lower dimensional accuracy, (4) sample surface oxidation

References

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