MANUFACTURING PROCESS

ES-119 UNIT -1

Department of Applied Sciences, BVCOE New Delhi

Manufacturing Process

- Arrived from the Latin word "*manu factus*", meaning "made by hand".
- Manufacturing is the process of converting raw materials into products.

Importance of Manufacturing towards Socioeconomic Developments

- Manufacturing drives innovation
- Increased production
- Increases export
- Improves Employment rate
- Open new opportunities
- Advances Welfare

Department of Applied Sciences, BVCOE New Delhi

Classification

Depending on their primary objective to use; and hence, three classes arise, as discussed below.

- Primary Manufacturing Processes
- Secondary Manufacturing Processes
- Advanced Manufacturing Processes

Primary manufacturing processes

- Casting
- Forming, such as Forging, Rolling, Extrusion, etc.
- Joining, such as Welding, Soldering, etc.

Secondary manufacturing processes

- Machining
- Surface working, such as Heat Treatment, Coating, etc.

Advanced manufacturing processes

- Powder Metallurgy (PM)
- Rapid Prototyping (RP) or 3-D Printing
- CNC machines, machining centers, etc.
- Dye Casting, etc.

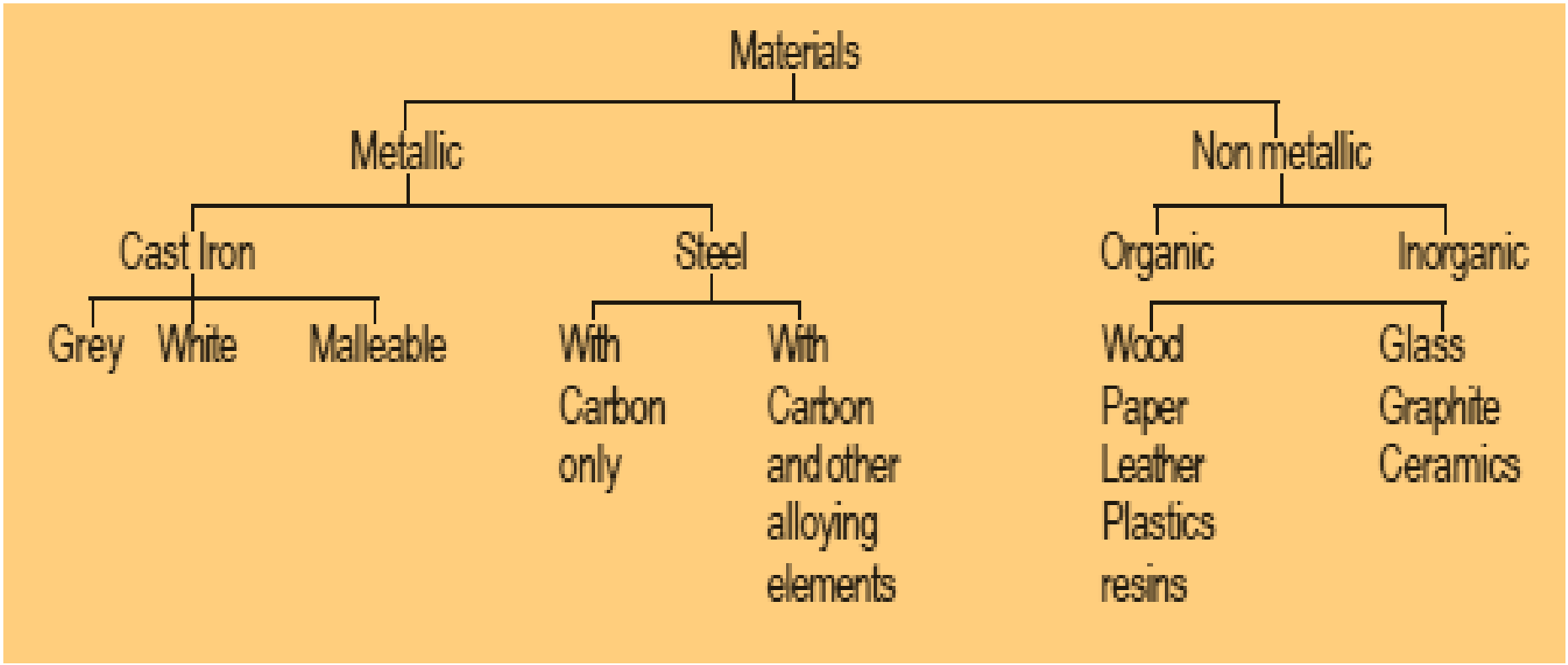
WHY STUDY MANUFACTURING PROCESSES?

- The designer and the drafter must have a working knowledge of the various processes that could produce a part in order to: lower cost and reduce production time.

Three Phases Of The Manufacturing Process

1. Product design.
2. Selection of materials.
3. Selection of production methods and techniques.

Engineering Materials: Classification



Manufacturing Materials

Fall into three general categories:

1. Metal
2. Plastic
3. Inorganic materials

Metals are classified as:

- **Ferrous -** contain iron and steel.
- **Nonferrous -** do not have iron content (such as copper and aluminum).
- **Alloys -** mixture of two or more metals.

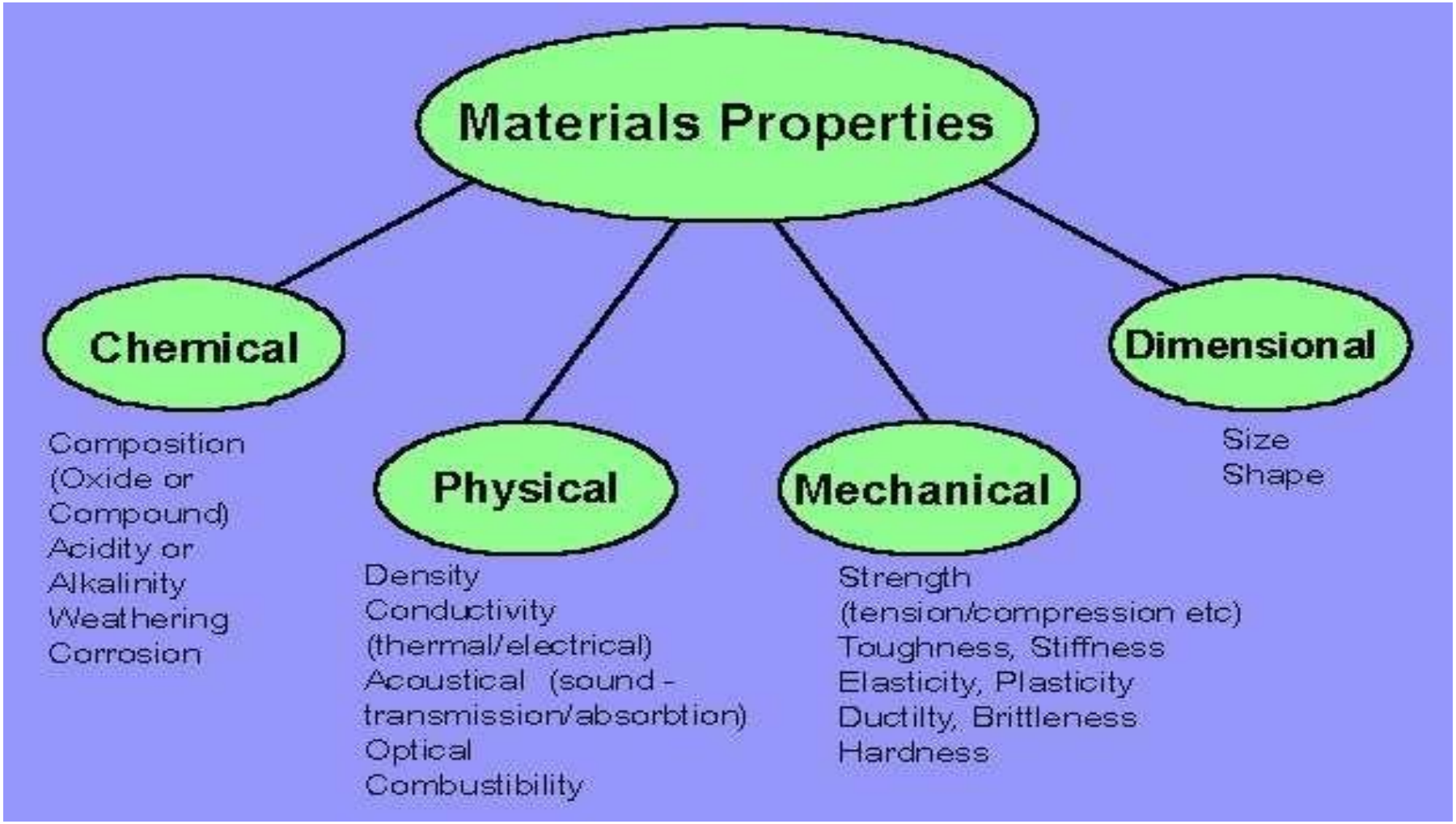
Inorganic Materials Include:

- Carbon and graphite - have low tensile strength (ability to be stretched).
- Ceramics are clay and glass materials. (resistant to heat, chemicals, & corrosion).

PROPERTIES OF MATERIALS

- The term”property” is a qualitative or quantitative measure of response of materials to externally imposed conditions like forces and temperatures.

Classification of material property



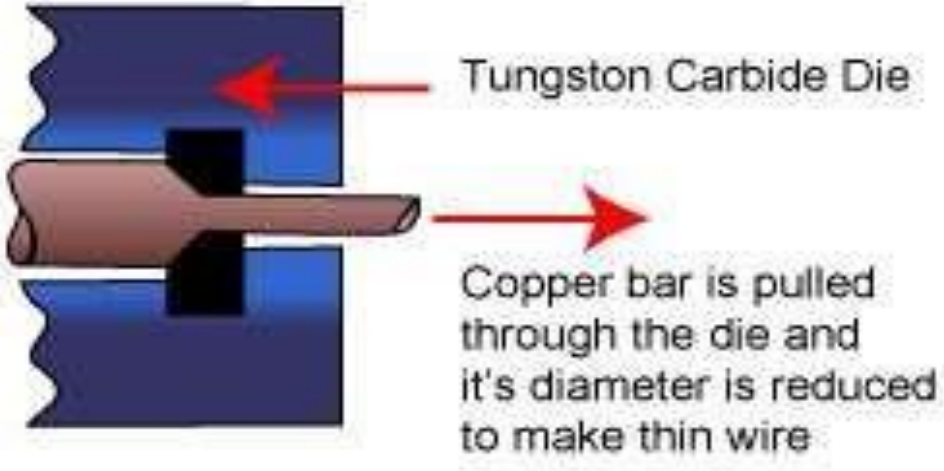
MECHANICAL PROPERTIES

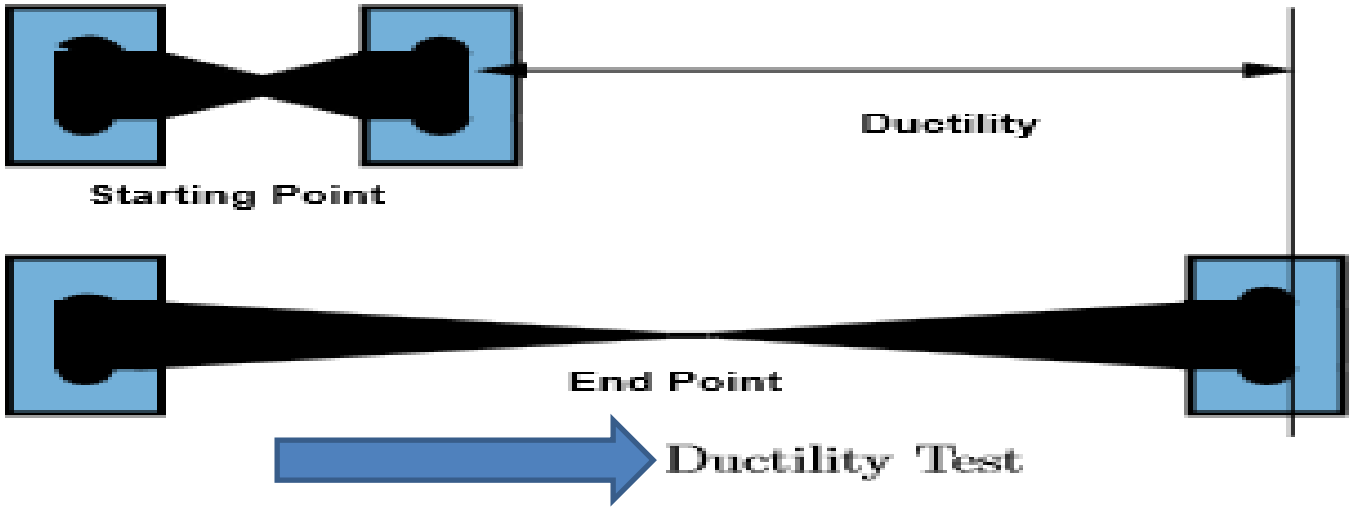
- The properties of material that determine its behaviour under applied forces are known as mechanical properties.
- They are usually related to the elastic and plastic behaviour of the material.
- These properties are expressed as functions of stress-strain,etc.

STRENGTH

The load carrying capacity of the product is known as Strength.

DUCTILITY


Tungston Carbide Die
Copper bar is pulled through the die and it's diameter is reduced to make thin wire


Ductility
Starting Point
End Point
Ductility Test

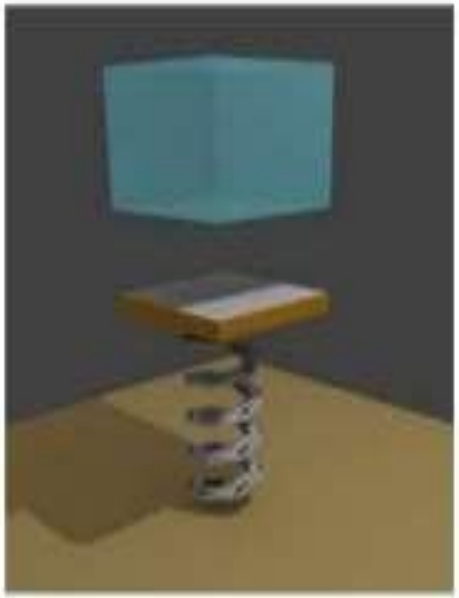
Malleability

Comparision of ductility and malleability

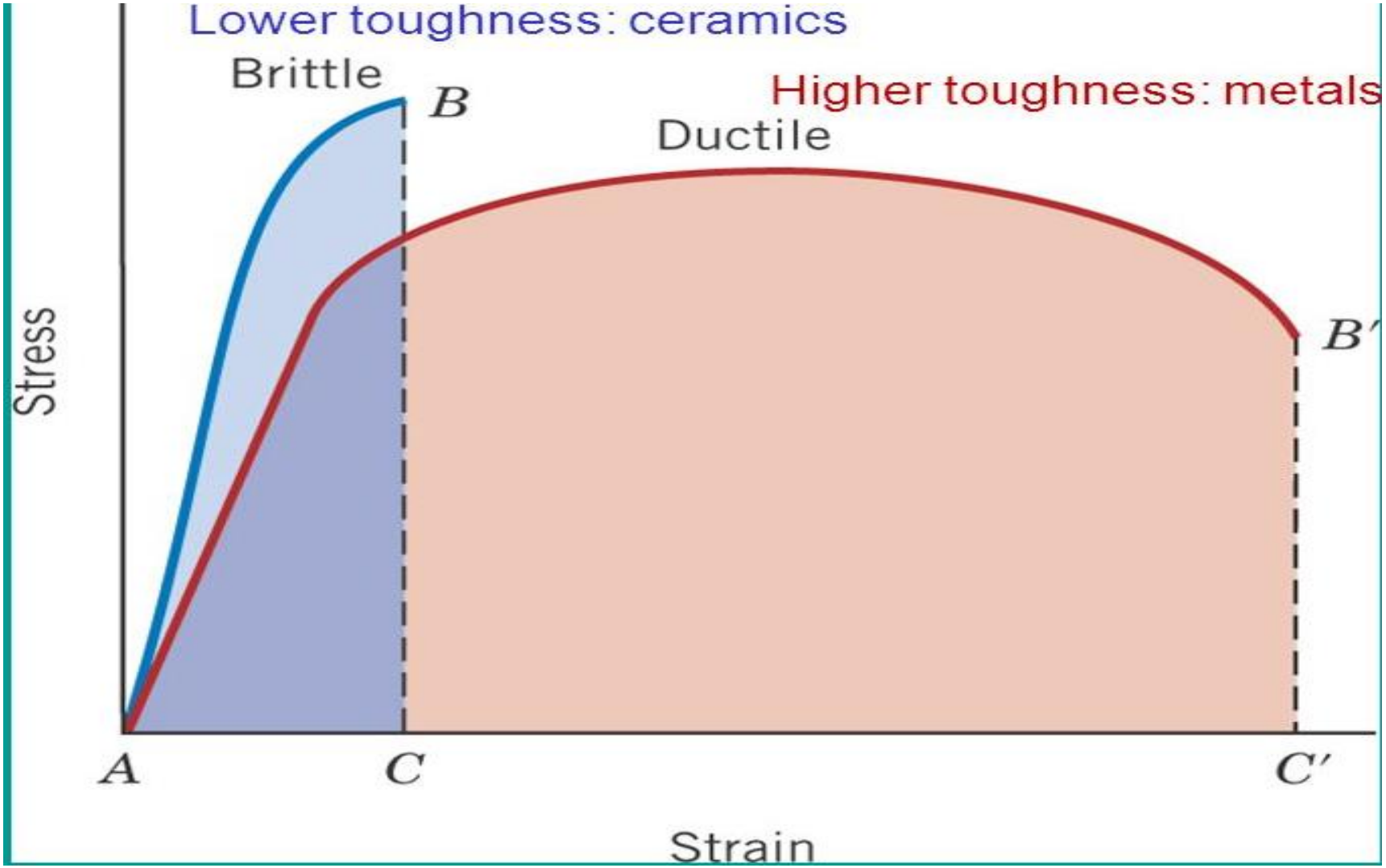
- Ductility is ***tensile quality, while*** malleability is ***compressive quality.***

RESILIENCE

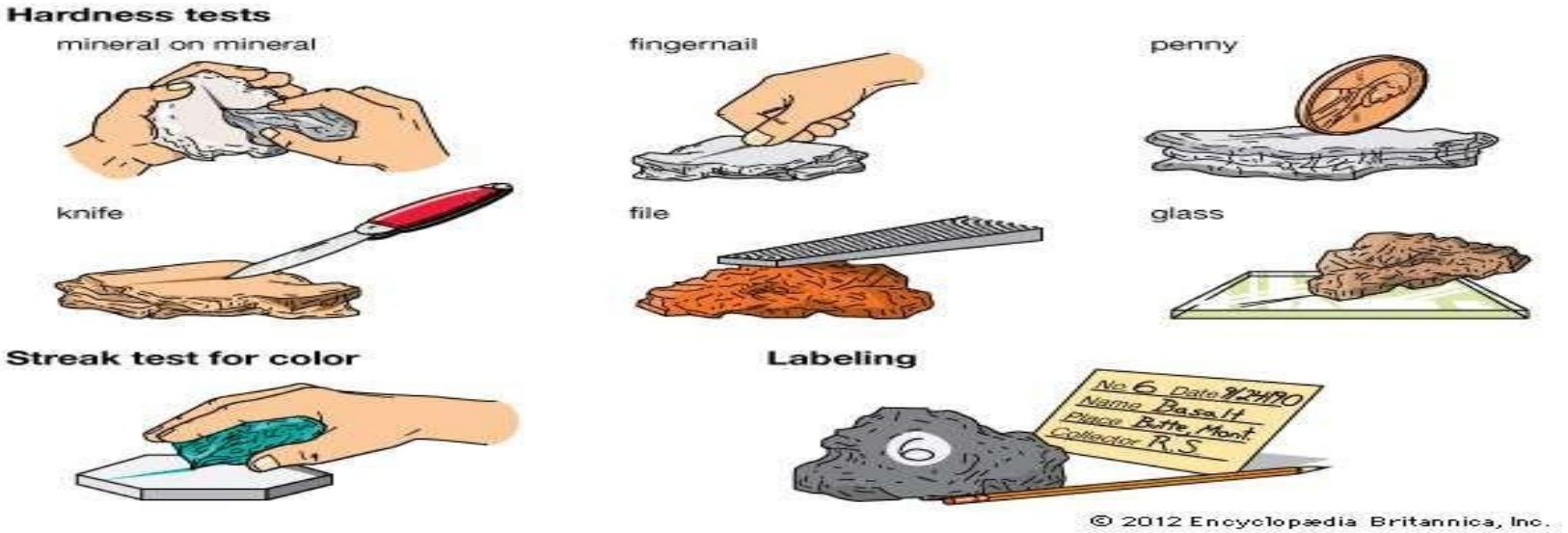
- It is the property of a material to absorb energy and to resist shock and impact loads. It is measured by the amount of energy absorbed per unit volume within elastic limit. This property is essential for spring materials.



Toughness


Lower toughness: ceramics
Brittle
B
Higher toughness: metals
Ductile
B′
Stress
A
C
C′
Strain

HARDNESS


Hardness tests
mineral on mineral
fingernail
penny
knife
file
glass
Streak test for color
Labeling
No. 6 Date 9/24/80
Name Basalt
Place Butte, Mont.
Collector R.S.
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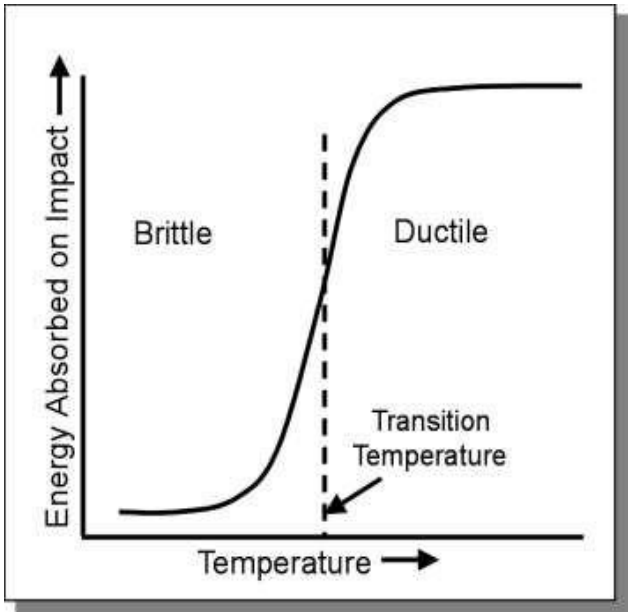
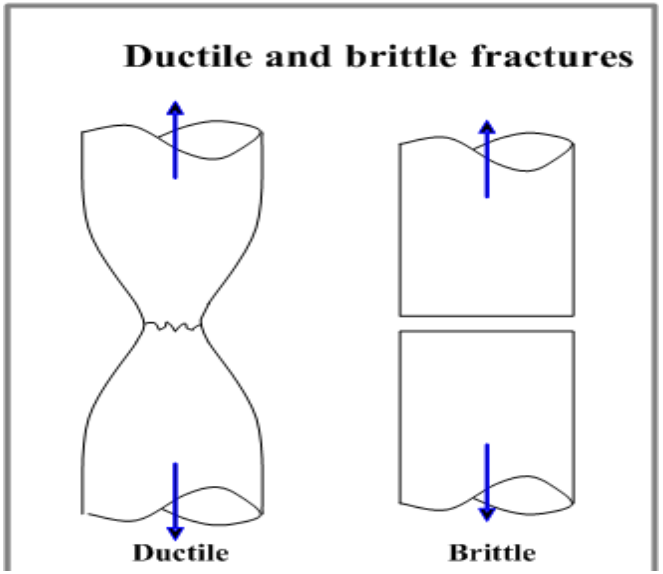
Hardness

BRITTLENESS





STIFFNESS

- The resistance of a material to elastic deformation or deflection is called stiffness or rigidity.
- A material which suffers slight deformation under load has a high degree of stiffness or rigidity.
- E.g. Steel beam is more stiffer or more rigid than aluminium beam.

MEASUREMENT OF PROPERTIES

1 Tensile test

- Stress–strain curve- Universal Testing Machine

2 Compressive test

- Stress-strain curve- -Do-

3 Hardness test

- 1-Brinnel Hardness No- (BHN)
- 2-Hardness Rockwell on C scale (HRC)
- 3-Vicker's Hardness No. (VHN)

4 Toughness test

- Impact Testing Machine(Pendulum Type)

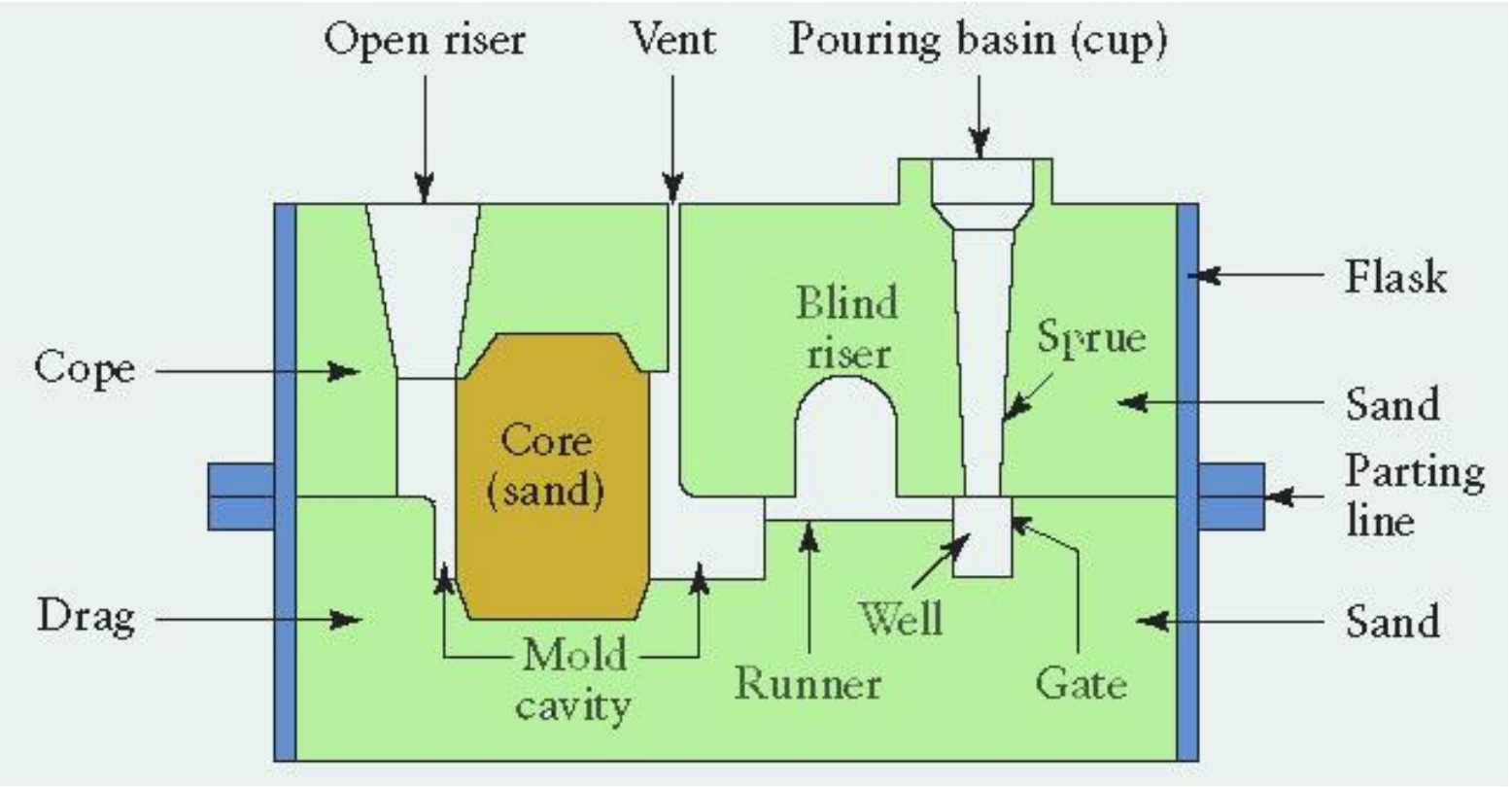
5 Fatigue test

- Fatigue Testing Machine (S-N Curve)
- 6-Creep test.
- Creep Testing Equipment (Creep curve at given stress and temp.)

CASTING PROCESS

- ✓In this process, the metal is first liquefied by heating -using furnace.
- ✓liquid metal is poured into -a mould cavity - allowed to solidify.
- ✓the product is taken out of the mould cavity.

Features of a Sand Mold



Schematic illustration of a sand mold, showing various features.

PARTS PRODUCED BY CASTING PROCESS

Most of the IC Engine Parts
Machine Tool Parts
Very Large Components for Hydraulic Turbines
Frying Pans

When Casting Process is Inevitable

- When you require to produce very large sized component (i.e. Dimension in meters).
- Workpiece is - very hard material.
- For producing parts of complicated shapes.

SAND CASTING PROCESS

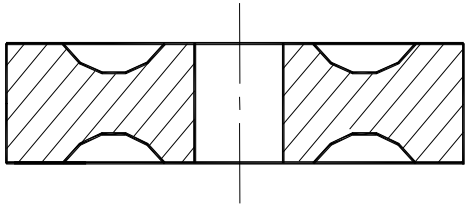
Steps involved in Casting Process

- Pattern making.
- Mould making.
- Core making.
- Gating and Riser making
- Melting of metal and pouring.
- Cooling and solidification.
- Cleaning of castings and inspection.

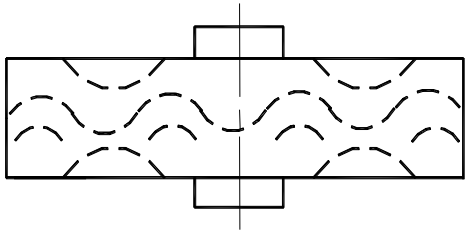
PATTERN MAKING

Pattern is a mould forming tool
A single pattern may be used for making many mould cavity.
Pattern making involves

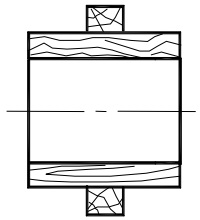
- **study of materials used for making patterns**
- **various types of patterns and pattern allowances.**



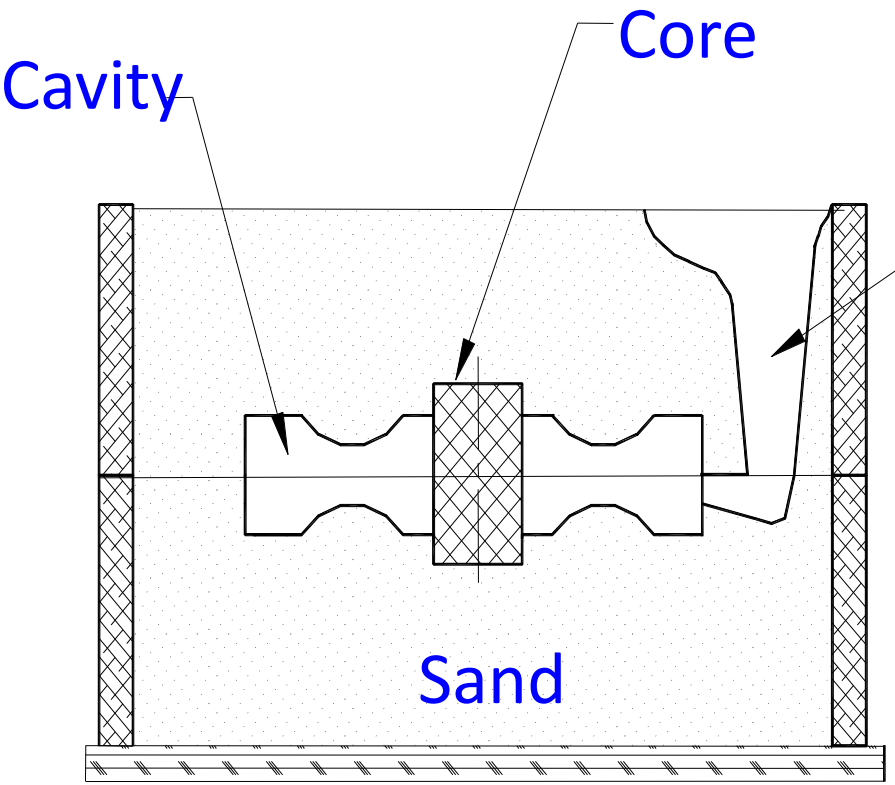
Required casting



Pattern



Core box



Sand mould in two-piece flask

PATTERN MATERIAL

Patterns can be made from- wood, metals, alloys, plaster, rubber, wax, etc.

The selection of a pattern material depends on

the size and shape of the casting

dimensional accuracy,

the quantity of casting required and the molding process.

PROPERTIES OF PATTERN MATERIAL

Easily shaped, worked, machined and joined.

Resistant to wear and corrosion.

Resistant to chemical action.

Dimensionally stable and unaffected by variations in temperature and humidity.

Availability and Economical.

WOOD

Easily available.
Low weight.
Low cost.
It absorbs moisture and hence dimensions will change.
Lower life.
Suitable for small quantity production and very large size castings.

METAL

Used for mass production

For maintaining closer dimensional tolerances on casting.

More life as compared to wooden patterns

Few of the material used include Al, Fe, Brass etc.

Aluminum is widely used.

PLASTIC

Low weight

Easier formability

Do not absorb moisture

Good corrosion resistance

POLYSTYRENE

Easy to make pattern as it is soft.
Polystyrene changes gaseous state on heating.
Used for prototype (single piece) castings.
Also known as Disposable patterns.

TYPES OF PATTERNS

SOLID PATTERN

- A pattern that is made without joints, parting or any loose pieces - called a single piece or solid pattern.
- It is not recommended except for limited production like large and small size castings of simple shapes.

SPLIT PATTERN

Most widely used type of pattern for intricate castings.

Used When

- **The depth of the casting is too high.**

The pattern is split into two parts.

The two halves of the pattern should be aligned by making use of the dowel pins.

Loose Piece Pattern

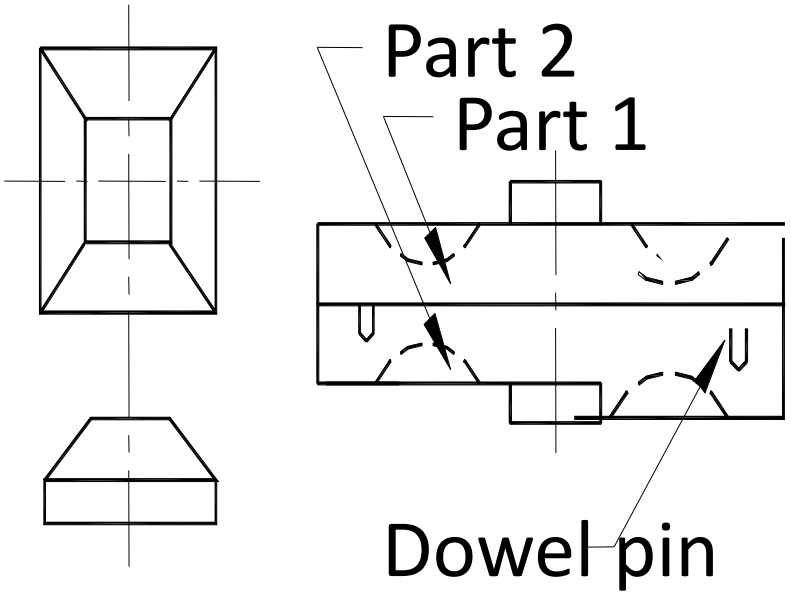
Used when

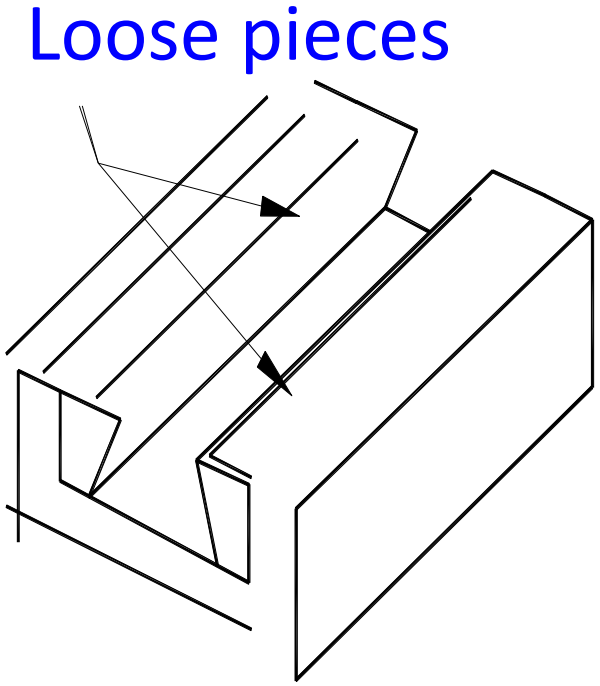
- **Withdrawal of pattern from mould is not possible.**
- **Castings is having projections, undercuts and etc.**

The obstructing part of the contour is held as loose piece by a wire.

After the molding -the main part is removed - loose pieces are recovered through the gap

TYPES OF PATTERNS





(a) Solid pattern (b) Split pattern (c) Loose piece pattern

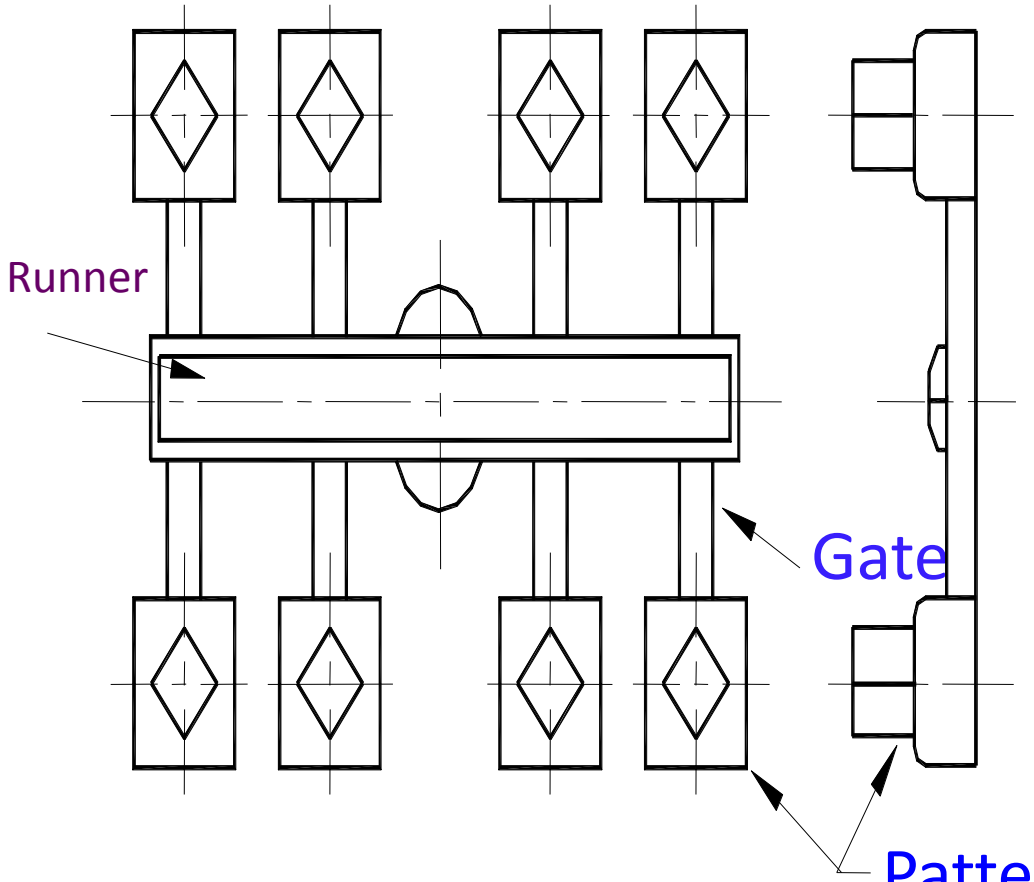
Match Plate Pattern

The cope and drag halves - along with the gating system and riser - are mounted on a match plate on either side.

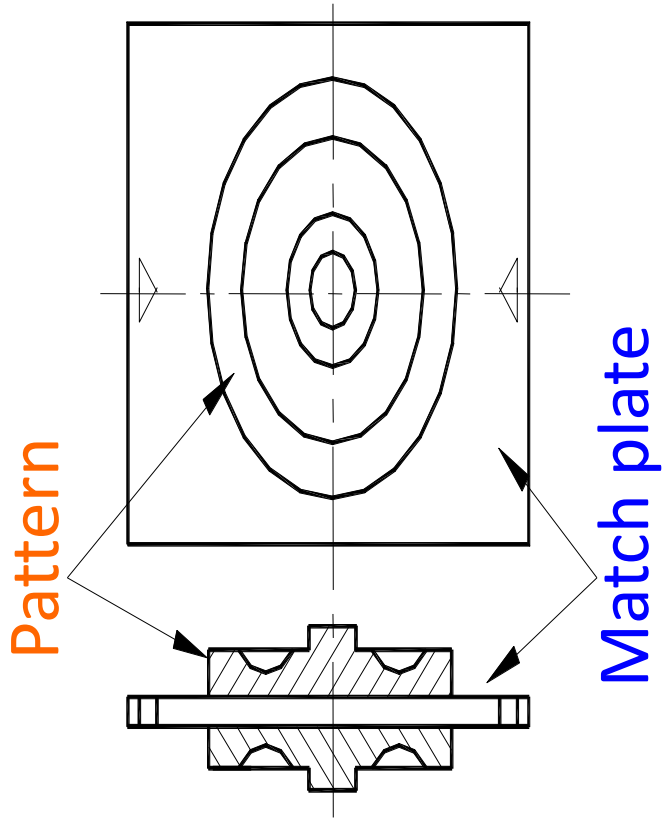
When removed after moulding, a complete mould with gating system is obtained.

Used for rapid production of small and accurate casting.

The match plate may be of wood, steel, magnesium or aluminum.



(a) Gated pattern for 8 castings



(b) Match plate pattern

Gated Pattern

It is used for producing small sized cavities in one mould.

The gating and runner system are integral part of the gated pattern.

A single runner is used for feeding considerable amount of the moulding time is saved.

Removable and Disposable pattern

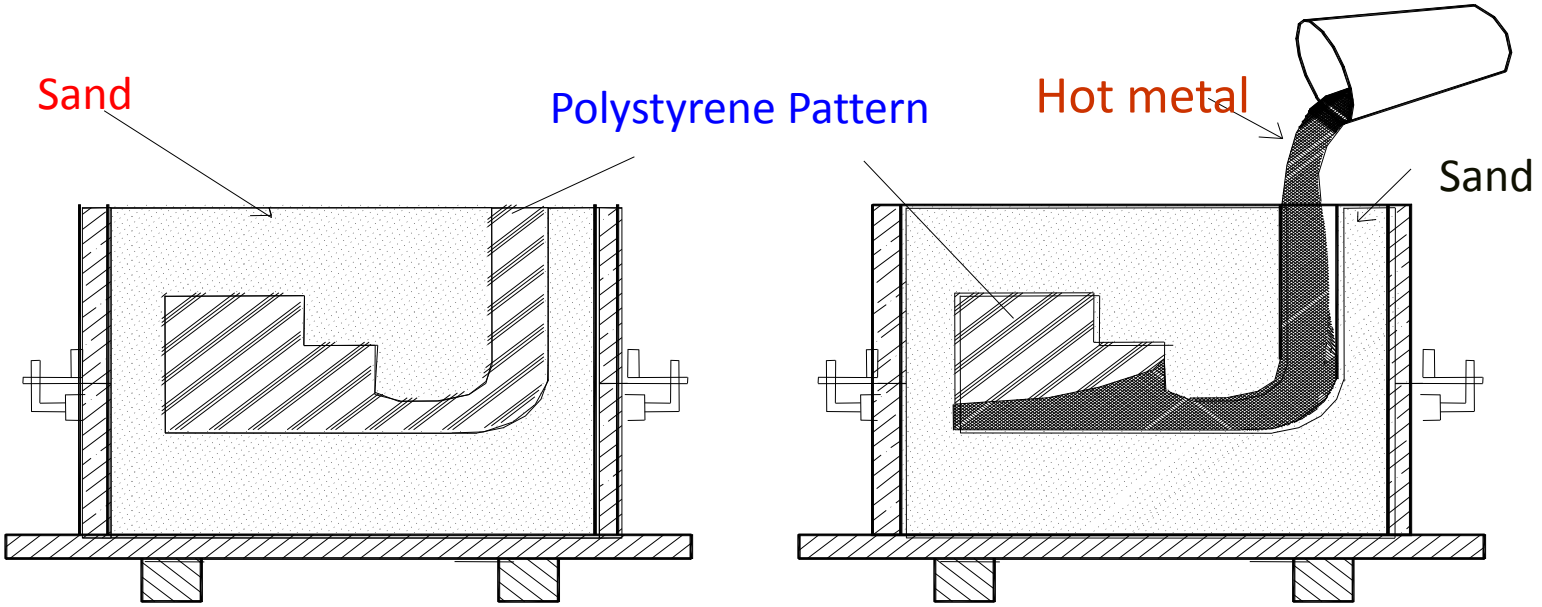
A removable pattern can be used for producing multiple identical moulds.

For disposable patterns, the pattern is left in the mould instead of being removed from sand.

The pattern material vaporizes when the molten metal is poured

cavity thus created is filled with molten metal. The method is also known as full mould process or cavity less method.

Disposable pattern



(a) Disposable pattern in sand mould

(b) Hot metal replacing disposable pattern

Pattern Allowances

a) Patterns are not made the exact same size as the desired casting due to metal shrinkage, draft, finish, distortion and rapping.

b) Allowances are given in the pattern to incorporate the effect of various factors.

Types of Allowances

Shrinkage Allowance
Machining Allowance
Draft or Taper Allowance
Distortion Allowance
Rapping or Shake Allowance

Shrinkage Allowance

Provided to compensate for shrinkage of metal during solid contraction.

Pattern is made slightly bigger.

Amount of allowance depends upon type of the material used, its composition, pouring temperature etc.

Note: The contraction of the metals is always volumetric, but the shrinkage allowances are always expressed as linear measures.

Shrinkage Allowance for different metals

Metal	Allowance mm/m
Cast Iron (Grey)	10.5
Steel	21.0
Brass	16.0
Aluminum	16.0
Zinc	24.0
Lead	24.0
Tin	7.00
Silver	10.0

Machining Allowance

Provided to compensate for machining on casting.

Pattern is made slightly bigger in size.

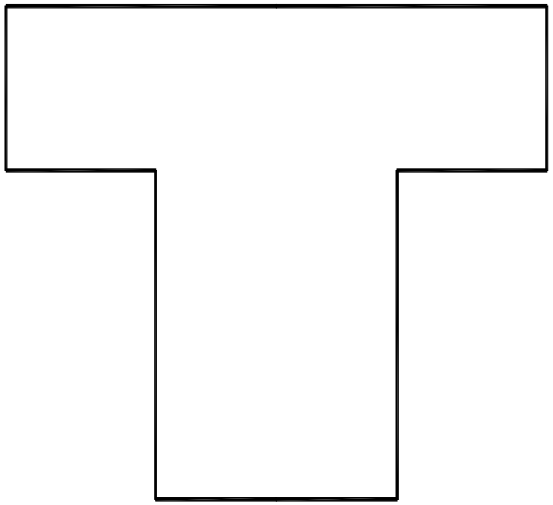
Amount of allowance depends on -

- ✓ size and shape of casting,
- ✓ type of material,
- ✓ machining process to be used
- ✓ degree of accuracy and surface finish required.

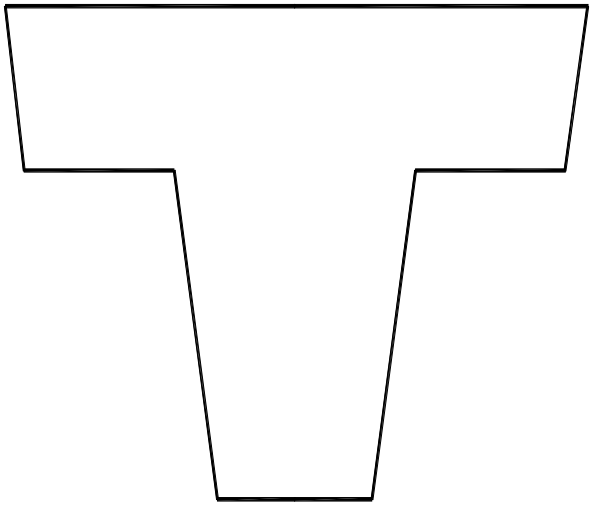
Draft or Taper Allowance

It is given on all the vertical surfaces to facilitate easy withdrawal of the pattern.
The factors influencing this allowance are the design of the pattern, its vertical height and the method of molding.
It can be expressed either in degrees or in terms of linear measures.
Typically it ranges from 1 degree to 3 degree for wooden patterns.

Draft or Taper Allowance



(a) Pattern with zero (no) draft



(b) Pattern with draft

(Not to scale)

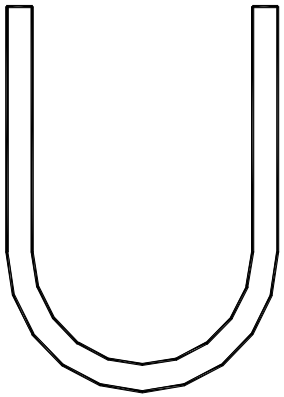
Distortion Allowance

Casting which has an irregular shape and some such design that the contraction is not uniform throughout will distort during cooling.

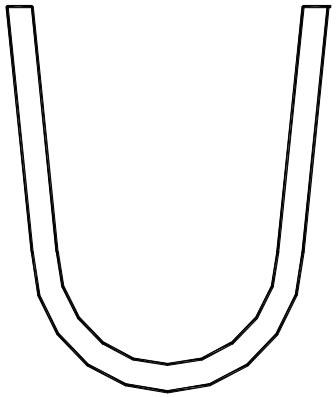
To eliminate this defect an opposite distortion is provided in the pattern so that the effect is neutralized and the correct casting is obtained.

This can be done in trial and error basis to get the distortion amount.

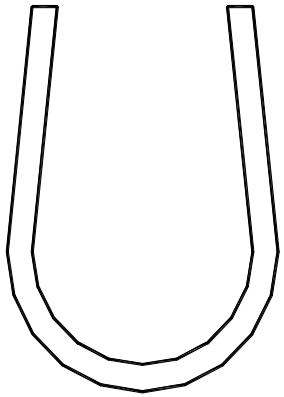
Distortion Allowance



(a)
Required shape of casting



(b)
Casting produced when no distortion allowance is provided



(c)
Pattern with distortion allowance

Rapping or Shake Allowance

When a pattern is to be withdrawn from the mould, it is first rapped or shaken, by striking over it from side to side, so that its surface may be free of the adjoining sand wall of the mould.

As a result of this the size of the mould cavity increases a little and a negative allowance is to be provided in the pattern to compensate it.

It is negligible in small and medium sized castings.

SAND CASTING PROCESS

Steps involved in Casting Process

- Pattern making.
- Mould making.
- Core making.
- Melting of metal and pouring.
- Cooling and solidification.
- Cleaning of castings and inspection.

Types of Moulding Sand

Natural foundry sand

- Taken from river bed.
- Possess clay - acts as binder.
- Ease of availability and low cost,
- Mostly used for the ferrous and non-ferrous light castings..

Synthetic (or Artificial) foundry sand

- Made in foundry by crushing sand stones
- Washing and grading to yield a sand grade of requisite shape.
- Desired strength and bonding properties of these sands are developed by separate additions such as binders, water and other materials

Common Moulding Sand

Green Sand:

18-30% clay, 4-8% water.

Collected from natural resources.

Maintains moisture content for long time.

Dry sand:

It is green sand dried and baked.

Yields porosity absent castings, as there is no moisture.

Suitable for very large size castings.

Loam sand:

Clay and silica are mixed in equal proportions.

Parting sand:

Used to permit easy withdrawal of the pattern from mould cavity.

Core sand:

Core oil is mixed with silica sand to get Core sand.

It should be stronger than moulding sand.

Properties of Moulding Sand

- Cohesiveness or Strength
- Chemical resistivity
- Permeability
- Flowability
- Adhesiveness
- Refractoriness
- Collapsibility

Cohesiveness or Strength

It is the property of sand particles to stick together firmly so that the pattern is withdrawn from the mould without damaging the mould surfaces and edges.

Moisture and clay content determine the strength of the moulding sand.

Chemical resistivity

The sand used for moulding should be inert and should not react chemically with the metal/alloy being poured into it.

Special care has to be taken for removing reactive metals like magnesium and titanium alloy while preparing moulding sand for casting.

Permeability

Property of the sand which allows gases and steam to escape through the sand mould.

Large amount gases and steam is formed due to heating of moisture, additives and other materials.

Gases must escape out, otherwise this will result unsound casting or blast the mould.

It largely depends on the sand grain size, shape, moisture content and clay content.

A soft ramming will increase permeability and hard ramming will decrease permeability

Flowability

Flowablity of moulding sand refers to its ability to behave like fluid to flow to different corners and intricate details on pattern without much special efforts when it is rammed.

It is more significant in the machine moulding.

Adhesiveness

The sand particles adhere to the mould box surfaces by the property called adhesiveness.

This property helps the sand to retain the mould cavity and stay in the box.

Refractoriness

Property of the moulding sand which enables it to withstand high temperature of the molten metal without fusing,

Depends upon the metal which is to be cast.

If the sand lacks this property, it will fuse on while coming into contact with the molten metal,

Collapsibility

Property due to which the sand mould easily collapses after solidification of the casting to allow a free contraction of the metal.

Absence of this property, the contraction of the metal will be hindered by the mould and results in tears and cracks in the casting.

Moulding

It is the process of making a mould with desired cavity in a suitable material like sand to pour the molten metal.

Types of Moulds

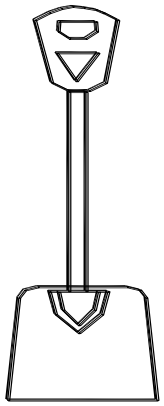
Green Sand Mould

Dry sand Mould

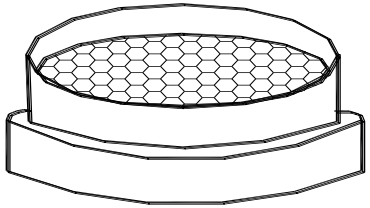
Loam Sand

Metal Mould

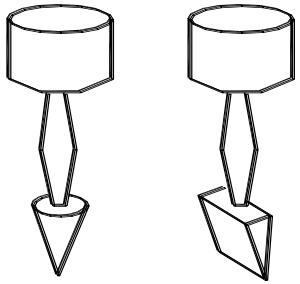
Tools used in Moulding Process



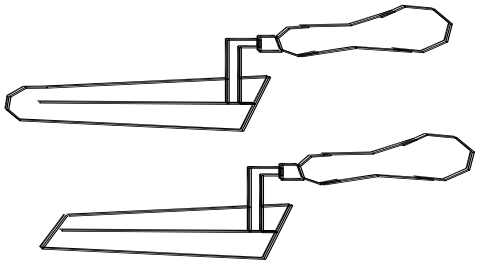
(a) Shovel



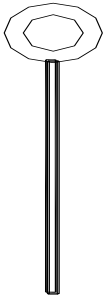
(b) Riddle



(c) Hand rammers

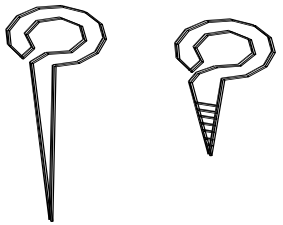


(d) Trowel



(f) Vent rod

(e) Sprue pin



(g) Draw spikes

Tools used in Moulding Process

Shovel: It is used for mixing moulding sand and filling moulding sand.

Riddle: It is used for removing foreign materials from the moulding sand.

Rammer: This is used for packing or ramming the sand into the mould.

Trowel: It is used for smoothening the surfaces of the mould.

Tools used in Moulding Process

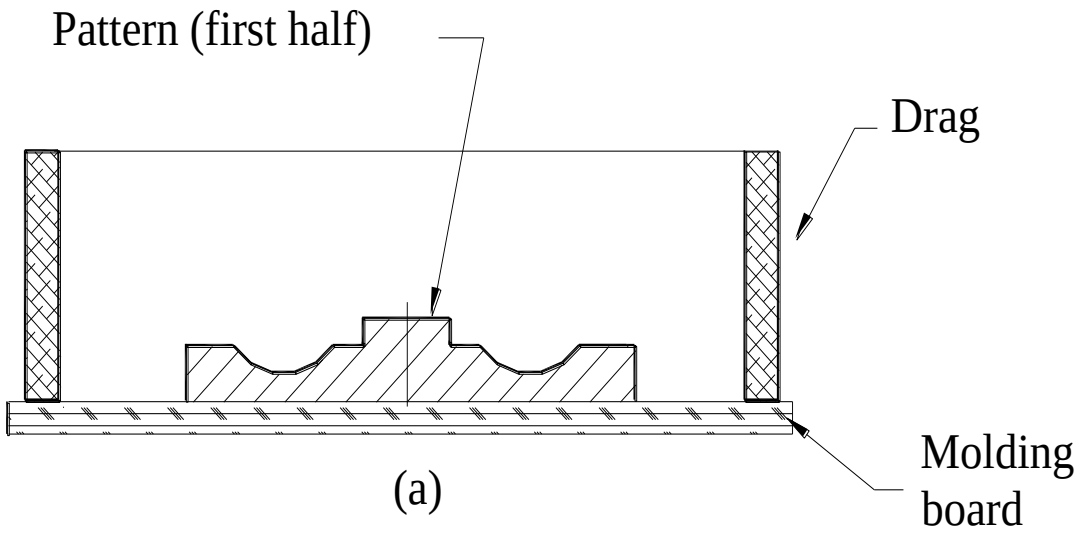
Sprue Pin: conical wooden pin used for making an opening to pour molten material into the cavity.

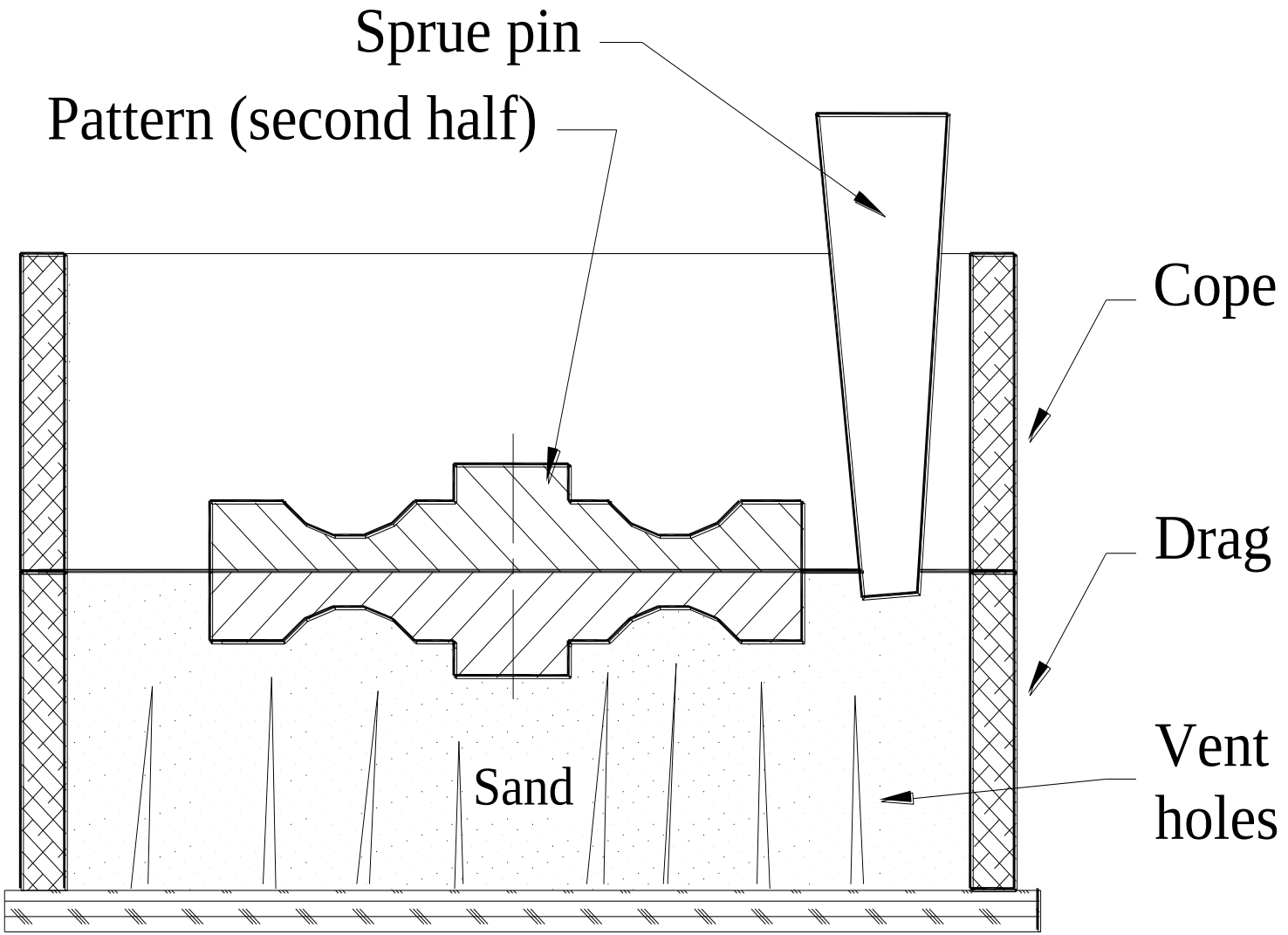
Vent Rod: Used for making small holes to permit gases to escape when the molten material is poured.

Draw Spike: Used for drawing pattern from the sand.

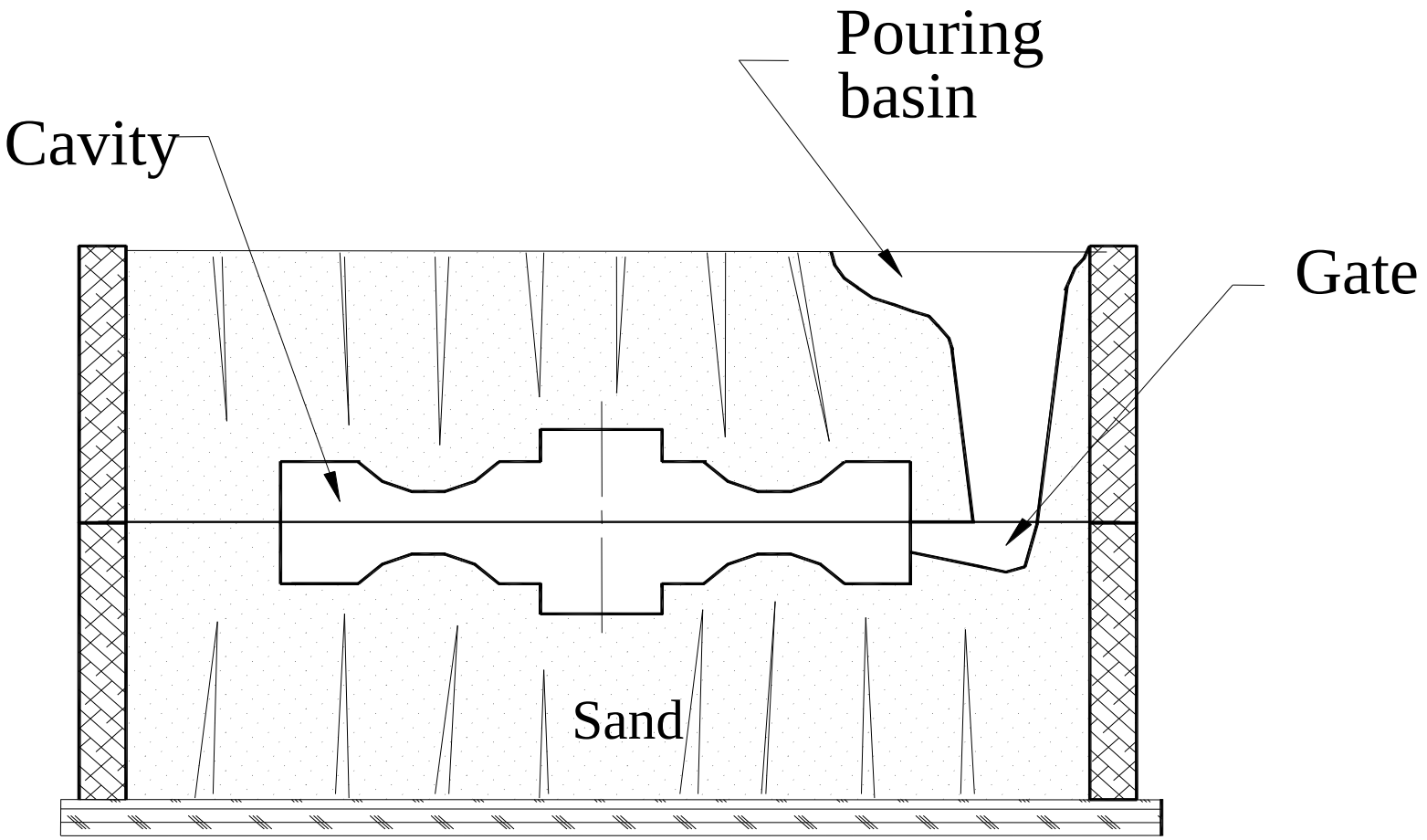
Moulding Boxes (Flasks): Rigid frames made of iron or wood to hold sand.They are usually made of two parts. The top flask is called **cope** and bottom flask is called **drag**.

Procedure for mould making





(b)



(c)

CORE

A core may be defined as a sand shape or form that makes the contour of a casting for which no provision has been made in the pattern.

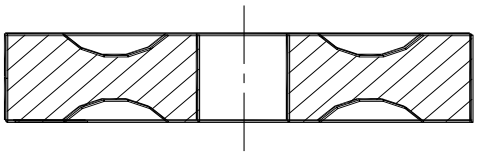
An obstruction placed and positioned in the mould.

Placed in the mould in specially created cavities called core print.

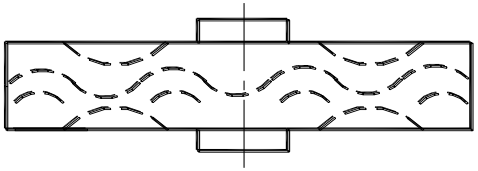
Made from sand, metal or ceramics.

Get holes or internal cavities.

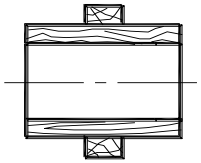
Cores



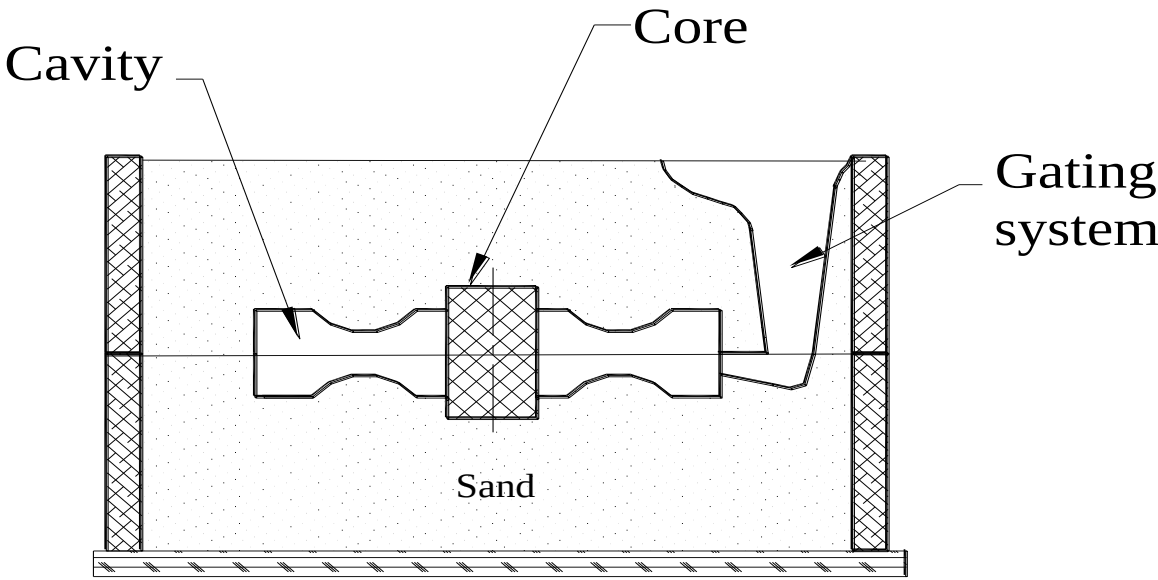
Required casting



Pattern



Core box



Sand mould in two-piece flask

Core Properties

Strong to retain the shape while handling.

Resist erosion by molten metal.

Permeable to gases.

High refractoriness.

Good surface finish to replicate it on to the casting.

STEPS IN CORE MAKING

Cores are made of clay free silica sand which is thoroughly mixed with suitable binders, water and other ingredients to produce a core mix.

The core mix is packed into a core box that contains a cavity of desired shape.

Core making has following operations:

Core sand preparation.

Core making

Core baking.

Core Sand Preparation

The core sand with additives is mixed homogenously to obtain uniform strength.

Core Making

The core sand is filled in the core box and rammed. Then it is removed from the core box. Cores can be made manually or using machines. Core box is essential for production of cores.

CORE BAKING

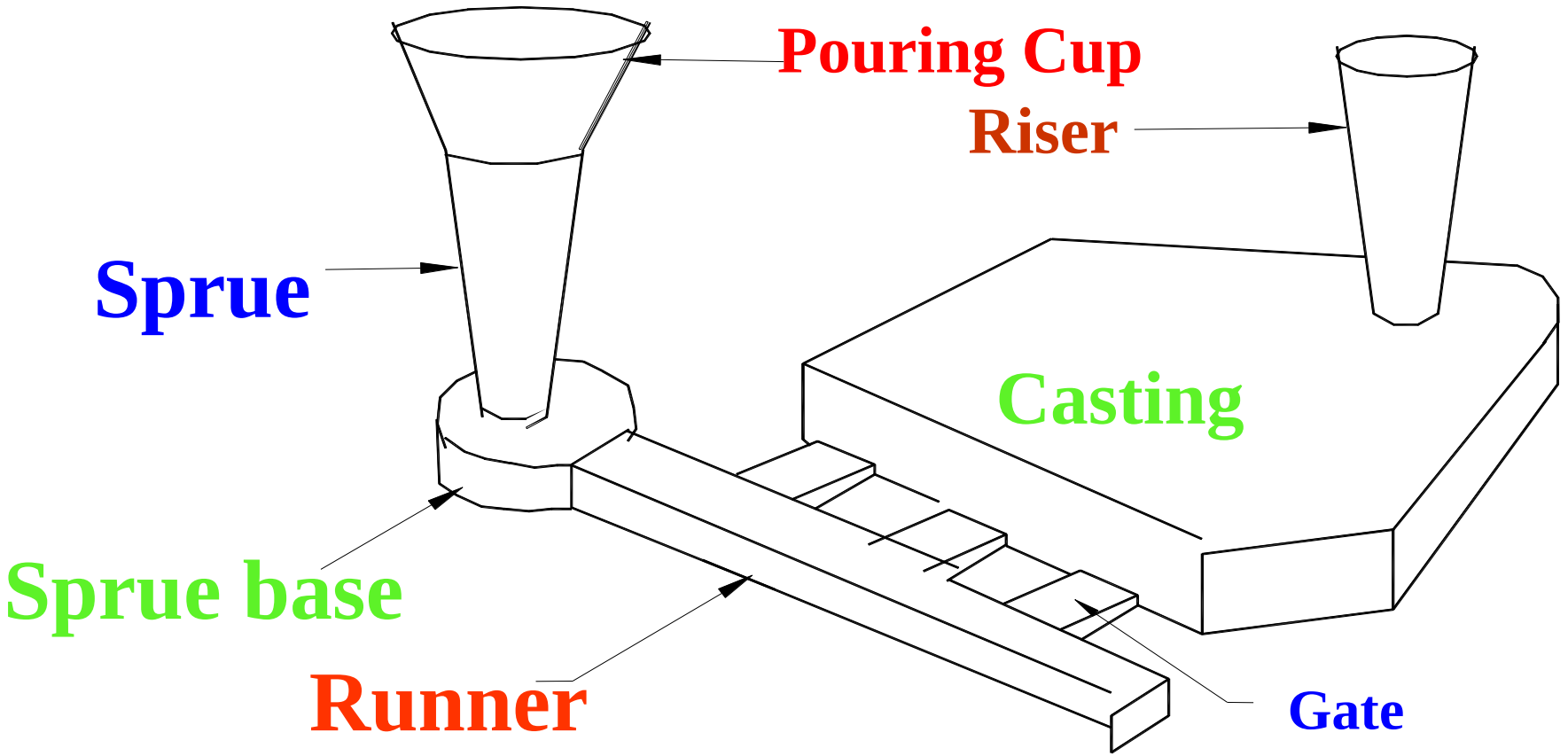
Carried out to remove moisture and to impart strength to the core.

Under-baked cores release gases and may cause many defects.

Over-baked cores may collapse too early and may break before solidification of the metal.

GATING SYSTEM

It refers to the passageway through which molten metal passes to enter mould cavity.

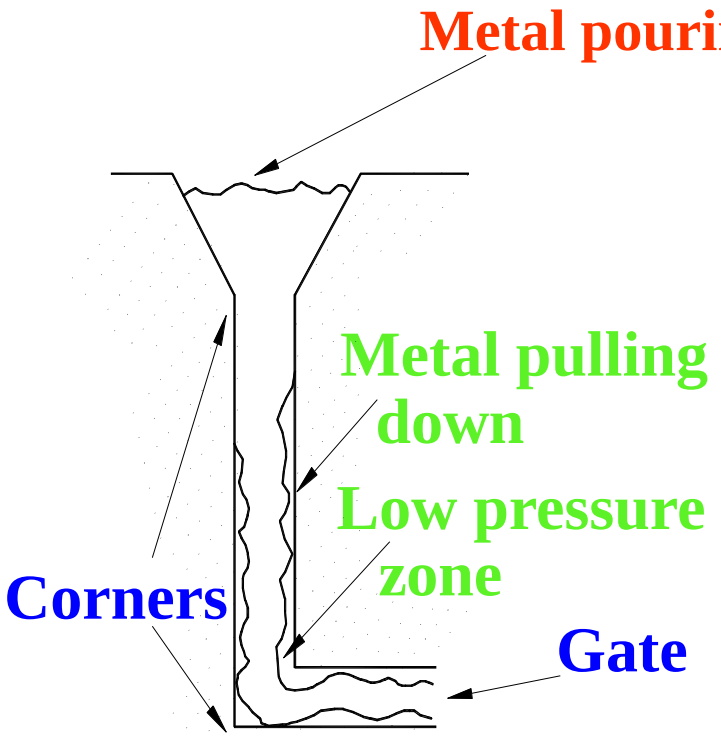


POURING CUP

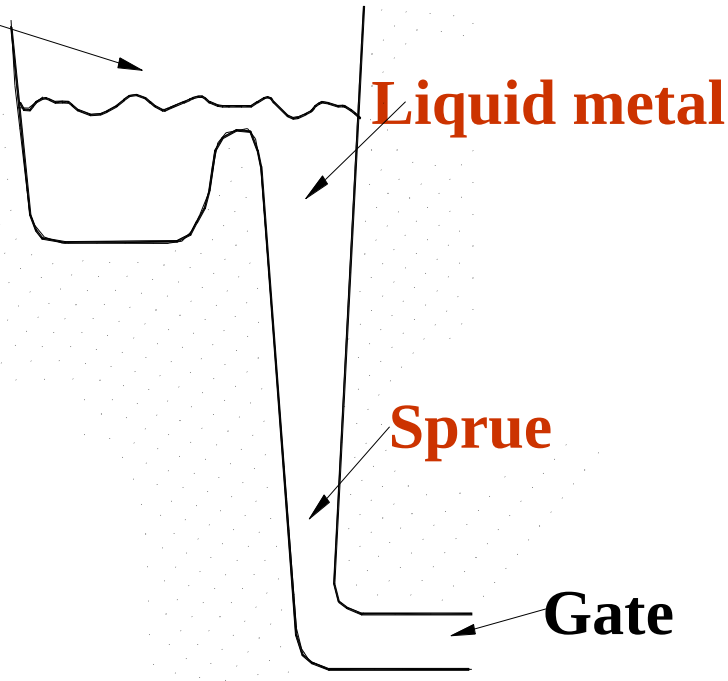
The molten metal is not directly poured into the mould cavity because it may cause mould erosion.

It acts as a reservoir from which liquid metal moves smoothly into the sprue.

SPRUE



(a) Straight sprue



(b) Tapered sprue

SPRUE

Sprue helps in feeding metal to the runner, which in turn reaches the cavity through gates.
The sprue may have either straight or taper shape.
In straight sprue, metal contracts inwards and is pulled away from sprue walls. This causes aspiration of gases and air from mould.
In a tapered sprue, the liquid metal flows down firmly in contact with walls and this reduces turbulence and eliminates aspiration.

SPRUE BASE

This is a reservoir for metal at the bottom of the sprue to reduce momentum of the molten metal.

The molten metal as it moves down the sprue gains in velocity, some of which is lost in the sprue base well by which mould erosion is reduced.

This molten metal changes direction and flows into the runners in a more uniform way.

RUNNER

It is used to take molten metal from the spure base and distribute it to the several gate passageways around the cavity.

In case of a single gate, the runner may not be required.

RISER

A riser is a passage of the sand in the cope to permit molten metal to rise above the highest point in casting after mould cavity is filled up.

It provides many advantages as follows:

1. At start it allows the air, steam and gases to go out of the mould.

2. It ensures that the mould cavity is completely filled.

3. Acts as a reservoir to feed the molten metal to the casting to compensate during solidification.

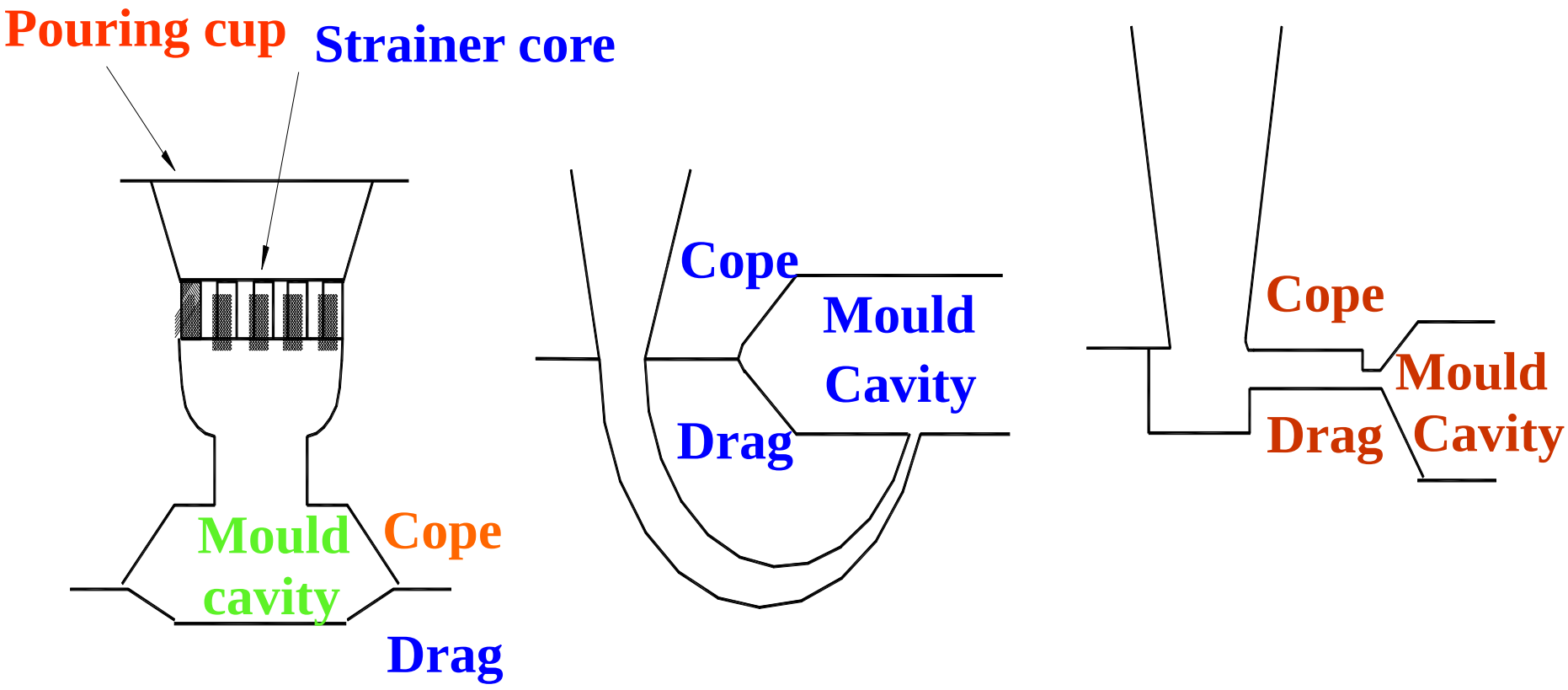
GATES

The gate is a channel which connects runner with the mould cavity and through which molten metal flows to fill the mould cavity.

Depending on the casting size and gating design, various types of gates are used in the moulds.

They are classified as Top gate, Bottom gate and Parting gate.

GATES



(a) Top gate (b) Bottom gate (c) Parting gate

TOP GATE

In this case, the molten metal flows down directly into the mould cavity.

Therefore, the hottest metal comes to rest at the top of the casting. As a result, proper temperature gradients ensures directional solidification.

The disadvantage of the top gating system is the erosion of the mould by the falling metal.

BOTTOM GATE

In this case, the molten metal flows down to the bottom of the mould cavity in the drag.

The main advantage is that the turbulence of the metal is kept at a minimum while pouring and mould erosion is prevented.

It is used for heavy castings.

The metal loose its heat as it rises in the mould cavity.

So the directional solidification is difficult to achieve.

PARTING GATE

In this type of gate, the metal enters the mould cavity at the parting plane.

It is very simple to construct and very fast to make.

It produces very satisfactory result when the drag is not deep.

This is most widely used gate in sand casting.

Directional Solidification

Stages of Contraction: The contraction of metal or volumetric shrinkage takes place in three stages: liquid, solidification and solid contraction.

Liquid Contraction: It occurs when the molten metal cools down from the pouring temperature to the temperature at which solidification starts.

Directional Solidification

Solidification Contraction:

It is that shrinkage which occurs when the change of state of metal takes place from liquid to solid.

Solid Contraction:

It is that shrinkage which occurs when the temperature falls from the end of the solidification to the room temperature.

Advantages of Casting

No restriction on type of metal or alloy.

No restriction on size of the component that can be casted.

Economically suitable for batch and mass production.

Advantages of Casting

- High energy consuming process.
- Highly labor intensive.
- Raw material requirement is quite high.
  - For producing 1 ton of steel casting about 2.2 tons of metal, 0.3 tons of facing sand and 4 tons of baking sand are needed apart from many other materials.
- More time is involved.
- High environmental pollution.

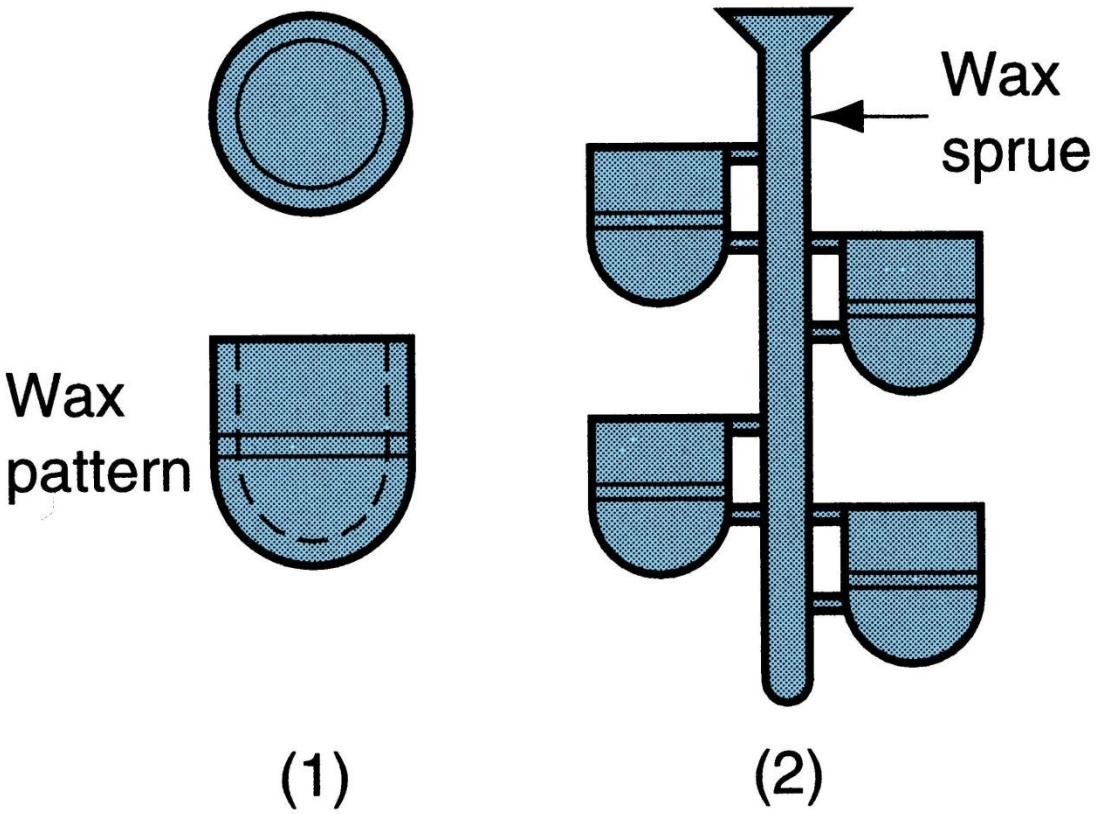
Selection of Casting Process

Quantity to be produced.
Requirement of the product in terms of surface finish, accuracy, complexity etc.
Physical properties of the material.
Process capability to meet the requirement of point 2 and 3.
Initial investment required and operational costs.
Other factors such as environmental pollution, availability of skilled operator (if required), possibility of automation.

Investment Casting (Lost Wax Process)

A pattern made of wax is coated with a refractory material to make mold, after which wax is melted away prior to pouring molten metal

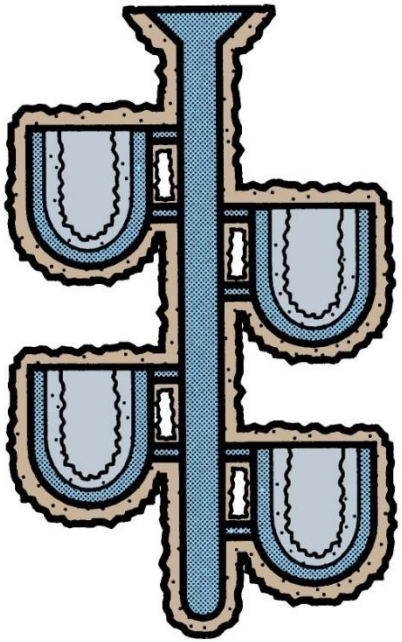
It is a precision casting process - capable of castings of high accuracy and intricate detail



Steps

1. wax patterns are produced
2. several patterns are attached to a sprue to form a pattern tree

(3)

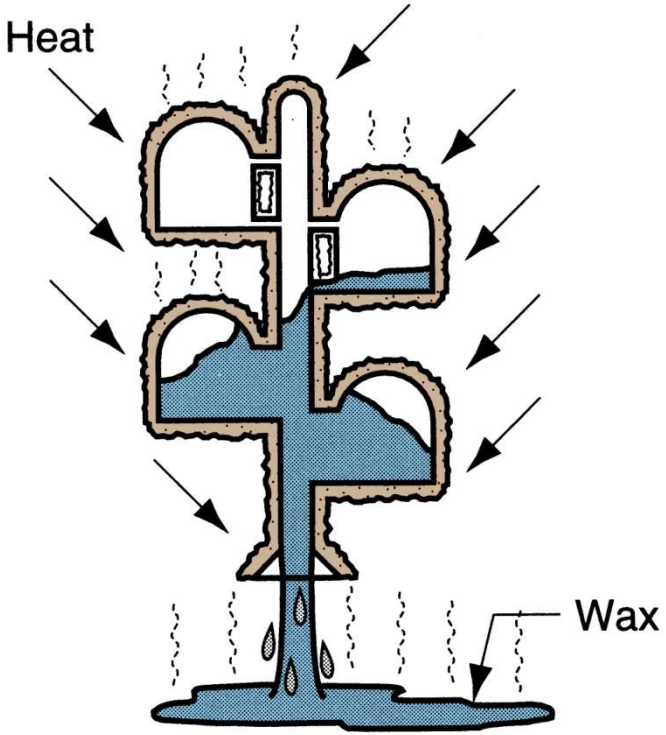


(4)

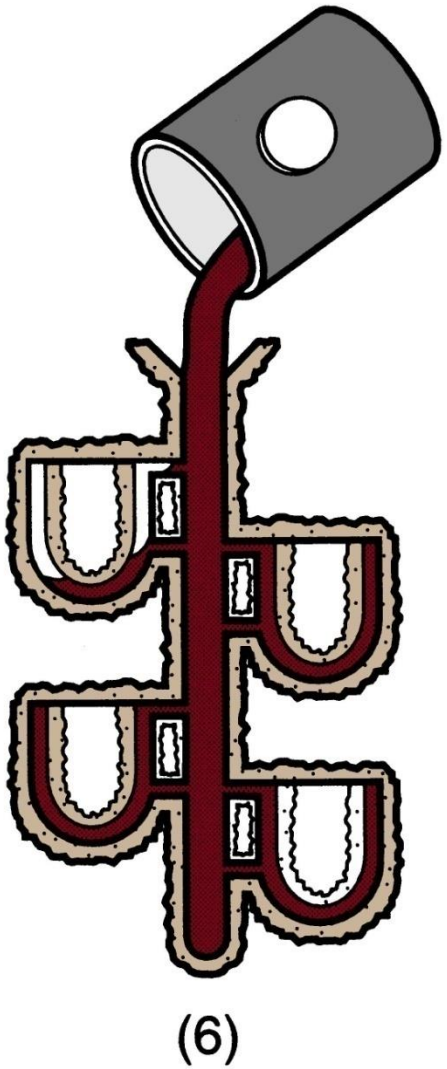
Steps :

(3) the pattern tree is coated with a thin layer of refractory material

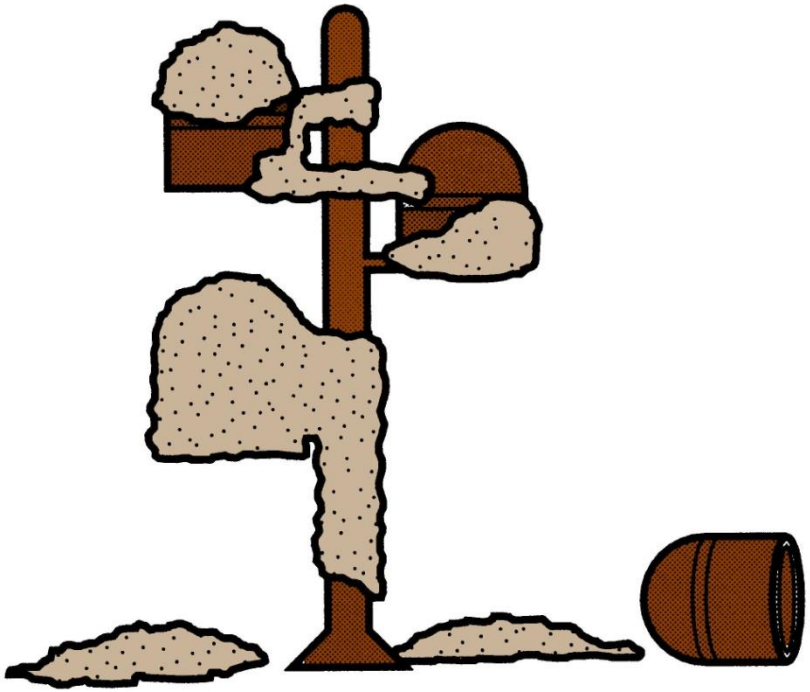
(4) the full mold is formed by covering the coated tree with sufficient refractory material to make it rigid



Step 5 :
the mold is held in an inverted position and heated to melt the wax and permit it to drip out of the cavity



Steps:
(6) the mold is preheated to a high temperature, which ensures that all contaminants are eliminated from the mold; it also permits the liquid metal to flow more easily into the detailed cavity; the molten metal is poured; it solidifies



(7)

Steps :

(7) the mold is broken away from the finished casting - parts are separated from the sprue

Advantages and Disadvantages of Investment Casting

Advantages:

Parts of great complexity and intricacy can be cast
Close dimensional control and good surface finish
Wax can usually be recovered for reuse
Additional machining is not normally required - this is a net shape process
No parting line

Advantages and Disadvantages of Investment Casting

Disadvantages:

- Many processing steps are required
- Relatively expensive process
- Size limitation, use for less than 0.5 kg
- Slow process

Applications of Investment Casting

- Milling machine cutters and tools
- Jet aircraft nozzles
- Jewellary
- Turbine blades
- Turbine Engine

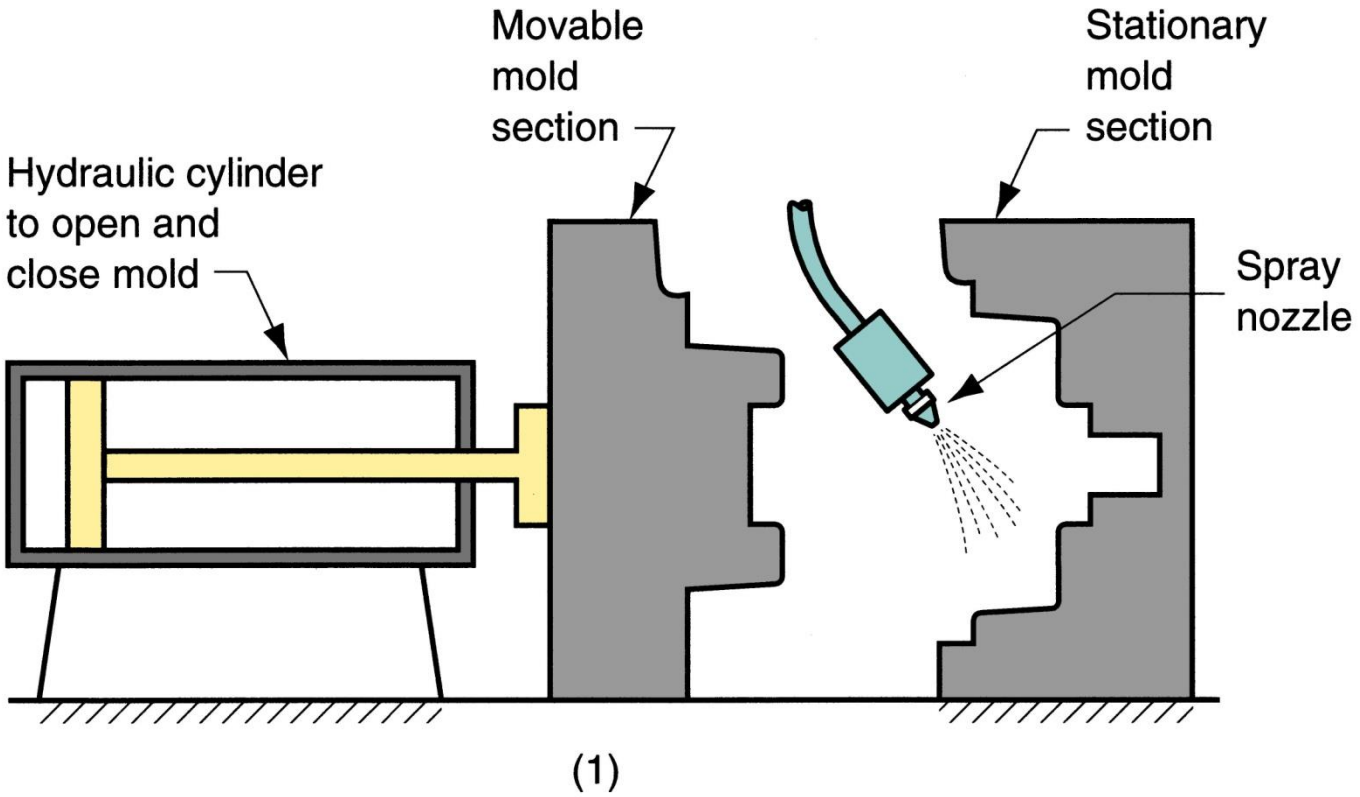
Permanent Mold Casting/ Gravity die casting

Uses a mould which is permanent i.e. mould can be reused many times before it is rebuilt.

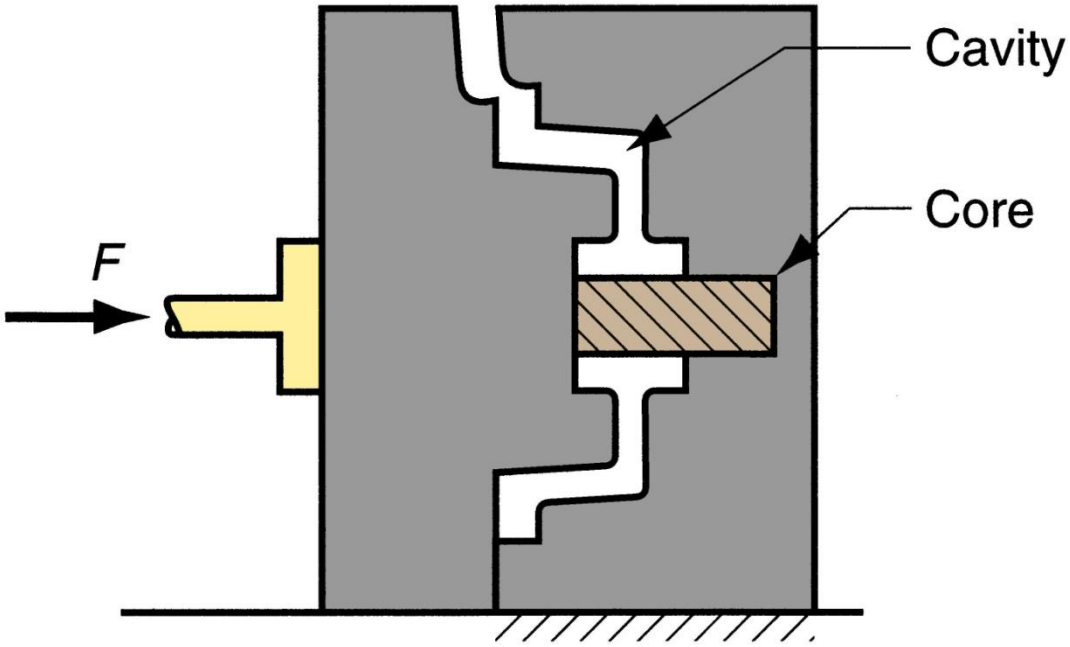
mold constructed of two sections designed for easy, precise opening and closing.

Molten metal poured under gravity action.

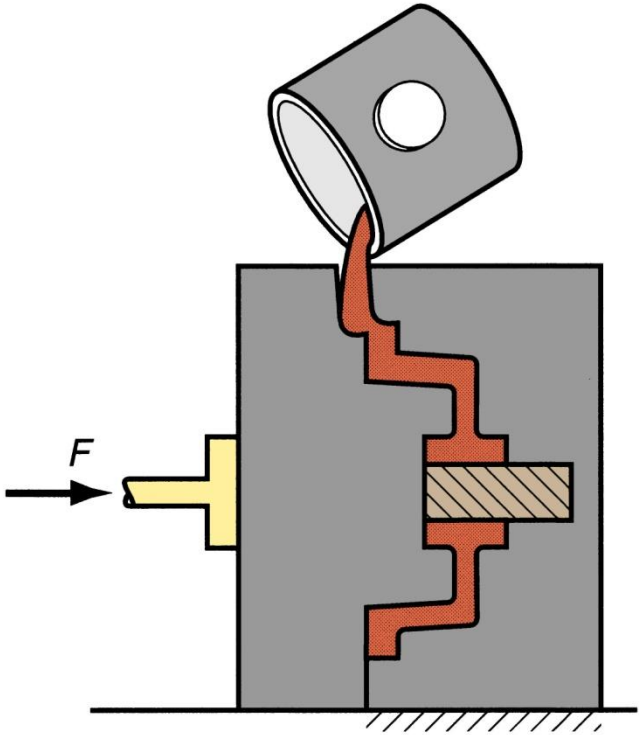
Mould made up of dense, fine grained and heat resistant metals.



Steps in permanent mold casting:
(1) mold is preheated and coated



Steps in permanent mold casting:
(2) cores (if used) are inserted and mold is closed



Steps in permanent mold casting:

(3) molten metal is poured into the mold

Advantages and Limitations of Permanent Mold Casting

Advantages:

Good dimensional control and surface finish
High production rate, so use in mass production.
mold results in a finer grain structure, so stronger castings are produced

Limitations:

Generally limited to metals of lower melting point
Complicated shapes can’t be produced.
High cost of mold
Not suitable for all metals.

Applications of Permanent Mold Casting

Due to high mold cost, process is best suited to high volume production and can be automated accordingly

Typical parts: automotive pistons, pump bodies, and certain castings for aircraft and missiles

Metals commonly cast: aluminum, magnesium, copper-base alloys, and cast iron

Die Casting/ Pressure die casting

Molten metal is forced into a permanent metal mold or die under certain pressure.

Pressure is maintained during solidification, then mold is opened and part is removed

Molds in this casting operation are called *dies*; hence the name die casting

STEPS

Closing of two halves of die.
Forcing the molten metal under pressure into die.
Holding the two halves together during pouring and solidification.
Opening the two halves and ejecting the casting.

Die Casting Machines

Two main types:

1. Hot-chamber machine
2. Cold-chamber machine

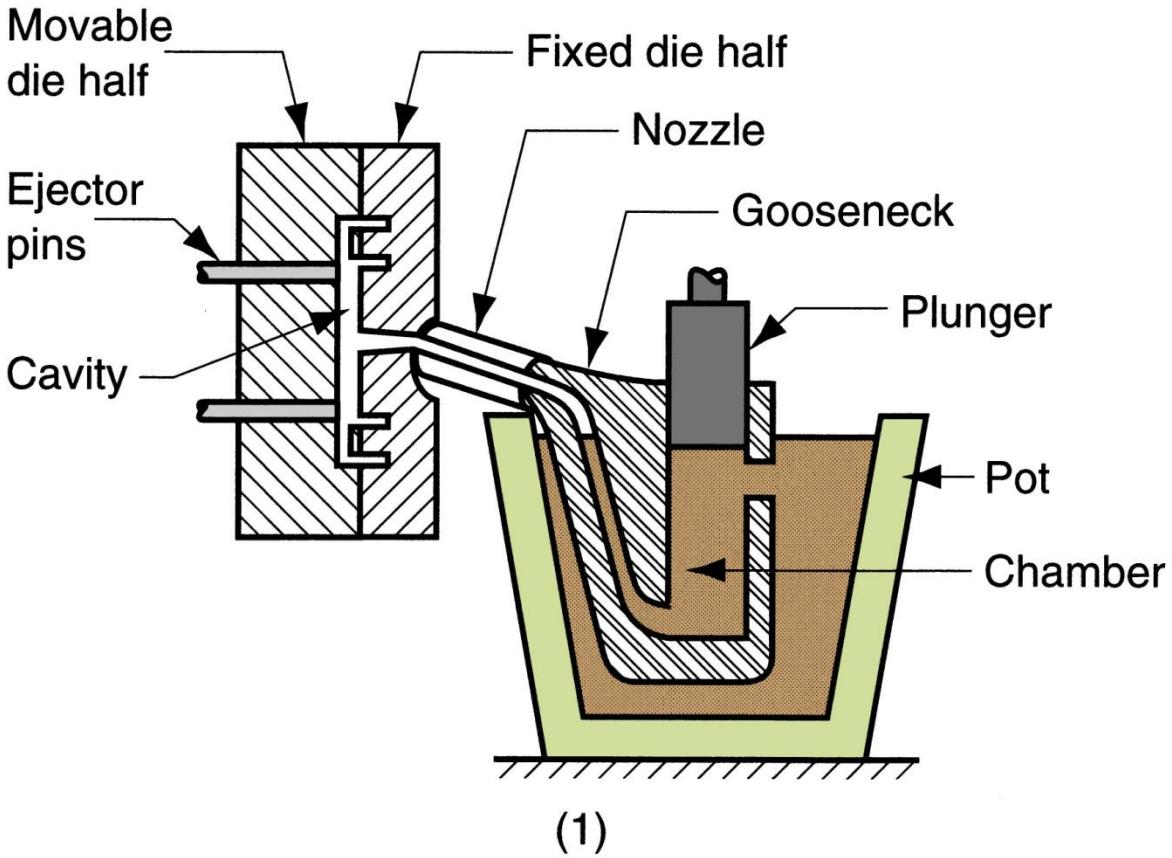
Hot-Chamber Die Casting

Metal is melted in a container, and a piston injects liquid metal under high pressure into the die

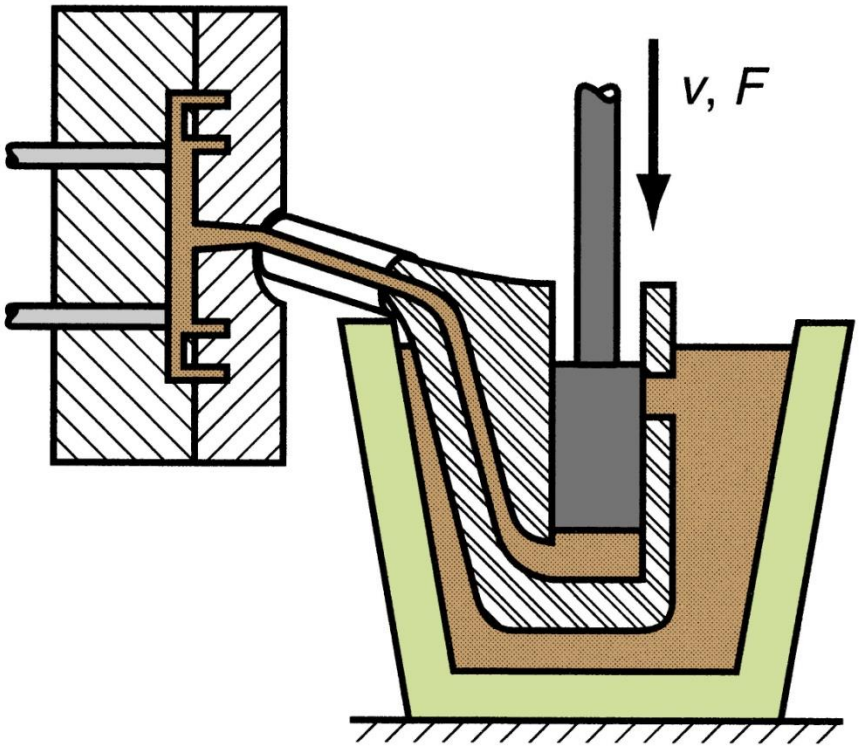
Machine is operated by a hydraulic plunger.

Applications limited to low melting-point metals that do not chemically attack plunger and other mechanical components

Casting metals: zinc, tin, lead, and magnesium



Cycle in hot-chamber casting:
(1) with die closed and plunger withdrawn, molten metal flows into the chamber



(2)

(2) plunger forces metal in chamber to flow into die, maintaining pressure during cooling and solidification

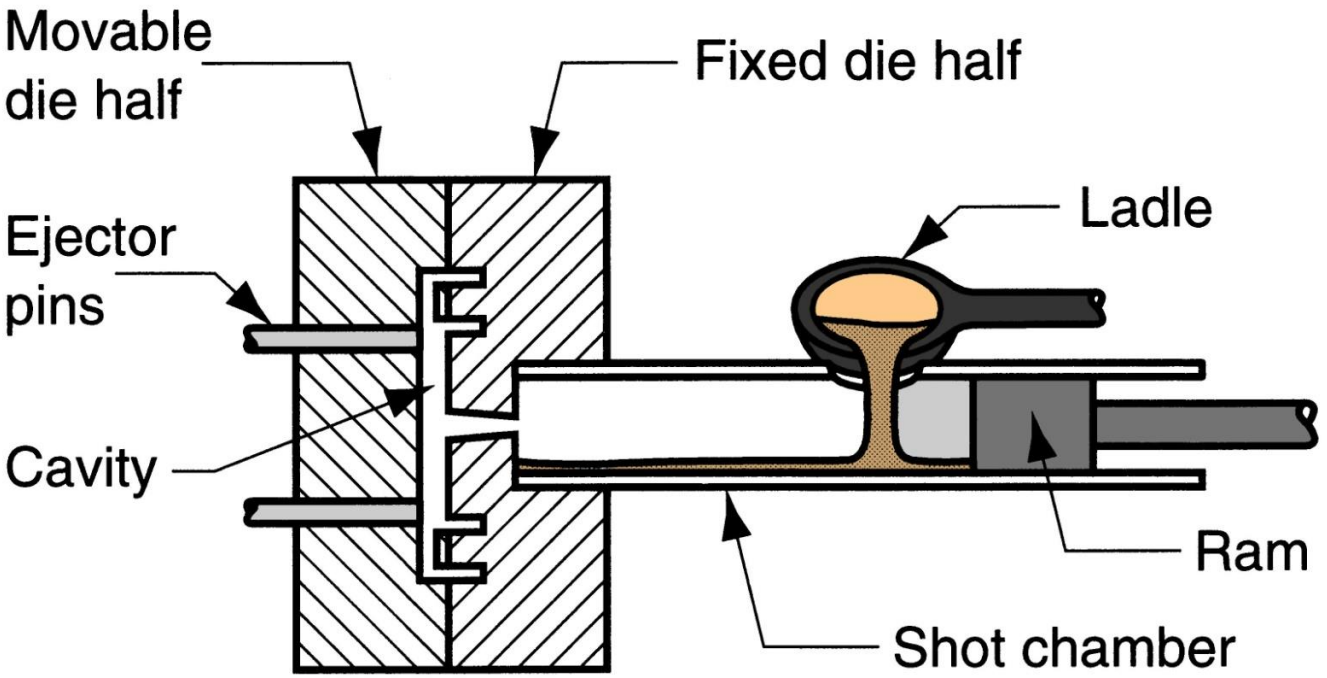
Cold-Chamber Die Casting Machine

Molten metal is poured into unheated chamber from external melting container, and a piston injects metal under high pressure into die cavity

High production but not usually as fast as hot-chamber machines because of pouring step

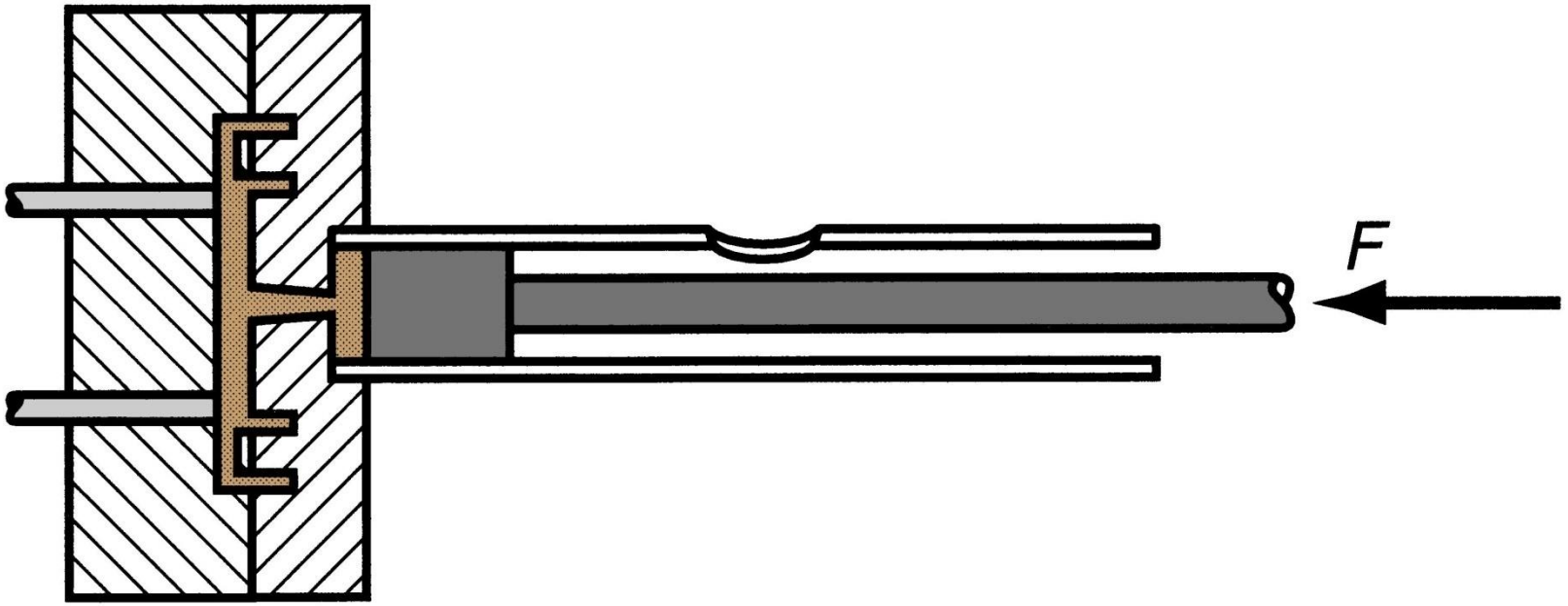
Casting metals: aluminum, brass, and magnesium alloys

Advantageous for high melting-point alloys



Cycle in cold-chamber casting:

(1) with die closed and ram withdrawn, molten metal is poured into the chamber



(2)

(2) ram forces metal to flow into die, maintaining pressure during cooling and solidification

Advantages and Limitations of Die Casting

Advantages:

- Economical for large production quantities
- Good dimensional accuracy and surface finish
- Thin sections are possible
- Rapid cooling provides small grain size and good strength to casting

Disadvantages:

- Generally limited to metals with low metal points
- Part geometry must allow removal from die cavity
- Every metal and alloy can not be cast.
- Equipments are costly

Centrifugal Casting

A group of casting processes in which the mold is rotated at high speed so centrifugal force distributes molten metal to outer regions of die cavity

The group includes:

- True centrifugal casting
- Semicentrifugal casting
- Centrifuging casting

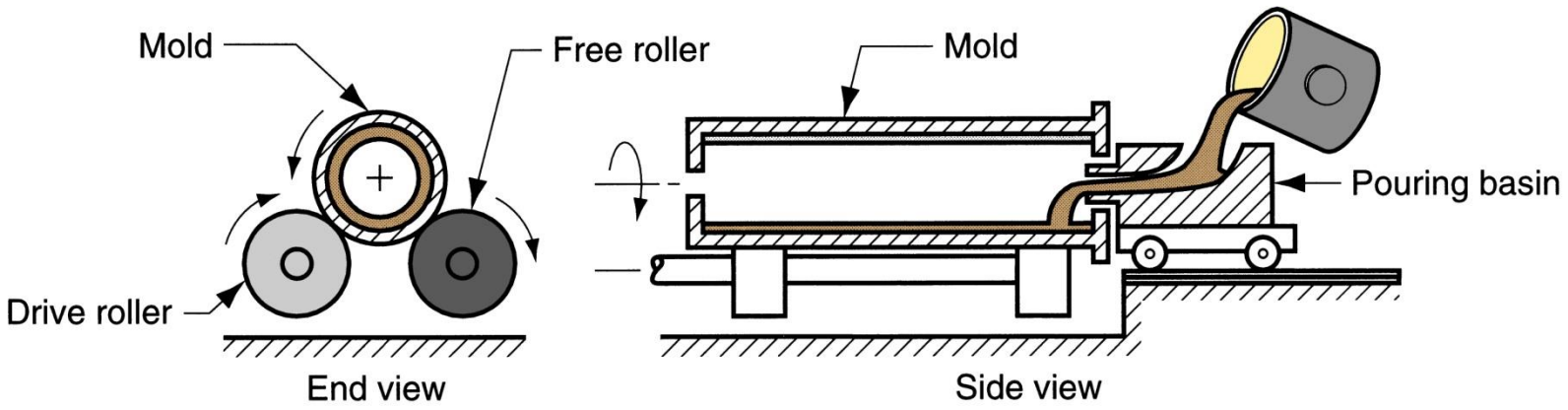
True Centrifugal Casting

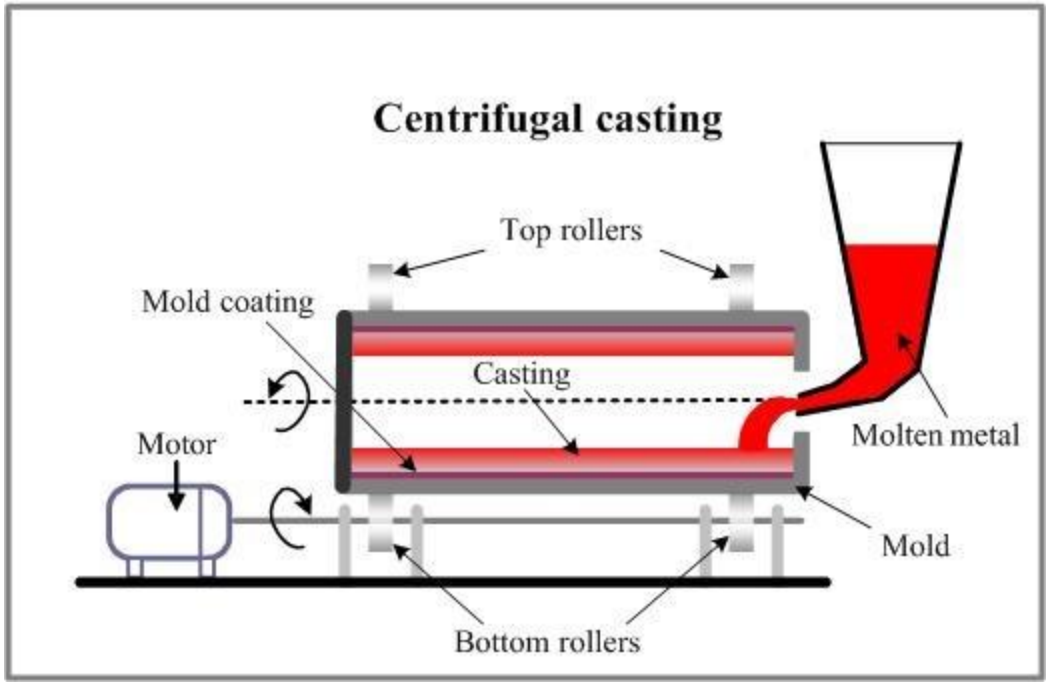
Molten metal is poured into rotating mold to produce a tubular part

Parts: pipes, tubes, bushings, and rings

Rotational axes can be either horizontal or vertical

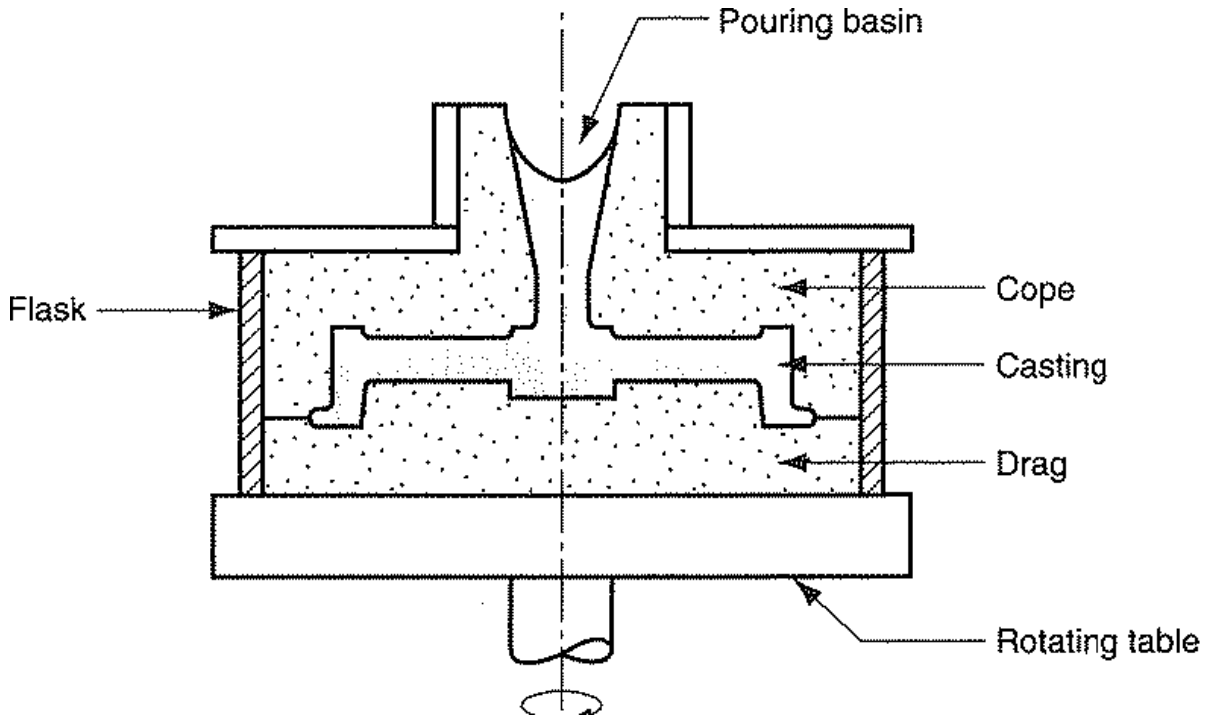
Outside shape of casting can be round, octagonal, hexagonal, etc , but inside shape is (theoretically) perfectly round, due to radially symmetric forces


Mold
Free roller
Drive roller
End view
Mold
Pouring basin
Side view

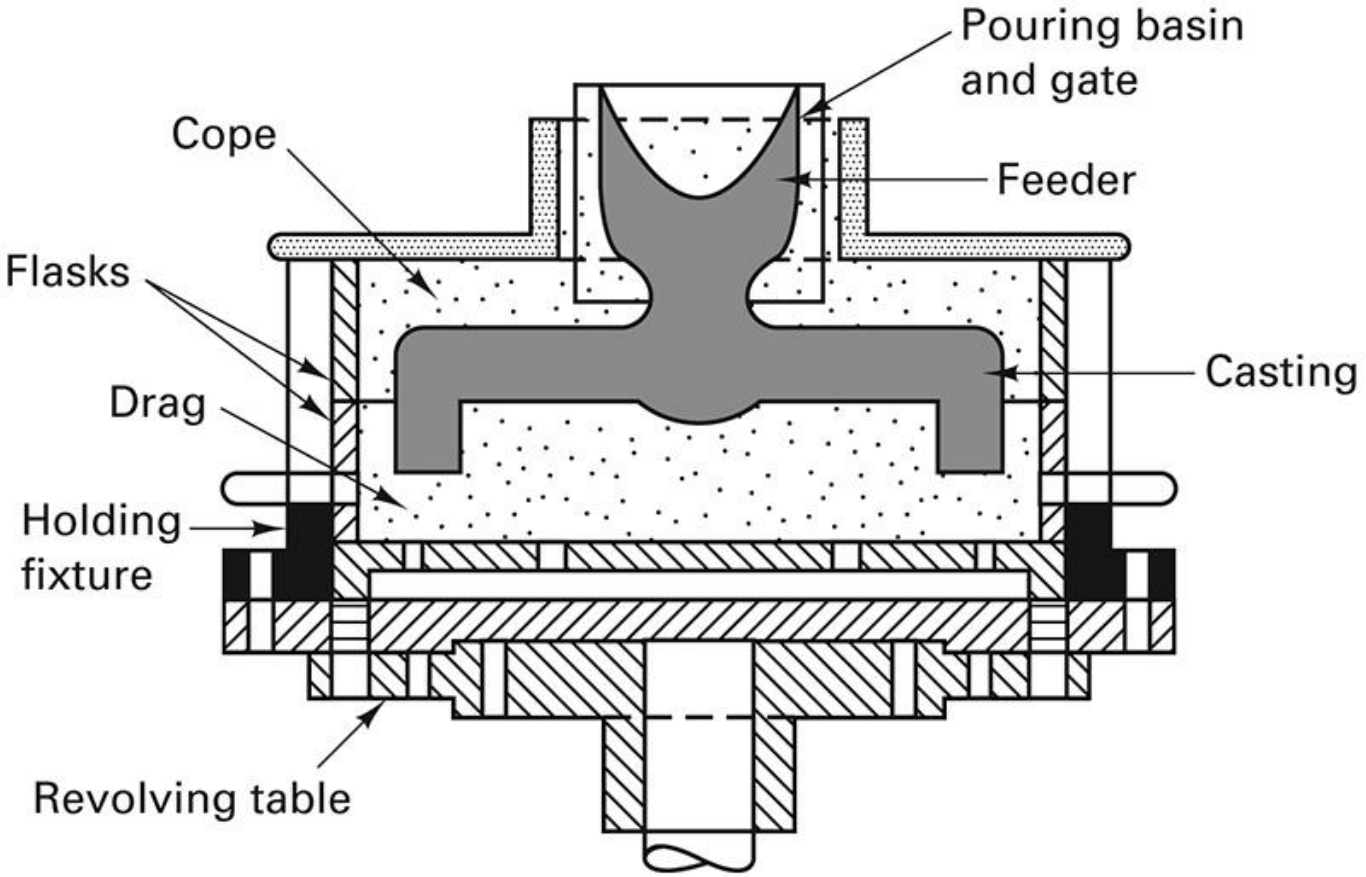

Centrifugal casting
Top rollers
Mold coating
Casting
Motor
Molten metal
Mold
Bottom rollers

Semicentrifugal Casting

Centrifugal force is used to produce solid castings rather than tubular parts
Molds are designed with risers at center to supply feed metal
Density of metal in final casting is greater in outer sections than at center of rotation
Often used on parts in which center of casting is machined away, thus eliminating the portion where quality is lowest
Examples: wheels and pulleys


Pouring basin
Flask
Cope
Casting
Drag
Rotating table

Semicentrifuging Casting

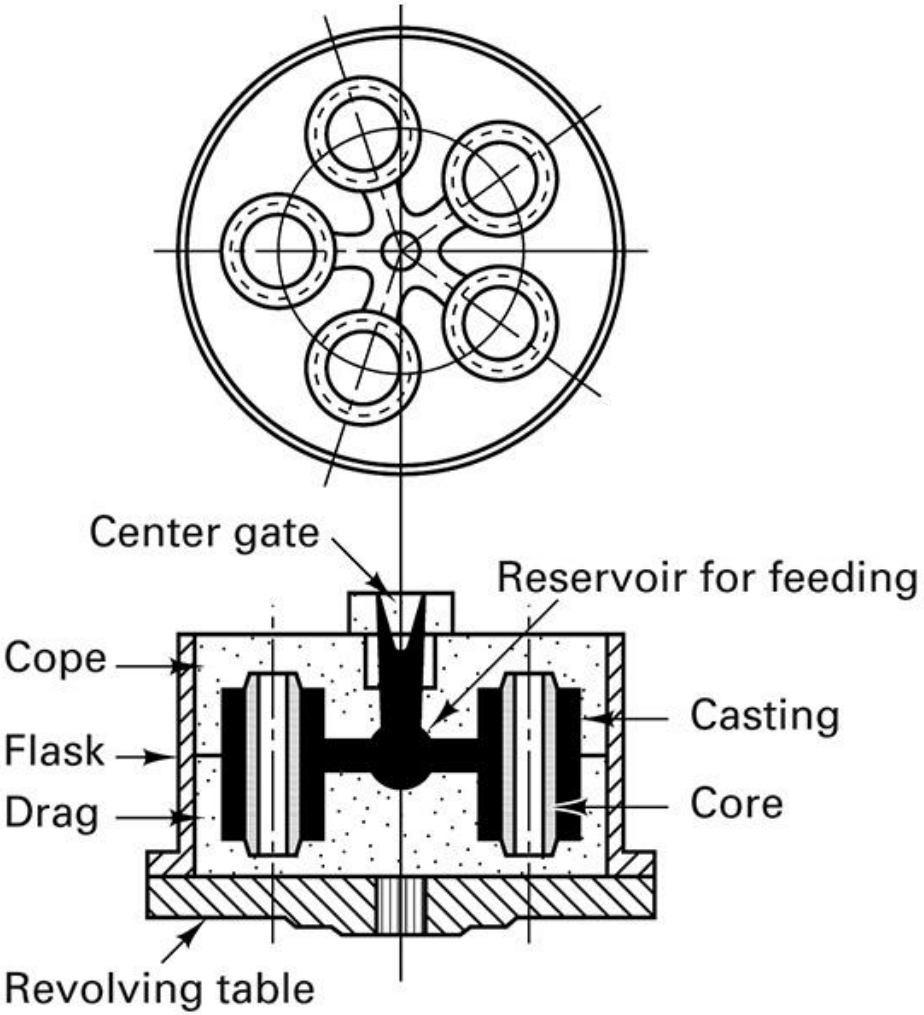


Schematic of a semicentrifugal casting process.

Centrifuge Casting

- Use centrifugal acceleration to force metal from a central pouring sprue into separate mold cavities that are offset from the axis of rotation.
- Axis of rotation of mold and casting are different
- Relatively low rotational speed
- Produce casting with thin walls and intricate shapes
- Radial symmetry of part is not required as in other centrifugal casting methods

Centrifuging Casting



Metal is poured into the central pouring sprue and spun into the various mold cavities.

Casting Quality

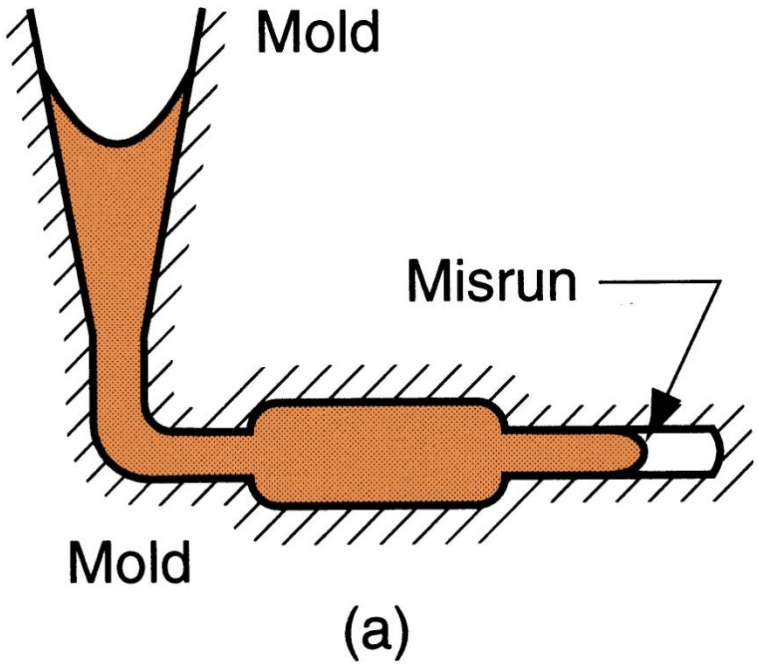
There are numerous opportunities for things to go wrong in a casting operation, resulting in quality defects in the product

The defects can be classified as follows:

- Defects common to all casting processes
- Defects related to sand casting process

Misrun

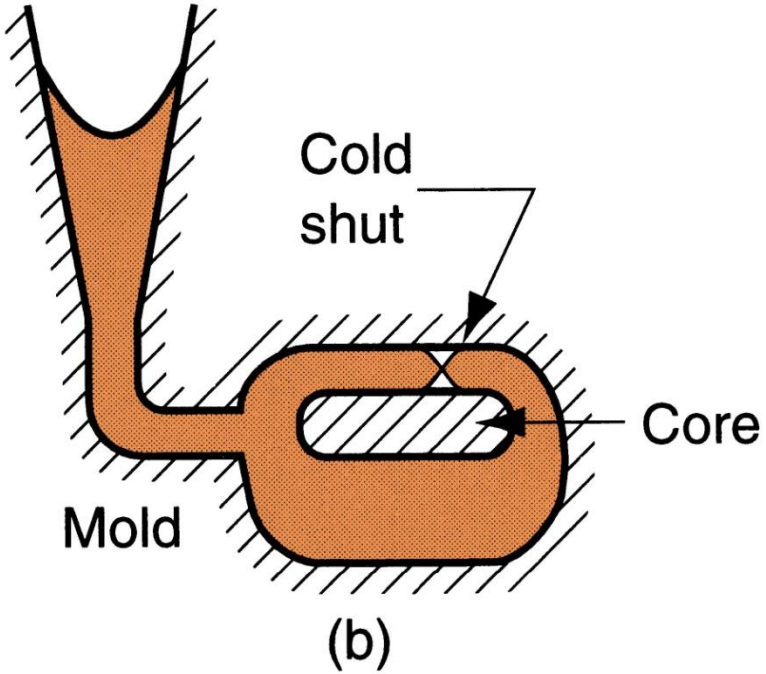
A casting that has solidified before completely filling mold cavity



Some common defects in castings: (a) misrun

Cold Shut

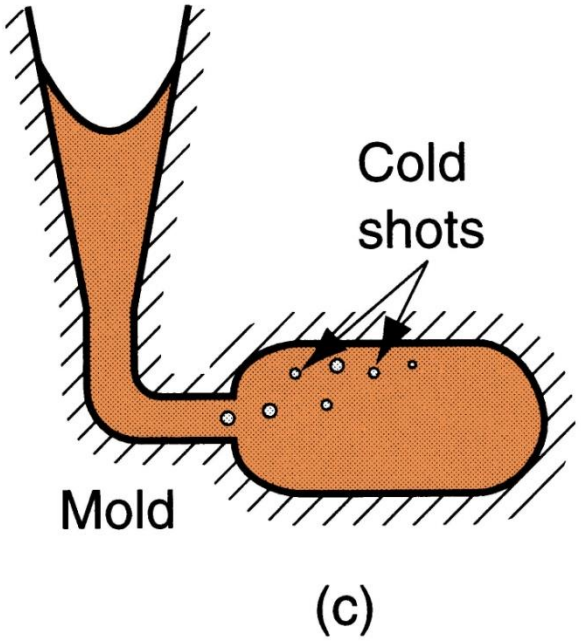
Two portions of metal flow together but there is a lack of fusion due to premature freezing



Some common defects in castings: (b) cold shut

Cold Shot

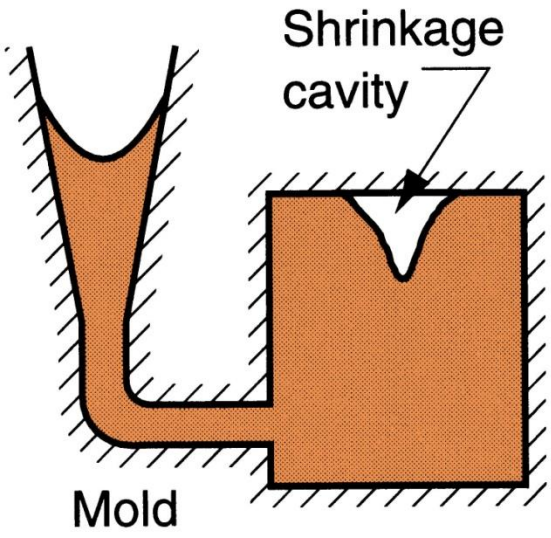
Metal splatters during pouring and solid globules form and become entrapped in casting



Some common defects in castings: (c) cold shot

Shrinkage Cavity

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

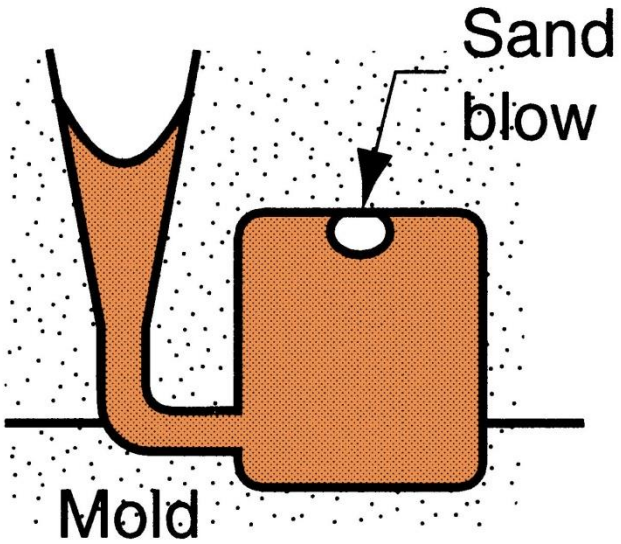


(d)

Some common defects in castings: (d) shrinkage cavity

Sand Blow

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

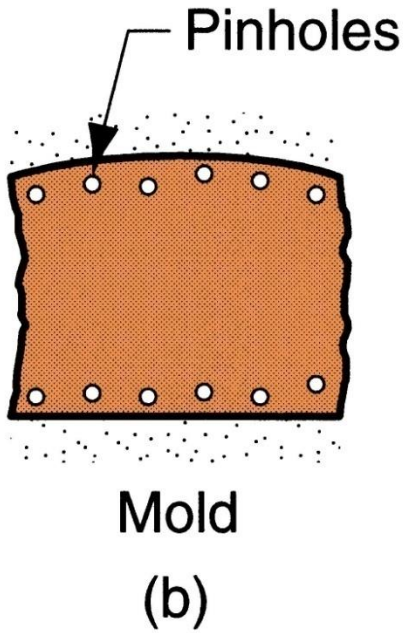


(a)

Common defects in sand castings: (a) sand blow

Pin Holes

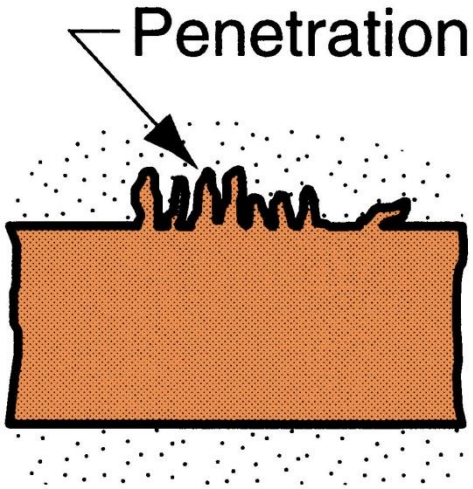
Formation of many small gas cavities at or slightly below surface of casting



Common defects in sand castings: (b) pin holes

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

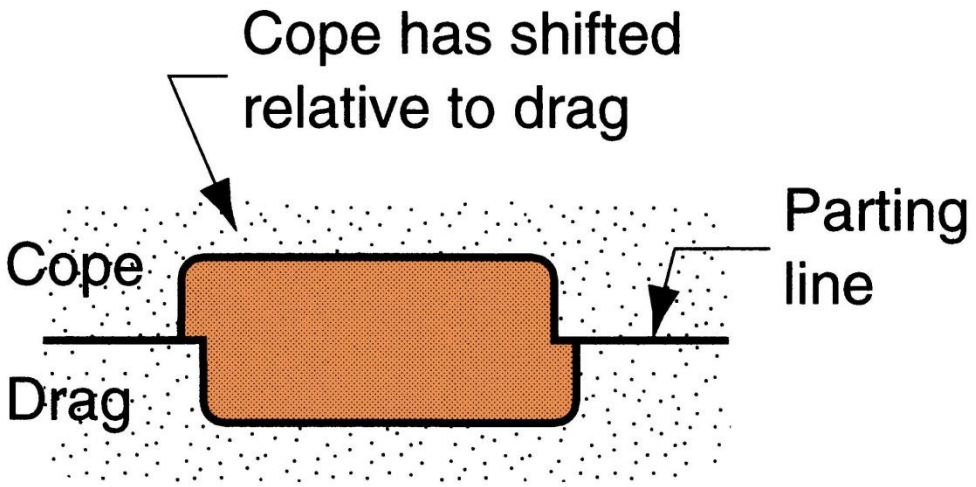


(e)

Common defects in sand castings: (e) penetration

Mold Shift

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



Common defects in sand castings: (f) mold shift

Defects in Casting

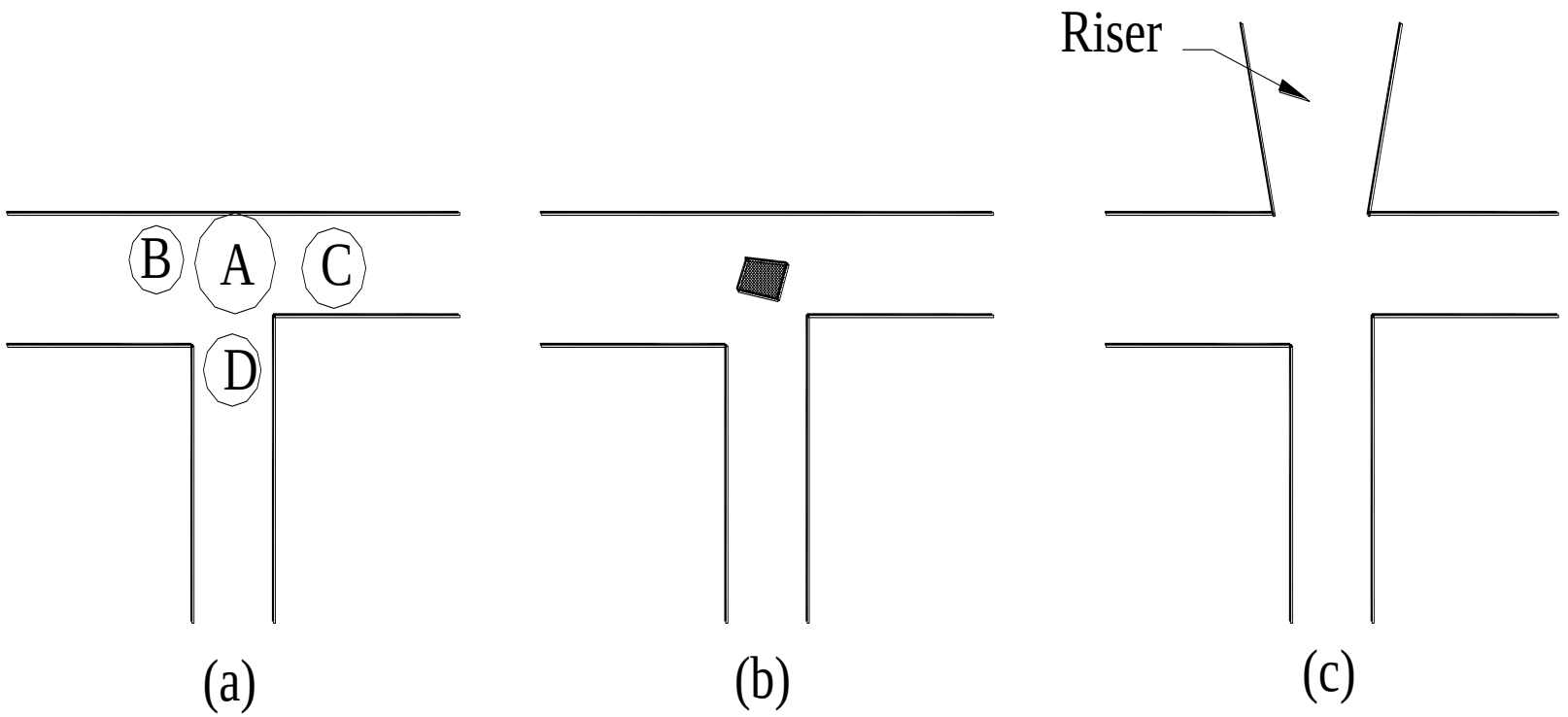
Blow Holes

Appears as small round voids opened to the casting surface. Caused by hard ramming and low permeability sands

Defects in Casting

Shrinkage Defects

Caused by inadequate feeding of molten metal.



Defects in Casting

HOT TEARS

Appears as external cracks or discontinuities on casting surface.

Caused by hard ramming, too much of shrinkage of molten metal and poor design of casting.

Defects in Casting

MISRUNS

A misrun casting is one that remains incomplete due to the failure of the metal to fill the entire mould cavity.

This can happen when the dimensions of a casting is very less or the metal temperature is too cold, so that the entire section is not filled before the metal solidifies.

Defects in Casting

COLD SHUT

Imperfect fusion of molten metal in the mould cavity.

POUR SHORT

Mould cavity is not completely filled for the want of molten material.

INCLUSIONS

Foreign material present within the metal of a casting. An inclusion may be oxides, slag, etc