# MANUFACTURING PROCESS

→ B.S. Ragnuvanshi Vol I
→ Hazare/Raja chaudhary Vol I

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2018 Manufacturing is a value addition process

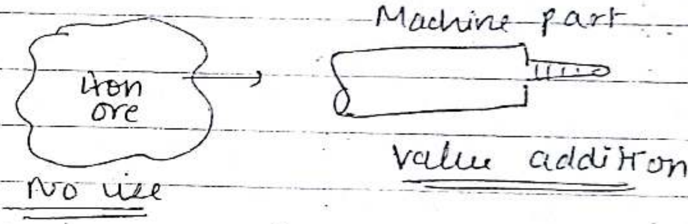
Men ↘ ↙ Money - (High utility)

Raw Material (low utility) → Processing → Finished product

↑ Material ↑ Machine

Manufacturing is a process of conversion of lower utility comp. into high utility comp. or low value comp. " " value ".

Example -




Manus + Factus
↓ Hand- or machine ↓ made

Literal meaning of manufacturing is making of goods and articles with the help of man or machine. It is the production of work pieces having defined geometric shapes.

Importance of Manufacturing -
→ National growth
→ Standard of living
→ Creation of employment

$$M.M.W = N.R \times (HE)^{Tools}$$

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MMW = Man Material Welfare
↳ Aim - improvement of standard of living

NR = Natural resources
(wind, water, sun light etc.)

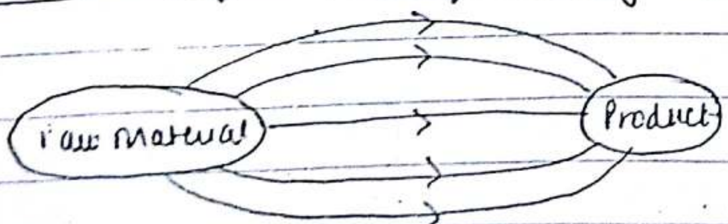
HE = Human effort
(Animal, man power)

Tools = power plant, steel plant, machinery

Technologically manufacturing is the application of physical and chemical process to alter the geometry, properties, appearance of a given starting material to make parts or products. Manufacturing also includes assembly of multiple parts to make the product.

Value addition process takes place in following fields -
1. Iron is converted into steel
2. Sand is transformed into steel
3. Petroleum is refined into plastic

2/8 Classification of manufacturing process -



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Objective -

① Min. Production Time ↓
② " " Cost ↓
③ Max. profit ↑
④ " " rate ↑

$$\text{Profit rate} = \frac{\text{Profit}}{\text{Time}}$$

⑤ Production rate high

We have broad classification of manufac-turing process is based on our objectives.

Manufacturing Process
- → Processing
  - different processes
    - casting
    - liquification. solidification
    - powder metallurgy ↓ bulb. filament
  - deformation ↳ ductile
  - turning ↳ material removal
- → Assembly

Processing -

① Shaping (Primary shaping or forming process)
- → solidification → casting
  - material in liquid state
- → deformation
  - → forging
  - ↳ extrusion
  - bending
  - solid + ductile
- → Material removal process
  - → Turning
  - → Milling
  - → drilling
  - → boring
  - → Reaming
  - solid ductile or brittle
- → Particulate processing ↓ powder form

② Property Enhancing Process ⟶

Strength, brittle, ductile

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Heat treatment (brittleness ↔ ductility vice-versa)
1. Annealing
2. Normalising
3. Quenching
4. Tempering

(3) Surface processing
- cleaning
- coating
- deposition

Assembly -
(1) Permanent joining
- welding
- brazing
- soldering
- adhesive bonding

(2) Temporary joining
- fastener
- nut bolt & screw

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PROPERTIES OF ENGINEERING MATERIAL:

* Properties are - characteristics of material of a system.
Materials which are used during engg. process are called engg. materials.
eg. different types of steel etc

Area under the curve = youngs modulus

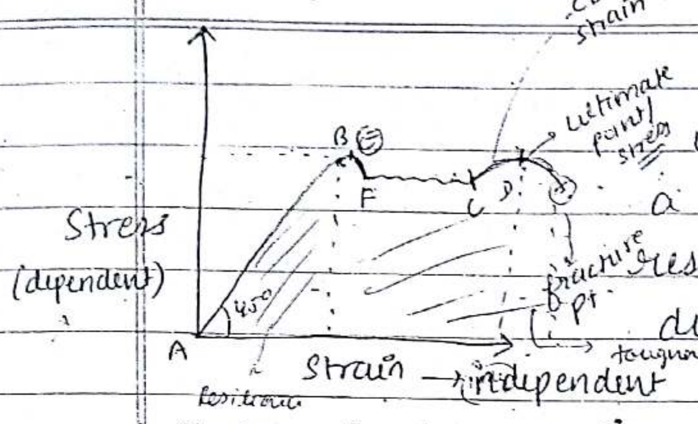
Stress
↳ tensor
(more than one dirⁿ)

Pressure = normal force per unit area
↓
scalar

Moment → bending ability
of
Inertia → internal resistance

$\tan 45° = \frac{y}{x}$
$\Rightarrow x = y$

vice-versa)




Stress is a type of internal resistance of a material. It will resist deformation caused due to external force.

→ Stress is the internal resistance per unit area offered by a material when material is subjected to deformation.

F = lower yield pt.
B = elastic limit
E = upper yield pt.

Q why stress is taken on y-axis & strain on x-axis?

→ The sum total of all the elementary inter-atomic forces or internal resistances which the material is called upon to exert to counteract the applied load is called stress and resultant deformation expressed as a fractional change in dimension is called strain.

→ Stress is a tensor quantity (more than one direction) 9 different dirⁿs

→ Pressure is normal force per unit area.

→ It is scalar.

stress causes strain

→ ∴ ~~strain~~ stress is the root cause of ~~strain~~ strain.

Strain hardening occurs due to dislocation and multiplication of end. (difficult to deform)

AB = Proportional limit

FC = yield plateau

TERIAL:

aterial

engg.

rials.

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## * CLASSIFICATION OF MANUFACTURING PROCESS:

(1) Primary Shaping or Forming Process
- manufacturing of a solid body from molten / gaseous / amorphous material - cohesion
- casting, powder metallurgy, plastic technology

(2) Deforming Process
- deformed and displaced - compression, tension, shear or combined stress
- forging, extrusion, rolling, sheet metal working, rotatory swagging, thread rolling, explosive forming, electromagnetic forming

forming processes

(3) Machining / Removing Process
- generate surface reqd. by providing suitable relative motions b/w workpiece & tool - material removed from unwanted regions
- Turning, drilling, milling, grinding, EDM, ECM, shaping and planing, ultrasonic machining

(4) Joining Process
- Pressure welding, diffusion welding, brazing, resistance welding, soldering

(5) Surface Finishing Process
- Plastic coating, metallic coating, organic finishes, inorganic finishes,

anodizing, buffing, honing, tumbling, electro-plating, lapping, sanding

(6) Material Properties Modification Process
- Heat and surface treatment, annealing, stress relieving

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Tensile test of mild steel (low carbon steel) - gives the graph.

→ Strength - It is the ability of a material to resist rupture, deformation or external force. There are different types of strength ⇒ It depends upon types of loading.

Away from the object

$F_2 \leftarrow \boxed{\text{Tensile}} \rightarrow F_1$

$F_2 \rightarrow \boxed{\text{compressive}} \leftarrow F_1$ ~~Towards the object~~

half arrow (force acting tangentially)

$\boxed{\text{Shear}}$ equal & opp. forces acting tangentially on a surface is called shear.

→ Ability of material to resist the external load causing tensile stress without rupture is called tensile strength.

→ The ability of material to resist external

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load that possesses compressive stress without rupture is called compressive strength.

→ The ability of material to resist external force causing shear stress without rupture is called shear strength.

DUCTILITY:

It is the property of material to convert into thin wires (tensile).

- Percentage elongation upto a ~~rupture~~ fracture point.
- It is the property of a material by virtue of which a metal bar can be converted into thin wire through tensile force.
- Those materials are ductile which undergoes large deformation after elastic limit before fracture point.

If deformation is less than 5%, then material is brittle and if deformation is more than 5% then material is ductile.

- %age elongation is more than 5% for ductile materials

IMP - eg. mild steel requires less amt. of force to deform.

driver | produces energy

driven | recieves energy

Stiffness is resistance of a material to elastic deformation.

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- eg. copper, gold, silver, aluminium

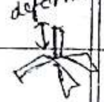
~~On the basis of ductility.~~

It is also known as index of forming process. Larger the %age elongation more will be the ductility.

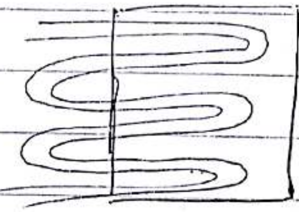
28/8 ~~PROPERTIES OF~~

CREEP:

fan deformation



- homogeneous mixture eg. fan
- same amount of load attached causing deformation in shaft under various temp. conditions for a long time period



FATIGUE:

(twisting turning)



eg. flywheel

clockwise & anticlockwise

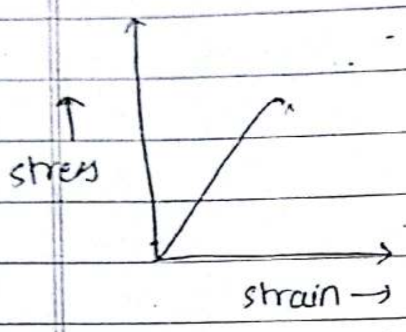
TOUGHNESS:

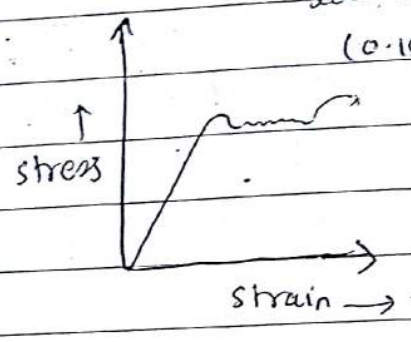
Before failure, how much work can you take from that material

both compatible with each
thermal expansion
same (mild steel & concrete)
→ construction
used at very large scale

Ductile (mild steel)
↓
low carbon steel
(0.15 to .3% C)

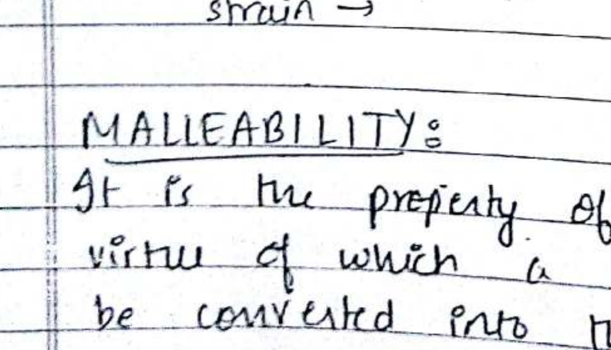
## BRITTLE:




- breaks immediately after the elastic limit
- If the %age elongation is less than 5%, the material is considered as brittle material.
- are those metals which undergoes fracture immediately after the elastic limit

eg. Rubber (also called elastomer)
↓




## MALLEABILITY:

It is the property of a material by virtue of which a metal bar can be converted into thin sheet of negligible thickness by compressive force other.

~~✱ Not ductile materials~~

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| Ductility | Malleability |
| --- | --- |
| → thin wire using tensile force (definition) | thin sheets using compressive force (definition) |
| → Temp inc., ductility ↓es | T ↑es, malleability ↑es |
| → tensile force is applied to deform the material. | compressive force is applied to deform the material. |
| → All malleable are not ductile | All ductile materials are malleable. |

ELASTICITY:

It is the ability of a material to regain its original shape & size after deformation when external force is removed.

HARDNESS: ~~(indicates strength)~~

It is the ability of a material to resist scratches and wear.

It is also defined as resistance to permanent deformation caused by plastic deformation.

eg. high carbon steel is harder than mild steel so it is able to cut the mild steel.

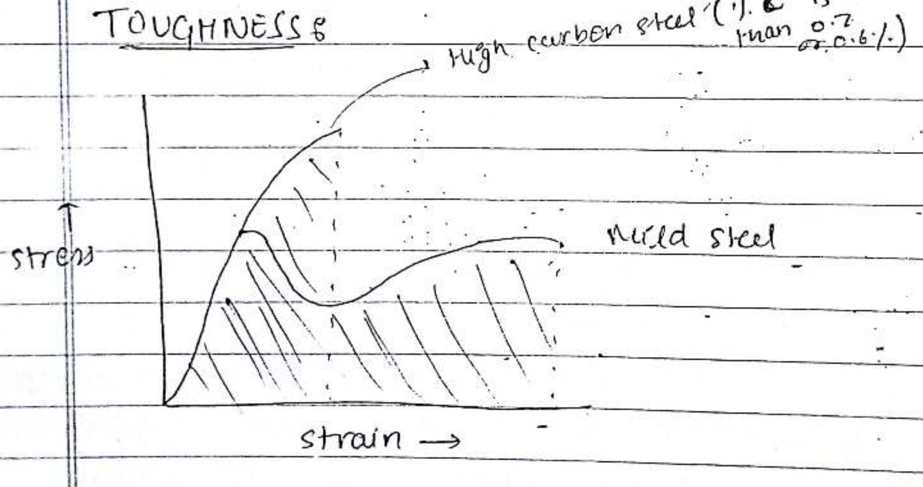
MODULUS OF ELASTICITY:

$$E = \frac{\text{stress}}{\text{strain}} = \frac{\sigma}{\epsilon}$$

It is the ratio of stress to strain in

elastic region ~~known as elasticity~~.
Higher the E value, higher is the load required to stretch the specimen to the same extent and thus stiffer the material
Stiffness depends on E.
eg. compare the stiffness of piece of metal with that of piece of rubber or plastic when they are stretched with same amt. of force.

TOUGHNESS:




Toughness of mild steel is more than that of high carbon steel
High carbon steel has more hardness than mild steel.
It is the ability of a material to absorb energy in plastic range before fracture. It represents the work done on a material per

unit vol.
It is the total energy which can be stored in given vol. of metal upto a fracture stage.

Area under the stress-strain curve measures the toughness.

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PLASTICITY:

It is the reverse of elasticity. It is essential in the forming process. It is expressed by permanent deformation.

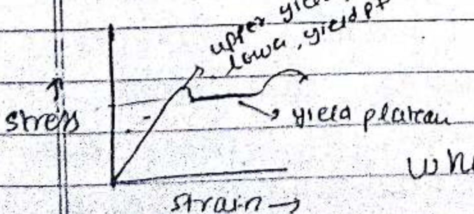
CREEP:

- occurs at elevated temp.
- condition for failure
- slow & progressive deformation at constant stress with passage of time is known as creep
- Three stages -
  1. Primary
  2. Secondary
  3. Tertiary

YIELD POINT:

require more stress → upper yield pt.

less stress → lower yield pt.




It is a condition at which stress is constant

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and strain varies. It occurs due to slipage of carbon atom. At last we have ultimate point & ultimate strength.

It is the max. stress offered by a material just before fracture point when the material is subjected to deform.

HEAT TREATMENT:

The control of material property can be also achieved without addition of other elements. This is done by subjecting a material to a control cycle of heating and cooling.

1. Annealing - The objective is as follows -
   - Alteration of ductility and toughness
   - Induction of softness
   - Refinement of grain structure
   - Removal of gases and stresses

Process - consists of heating to a suitable temp. (beyond critical temp), maintaining this temp for a definite period of time, allow the complete transformation followed

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by slow cooling in furnace.

② Normalising
- similar to annealing
- here the specimen is heated beyond the critical temp and is cooled still in air rather than in furnace.
∴ the rate of cooling gets ↑'ed. and thus material will be slight hard as well as loss of ductility unlike in annealing.
- This process improves strength and machineability.

③ Quenching
The objective of quenching is to produce martensite. It is the state of steel (steam) ~~steel~~
It consists of heating the component to the critical temp. and allow it to cool in water. It ↑'es hardness and wear resistance

④ Tempering
It consists of re-heating the quenched component to a temp. below to the transformation range followed by cooling at desired rate. This process hardens the steel with reduction in strength it adds toughness &

ductility.

(5) Case hardening -
In this process, hardness is normally required only at the surface of specimen. Alloying of the whole specimen is not required.

> Applications -
→ Gear teeth
→ Automotive clutch
→ Bearing - It is useful for improving resistance to surface identation fatigue, abrasion

Purposes of heat treatment -
→ Improves machinability
→ relieve internal stresses
→ improves mechanical properties such as ductility, strength, hardness, toughness etc.
→ change the grain size
→ ↑ resistance to heat & corrosion
→ Modify electrical & magnetic properties
→ change chemical composition.
→ remove gases.

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$\rightarrow NH_3$
also nitriding, cyaniding

Carbürizing (Type of case hardening)
The specimen is heated beyond the upper critical temp. in a sealed container having atmosphere of carbon, the heating is contd. for 4-10 hours depending upon the depth of penetration, as a result carbon diffused into the surface layer and making the surface harder.

Nitriding > cyaniding > carborizing
$\xrightarrow{\hspace{3em}}$
↓ing hardness

ENGINEERING MATERIALS:

- Ferrous
- Non-ferrous
- Polymer
- Ceramic
- Composite

Ferrous :- Iron is chief constituent
- → major amount

(1) Plain carbon steel = (%age of C - 0.05% to 2%) - It is an alloy of carbon, silicon, manganese, sulphur and phosphorus

(2) Dead mild steel = (%age of C less than 0.15%) - It is used in chains, rivets

axle - bending
shaft - bending + relative motion giving torque

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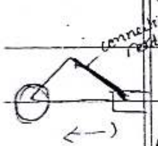
seam, (leak proof joint - requires more ductility) welded pipe

(3) Low carbon steel (mild steel) - used at very large scale for industrial purposes, %age of C ranges from 0.15 to 0.3%. It is widely used in different fields because it has good strength, weldability, deformability and good thermal expansion with concrete.
screws, nuts, bolts, gear, shaft

(4) Medium carbon steel (% C ranges from 0.3 to 0.7%) - used in connecting rods, axle, shaft.




(5) High carbon steel (carbon content is beyond 0.7%) - wire ropes, drop hammer, hacksaw blade, hammer, punches, cold chisel.

most hard due to high carbon content

(6) Stainless (no corrosion) steel (18/8, 18% - chromium, 8% - Ni) - Nickel is used to stabilize the phase which ↑'es toughness. Chromium combines with $O_2$ to form $Cr_2O_3$

It is called stainless ∵ in presence of oxygen, it develops thin, hard, adherent film of chromium oxide which protects the material from corrosion. It has high strength, toughness and good resistance to corrosion. It is used in surgical

↑ing carbon content → ↑ing hardness → (← interstitial - carbon site) ↓ing ductility

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instruments, steel ruler, cooking utensils.

(7) Black Iron (% C - 2.2% to 2.8%) - sheet used in sheet metal before coating

(8) Wrought Iron :- It is the purest form of iron containing 99.9% of iron. It is obtained by remelting of pig iron. It is tough, malleable, ductile, easily forged. It cannot be melted while heating it becomes soft enough to take any shape. It is non-corrosive and able to withstand shock load. App. - coupling of trains (crane hooks etc.)

(9) Cast Iron - better fluidity (∵ of less mushy zone)
(% C - 2 to 4%)
widely used in casting process

$$\text{fluidity} \propto \frac{1}{\text{mushy zone}}$$

mushy zone is a combination of solid and liquid called paste

It is an alloy of carbon (2.1 to 4%), silicon (1 to 3%), manganese (0.15 to 1%), sulphur (0.03 to 0.25%), phosphorus (0.05 to 1%)

cast iron → good absorption of vibrations

Tungsten → bulb filament

Tung + sten
↓ ↓
heavy stone

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cast iron is an alloy containing manganese (0.15 to 1%), sulphur (0.03 - 0.25%), carbon (2.1 to 4%), silicon (1 to 3%).
It is widely used for machine body due to its good damping property (ability to withstand vibration developed at higher speed). It is used at large scale for casting purpose due to its better fluidity (less mushy zone)

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Different types of cast iron -
(1) Grey - colour is grey
(2)
(3)

NON - FERROUS MATERIALS:
Iron is not the chief constituent.
In non - ferrous material, iron is not a chief constituent. It is found in very less amount depending upon the requirement.
More common non - ferrous materials are aluminium, copper, magnesium, zinc, tungsten, molybdenum etc.
They have high strength, higher melting point, good anti-corrosive, better appearance, better electrical and thermal conductivity, better

1½ unit.

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strength to weight ratio.

5%)

Application of non-ferrous metal :
Due to their light weight (aluminium), they are used in aircraft, aerospace and cooking utensils because of good thermal and electrical conductivity. They are used at large scale for electrical and electronic components.

10/9 Copper and copper alloys -
Copper is relatively soft and is very malleable, ductile and flexible, yet very tough and strong. A very efficient conductor of heat and electricity and is largely used in wire and sheet form for electrical purposes. It may be cast, forged, rolled and drawn into thin wires. It is non-corrosive under ordinary conditions and it resists weather very effectively.

(1) Brass - It is an alloy of copper (65%) and zinc (35%). Different types of brass lend themselves to the following processes: casting, hot forging, cold forging, cold rolling into sheets, drawing into wire.
Apps. -

- electrical and electronic component
- spring
- steam exchange (heat exchanger)
- cooking utensils
- jewellery and decorative objects

Properties -
- ~~[illegible]~~ - non corrosive
- soft, ductile, tensile strength with good fusability and surface finish characteristic
- non-magnetic and poor conductor of electricity

Qualities reqd. of copper alloys-
- combination of electrical, mechanical, non-magnetic, corrosion resistance, thermal conductivity, wear resistance
- copper is 3 times more anti-corrosive as compared to chromium

(2) Bronze - It is an alloy of copper (90%) and tin (10%).

Properties -
- hard, resist surface wear
- can be cast into shape or rolled into wire, rods and sheets very easily
- in corrosion resistant properties bronzes are superior to brasses

Applications -

- hydraulic fittings, pump linings, in making utensils, bearings, bushes, sheets, rods, wires and many other stamped and drawn articles.

Aluminium and its alloys

- white metal produced by electrical processes from oxide (alumina) prepared from clayey material called bauxite.
- silvery - white in colour
- high strength to weight ratio
- better resistance to corrosion
- good thermal and electrical conductivity
- non - toxic
- reflectivity and appearance
- used as silver foil

(1) Duralumin - It is an alloy of copper (3.5 to 4.5%), manganese (0.4 to 0.7%), silicon (0.4%) and sometimes magnesium is used. It is extensively used for forged and stamped components.

CASTING (Uniform grain structure)

Principle of casting / metal casting:
The purpose of casting is to obtain a complex material with accurate shape.

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solidified component is known as casting. It is performed near a place called foundry taken from the word fundre meaning melting and pouring.

In this process, the material is first liquified while properly heating in a suitable furnace. This liquified material is collected and poured into a previously made mould cavity (it is a dimension or hollow space to collect something) where it is allowed to solidify. Subsequently, the product is taken out of the mould cavity (breaking or without breaking of mould).

If the mould is broken to obtain a solidified component, it is known as expendable mould. If the same mould is used again and again for a number of casting it is known as permanent mould.

eg. of expendable mould - sand mold, Plaster mold mould, used in investment casting

eg. of permanent mould - die casting, centrifugal casting

made of - grey cast iron

Expendable mold / reusable pattern
Expandable mold / Expendable pattern
Permanent mold / No pattern

melting pt. higher

is the property of material by virtue of which it can remain at solid state even at high temp. eg. sand, silica

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MOULD : (Mold)

It is an assembly of two or more metal block or bonded refractory material consisting of primary cavity to hold a liquid metal. It is finally known as mould cavity where we pour the molten metal during casting. Mould may be permanent, semi-permanent, temporary (expendable). Permanent mould is used in die casting, centrifugal casting, generally used for mass production. Temporary (expendable) mould is used in investment casting, sand casting.

Moulding Flask : It is used to hold moulding material during ramming. Generally we use two types of moulding flask -

1. upper part known as cope
2. lower " " " drag

If the intermediate part is used, it is called cheek.

Core : It is a sand-made body used to make hollow projection, hollow space in a casted component. For producting hollow section, the entry of liquid metal is prevented by placing a core inside the mould cavity

Core Print: It is the type of projection made on pattern for locating the core in the mould.

Selection of Pattern:
- easily available
- cheap
- shape and size
- light in weight
- high strength weight ratio
- method of moulding

1. It should be cheap and easily available
2. shape and size of casting
3. hight strength and durability
4. simple in design for ease of manufacturing
5. light in weight (convenient to handle)
6. surface finish and dimensional accuracy
7. method of moulding

Pattern Material:
depends on type of casting eg. large scale, medium scale, small scale

Allowance refers to tolerance in dimension that is deliberately given to a metal during the process of manufacture and design.

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Selection of pattern material depends upon following factors -

1. Piece and short run production - wood pattern (mango wood, teak)
2. Large and vast production - metal pattern (cast iron, aluminium, brass)
3. Batch production - plastic pattern eg. PVC and phenol-formaldehyde

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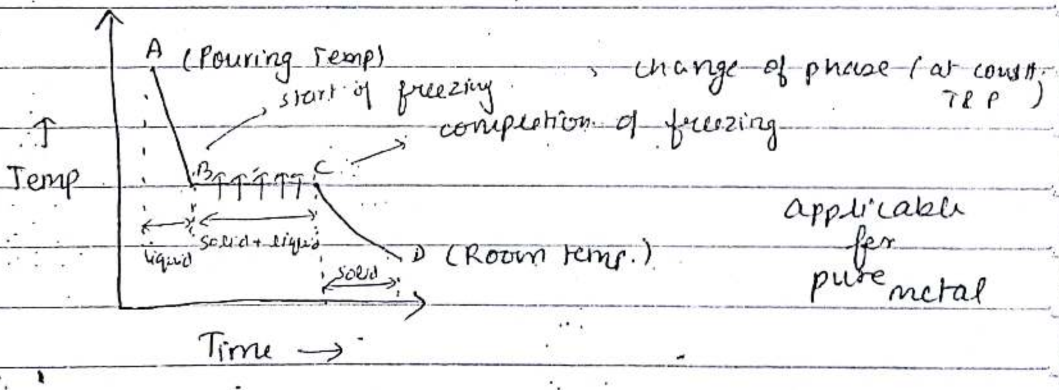
## Pattern Allowance:

Temp.-time graph for pure material




Variation in dimension of pattern (material) is called pattern allowance. Due to heat transfer, size ↓es

Diff. b/w pattern allowances & tolerances -

Allowance is a prescribed difference in dimensions of two closely fitting parts with regard to min. clearance.

Tolerance is the permissible range of variation in a dimension of an object.

Tolerance is the limit of random (unintentional) variation of a dimension from its nominal value. Allowance is the amount of designed (intentional) deviation b/w two mating dimension in fit.

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Pattern is made somewhat larger than the reqd. size, the excess in dimension is known as pattern allowance. The objective of the pattern allowances is to reduce the casting defects.
The allowances are classified in such a way -

1. liquid shrinkage - b/w A & B
2. Solidification shrinkage - b/w B&C
3. solid shrinkage - b/w C & D
4. Ramming and shake allowances
5. Distortion allowances

1. liquid shrinkage - It occurs from a pouring temp. upto a temp. where freezing starts. It consist of contraction of liquid from pouring temp. to freezing temp.
2. Solidification shrinkage - It occurs b/w start of freezing to the completion of freezing. It consists of contraction associated with change of phase from liquid to solid. It is also known as latent heat of fusion.

* The first liquid shrinkage and second solidification shrinkage is compensated by riser. ∴ it acts as a reservoir | which supply the molten
it shows the level of molten metal in the mould

Q What do you mean by riser?

Ans The riser material in riser should be solidified at a later time. First the material in mould cavity should be solidified. It is designed in such a way.

metal inside the mould cavity from pouring temp. upto the freezing temp. (completion)

(3) Solid shrinkage - It occurs during end of solidification upto the room temp. It consists of contraction of solid casting from freezing to room temp. This can be minimised by over sizing of the pattern.

Q While cooling of cubical casting of side 40mm undergoes 3%, 4% and 5% vol. shrinkage during liquid state, phase transition and solid state resp. Calc. the vol. of metal compensated by riser.

% vol. shrinkage (liquid state) = 3%

~~for liquid state, $40 \frac{3}{100} \times 40$~~

% vol. shrinkage (phase transition) = 4%

% vol. shrinkage (riser) = 7%

Vol. of metal compensated by riser = 7% of $(40\ mm)^3$

$= \frac{7}{100} \times (40)^3 mm^3$ = 4480 $mm^3$

= 4 48 $m^3$

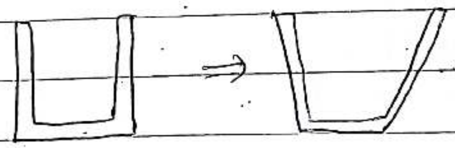
(4) Ramming and shake allowances - The patterns are wrapped for easy withdrawal

from the mould cavity. certain gap is provided b/w pattern and mould cavity. The gap is known as shake allowance. In other way, we have to make large cavity and small pattern.

(5) Distortion allowances - This type of allowance ~~occurs~~ ~~in~~ is given in case of complex geometry. The

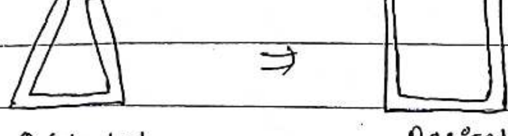


distortion in casting may occur due to internal (residual) stresses or set up during casting. Residual stresses are developed due to uneven cooling in casted ~~form~~ part.



Desired casting

~~Rocked~~ Poor casting



Distorted casting

Desired casting

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(6) Machine allowance - Extra material is added to a certain part of casting to enable their machining, surface finishing ~~or~~ are reqd. The excess

Q What do you mean by pattern allowance? Describe any 2. with diagrams

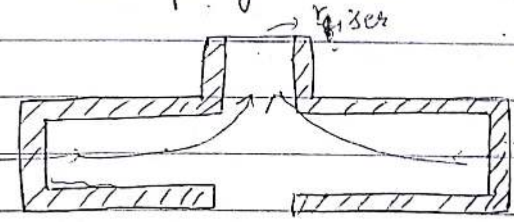
Exam

in dimension of casting (consequently in the dimension of the pattern). Overdose of the final job to take care of machining is called machine allowance.
It depends upon following factors -
(1) Way of machining
(2) Properties of material
(3) Size and shape of casting
(4) Casting method

## DIRECTIONAL SOLIDIFICATION:

Exam Imp

It is the growth of partially solid and partially liquid state from outside to inside. It is also called progressive solidification.




lower $\frac{V}{A}$ ratio for riser away from the section having lower $\frac{V}{A}$ ratio

23/9

Green Sand -
↓
because it contains moisture during pouring of molten metal
75-80% silica, 10-20% clay, 3-6% water
1-2% additives (some additional amt.)

Exam Q What do you mean by green sand?

It contains moisture while pouring of

molten metal inside the mould cavity
It contains 70-85% sand, 10-20% clay, 3-6% water, 1-6% additive. Sand has refractory ability, clay has binding ability and additive ↑es the existing properties of molten material.

Types of additive-

1. Dextrin - It increases the air setting strength, toughness and ~~collapse ability~~ collapsibility and prevents the sand from drying rapidly.

2. Silica Flour- It is very fine ground silica. It is generally mixed with about twice as much conventional moulding to make facing sand. (used to make surface finish)

3. Sea coal - It tends to obtain smoother and cleaner surface of casting and also reduces the adherence of sand particle to the casting

4. Cereals - It ↑es the green and dry strength.

5. Saw dust - It ↑es the gas permeability of mould and core.

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# PROPERTIES OF MOULDING MATERIALS:

→ resistance against deformation due to external force

(1) **Strength:** It is a characteristic of moulding sand. The strength of moulding sand are - green sand strength, dry sand strength and hot strength

→ Green sand strength - It is ability of moulding sand to retain the shape of constructed mould.

→ Dry sand strength - It is ability of moulding sand to retain cavity during dry condition.

→ Hot strength - It is ability of moulding sand to retain shape of moulding cavity at higher temp.

(2) **Flowability:** It is the ability of moulding material to flow all around the pattern during ramming.

(3) **Refractoriness:** It is the property of moulding material to withstand higher temp. without going fusion.

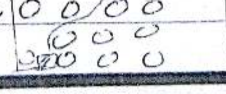
OR It is the ability of moulding material to remain in solid state at elevated temp.

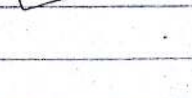
(4) **Permeability:**

By adding water permeability first inc, and when exess added it dec.

water

dust



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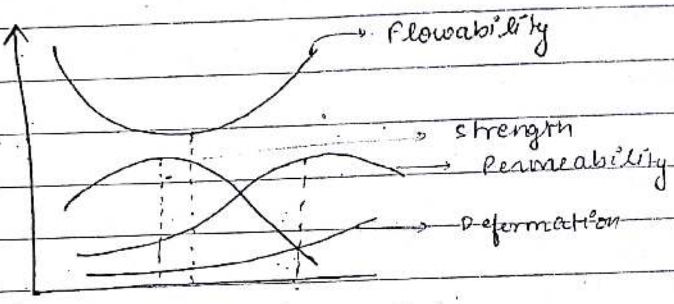
Easy outflow of infrapped gases through the sand voids by the specified pressure diff. is called permeability.
Permeability of sand depends upon size, shape, moisture and clay content.




From above graph, it is clear strength is inversely proportional to permeability. Permeability ↑'es and strength ↓'es.
Permeability also depends upon %age of water content. Initially by adding water, permeability ↑'es upto a certain limit. By adding more amt. of water, permeability will ↓.

(5) Cohesiveness - It is applied with wind to similar particles (sand) during ramming.

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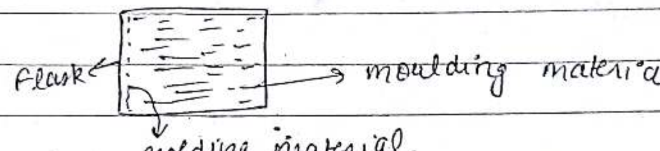
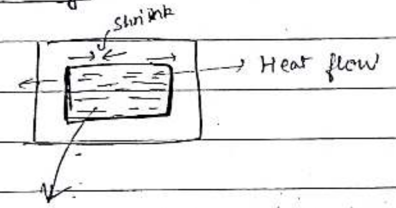
(6) Adhesiveness - It is type of attractive force applied b/w two dissimilar type of particles (moulding material & molding flask)




(7) Collapsability -




Allow to shrink while cooling
During contraction of casted part if the mould face provides resistance during contraction, crack may appear. So the property of moulding material does not provide any type of resistance while contraction of casted part.

(8) Durability - It is the property of moulding material due to which it can be used again and again for no. of casting.
eg. Green Sand.

(6.5M)

IMP. GRATING SYSTEM :

~~type of passage way to push molten material~~ fa safely into ~~molten~~ mould cavity without any excessive turbulence

↳ type of arrangement

- reduce defects

- for these gating system is reqd.
- deform the face.
- mixing of atmospheric gases
  ie turbulence - can waste material
- heavier impurities settle down

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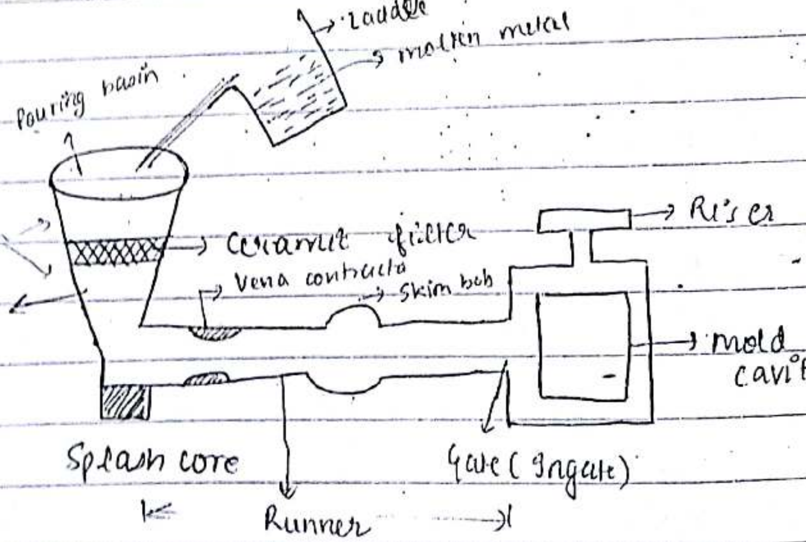
It is type of arrangement of passage way to bring the molten metal inside the mould cavity. If we directly pour the molten metal inside the mould cavity, the shape of the mould surface may get disturbed by erosion of sand wall. The atmospheric gases may involve along with the molten metal, this may produce casting defects such as blow holes, gas holes, pin holes, porosity. So we need a passage way to bring the molten metal inside the mould cavity.




laminar flow (layer by layer)

due to momentum loss, boundary separation is there, vena contracta is used

reduce aspiration effect

shape is tapered

Q What do you mean by aspiration effect?

∴ at same vel. pressure diff. mixing of atmospheric gases & hence casting defect

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Function of good gating system:

A good gating system ensures the complete filling or proper distribution of molten metal inside the mould

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cavity without -
① creation of turbulence
② excessive temp. loss
③ entrapment of atmospheric gases
④ involvement of impurities, slag
within a specified period of time

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Pouring basin: It is used to reduce turbulence of molten metal as coming directly from furnace. A constant pouring head is also maintained by using pouring basin.

Sprue: It is a type of vertical channel through which molten metal flows in downward direction. It is tapered to remove aspiration effect (creation of -ve pressure). It is used to maintain uniform pressure through outer section.

Ceramic Filter: It is used to remove the lighter impurities (dross). It is made of ceramic to withstand higher temp.

Splash core: It is used to prevent the sand erosion created by heating action of the molten metal. If it is not present, sand valve may erode.

(2.5M) Blind riser - placed in mould cavity - an internal riser that does not extend to the outer surface of a mould - completely contained in the mould

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Vena contracta: The function of Vena contracta is to prevent the boundary layer separation caused by excessive momentum loss due to sudden change in flow direction

Runner: It is horizontal channel connected b/w sprue and gate to carry the molten metal inside the mould cavity.

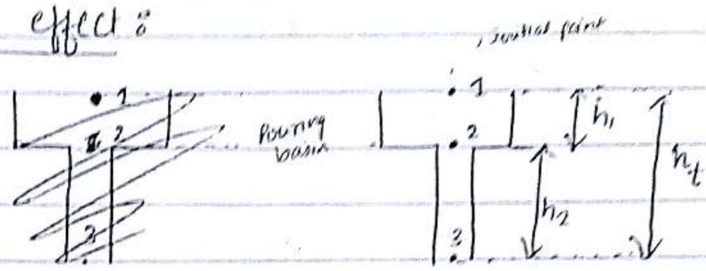
Skim bob: It is used to segregate heavier & lighter impurities.

Gate: (Ingate) It is the actual entry point of molten metal through which it enters into the mould cavity.
~~Gate is that portion of the runner through~~

IMP Riser: It acts as a reservoir. It is used to compensate the molten metal during shrinkage from pouring temp. upto the solidification and it is used to show the level of molten metal inside the mould cavity. Riser should be designed in such way so that it solidifies after the casting. It means the molten metal which is inside the lower $\frac{V}{A}$ ration, more area, fast heat transfer ∴ quickly solidify. riser should be placed away from the region.

riser should remain in liquid state for longer period of time.

<u>Aspiration effect :</u>




for a mould of permeable material (sand), care should be taken to ensure that pressure anywhere in the liquid metal stream does not fall below the atmospheric pressure otherwise the gases originating from baking of organic compound in the mould will enter the molten metal stream producing porous casting. This is known as aspiration effect.

the along streamline flow remains constant.

Bernoulli's eqn. $\frac{P}{\rho g} + \frac{v^2}{2g} + h = \text{constant}$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + h_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_2$$

Applying Bernoulli's eqn. b/w pt. (2) & (3) in fig.

$$\frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_2 = \frac{P_3}{\rho g} + \frac{v_3^2}{2g} + \underbrace{h_3}_{=0}$$

$P_3 = 0$ (assuming pt. 3 is at atmospheric pressure) ⟶

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$m = \rho \times A \times L$

Eqn. of continuity

conservation of mass

$\dot{m} = \rho \times A \times \frac{L}{t} = \rho \times A \times V$

mass rate

$\rho A V = \text{constant}$

$\rho_2 A_2 V_2 = \rho_3 A_3 V_3$

$\therefore A_2 V_2 = A_3 V_3$

$\rho_2 = \rho_3 = \text{constant}$

$\Rightarrow \underline{V_2 = V_3}$

$A_2 = A_3$

7/10

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_2 = \frac{V_3^2}{2g}$$

On applying the continuity eqn. b/w pt. 2 & 3

$\rho_2 A_2 V_2 = \rho_3 A_3 V_3$

$\underline{A_2 = A_3}$.

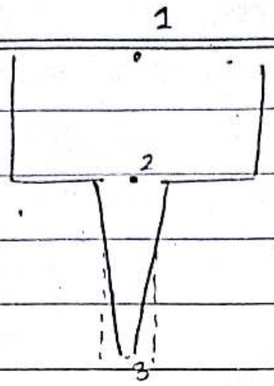
For incompressible fluid, $\rho_2 = \rho_3$

$\therefore \underline{V_2 = V_3}$

$\therefore \frac{P_2}{\rho g} + h_2 = 0$

$\Rightarrow \boxed{P_2 = -h_2 \rho g}$.

At pt. 2 negative pressure is generated. Tapering is done to avoid pressure difference.




On applying Bernoulli equation b/w (1) & (3)

$$\frac{P_1}{\rho g} + \frac{v_2^2}{2g} + h_2 = \frac{P_3}{\rho g} + \frac{v_3^2}{2g} + h_3 (0).$$

To ~~av~~ maintain uniform pressure.

$$P_2 = P_3$$

$$\frac{v_2^2}{2g} + h_2 = \frac{v_3^2}{2g}$$

Applying eqn. of continuity

$$\rho_2 A_2 v_2 = \rho_3 A_3 v_3$$

$$\Rightarrow A_2 v_2 = A_3 v_3$$

$$\Rightarrow v_2 = \frac{A_3 v_3}{A_2}$$

Put $K = \frac{A_3}{A_2}$ $\therefore$ $v_2 = K v_3$

$$\therefore \frac{K^2 v_3^2}{2g} + h_2 = \frac{v_3^2}{2g}$$

$$\therefore \frac{v_3^2}{2g}(1 - K^2) = h_2$$

$$\Rightarrow \cancel{v_3^2} \; 1 - K^2 = \frac{2gh_2}{v_3^2}$$

Applying Newton's eqn. b/w (1) & (3)

$$v^2 - \cancel{2}u^2 = 2gh$$

$$\Rightarrow v_3^2 - 0 = 2g \times h_t$$

$$\Rightarrow v_3^2 = 2gh_t$$

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$$1-K^2 = \frac{2gh_2}{v_3^2} = \frac{\cancel{2g}h_2}{\cancel{2g}h_t}$$

$$\Rightarrow 1-K^2 = \frac{h_2}{h_t}$$

$$\Rightarrow K^2 = 1-\frac{h_2}{h_t}$$

$$\Rightarrow K^2 = \frac{h_t - h_2}{h_t}$$

$$\Rightarrow K^2 = \frac{h_1}{h_t}$$

$$\Rightarrow K = \sqrt{\frac{h_1}{h_t}}$$

$$\therefore A_3 \propto \sqrt{h_1}$$
$$A_2 \propto \sqrt{h_t}$$

Here $h_1 < h_t$

$A_3 < A_2$ or $\boxed{A_2 > A_3}$

From the above expression it is clear the cross-sectional area at pt. ~~A~~ 2, $A_2$ will be more than the cross-sectional area at pt. 3, $A_3$.

According to the above expression, ~~As~~ the cross-sectional are of the sprue should decrease linearly but straight tapered is preferred.

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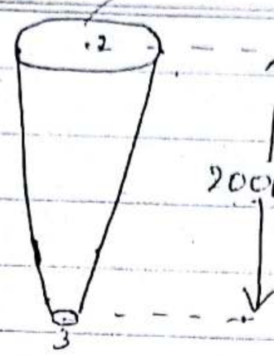
$A_2 = 650mm^2$

Q




$Q$ = Flow of molten metal $= 6.5 \times 10^5\ mm^3/s$

$g$ = Acc. due to gravity $= 10^4\ mm/s^2$

$A_3 = ?$

Applying Bernoulli's eqn. at pt. (3) & (2)

$$\cancel{\frac{P_2}{\rho g}} + \frac{v_2^2}{2g} + h_2 = \cancel{\frac{P_3}{\rho g}} + \frac{v_3^2}{2g} + \underbrace{h_3}_{zero} \quad -(1)$$

$P_2 = P_3$

$$A_2 v_2 = A_3 v_3 = 6.5 \times 10^5$$

$$\Rightarrow v_2 = \frac{\cancel{650} \times 10^{3}}{\cancel{650}} = 10^3\ mm/s \quad -(2)$$

$\therefore$ Subs. (2) in (1)

$$\frac{10^6}{2 \times 10^4} + 200 = \frac{v_3^2}{2 \times 10^4}$$

$$250 = \frac{v_3^2}{2 \times 10^4}$$

$$\Rightarrow v_3 = \sqrt{250 \times 2 \times 10^4}$$

$$\Rightarrow v_3 = \cancel{100\sqrt{500}} = \sqrt{5 \times 10^6}$$

$$= 2.23 \times 10^3\ mm/s$$

$$A_3 = \frac{6.5 \times 10^5}{2.23 \times 10^3} = \frac{650}{2.23}$$

$$= 291.47\ mm^2$$

## SOLIDIFICATION TIME :

It is the time required for the solidification. Also called total solidification time (TST) :

9/10 Most Imp. (6-5M)

Heat transfer (Q) $= -K \times A \times \frac{dT}{dx}$

V → vol. of molten metal

Chorinou's Rule

The solidification time is denoted by $t_s$.

$$t_s = K \times \left(\frac{V}{A}\right)^n$$

where K is constant, V is vol. of molten metal, A is the surface area

V ∝ amt. of heat content

A ∝ rate of heat dissipation

The solidification time is known as TST. This is known as Chorinou's Rule.

K is a constant which depends on mold cavity & mold temp.

Value of n is taken b/w 1.5-2.

$$\boxed{t_s = K \times \left(\frac{V}{A}\right)^2}$$

$$\left(\frac{A}{V}\right)_{riser} < \left(\frac{A}{V}\right)_{casting} \quad \text{--- (i)}$$

Riser should be designed in such a way so that (1) is satisfied.
It means riser should not solidify before the casting.

9/10 Most Imp. (6-5M)

## CASTING DEFECTS:

Exam Q Write 5 casting defects & their remedies.

Defects in casting may arise due to defect in one or more of the following -
1. Design of casting and pattern
2. Metal composition
3. Gating and risering → design & location should be proper
4. Moulding sand and design of mould and ~~pou~~ pour.

⇒ Defects due to evolution of gases (exposed cavity -
1. Blow holes
2. Pin holes
3. Porosity
4. Blister
5. Scar

⇒ Defects due to pouring of melt -
1. Misrun → insufficient fluidity
2. Cold shut
3. Inclusion - involvement of foreign material

⇒ Defects due to metallurgical factors -
1. Hot tear

chills is used to have directional solidification.

Q Diff. b/w porosity & permeability.

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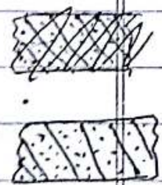
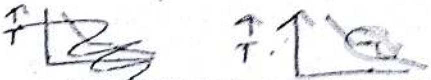
⇒ Defects caused by moulding material –
(1) Scab (2) Flash (3) Metal composition
(4) Lug

| Defects | Causes | Remedies |
|---|---|---|
| (1) Blow holes | → Excessive moisture is present in the mold cavity<br>→ if the slag (impurities) reacts with carbon, it will liberate CO & $CO_2$<br>→ If rusted chills (oxidised) is used, it will produce CO & $CO_2$ by reacting the carbon from ferrous material | → avoid excessive moisture in mold cavity<br>→ ~~Avoid the use o~~ preventing reaction b/w slag & ferrous material.<br>→ avoid the use of rusted chills. it can also be avoided by proper venting & permeability. if excess $O_2$ is present in the molten metal, it can be avoided by using silicon which acts as a deoxidiser |
| (2) Porosity | This type of defect is very generally developed due to presence of moisture inside the mould cavity. When moisture comes in contact with molten metal, $H_2O$ will dissociate into $H_2$ and $O_2$. These are insoluble in molten metal. Upon solidification it will try to come | → Avoided by removing excess moisture from the mould cavity and by maintaining proper venting<br>→ The porosity is avoided by supplying proper amt. of molten metal during solidification, Internal & External chills |



Q Why steel is not easily casted?
↓
mushy zone is more



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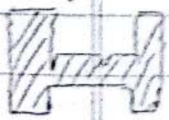
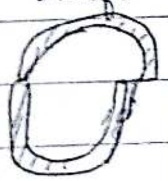
10/10

| | | |
|---|---|---|
| | out and form various small holes throughout the casting surface. It can also be developed due to shrinkage of solidified metal or uneven contraction of casting surface. | are used to remove the porosity. |
| 10/10 ③ Cold shut  | → When the two stream of molten metal are coming from two different gate not able to fuse together, cold shut is developed. | → Use of multiple gates |
| | → When the dist. of two gates is very much large, the time reqd. to fuse together is very long. during this time period the molten metal will losse heat rapidly due to loss in heat from two streams, cold shut is developed. | → Making an optimum dist. b/w two gates. |
| | → It can also develop due to low pouring temp. | → Ting pouring temp. |
| ④ Hot Tear - type of metallurgical defect  | This type of defect is generally developed due to ① uneven cooling ② presence of residual stress ③ presence of sulphur content ④ variation in freezing | → use of exothermic pad on the portion which solidifies first or by delaying the freezing rate which solidify first |

* Mold is an assembly of two or more metal block.
* More chances of shrinkage in the middle because solidification start from outside to inside
* Riser should be placed away from section having lower $\frac{V}{A}$ ratio. ($\frac{V}{A}$ ratio is lower when A is more i.e. increasing from sides & towards centre)

$\left(\frac{A}{V}\right)_{riser} < \left(\frac{A}{V}\right)_{casting}$

$\left(\frac{V}{A}\right)_{riser} > \left(\frac{V}{A}\right)_{casting}$

| | | |
|---|---|---|
| | | → Segregate the sulphur content from the molten metal<br>→ use of chills (to ~~obtain directional~~ solidification by accelerating the solidification rate) |
| (5) Core Shift  | This type of defect is developed due to shifting of core from the mould cavity. | locating the core at proper position with the help of core print in the mould cavity. |
| (6) Mould Shift  | This defect is developed due to misalignment of two mating moulds | This is avoided by proper alignment of two mating moulds |
| (7) Shrinkage  | This type of defect is developed due to improper location & shape of the riser | Avoided by selecting the proper location and shape of the riser. |

IMP. Q What is the difference b/w porosity and permeability?

Foundry → permeability is the easy outflow of intrapped gases through sand voids by specified pressure difference.

General → geology → capability of a porous rock or sediment to permit the flow of liquids through its pore spaces.

Parting line → line b/w cope & drag

→ It is the quality of having many small holes that allow water or air to pass through slowly.

Porosity → the state or quality of being porous (full of pores)

Geology → porosity → ratio expressed as a %age of the vol. of the pores or interstices of a substance as a rock, to the vol. of the mass

14/10

| Defects | Causes | Remedies |
|---|---|---|
| (8) Flash | This type of defect occurs because of molten metal has gone in unwanted area along the parting line as moulding sand is not properly compacted. | Moulding sand should be compacted properly. |

Exam Imp

INVESTMENT CASTING:

- also called precision casting

⇒ higher dimensional accuracy & surface finish

- pattern material → expendable pattern ↓ wax, plastic, rubber, mercury ↳ mercast

~~lost wax method~~

Objective → to obtain higher dimensional accuracy with good surface finish.

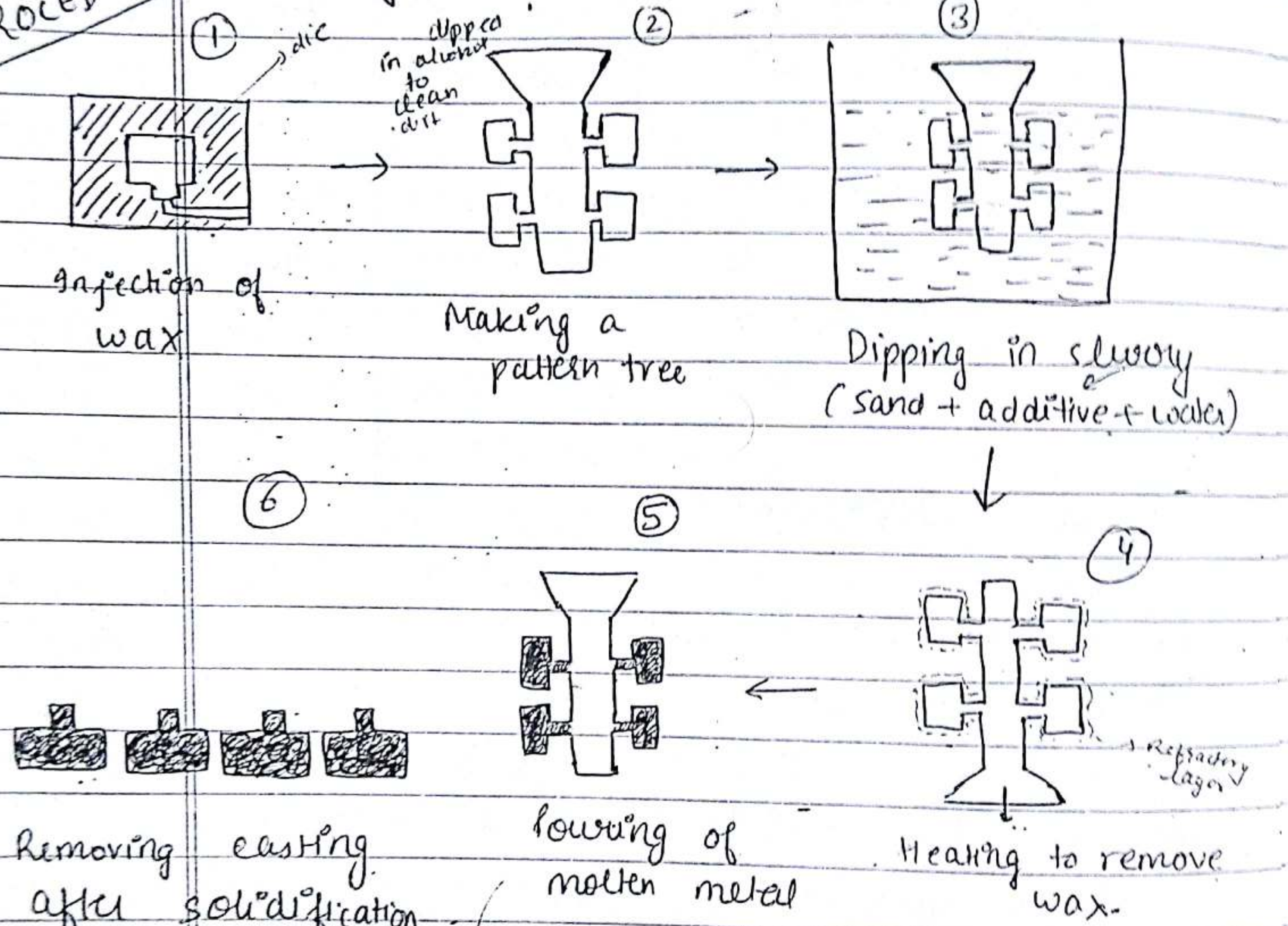
→ to produce better tolerances and accuracy

~~to produce better to~~

In this, we use expendable mould and pattern. The pattern materials are - wax, plastic, rubber, and mercury.

If the pattern material is made of wax, it is known as lost wax.
If the pattern material is made of mercury, it is known as mercast.

PROCEDURE




Inert gas atmosphere → to prevent gases from entering

Application - jewellery, turbine, jet, dentist.

Limitations - expensive, Precise control is reqd. in all stages of casting

In the ans., Steps
Advantages
Limitation
Application

The process can be understood by the following steps.

(1) Wax is initially injected into a die (assembly of place) to make the pattern by the action of centrifuge.

(2) A no. of these patterns are joined together with a central sprue to make the process economical.

(3) Since the worker handles these patterns, it may become dirty. The pattern tree is then dipped in alcohol to clean it.

(4) The pattern tree is dipped into a slurry (sand + additive + water). After removing it from slurry, it is dried. The tree is then again dipped and dried. by repeating this process for sometime. A layer of sand will appear over the pattern.

(5) The shell is heated to remove wax.

(6) The shell is then fired in a furnace at 550°C - 1100°C. This ensures complete removal of wax and also gives strength to the shell.

(7) Pour the liquid metal when the sand is still hot otherwise ~~sel~~ shell will capture moisture from the surroundings.

(8) After solidification, shell is broken to get the final product.

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Application -
→ It is used to make turbine plate, jet engine plate and dental fixtures
→ It is also used in making jewellery.
This process is capable of producing intricate shape weighing from 1g to 35kg from a wide variety of ferrous and non-ferrous metals and alloys. Typical mechanical parts are made - gear, can, valve, ratchet.

16/10

Limitations -
→ In investment casting, to manufacture any component, one pattern and mould have to be invested. So, the process is uneconomical.
This process is usually selected to manufacture a very special type of component where precision & dimensional accuracy, surface finish is preferred as compared to manufacturing cost

IMP. 2.5M

arrangement
→ assembly of two or more metal block → forms hollow cavity

DIE CASTING:
→ made up of grey cast iron, tool steel, aluminium
Permanent mould is used
↳ same mould is used again & again for no. of casting

Two types -

- Gravity die casting
- Pressure die casting
  - Hot chamber
    - furnace inside machine
    - integral part
    - fast
  - Cold chamber
    - furnace outside machine
    - not integral part
    - slow.

<u>Gravity Die casting</u> - when molten metal is poured under gravity inside the mould cavity, it is known as gravity die casting. In this, the chances of entrapment of atmospheric gases is more.

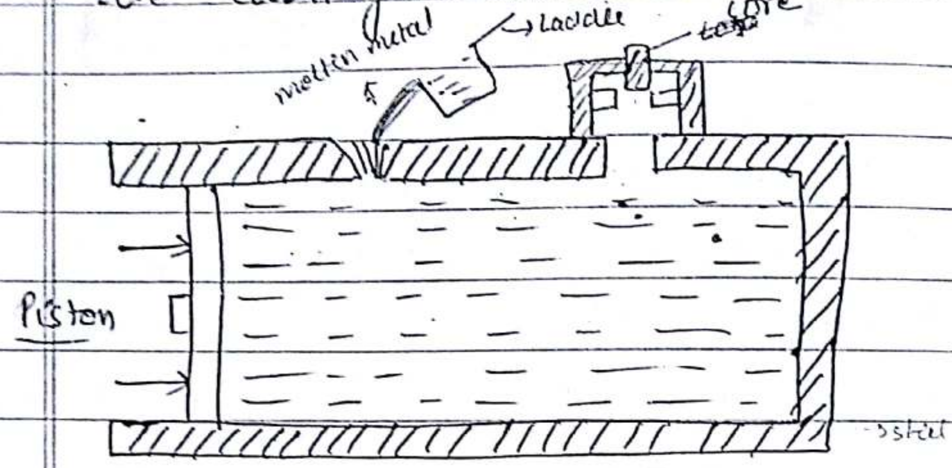
<u>Pressure Die Casting</u> - When the molten metal is injected inside the mould cavity under the influence of certain amount of pressure, it is known as pressure die casting. In this, pressure is maintained during the solidification.

<u>IMP.</u> Q Why riser is not used in die casting? (2.5M)

no chances of shrinkage in the middle as pressure is applied

high pressure ensures the complete filling of molten metal inside the mould cavity.

Cold chamber Die casting – In this, furnace is not an integral part of die casting machine.




Hot chamber Die casting – In this, furnace is an integral part of casting. It is fast as compared to cold chamber die casting because in the latter furnace is far away from die casting machine so, one has to carry and collect the molten metal. Subsequently pouring may occur. So it takes much more time as compared to hot chamber process.

In cold chamber process, pressure ranges from 20 MPa to 70 MPa.

IMP. Q why high melting alloys are successfully cast by cold chamber & not hot chamber?

as in hot chamber reaction takes place which causes corrosion

Hot chamber
↳ liquefy + pour

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IMP. Q High melting pt. alloys are successfully cast by cold chamber die casting process. Why?

The cold chamber process is ideal for metal such as aluminium and its alloys which cannot be cast in hot chamber machine due to high reactivity of molten aluminium with steel. High melting pt. alloys of the non-ferrous type also best die cast in cold chamber. In cold chamber, the pickup of iron by aluminium is negligible (∵ of momentary contact) as the actual contact b/w the molten metal and chamber and its plunger is only momentary.

Hot chamber
→ ~~The disadvantage of this system are that it is~~ limited to use with low-melting point metals and that aluminium cannot be used because it picks up some of the iron while in the molten pool. ∴ hot chamber ~~process~~ machines are primarily used with zinc, tin, and lead based alloys.

Q Why risers are not used in die casting?
Die castings are made by forcing molten metal at high pressure into a split steel die cavity. within a fraction of

second, the fluid alloy fills with entire die. The die is water cooled; ∴ low temp. is being maintained. Because of the low temp. of the die, the casting solidifies quickly. ∴ risers are not reqd. in die casting.

→ Using risers would slow the cooling time, and ∴ they are economically undesirable. Further, the metals that are used in die casting will ∴ be the ones that develop internal shrinkage porosity, but do not separate from the mould wall, so that risers are not necessary.

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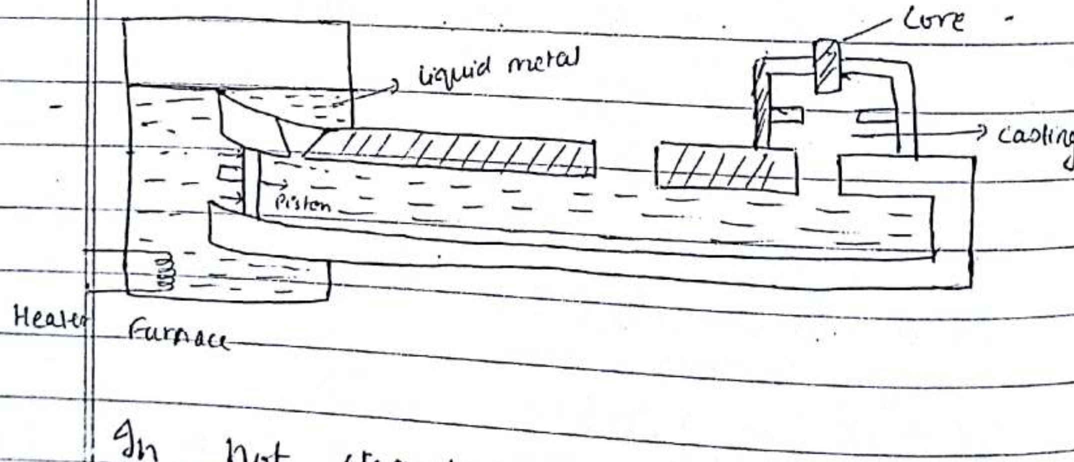
Diagram of hot chamber process –




In hot chamber process, pressure ranges between 15 to 35MPa. It is maintained during complete solidification. It is generally applicable for low melting

Imp. Q. What is func.ⁿ of ejector pin in die casting?

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point of alloys.

Steps in die casting -

(1) Closing and locking of two sets of die (one die is fixed and other is movable). Locking pressure should be higher than that of molten metal

(2) Forcing the molten metal inside the mould cavity

(3) Maintaining the same pressure during complete solidification.

(4) Ejecting the casting with gating system (sprue, runner & gate)

Advantages of die casting -

(1) applicable for mass production - in hot chamber type, 300-350 casting per hour and with cold chamber 75-150 casting ~~pour~~ per hour

(2) Closed dimensional control can be maintained - very thin section can be successfully cast by die casting machine (0.50mm)

(3) The saving of labour and time and the elimination of machining renders it extremely economical for large scale production.

(Disadvantages)
Limitations of die casting -

(1) Only certain non-ferrous alloys can be

Q How venting is provided in die casting machine?

Q Name different types of components casted by die casting process

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economically die cast

(2) The high cost of dies & die casting equipment requires sufficiently large production quantities to make the process economically feasible.

(3) Die casting usually contains some porosity due to entrapped air.

Q→ IMP

Vents are ~~are~~ fitted on the die parting to allow the air to escape when molten metal is injected.

Applications of die casting -

(1) The weight of most of the casting 90g - 25kg

→ washing machine → carborater

→ refrigerator

→ toys

→ pistols

Q Difference b/w core print & chaplet

| Core Print | Chaplet |
| --- | --- |
| → The projection made on the pattern to locate the core in the mould. | type of metallic object generally used for supporting core, internal chills inside the mould cavity. It has ability to fuse in molten metal so that material of chaplet should be same as that of molten metal. |

recess where core resides

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* Chaplets are small metal supports that bridge the gap b/w the mold surface and the core and thus become part of the casting. ∴ they must be of the same material as the metal being cast. Moreover their design must be optimized ∵ if they are too small. they will completely melt and allow the core to move, but if they are too big then their whole surface cannot melt and fuse with the poured metal. Their use should also be minimized because they can cause casting defects or create a weak spot in the casting

Q What is the function of ejector pin in die casting?

Two dies → cover die half → allows molten metal to spree (hot chamber) flow into dies
→ ejector pin die half
meeting → parting line

The ejector die contains the ejector pins and usually the runner, which is the path from the sprue to the mold cavity. The casting will be ejected every cycle because the ejector half ~~die~~ contains ejector pins to push the casting out of that die half. The ejector pins are driven by an ejector pin plate, which accurately drives all of the pins at the

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same time and with the same force, so that casting is not damaged. It also retracts the pins after ejecting the casting to prepare for the next shot.

Q) How venting is provided in die casting?
Since the mould is not permeable, adequate vents need to be provided for the elimination of gases during the metal casting process. These vents are usually placed along the parting line between the die.

Q) Name different types of components casted by die casting process.
Tools, toys, carburetors, machine components, various housings and motors.

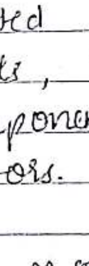
21/10 → solid casting possible

CENTRIFUGAL CASTING:

→ no gating system is used
casting yield - 99.9%
cast iron pipe

$F = \frac{mv^2}{r}$

dense structure of casting



metal mould
(permanent mould)
↓
rotating

→ gun barrel are manufactured by centrifugal casting

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It utilises centrifugal force which is caused by rotation to distribute the molten metal into the mould cavity.
In this type of casting, mould is permanent in nature. It may be horizontal, vertical or inclined.
Mold is rotated b/w 200 to 3000 rpm.
In this, no gating system is used & so the wastage is less as compared to die, sand, investment casting.
In centrifugal casting, the casting yield is found to be 99.9%.

$$\text{Casting yield} = \frac{\text{Wt. of casted final product}}{\text{Wt. of molten metal poured}} \times 100$$

Molten metal is solidified during rotation. After complete solidification we extract the component from the mould. Slag or lighter impurities collected near centre because centrifugal force falling on these particles will be less and they are finally removed by grinding and fettling.

It is done after the casting for trimming and surface finish of the final component.

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## Types of Centrifugal Casting:

1. True centrifugal casting
2. Semi " "
3. centrifuge

### 1. True Centrifugal casting -

In this, hollow projection or hollow section can be produced because of centrifugal force alone not with the use of core.
For producing hollow part, the axis of rotation is placed at the centre of the desired casting. Solid parts can also be cast by this process by placing the entire mould cavity on one side of axis of rotation.

Product application → cast iron pipe, gun barrel, propeller shaft

### 2. Semi - centrifugal casting -

core is not used

In this type of casting, mould is placed on horizontal plane and is rotated along vertical axis. The outer portion of the mould will be filled by purely centrifugal action as the liquid metal approaches towards the centre, the centrifugal force is

Diff. b/w semi-centrifugal & centrifugal
↳ axis

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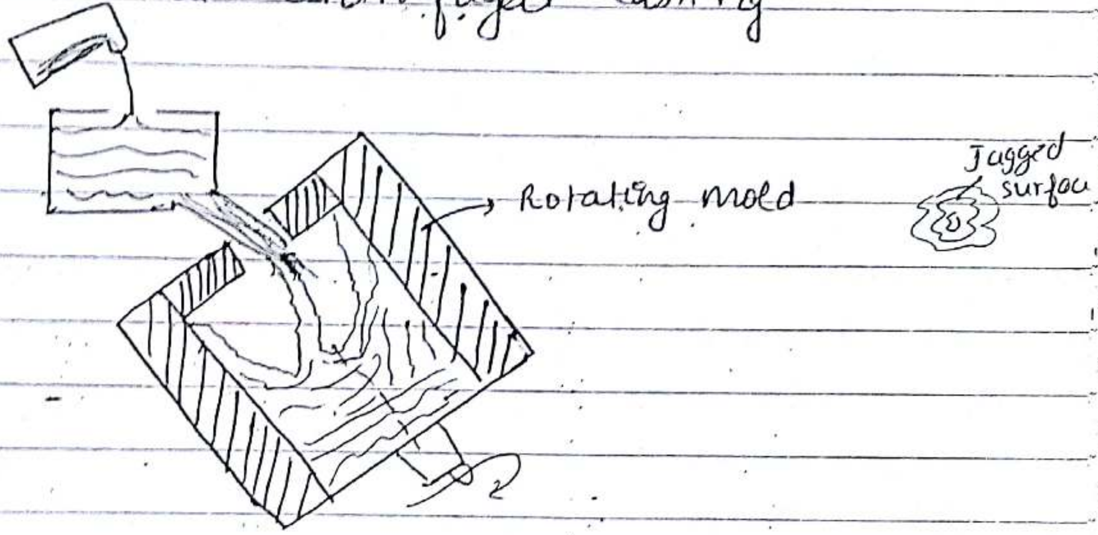
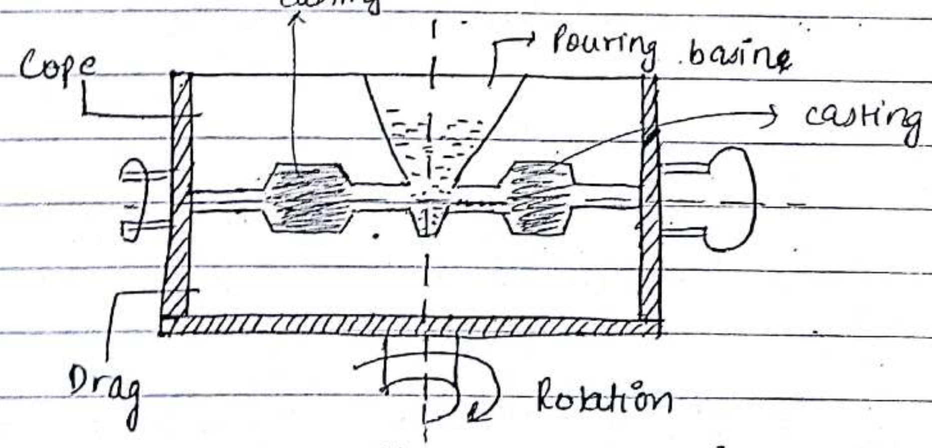
comp. ↓'es and gravitational force comp. ↑'es. So the central portion is filled by gravitational force. & outer portion by centrifugal ".
The %ent yield is lower as compared to true centrifugal casting




Centrifugal casting (True centrifugal casting)

Diagram for semi-centrifugal casting -




Axis of rotation of mould and axis of rotation of casting will be same. or will coincide.

flux → rejecting impurities ~~but~~ by reacting with slag & which is lighter & comes up.

Cupola furnace

Q write merits & demerits

Q what are different zones of furnace?

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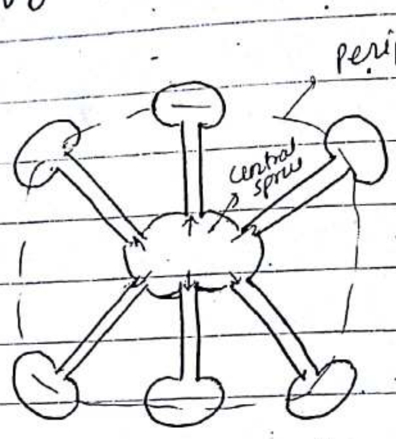
③ Centrifuge -




In this type of casting, axis of rotation of casting and axis of rotation of mould do not coincide. Flow of molten metal is done through the central sprue, common to all the mould. Speed of rotation of mould is much lower. The casting need to be axis of symmetry. Casting ~~rate~~ speed is lower as compared to both the casting 5-10%.

~~Eg~~ working

Forming → type of manufacturing process
↳ material will be in solid state

deformation → undesirable

Strain hardening is ~~a type~~ the process of edge ~~less~~ dislocation multiplication where ductility ~~is~~ will decreased and strength will ↑.

Cold forming → recrystallization

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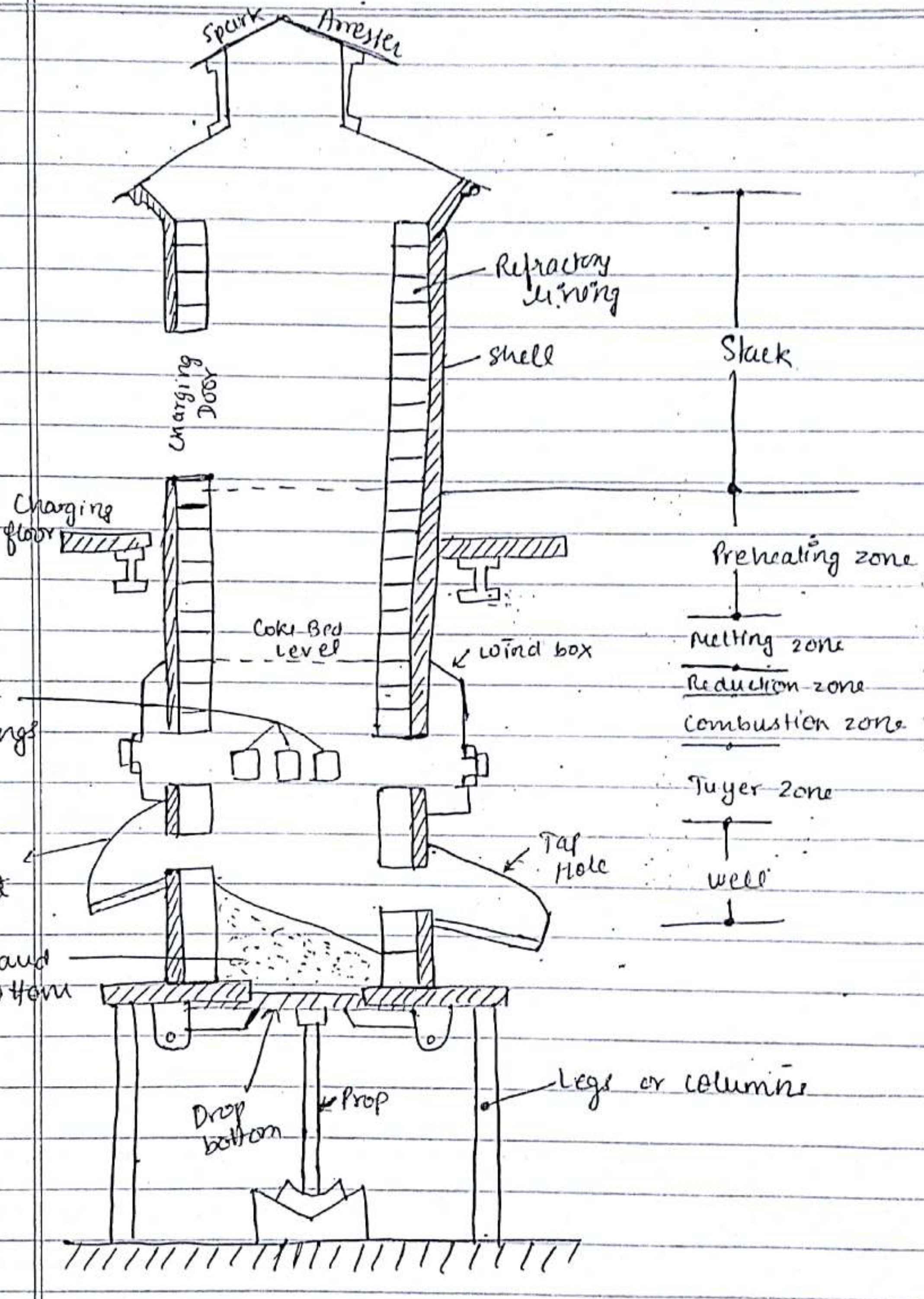



CUPOLA

R.

Read

* Forging tools & equipments ——— high carbon steel
- types of hammer used & classification
anvil, hammer, tong

13/11

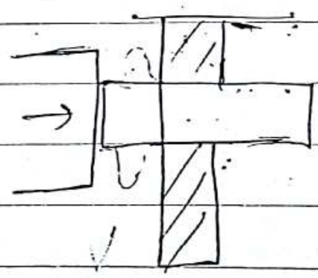
Smithy
→ Smite → To ~~beat~~ hit
→ ~~Hand held devices~~

FORMING:
- no significant part of the material is removed.
- economical
- strain hardening phenomena is undesirable ble in forming process.

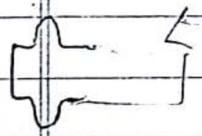
Smithy
→ smite → to hit
- hand held devices

Forging
- machine operating ~~held~~ devices

upsetting → heading process



process
types
Apps



* Book → draw forging & press forging diagram.

Screw, Nut, Bolt ←

River, Staple, Stitches, Shrink fit