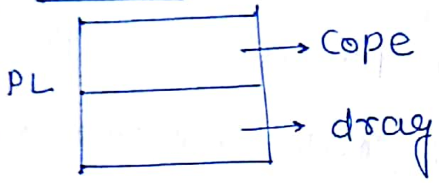
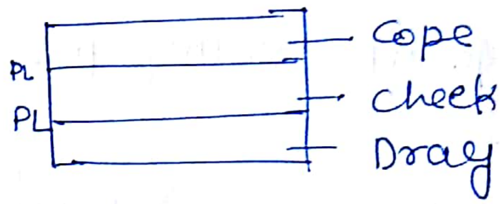
Casting :- It is a process in which mottom liquid will be allow to solidify in a predefine mould carity. after the solidification by braking the mould require shape of the object can be produced.

mould box :-

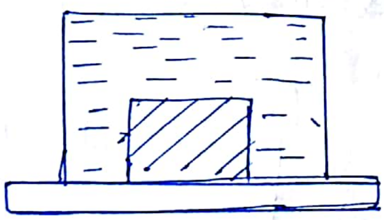
① Two box

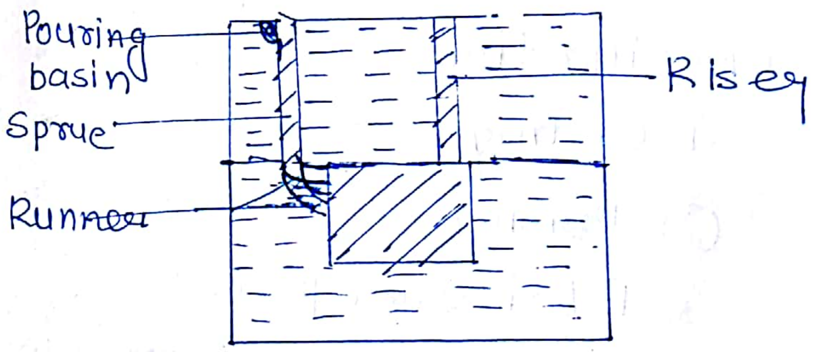


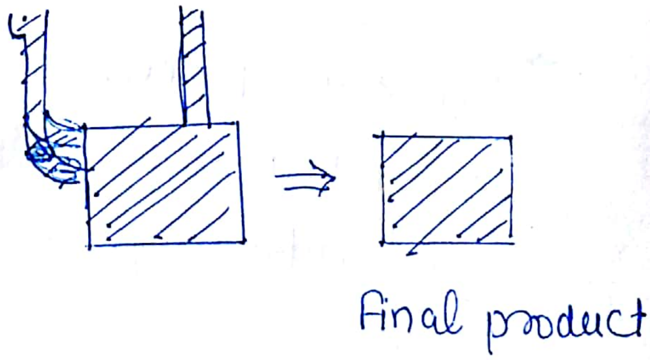
② Three box



Process — ① pattern
② moulding sand
③ Tools







we can produce following part / Application
① m/c tool bleds
② Road Roller
③ Engine blocks
④ Gear box

Advantages:-

1. Complex shape of the object can be produced.
2. It is simple and less expensive process.
3. Ductile and brittle material can be produced.
4. large size object can be produced by casting only

limitations:—

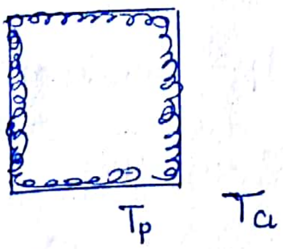
1. Casting object are not having smooth surface finish
2. It is labourers and time consuming process.
3. There is a posibility of gas deffect can be expected in Casting
4. Mechanical properties of casting not having uniform properties due to non-uniform Cooling

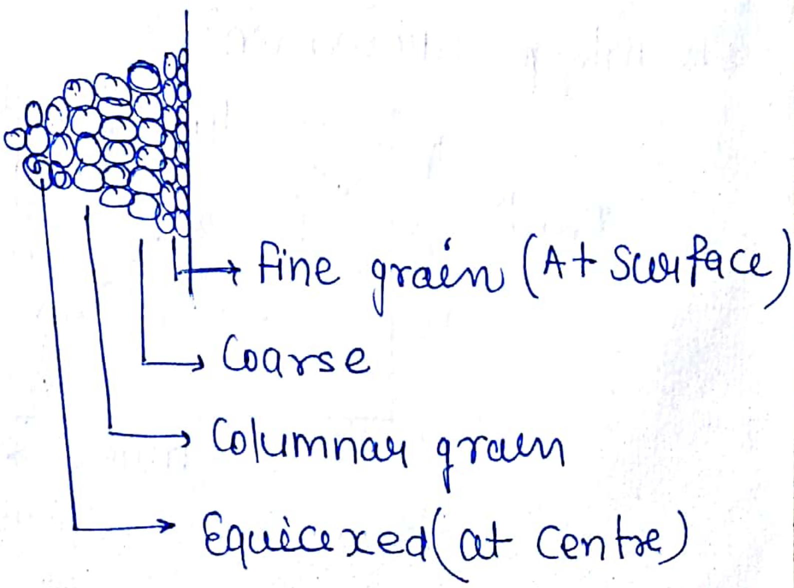
$$T_p = T_m + \Delta t$$

T_p → Pouring temp

T_m → mellting teemp

Δt → Degree of super heat (100-250 °C)





Selection of manufacturing Processes will depands on :—

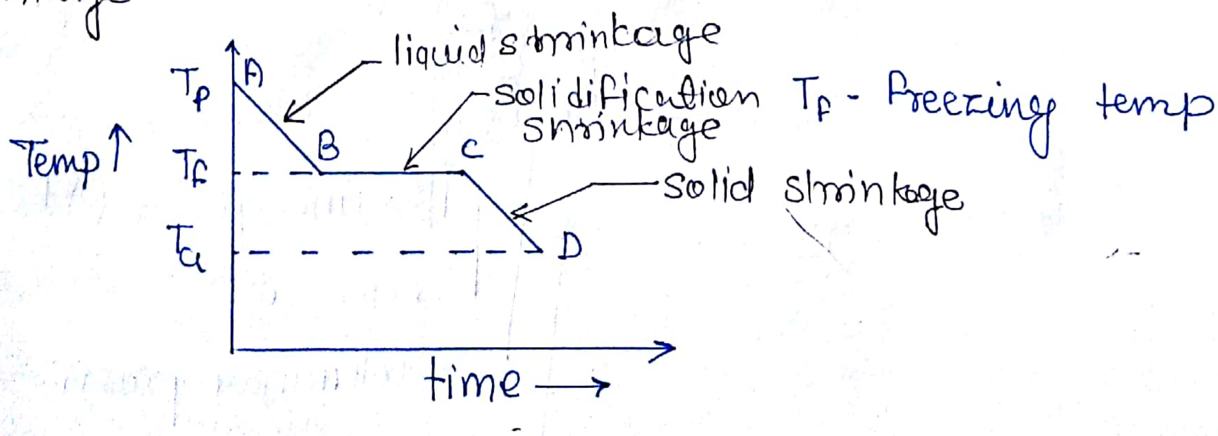
1. shape and size of object to produced.
2. Properties required by the object.
3. Accuracy and surface finish required by the object.
4. No. of Component to be produced.
5. Cost of object.

Pattern :- It is replica of final casting to be produced with some modification.
modification are in form of allowances.

Allowance

1. shrinkage (or) contraction
2. Draft (or) taper
3. Machining (or) finish
4. Shake (or) Rapping
5. Distortion (or) chamber

Shrinkage Allowance :—



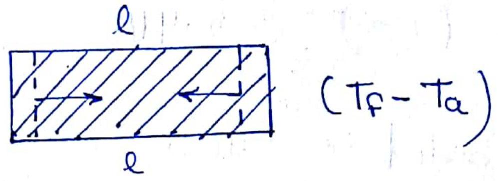
when the liquid metal is allow to solidify there is a possibility of contraction of material during Solidification process. due to this size of casting decrease.

(i) When liquid metal is. Cooled from pouring temp to freezing temp The shrinkage is liquid shrinkage

(ii) During phase transformation process the shrinkage is solidification shirkage. When solid casting is cooled from freezing to ambient temp. shinkage is solid shrinkage

✱ Liquid & solidification shrinkage can be componseted by providing riser there value are express in term of percentage of shrinkage Volume.

Solid shrinkage can be componseted by increasing the dimesion of pattern provideing shrinkage allowance These value are express in terms of linear dimension (mm/m).



Solid shrinkage value

1. Bismuth → Negligible
2. white Metal - 5 mm/m
3. cast irom → 10 mm/m
4. Aluminium → 13 mm/m
5. Copper → 17 mm/m
6. steels - → 20 mm/m
7. Brass - → 23 mm/m

* liquid and solidification shrinkage is maximum for 'Al' which require more volume of Raiser.

* Solid shrinkage is maximum of brass which require large size pattern

* Total shrinkage is maximum for steel

Problem:- A Cubical casting of 50mm size undergoes Volumetric solidification shrinkage of 4% and volumetric ~~solidification~~ solid contraction is 6%. There is no Raiser is used and pattern making allowance is not considerd what is the final size of casting.

Soln

Initial Volume $= (50)^3 \ mm^3$

Volume after ~~to~~ solidification shrinkage 4%

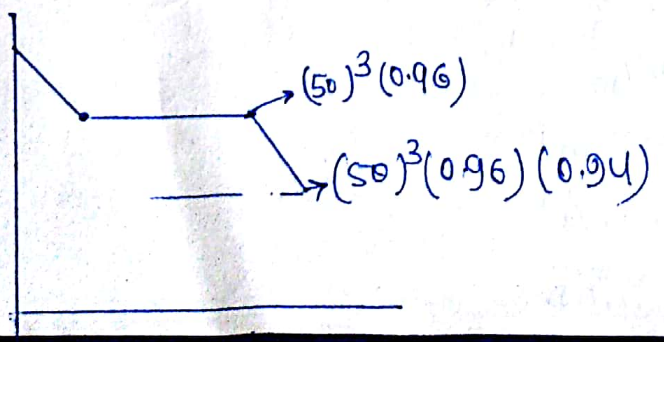
$= (50)^3 \times 0.96$

Volume after solid contraction 6%

$= [(50)^3 \times 0.96] \ 0.94$

Final Volume $V = a^2 = 112800 \ mm^3$

$a = 48.317 \ mm$



Composition (2-5-4% Carbon) & iron
(1-3% silicon)

Gray Cast iron:— In case of Gray Cast iron their is possibility of expansion of material in liquid & solidification state. Due to this no. riser is require this is due to conversion of free form of the carbon in to graphite flex (BCC to HCP)

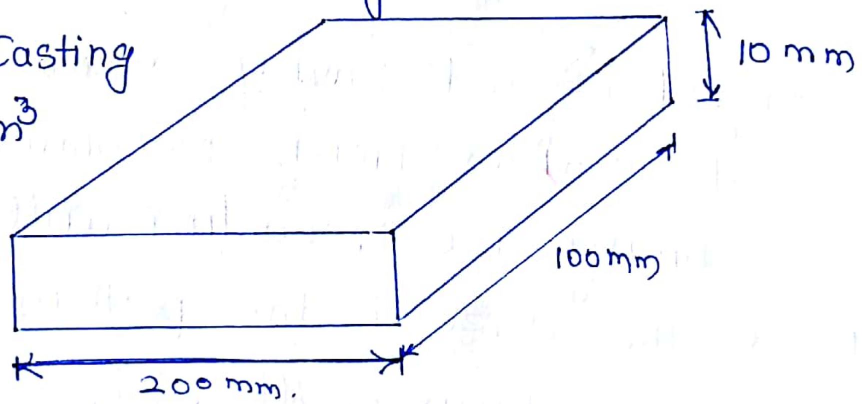
In solid state there is a posibility of contraction of material.

$$\Delta V = 2(\text{\% of Carbon} - 2.8\%)$$

% of Carbon > 2.8% expansion
< 2.8% contraction

Problem:- A Gray Cast iron block of dimension $(200 \times 100 \times 10)\ mm^3$ is produced by sand moulding process pattern making allowance is 1% what is the ratio of volume of pattern to the casting.

Sol^n Volume of Casting
$= (200 \times 100 \times 10)\ mm^3$

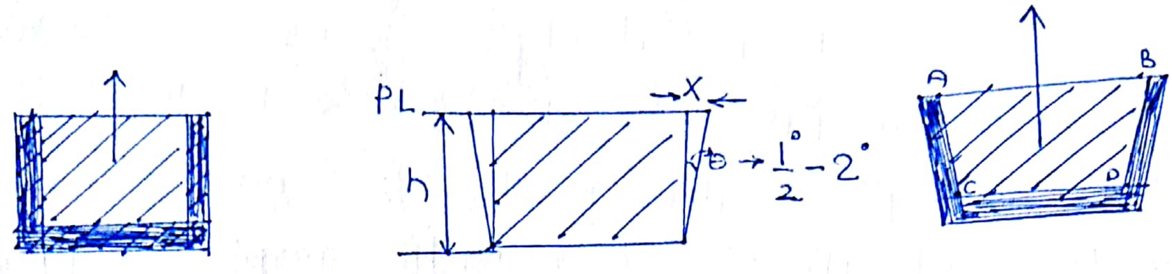


Volume of pattern $= (200+2) \times (100+1) \times (10+0.1)\ mm^3$

$$\frac{\text{volume of pattern}}{\text{Volume of casting}} = \frac{(200+2)(100+1)(10+0.1)}{200 \times 100 \times 10} = 1.03$$

If % of carbon not given assume contraction

Draft (or) Taper Allowance :-

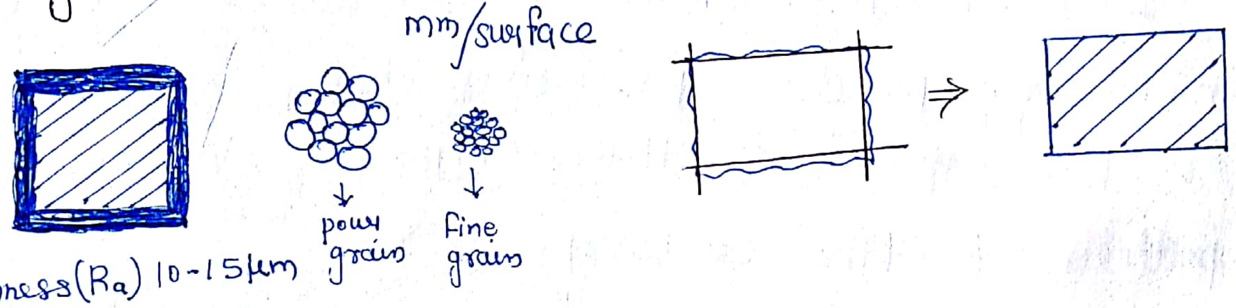


$x = h \tan\theta$

$\tan\theta = x/h$

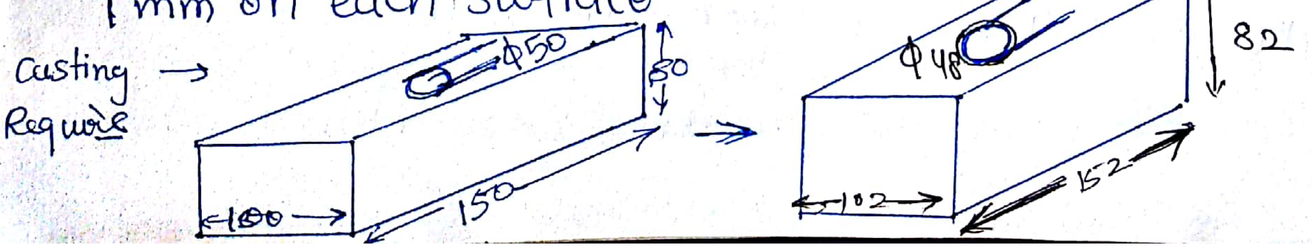
For easy removal of pattern from the mould for the verticle surface of pattern to minimise continues contact with pattern and mould surface, draft or taper allowance is provided.

Maching (or) finish allowance :-

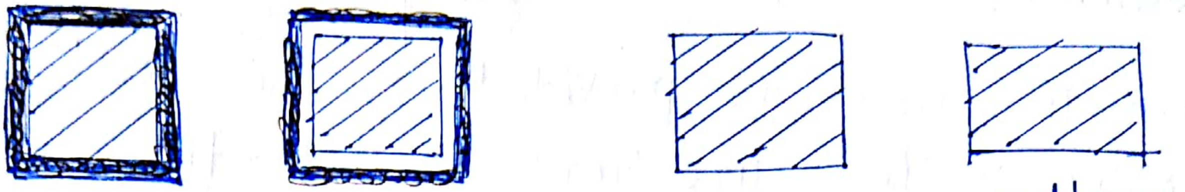


Casting object are not having smooth surface finish machining is require. To get smooth surface finish size of casting will decrease. Due to machining size of the pattern can be increase. To overcome this by providing machining allowance

Problem Calculate the dimension of pattern for the casting shown below by condidering Maching allowance 1 mm on each surface

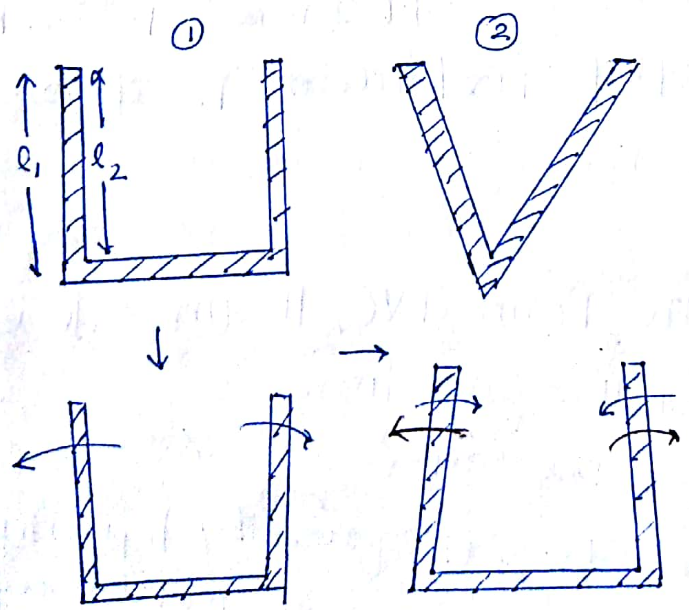


Shake (or) Rapping Allowance:-



Moulding sand will be stick to the surface of pattern due to adhesive property. For easy removal of the pattern from mould some clearance is require between pattern and mould surface this can be produced by shaking of pattern. Due to shaking of pattern size of cavity slightly increase. To overcome this size of pattern can reduced by providing ~~by~~ shake allowance. It is -ve allowance provided on the pattern

Distortion (or) Cambee Allowance:-



* Distortion will takes place out side due more stress outside ($l_1 > l_2$)

it dep

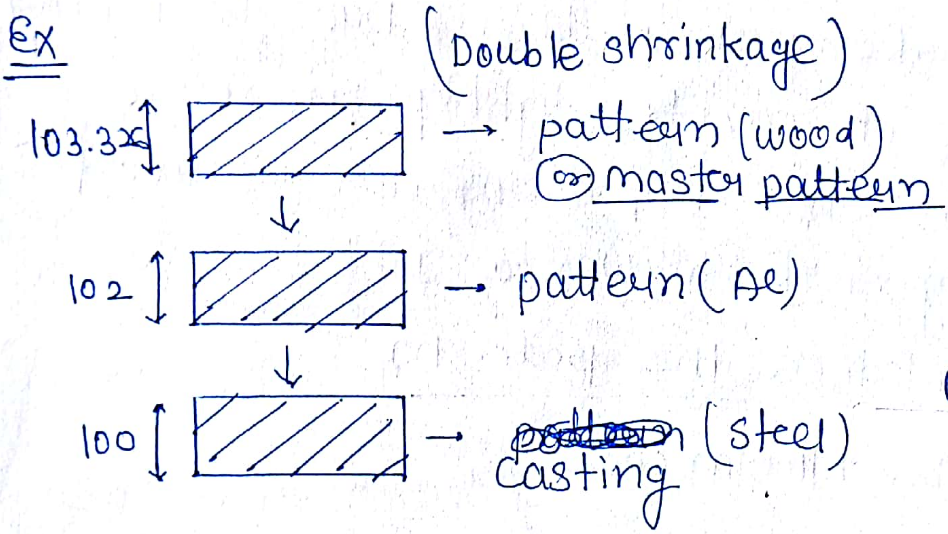
* it is a zero allowance because we are only changing to shape of pattern.

* Due to differance in linear dimension there is possibility distortion of casting. To overcome this distortion allowance provided on the pattern opposite to the direction of distortion. This values will depands on $\left(\frac{l}{t}\right)$ ratio.

Pattern Materials :-

1. Wood - low cost, easy to manufacture, easily available,
2. Metals & Alloys - Al, brass, CI, steel etc.

Ex



① steel (20 mm/m) :-

1000 mm → 20 mm

100 mm → 2 mm

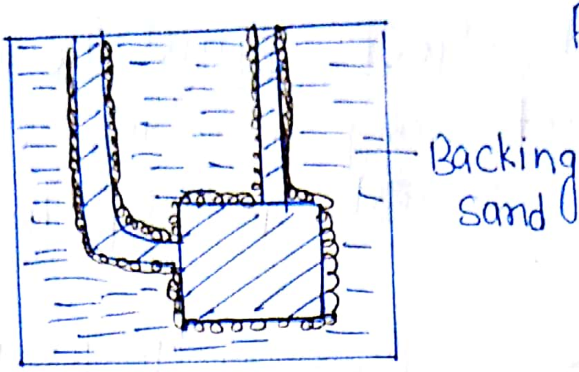
② Al (13 mm/m)

1000 mm → 13 mm

102 mm → 1.326 mm

Ex
To produce casting of steel first need wood pattern and then Al

3. Plastic :- Polystyrene, Foam, PVC, thermocole etc.
   - These pattern can only use one time
   - Expendable or disposable pattern.
     - Wax - investment casting (prepared by Injection moulding)
   - Hg - mercast process (-39°C) freezing temp.

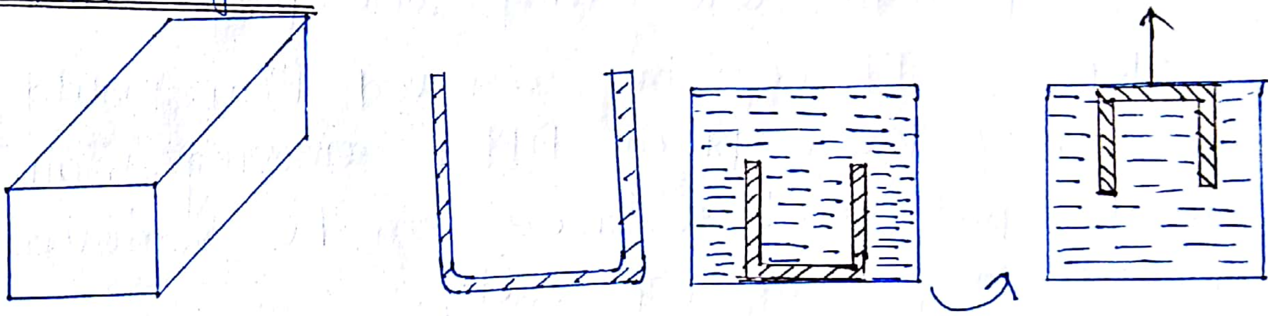


Full Moulding / EPC
cavity less

* Draft & shake allowane are not require in ~~pat~~ plastic pattern because it is in gaseous form.

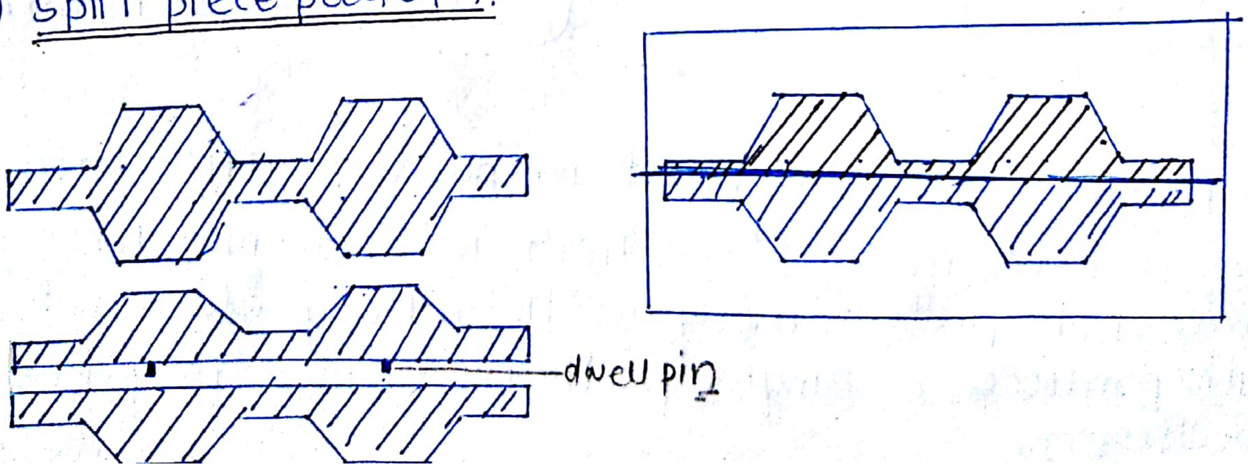
Types of pattern :-

① Solid (or) Single :-



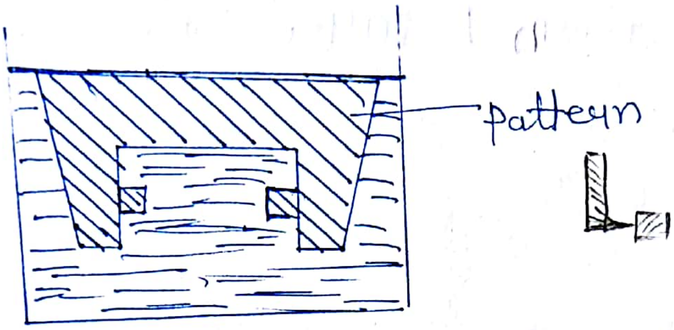
If ~~the~~ the object to be produced is simple in shape and size Solid or Single piece pattern can be used one of the surface of pattern must be flat it is simple and less expansive

② Split piece pattern :-



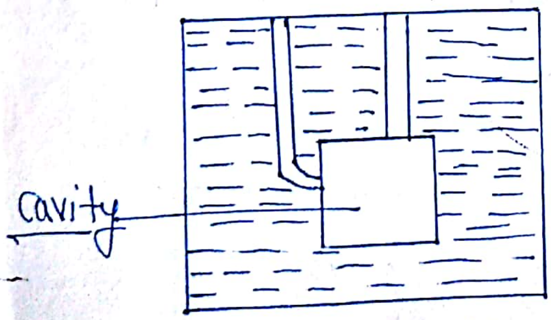
If the complexity of object will be more pattern can be split along parting line they can be removed from mould sprately to get required cavity.

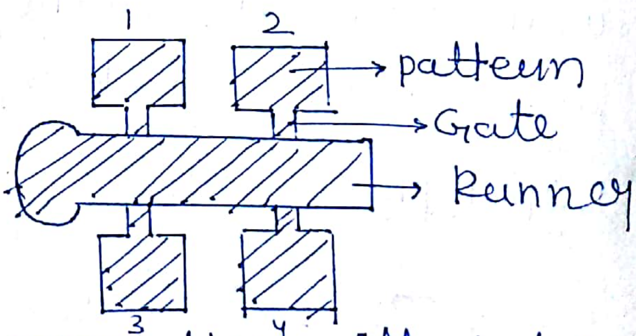
③ **loose piece pattern:-** Used in projections & Undercuts



If the patterns are having some projections and undercuts It can be removed from mould by assuming loose piece. After removing main part of the pattern loose piece can be removed from mould to get required cavity.

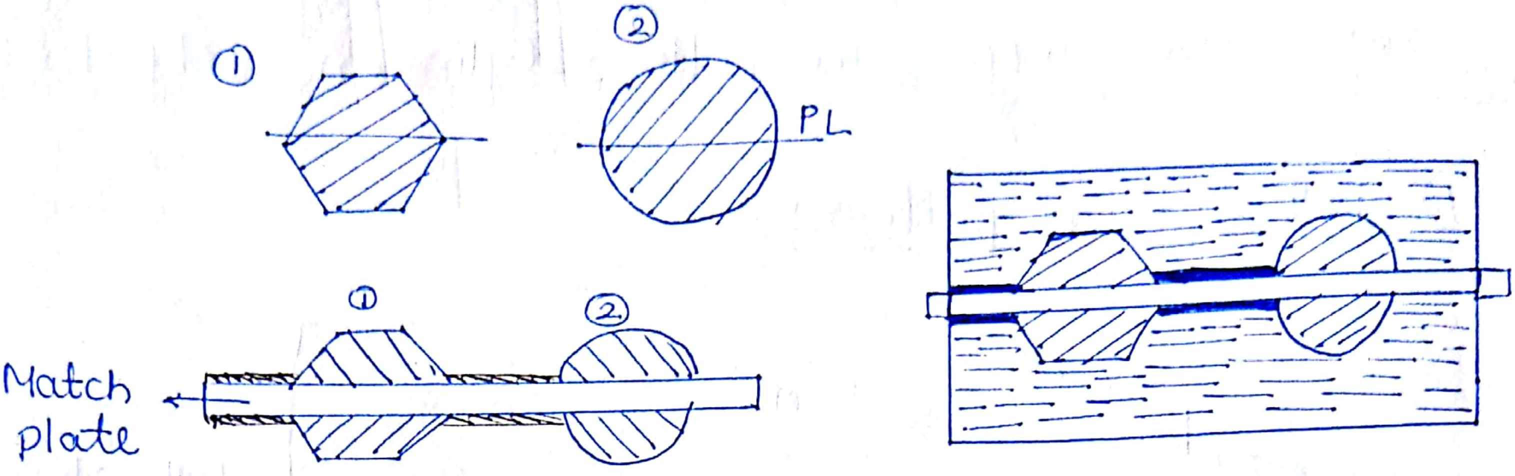
④ **Gated pattern:-**





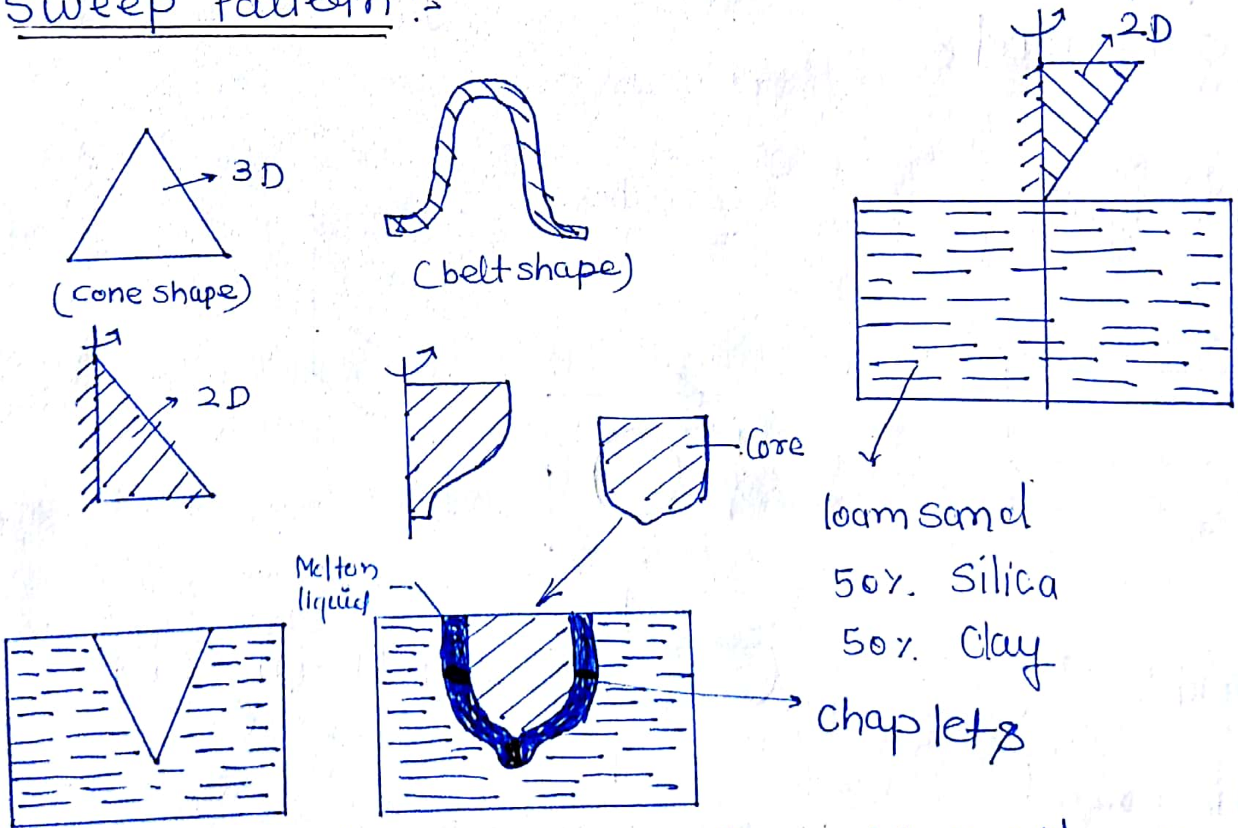
To produce gating element manually will take more time in mass production To overcome this number of pattern along with getting element will produce a single pattern know as gated pattern.

⑤ Match plate pattern:-



To produce complex shape of the object in mass production Number of patterns can be ~~spe~~ split along particle line and they will be added on both side of match plate along with gating element.

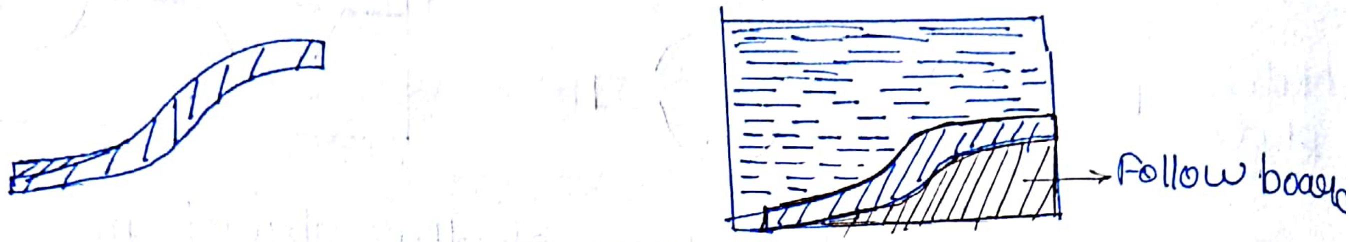
⑥ Sweep Pattern:-



To produce 3-D complex shape of mould cavity 2-D plane pattern will be rotated on the surface of mould to get required shape of cavity.

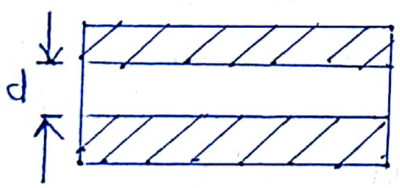
it is not the true shape of pattern it used for axis symmetric object only
Ex:- Cone, large size belt . or Cylinderical object etc

⑦ Follow board pattern:-

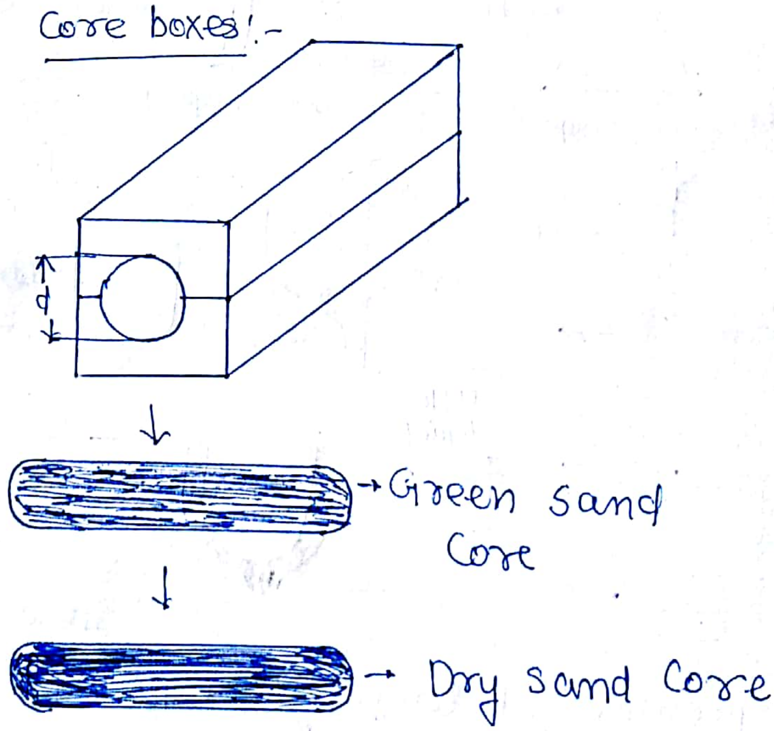


If the pattern are not having sufficient strength due to ramming force there is a possibility of breaking of pattern to overcome this pattern are supported by providing follow board.

Core Design:-



Core boxes:-



Core sand:-

moulding Sand
+
organic binders
(linssed oid, Molasses etc)

Net Buyoncy Force (P) = (Wt. of liquid Metal displace) − (Wt. of core) ~~metal displaced cores~~

$P = Vg\rho_m - Vg\rho_c$

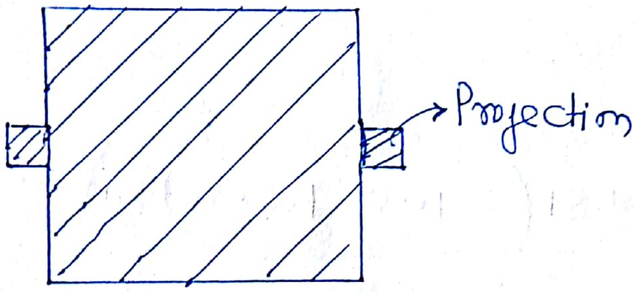
ρ_m - density of Molten Metal
ρ_c - density of Core
V - volume of core
A_c - X-S/c Area of Core

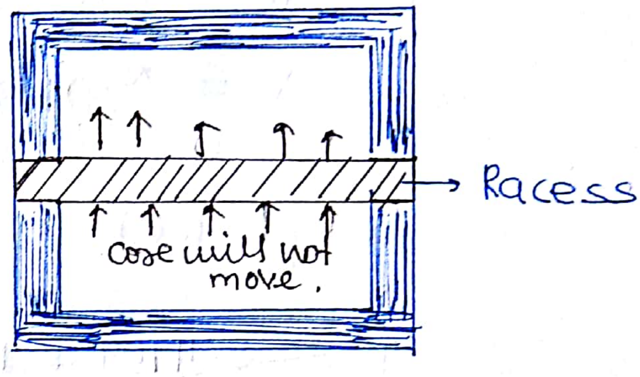
$$P = Vg(\rho_m - \rho_c)$$

$P \leq 3.5 A_c \rightarrow cm^2$

$A_c = \frac{\pi}{4}d^2 + \pi dh$

Core prints:

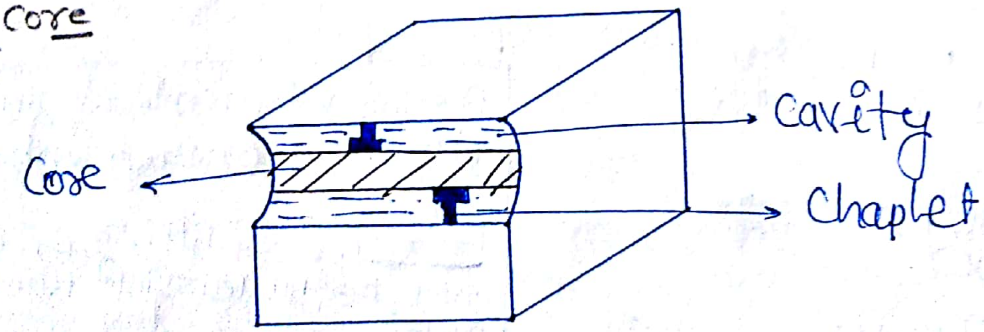




⇒ These are the projections on pattern and produce Recess inside the cavity to position the core properly.

Chaplet:- These are the mettalic object used to support the core inside the cavity they are made up of same material as Casting.

To provide support to ~~core~~ core



Problem:- A hollow casting is produce a cylindrical Core with ~~height~~ h = d = 100 mm. Density of molten metal $\rho_m = 2700\ kg/m^3$ & density of Core ~~matel~~ material is $\rho_c = 1600\ kg/m^3$ What is net buoyancy Force (P) = ?

Sol^n

$$H = D = 100\,mm$$

$$\rho_m = 2700\ kg/m^3$$

$$\rho_c = 1600\ kg/m^3$$

$$V = \frac{\pi}{4} D^2 H$$

$$P = \frac{\pi}{4}(100)^2\, 100 \times 9.81\,(2700-1600) \times 10^{-6}$$

~~P = 8.470435 N~~

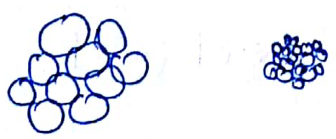
$$P = 8.475231581$$

Moulding Sand and their property:-

Moulding Sand Consist of

- Silica → 70 - 85%.
- Clay → 10 - 20 %.
- water → 2 - 8%.
- Additive → 1 - 6 %.

Clay – Bentonite, – Kalonile } both are in In power form



Grains

Fission & Fusion are nuclear rxn that produce energy

Fission = splitting of a heavy unstable nucleus into two lighter nuclei

Fusion: where two light nuclei combine together release vast amount of energy

Properties of Moulding sand

① **Refractoriness:** Ability of moulding sand to withdstand high temp. of liquid metal without fusion called refractoriness.

② **Permeability** :- Ability of moulding sand to allow the gases escape is known as permeability.

– It is expressed by permeability number

$$P_m = \frac{VH}{PAT}$$

V – Volume of air passing through speciman ($V = 2000\ cm^3$)

$P_n \propto \frac{1}{T}$ $\quad$ $P_n \to 60\text{-}120$

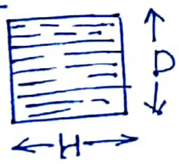
H = Height of cylinderical speciman = 2" = 5.08 cm

P = difference of pressure of air (g/cm^2)

A = X-S/c Area of Speciman ($A = \frac{\pi}{4} D^2\ cm^2$)

T = Time taken by air to allow to escape (min)

A.F.S

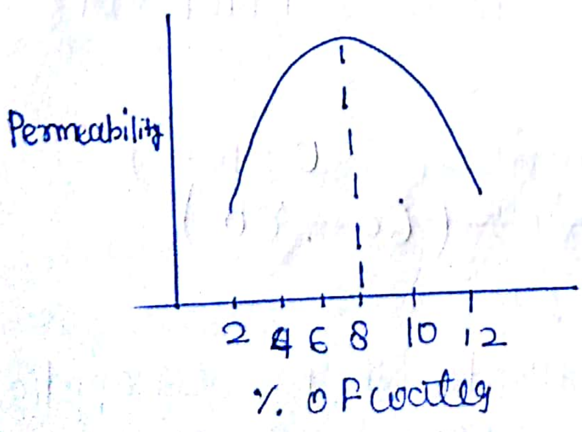


H = D = 2"

= 2 × 2.54

H = D = 5.08 cm

V = 2000 cm^3



* Higher clay (>20%) – Permeability (↓)

$$P = \frac{501.2754}{PT}$$ (cm^2)

P – g/cm^2

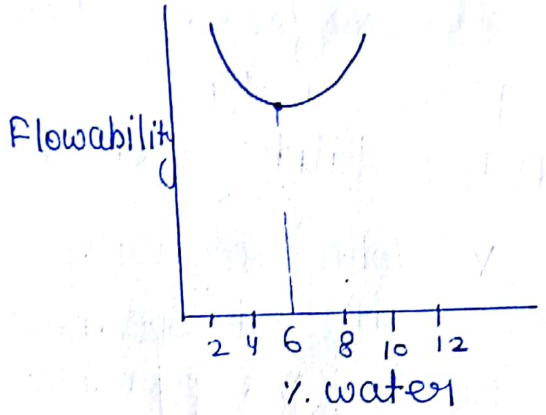
T – min

$$P = \frac{3007.652}{T}$$

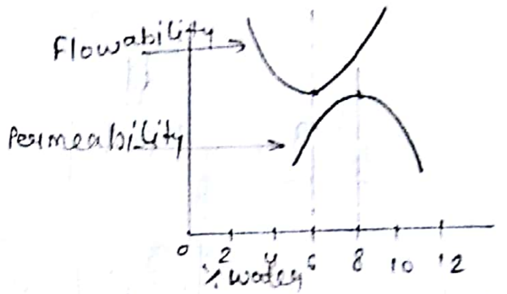
T – sec $\quad$ $g = 10\ g/cm^2$

③ **Flowability:-** Ability of Moulding sand to enter In to all the corner of ~~box~~ mould box due to ramming force this know as Flowability:-

~~[scribbled]~~ % of water Vs Flowability

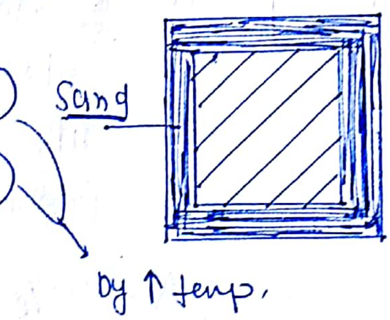


Small grain
- Flowability (↑)



④ **Strength:-**

At start — Green Sand
As we pour metal in cavity — Dry sand
— Hot Sand
↳ After Moisture evaporation



strength → Retain shape

Hardness → Reduce erosion

To retain the shape of the cavity and to widthstand forces applied by liquid metal on the mould surface mould must have sufficient strength.

⑤ **Hardness:-** Mould hardness Number (0-100)
* Avg:- (60 - 80)

hardness is a surface property.
To minimise erosion and to widthstand forces applied by liquid metal on mould surface Mould must be having sufficient hardness.

- If the hardness is < 60 dimensional stability of the casting will be decrease
- If the hardness is > 80 permeability of mould will be decrease.

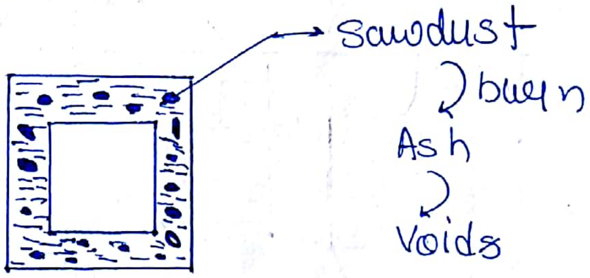
⑤ Adhessive property:
Cohessive property:

⑥ Adhessive property:- bond formation between two different Material

⑦ Cohessive property - bond formation between two similar Material.

* Moulding sand also require sufficient thermal conductivity (k) & low Coefficient of linear expansion(α).

⑧ Collapsibility



As temp ↑ → sawdust burn & Ash produce → Voids occur
then → permeability (↑)
→ Collapsibility (↑)

Ability of the moulding sand due to which mould surface will not provide any resistance due to solid contraction of the casting is know as collapsibility. ⇒ High Collapsibility
↳ low strength & hardness

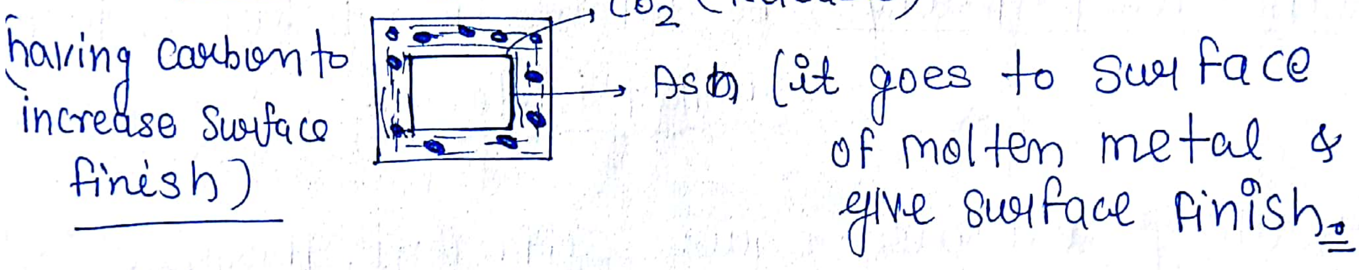
Additive used in Moulding Sand

① Sawdust (or) wood flour } Collapsibility & permeability

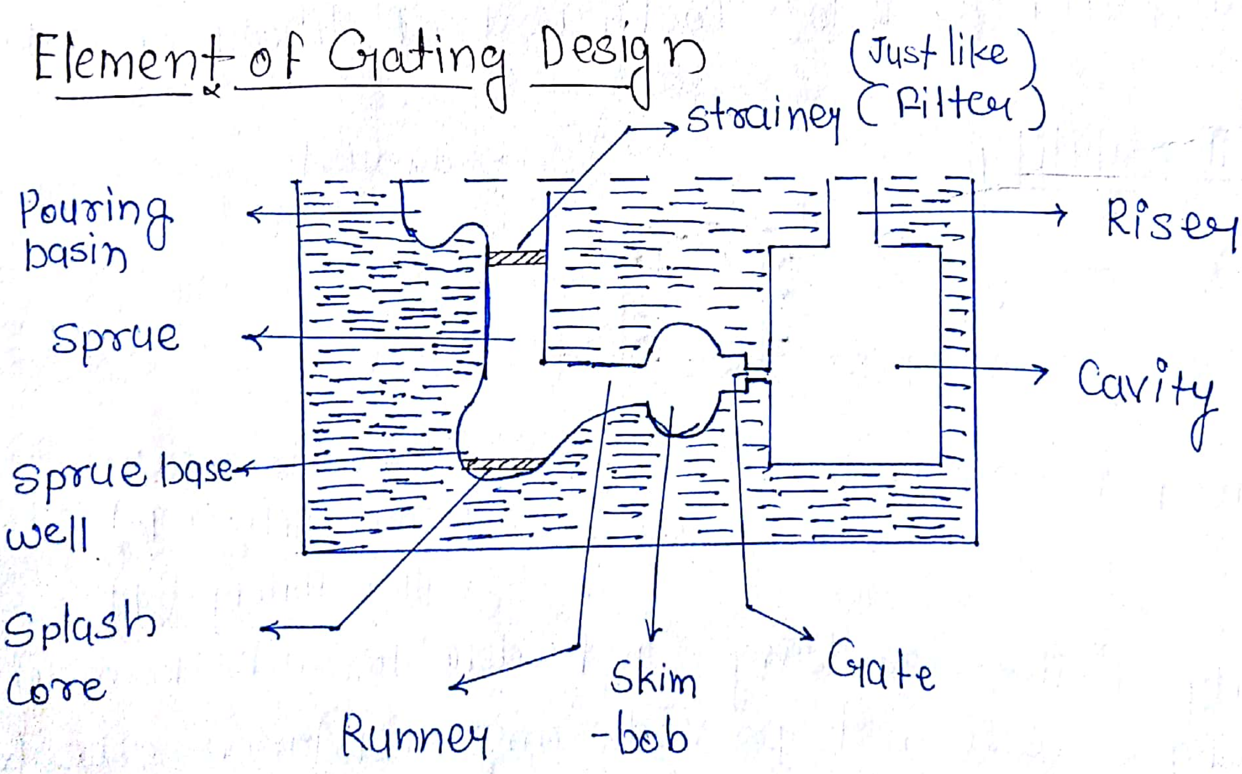
② linseed oils, Molasses, dextrin } Hardness & strength.

③ Coal dust } surface finish

mould wash



Element of Grating Design



* strainer & splash core made of ceramics (withstand high temp)

Objective of gating design

(i) Design the gating element such that liquid metal can be enter ~~into~~ into the cavity within a given time with optimum velocity without causing turbalance, splashing of the liquid metal and mould erosion.

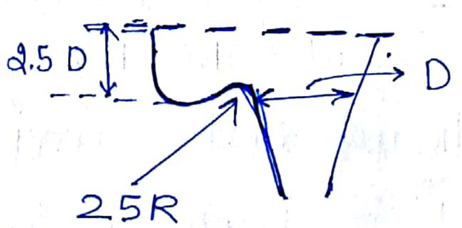
(ii) Produce the gating element such that pure liquid metal can be enter into cavety without Air aspiration effect

(iii) Design the gating to produce maximum casting yield.

$$\text{Casting Yield} = \frac{\text{Vol. of Cavety}}{\text{Vol. of Cavity + Volume of gating element}}$$

$$\boxed{\text{Casting Yield} = \frac{V_c}{V_c + V_g}}$$

Pouring basin:-

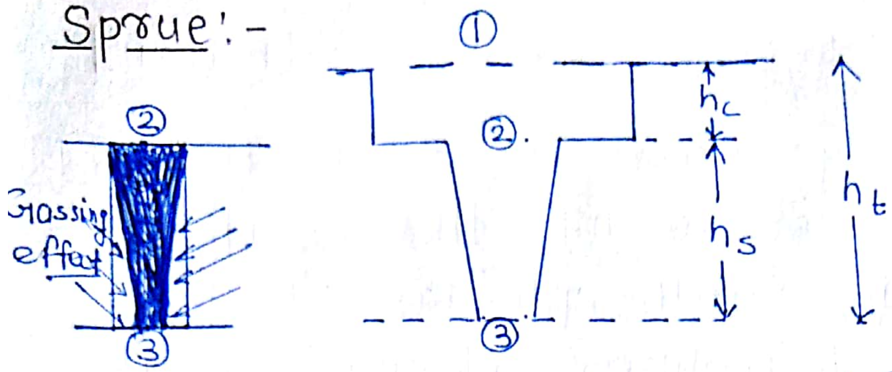


* Pouring basin is design to reduce to velocity of liquid metal which is enter into the sprue.

D - diameter of sprue at top

$R = D/2$

Sprue :-



$\Rightarrow$

$u_3 >> u_2$

$Q = A_2 u_2 = A_3 u_3$

$A_3 << A_2$

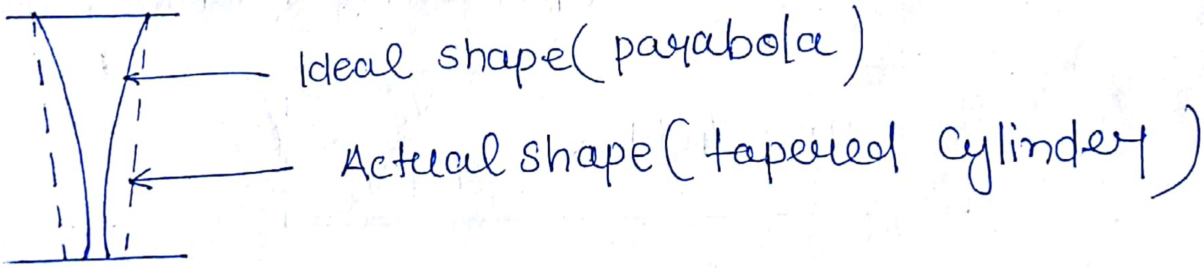
$\because v = \sqrt{2gh}$

$u_2 = \sqrt{2gh_c}$

$u_3 = \sqrt{2gh_t}$

$$\Rightarrow \frac{A_2}{A_3} = \frac{u_3}{u_2} = \frac{\sqrt{2gh_t}}{\sqrt{2gh_c}} = \sqrt{\frac{h_t}{h_c}}$$

$$\frac{h_t}{h_c} = \left(\frac{A_2}{A_3}\right)^2 \Rightarrow y = x^2$$



Air aspiration effect :- Atmospheric gasses can be absorbe in geting element will mixup with liquid Metal and form gas defect this effect is know as air aspiration effect

→ To overcome this effect the ideal shape of sprue is parabola. To reduce the manufacturing dificulties shape of sprue considered as tapered cylinder.

Problem:- In a gating design height of sprue is 200 mm. X-S/c Area of sprue at beginning is 650 mm². Discharge rate of liquid metal is 6.5×10^5 mm³/s. What is the X-S/c Area of sprue at bottom.

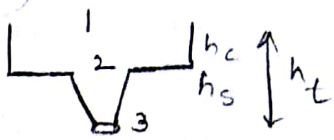
Soln

$h_s = 200$ mm

$A_2 = 650$ mm³

$Q = 6.5 \times 10^5$ mm³/s

$A_3 = ?$



$Q = A_2 u_2$

$\frac{6.5 \times 10^5}{10} = 650 \times u_2 \Rightarrow$

$\Rightarrow u_2 = 10^3$ m/s

~~$u_3 = \sqrt{2gh_s} = \sqrt{2 \times 10 \times 200 \ldots}$~~

~~$u_3 = 6264$ m/s~~

~~So $A_3 = \ldots$~~

$u_2 = \sqrt{2gh_c} = \sqrt{2 \times 9810 \times h_c} = 1000$

$h_c = 50.96$ mm

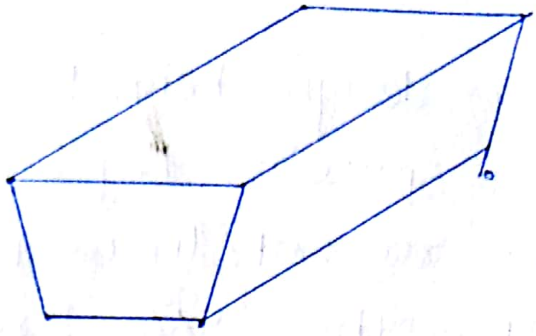
$h_t = 200 + 50.96 = 250.96$ mm

$\frac{A_2}{A_3} = \sqrt{\frac{h_t}{h_c}} \Rightarrow \frac{650}{A_3} = \sqrt{\frac{250.96}{50.96}}$

$A_3 = 292.92$ mm²

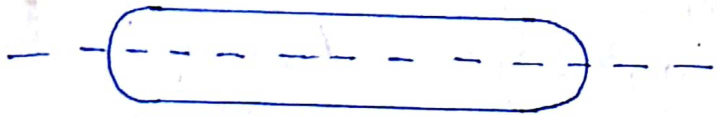
Runner :-

(i)



Heat transfer losses more
(High surface Area)

(ii)



⇒ To minimise ~~heat~~ turbulant and discharge losses of Metal shape of runner is considered as trapizoidal but it is having more surface Area

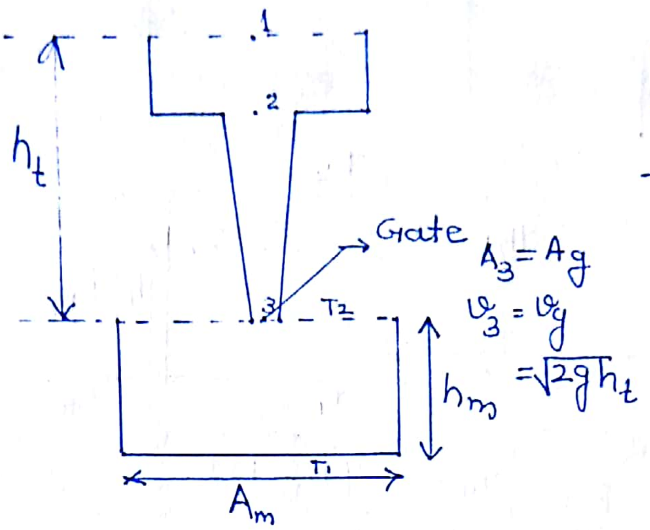
⇒ To minimize heat transfer losses of liquid Metal shape of the runner is considered as cylindrical.

28 July 2016

Gate (Ingate)

1. Top Gate (vertical)
2. Bottom Gate
3. Parting line Gate
4. Step Gate

Top Gate :-



Prefferred for

- Ferrous Material
- Min. depth of cavity
- low thickness
- High Surface Area.
- $\frac{\Delta T}{h}$ temp Gradient low
- ~~loses loss heat~~
- $(T_1 - T_2)$ less
- Low heat loss

- Liquid Metal is directly enter into the cavity from the bottom of sprue at atmospheric pressure.
- Velocity of liquid metal which enter in the cavity is very high. There is possibility of turburlance & splashing of liquid Metal. It is not used for casting non-ferrous material it can be use for ferrous Material with min. depth of Cavity.
- There is favorable temp. Gradient of liquid Metal in the cavity.

Gate $A_3 = A_g$: $v_3 = v_g$ velocity at Gate

$$dt \cdot A_g v_g = A_m \, dh$$

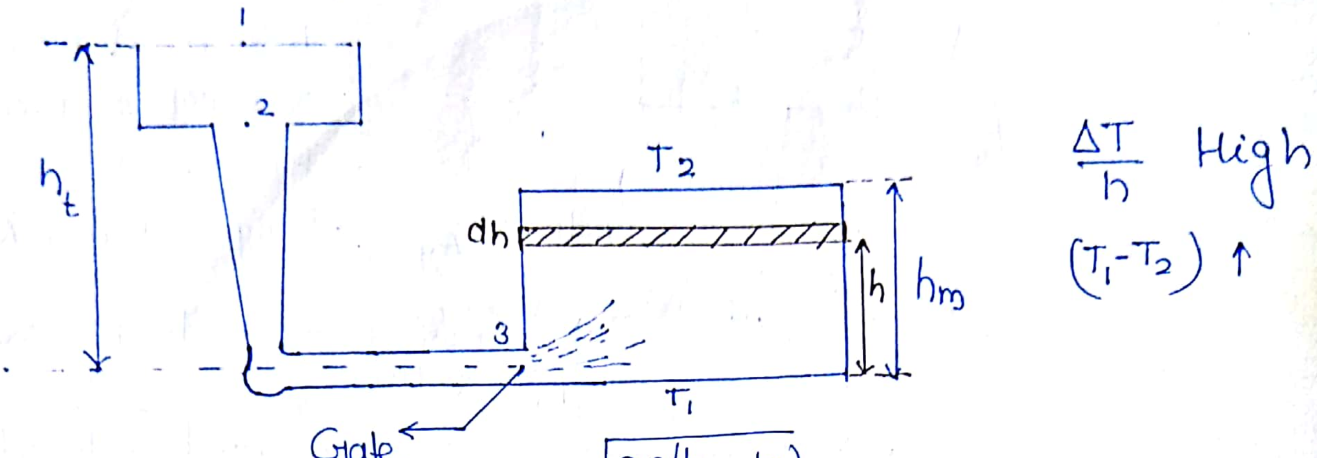
$$t_f \cdot A_g v_g = A_m \cdot h_m$$

Time taken to fill Cavity or filling time

$$t_f = \frac{A_m \cdot h_m}{A_g v_g} = \frac{V_m}{A_g v_g}$$

V_m - Volume of cavity

Bottom Gate:-



$A_3 = A_g$; $V_g = \sqrt{2g(h_t - h)}$

→ Gate is provided at the bottom of the cavity. liquid Metal is enter into the cavity from bottom to top. Velocity of the liquid Metal in cavity is negligible there is no turbulent & splashing. It can be use for casting of non-ferrous Material. There is unfavorable temp. Gradient of Liquid Metal in cavity (ΔT high होने के कारण ferrous material वर्ना में oxide बन जायेगा.)

→ velocity of gate change w.r.t. h

$$dt \cdot A_g V_g = A_m \cdot dh$$

$$\int_0^{t_f} dt = \frac{A_m}{A_g} \int_0^{h_m} \frac{dh}{\sqrt{2g(h_t - h)}}$$

$t = 0, \quad h = 0$

$t = t_f, \quad h = h_m$

$$t_f = \frac{A_m}{A_g\sqrt{2g}} \left[\frac{(h_t - h)^{-\frac{1}{2}+1}}{(-\frac{1}{2}+1)} (-1) \right]_0^{h_m}$$

Time taken to fill the Cavity.

$$\boxed{t_f = \frac{2A_m}{A_g\sqrt{2g}} \left[\sqrt{h_t} - \sqrt{h_t - h_m}\right]}$$

if $h_t = h_m$

$$t_f = 2 \frac{A_m}{A_g \cdot \sqrt{2g}} \sqrt{h_t} \times \left(\frac{\sqrt{h_t}}{\sqrt{h_t}} \right)$$

$\because h_t = h_m$

$$t_f = \frac{2 \cdot A_m h_m}{A_g \sqrt{2gh_t}}$$

$$\boxed{t_{f_b} = 2 \cdot t_{f_T}}$$

* Time require to fill the cavity by bottom gate is 2 times of fill by top gate when $h_t = h_m$
* if $h_m > h_t$ → then it can only fill $(P_1) > P_{atm}$ ~~pressure~~

Problem:- In a Gating design dimension of cavity is given by $(50 \times 25 \times 10)\ cm^3$ it is filled by top gating with pouring height of 15 cm and area of gate is $5\ cm^2$ Time taken to fill the cavity is ?

Ans

$V_m = (50 \times 25 \times 10)\ cm^3$

$A_g = 5\ cm^3$

$h_t = 15\ cm$

$V_g = \sqrt{2gh_t} =$

$$t_f = \frac{V_m}{A_g V_g} = \frac{50 \times 25 \times 10}{5 \times \sqrt{2 \times 981 \times 15}}$$

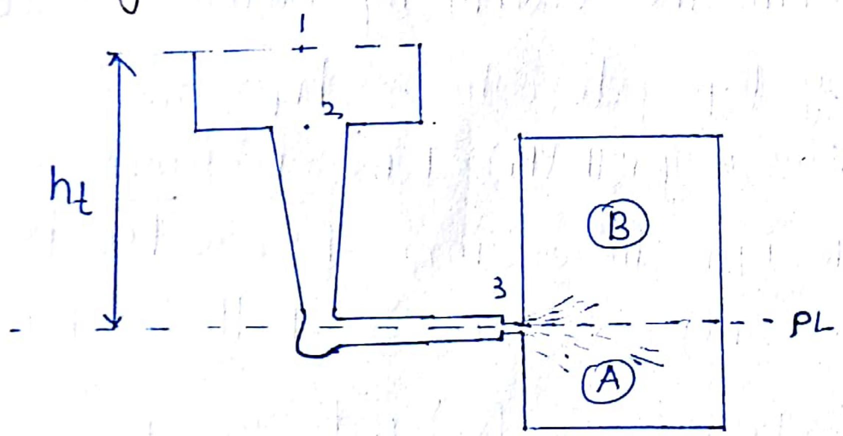
$$t_f = 14.57\ Sec.$$

by bottom gate $h_m = 10$ cm

$$t_{fb} = \frac{2 \cdot (50 \times 25)}{5 \times \sqrt{2 \times 981}} \left(\sqrt{15} - \sqrt{(15-10)} \right)$$

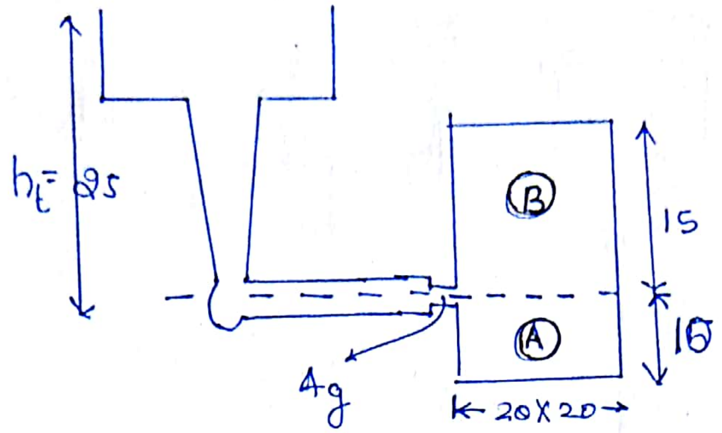
$$t_{fb} = 18.47 \text{ sec.}$$

Parting Line Gate :-



To get the advantage of both top & bottom Gate, gate is provided along the parting line such that liquid metal can be filled into the cavity below the parting line by assuming top gate and above the parting line it can be filled by assuming bottom gate it is the most commonly used type of gate

Problem



All dimesion are in Cm

Calculate the dimesions of gate liquid metal can be complelely fill into the cavity with mein 10 sec.

$$t_f = t_{f_T} + t_{f_b}$$

$$= \frac{A_m h_m}{A_g \cdot V_g} + \frac{2 \cdot A_m}{A_g \sqrt{2g}} \left(\sqrt{h_t} - \sqrt{h_t - h_m} \right)$$

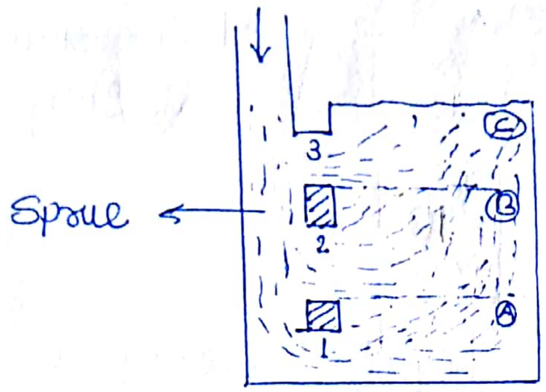
$$10 = \frac{20 \times 20 \times 10}{A_g \sqrt{2 \times 981 \times 25}} + \frac{2 \cdot (20 \times 20)}{A_g \sqrt{2 \times 981}} \left(\sqrt{25} - \sqrt{10} \right)$$

$$10 = \frac{18.06}{A_g} + \frac{33.19}{A_g}$$

$$A_g = \frac{51.25}{10}$$

$$A_g = 5.125 \ Cm^2$$

Step Gate:-

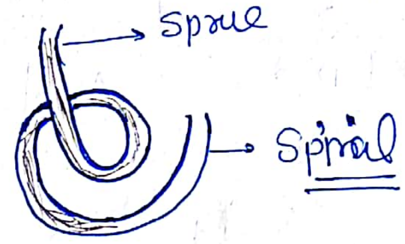


To fill the molton liquid into very large size of cavity no. of gates are provided in to form of step such that liquid metal filled into cavity within giving time without causing turbulance and splashing of liquid Metal.

Fluidity of Liquid Metal:-

AFS - American foundary society

Spiral test:-



Ability of the liquid metal to fill into the cavity is know as fluidity it is the property of a liquid metal it can be determinant by conducting spiral test. Distance covered by liquid metal in a standard spiral before solidification will gives the value of fluidity.

Property		Fluidity
① Pouring temp	↑	↑
② Viscosity	↑	↓
③ Density	↑	↓
④ %.of water in sand	↑	↓
⑤ Surface finish of Cavity	↑	↑

* If %. water increase it require more heat to evorate so fludity decrease
* Density increase mass will increase so fludity ↓

Choke Area :-

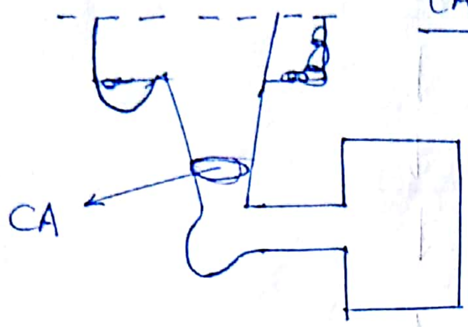
$$C_A = \frac{m}{\rho t_f C_d \sqrt{2 g h_t}}$$

It is the minimum x-S/c area in all the gating element. It will Control the flow of metal which enter in cavity. It is the first parameter to be calculated in all the gating element

m = mass of casting
ρ = density of material
C_d = coefficient of discharg
t_f = filling time

Un-pressurised Gating

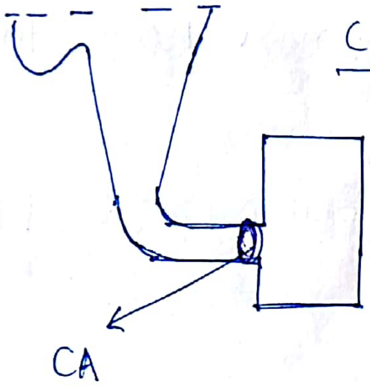
CA = A_s



* low casting yield
* used for non-ferrous.

Pressurised Grating

CA=A_g



* high casting yield
* used for ferrous
* V ↑, back pressure develope back flow also occure.

Un-pressurised Gating

Chock Area is at the bottom of sprue. Velocity of liquid metal which is enter in ~~sprue~~ cavity will be less. The is no possibility of turbulance & splashing it can be used for casting of non-ferrouse material. Casting yield will be less. There is a posibility of air aspiration effect.

Pressurised Gating

Chock area is at the gate velocity of liquid metal which is enter in cavity. ~~The~~ will be high. There is possibility of turbulance & splashing. It can be used for casting of ferrouse material. Casting yield will be high. There is no posibility of air aspiration effect

Gating Ratio

$A_s : A_r : A_g$

A_s - Area of sprue
A_r - Area of runner
A_g - Area of Gate.

1 : 2 : 1 - pressurised gating (no back flow occurs) P↑

1 : 1 : 1 - Un-pressurised gating

U.P.G.	P.G.
1 : 2 : 3	3 : 2 : 1
1 : 2 : 2	2 : 2 : 1
0.5 : 1.5 : 1	2 : 3 : 0.5

Problem: In a gating design gating ratio is 1:2:4 is used to produce casting of mass m = 2 kg & t_f = 11.2 sec. density of material is ρ = 2700 kg/m³ height of liquid metal above the gate is h_t = 250 mm assuming coefficient of discharge C_d = 0.98 calculate the dimension of gate

Soln: G.R. ⇒ 1 : 2 : 4 = $A_s : A_r : A_g$

m = 20 kg, t_f = 11.2 sec., ρ = 2700 kg/m³, h_t = 250 mm

C_d = 0.98

$$\text{Choke Area } A_s = CA = \frac{20}{2700 \times 11.2 \times 0.98 \times \sqrt{2 \times 9.81 \times 0.250}}$$

$$CA = 3.047 \times 10^{-4}\ m^2$$

Choke area CA = 3.04 cm^2

it is un-pressurised gating so $A_s = CA$

$GR = A_s : A_r : A_g = 1 : 2 : 4$

$CA = A_s = 3.04\ cm^2$

$A_g = 4A_s = 4 \times 3.04$

$A_g = 12.18\ cm^2$

$A_g = \frac{\pi}{4} d_g^2 = 12.18 \Rightarrow d_g = 3.9\ cm$

$A_r = 2A_g = 2 \times 3.04$

$A_r = 6.08\ cm^2$

$A_r = \frac{\pi}{4} d_r^2 = 6.08 \Rightarrow d_r = 2.78\ cm$

If the Gating ratio chage G.R ⇒ 4 : 3 : 1

then $CA = A_g$

$A_s = 4 A_g$

$A_r = 3 A_r$

G.R $4:3:1 = A_s : A_r : A_g$

Solidification Time :-

Chvorinov's principle

$$t_s \propto \left(\frac{V}{A}\right)^2$$

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

Always

$(t_s)_r > (t_s)_c$

$r \rightarrow$ ~~casting~~ riser

$c \rightarrow$ casting

$k \rightarrow$ solidification Factor (s/m^2)

$t_s \propto \frac{1}{k} \rightarrow$ thermal Conductivity

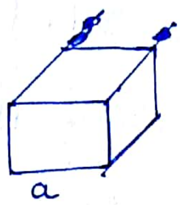
$t_s \propto \frac{1}{\alpha} \rightarrow$ thermal diffusivity

$t_s \propto c \rightarrow$ Heat capacity

High thermal Conductivity, higher the heat transfer rate so time taken in Solidify is less.

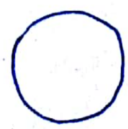
$\left(\frac{V}{A}\right)$ Calculation $\left(\frac{\text{Volume}}{\text{Surface Area}}\right)$

① Cube :-



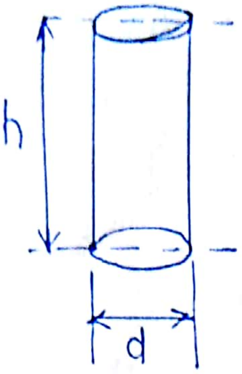
$$\frac{V}{A} = \frac{a^3}{6a^2} = \frac{a}{6}$$

② Sphere:-



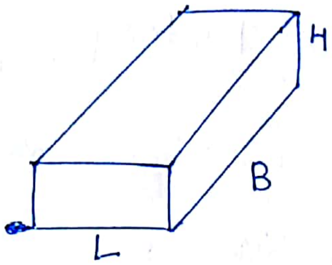
$$\frac{V}{A} = \frac{\frac{4}{3}\pi R^3}{4\pi R^2} = \frac{R}{3}$$

③ Cylinder:-



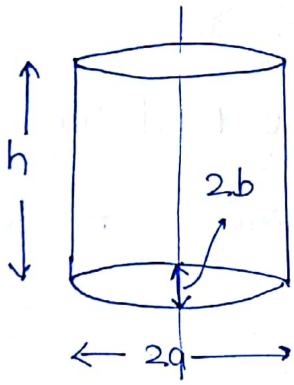
$$\frac{V}{A} = \frac{\frac{\pi}{4} d^2 \cdot h}{2 \cdot \frac{\pi}{4} d^2 + \pi d h}$$

④ Slab:-



$$\frac{V}{A} = \frac{LBH}{2(LB + BH + HL)}$$

⑤ Eiliptical Cylinder:-



$$\frac{V}{A} = \frac{\pi a b h}{2\pi a b + \left(2\pi\sqrt{\frac{a^2+b^2}{2}}\right) h}$$

Problem:- A molton drop of metal in spherical shape with 2mm radius will solidy in 10 sec. what is Solidification time of same molton drop with double radius.

Sol^n $t_{s_1} = 10$ sec. $r_1 = 2$ mm , $t_{s_2} = ?$, $r_2 = 4$ mm

$t_s \propto (V/A)^2$

$t_s \propto (r/3)^2 \Rightarrow \frac{t_{s_1}}{t_{s_2}} = \left(\frac{r_1}{r_2}\right)^2 \Rightarrow t_{s_2} = 10 \times \left(\frac{4}{2}\right)^2$

$t_{s_2} = 40$ sec.

Q.17
Pg.72
workbook

$k = 0.97 \times 10^6 \; s/m^2$

$t_s = ?$ sphere $D = 200$ mm

$$t_s = k\left(\frac{V}{A}\right)^2 = k\left(\frac{R}{3}\right)^2 = k\left(\frac{D}{6}\right)^2$$

$$t_s = 0.97 \times 10^6 \left(\frac{0.2}{6}\right)^2$$

$$t_s = 1077.78 \text{ sec.}$$

Q.15

$$(t_s)_{cube} / (t_s)_{sphere}$$

$$= \left(\frac{V}{A}\right)^2_{cube} / \left(\frac{V}{A}\right)^2_{sphere}$$

Volume same
$V_c = V_s$

$$\frac{(t_s)_{cube}}{(t)_{sphere}} = \frac{(V/A)_c}{(V/A)_s} = \frac{(4\pi r^2)^2}{(6l^2)^2} = \left(\frac{4\pi}{6}\right)^2 \left(\frac{r}{l}\right)^4$$

$$V_c = V_s$$

$$l^3 = \frac{4\pi}{3} r^3 \Rightarrow \left(\frac{r}{l}\right) = \left(\frac{3}{4\pi}\right)^{1/3}$$

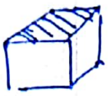
$$\frac{(t_s)_c}{(t_s)_s} = \left(\frac{4\pi}{6}\right)^2 \left(\frac{3}{4\pi}\right)^{4/3} = 0.649$$

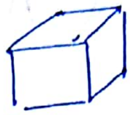
Q 26

$$(t_s) \propto \left(\frac{V}{A}\right)^2$$

$V_1 = a^3$ $\quad\quad$ $V_2 = a^3$

$A_1 = 5a^2$ $\quad\quad$ $A_2 = 6a^2$





$$\frac{(t_s)_1}{(t_s)_2} = \frac{\left(\frac{V}{A}\right)_1^2}{\left(\frac{V}{A}\right)_2^2} = \frac{\left(\frac{a}{5}\right)^2}{\left(\frac{a}{6}\right)^2} = \frac{36}{25}$$

Q.28 $\quad r = h = 6\,cm$

For ractangular plate $(7 \times 10 \times 2)\ cm^3$

$t_s = 1.36$ sec.

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

$$1.36 = K\left(\frac{7 \times 10 \times 2}{2(70 + 20 + 14)}\right)^2$$

$K = 3 \ min/cm^2 =$ ~~[illegible]~~

$$\frac{(t_s)_c}{(t_s)_R} = \frac{\left(\frac{V}{A}\right)_c}{\left(\frac{V}{A}\right)_R} = \frac{\left(\frac{7 \times 10 \times 2}{2(70+20+14)}\right)^2}{\left(\frac{\frac{\pi}{4}(6)^2 \cdot 6}{2 \cdot \frac{\pi}{4}(6)^2 + \pi(6)(6)}\right)^2} = 0.45$$

$$(t_s)_R = \frac{1.36}{0.45} = 3.022 \text{ mins.}$$

(29)

$a = 2h \quad , \quad h = r$

$$\frac{(t_s)_{cy}}{(t_s)_c} = \frac{\left(\frac{\pi r^2 h}{2\pi r^2 + 2\pi r h}\right)^2}{\left(\frac{a}{6}\right)^2} = \frac{\left(\frac{r^3}{4r^2}\right)^2}{\left(\frac{a}{6}\right)^2}$$

$$\frac{(t_s)_{cy}}{(t_s)_c} = \left(\frac{h}{4}\right)^2 \cdot \left(\frac{6}{2h}\right)^2 = 0.5625$$

(31)

$$\frac{(t_s)_c}{(t_s)_s} = \frac{\left(V/A\right)_c^2}{\left(V/A\right)_s}$$

$V_c = V_s$

$a^3 = \frac{4}{3}\pi r^3$

$\frac{r}{a} = \left(\frac{3}{4\pi}\right)^{1/3}$

~~$\frac{4}{(t_s)_s} = \frac{(A)_s^2}{(A)_{cu}^2} = \left(\frac{6a^2}{4\pi r^2}\right)^2$~~

~~$\frac{4}{(t_s)_s} = \left\{\frac{6}{4\pi}\left(\frac{3}{4\pi}\right)^{2/3}\right\}^2$~~

~~$(t_s)_s = 21.76$ sec~~

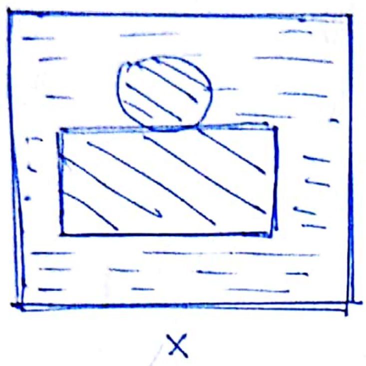
$(t_s) = 6.15$ sec.

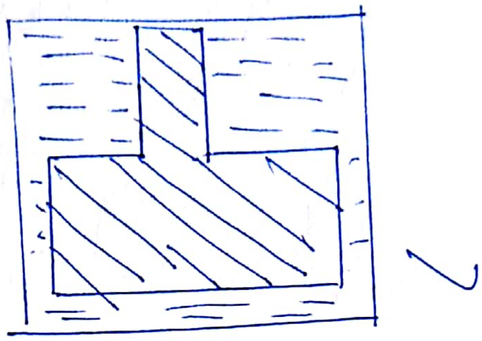
$$\frac{(t_s)_c}{(t_s)_s} = \left(\frac{A_s}{A_c}\right)^2 = \left(\frac{4\pi r^2}{6a^2}\right)^2 = \left(\frac{4\pi}{6}\right)^2 \left(\frac{r}{a}\right)^4 = \left(\frac{4\pi}{6}\right)^2 \left(\frac{3}{4\pi}\right)^{4/3}$$

$t_s = 6.15$ sec

Riser :-

$\left(\frac{A}{V}\right) \rightarrow$ Cooling Characterstics



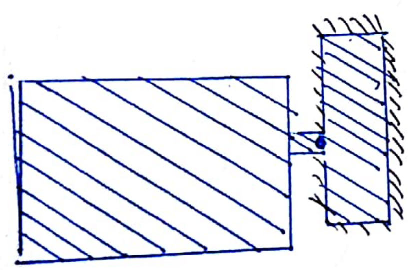


For a given Volume of riser sphere is having min (A/V) ratio but it is not Considered as the shape of riser this is due to availibity of liquid metal in the spherical riser is at center.

Cylinder will be considerd as the shape of riser.

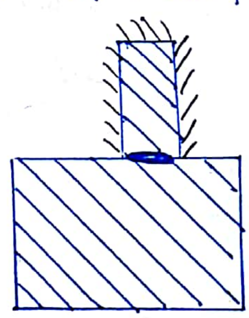
Types of Riser :-

① Side Riser



$A = 2 \cdot \frac{\pi}{4} d^2 + \pi d h$

② Top Riser



$A = \frac{\pi}{4} d^2 + \pi d h$

Top Riser is effective as compare to Side riser because it's is having less surface Area.

optimum Condition

① Side riser

$$A = 2.\frac{\pi}{4}d^2 + \pi d h$$

$$\because V = \frac{\pi}{4}d^2.h \Rightarrow h = \frac{4V}{\pi d^2}$$

$$A = 2.\frac{\pi}{4}d^2 + \pi.d.\frac{4V}{\pi d^2}$$

$$A = \frac{\pi}{2}d^2 + \frac{4V}{d}$$

$$\frac{\partial A}{\partial d} = 0 \Rightarrow \pi d - \frac{4V}{d^2} = 0$$

$$V = \frac{\pi}{4}d^3 = \frac{\pi}{4}d^2.h$$

$$\boxed{h = d}$$

$$\left(\frac{A}{V}\right) = \frac{2.\frac{\pi}{4}.d^2 + \pi d h}{\frac{\pi}{4}d^2.h} \quad \because h = d$$

$$\left(\frac{A}{V}\right) = \frac{2.\frac{\pi}{4}d^2 + \pi d^2}{\frac{\pi}{4}d^3} = \frac{\frac{3\pi}{2}}{\frac{\pi}{4}d} = \frac{6}{d}$$

$$\therefore \boxed{\left(\frac{A}{V}\right) = \frac{6}{d}}$$

② Top Riser

$$A = \frac{\pi}{4} d^2 + \pi d h$$

$$V = \frac{\pi}{4} d^2 h \Rightarrow h = \frac{4V}{\pi d^2}$$

$$A = \frac{\pi}{4} d^2 + \frac{4V}{d}$$

$$\frac{dA}{d(d)} = 0 \Rightarrow \frac{\pi}{2} d - \frac{4V}{d^2} \Rightarrow V = \frac{\pi}{8} d^3 = \frac{\pi}{4} d^2 h$$

$$\left(h = \frac{d}{2} \right)$$

$$\frac{A}{V} = \frac{\frac{\pi}{4} d^2 + \pi d h}{\frac{\pi}{4} d^2 \cdot h} \Rightarrow \boxed{h = \frac{d}{2}}$$

$$\frac{A}{V} = \frac{\frac{\pi}{4} d^2 + \frac{\pi d^2}{2}}{\frac{\pi}{8} d^3} = \frac{6}{d}$$

$$\boxed{\frac{A}{V} = \frac{6}{d}}$$

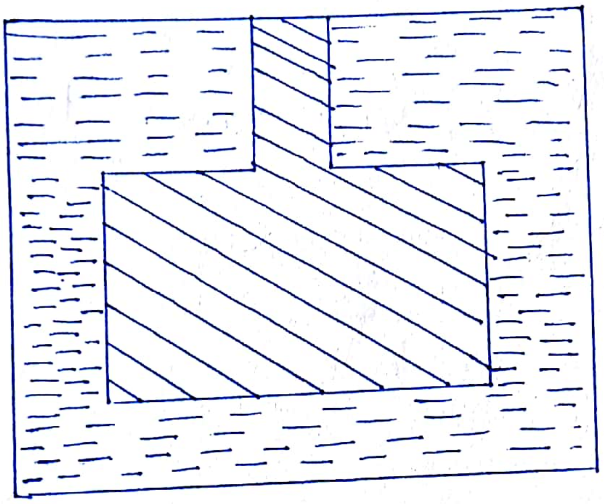
Side Riser	$h = d$	$\left(\frac{A}{V}\right) = \frac{6}{d}$
Top Riser	$h = \frac{d}{2}$	$\left(\frac{A}{V}\right) = \frac{6}{d}$

Riser Design:-

Method-I

① (a) Vol. of Riser = 3 x % Shrinkage Vol. Of Casting

(b) $\left(\frac{A}{V}\right)_C \geq \left(\frac{A}{V}\right)_R$



* By using this method dimension of riser can be calculated if % of shrinkage of the material will be given.

Method to increase the performance of riser !

① provide insulating material

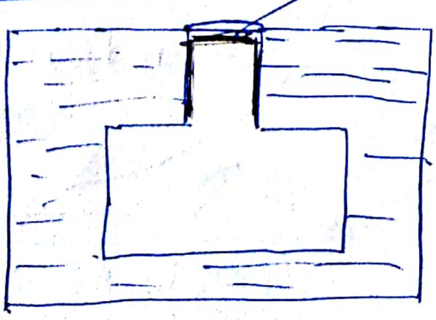
② Exothermic Material

③ Use optimum Condition ($h = d/2$, $h = d$)

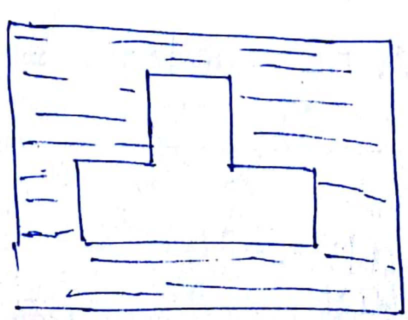
④ Provide Blind riser

insulating material put here

Open riser



Blind riser



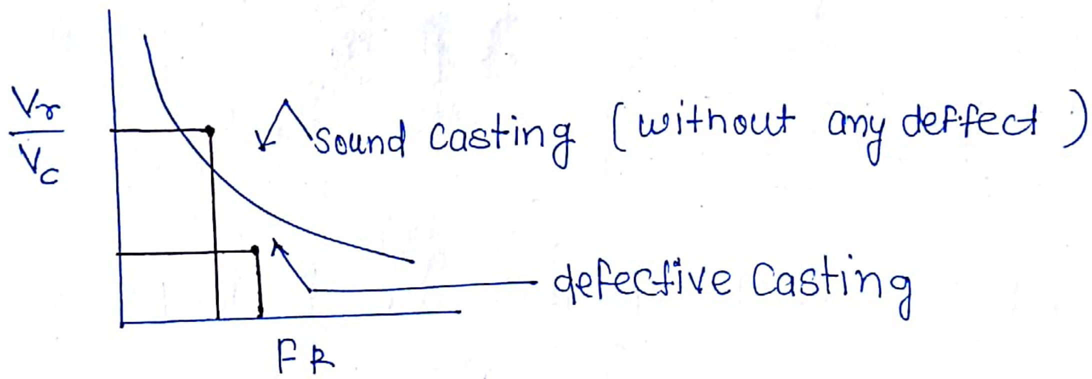
Method - II

② Caine's Method :-

$$\text{Freezing Ratio (FR)} = \frac{\left(\frac{A}{V}\right)_c}{\left(\frac{A}{V}\right)_r}$$

$$X = \frac{a}{Y-b} + c$$

$X = FR$, $Y = \frac{V_r}{V_c}$, a, b, c are constant.



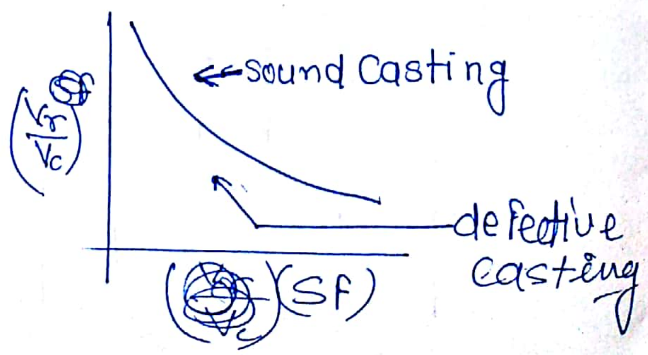
Using this method dimensions of the riser can be calculated for a simple shape of casting

Method - III

③ Modified caine's Method :- (Naval research laboratory Method)

$$\text{Shape factor (SF)} = \frac{L+W}{T}$$

L - length.
W - width.
T - thickness.



Geometry	Safe Factor (SF)
i> Cube	$\frac{a+a}{a} = 2$
ii> Sphere	$\frac{D+D}{D} = 2$
iii> Cylinder	$\frac{H+D}{D}$
iv> slab	$\frac{L+B}{H}$

Method - IV

④ modulus Method :-

$$\boxed{\text{modulus} = \left(\frac{V}{A}\right)} = \frac{\text{Volume}}{\text{surface area}}$$

$$\boxed{M_R = 1.2\, M_c}$$

Q. T1
P.g. 74

$V_c = (25 \times 12.5 \times 5)\ cm^3$

$V_r = 3 \times 3\%\ V_c$

$V_r = \frac{3 \times 3 \times (25 \times 12.5 \times 5)}{100} = 140.625\ cm^3$

$V_r = \frac{\pi}{4} d^2 . h$ Side riser $h = d$

$140.625 = \frac{\pi}{4} d^3$ $\Rightarrow d = 5.636258259\ cm$

shrinkage along is mention
so this is Answer.
if nothing mention go further.

$$\left(\frac{A}{V}\right)_c = \frac{2[25\times12.5+12.5\times5+5\times25]}{25\times12.5\times5} = 0.64$$

$$\left(A/V\right)_r = \left(\frac{6}{d}\right) = \frac{6}{5.636} = 1.064$$

$$\left(A/V\right)_c < \left(A/V\right)_r$$ Condition is Failed

So Need Redesign Riser

$$\left(\frac{A}{V}\right)_c = \left(A/V\right)_r$$

$$\frac{6}{d} = 0.64$$

$$d = 9.375 \text{ cm}$$

Q.32

$$X = \frac{a}{Y-b} + c$$

$$X = FR = \frac{(A/V)_c}{(A/V)_R}$$

$$Y = \frac{V_r}{V_c}$$

$$X = \frac{0.10}{Y-0.03} + 1$$

$$\left(\frac{A}{V}\right)_c = \frac{2[250\times250+(250\times50)2]}{250\times250\times50}$$

$$\left(\frac{A}{V}\right)_c = 0.056$$

$$\left(\frac{A}{V}\right)_r = 6/d \qquad h=d$$

$$V_r = \frac{\pi}{4}d^3$$

$$X = FR = \frac{0.056}{6/d} \; ; \; Y = \frac{V_r}{V_c} = \frac{\frac{\pi}{4} d^3}{(250 \times 250 \times 50)}$$

$$FR = \frac{0.1}{V_r/V_c - 0.03} + 1 \Rightarrow \frac{0.056}{6/d} = \frac{0.1}{\frac{\frac{\pi}{4} d^3}{3125000} - 0.03} + 1$$

~~$$\left(\frac{0.056\, d}{6} - 1\right)\left(\frac{\frac{\pi}{4} d^3}{250 \times 250 \times 50}\right) = 0.1$$~~

$$\left(\frac{0.056}{6} d - 1\right)\left(\frac{\frac{\pi}{4} d^3}{3125000} - 0.03\right) = 0.1$$

$$d = 128.4 \text{ mm}$$

Q. 30

$$V_c = 25 \times 15 \times 5 \text{ cm}^3$$

$$SF = \frac{25+15}{5} = 8 \quad \underline{So}$$

$$\Rightarrow \frac{V_r}{V_c} = 0.50$$

$$\frac{\frac{\pi}{4} d^3}{(25 \times 15 \times 5)} = 0.50 \Rightarrow d = 10.60784 \text{ cm}$$

Q. A cylindrical riser $h = d$ is positioned on top surface of a cylinderical casting with $d = 200\,mm$ & $h = 100\,m$ using Modular Method calculate the dimension of riser.

$$M_R = 1.2 M_c$$

$$\left(\frac{V}{A}\right)_R = 1.2\left(\frac{V}{A}\right)_c$$

$$M_R (\ )_R = 1.2\left(\frac{\frac{\pi}{4}d^2 \cdot h}{2\frac{\pi}{4}d^2 + \pi d h}\right) = \frac{dh}{4\left(\frac{d}{2}+h\right)}$$

$$M_R (\ )_R = 1.2\left(\frac{\frac{\pi}{4}\times(200)^2 \cdot 100}{2 \cdot \frac{\pi}{4}(200)^2 + 200\times100\times\pi}\right)$$

$$M_R = 1.2 \times 25$$

$$M_R = 30$$

$$M_r = \frac{\frac{\pi}{4}d^2 \cdot h}{\frac{\pi}{4}d^2 + \pi d h} \qquad \underline{\underline{h = d}}$$

$$M_r = \frac{d}{5}$$

$$\frac{d}{5} = 30 \Rightarrow d = 150\ cm$$

(T2)

$$t_s = k\left(\frac{V}{A}\right)^2$$

$$\left(\frac{V}{A}\right)_1 = \left(\frac{\pi \frac{D^2}{4} h}{2 \cdot \frac{\pi}{4} D^2 + \pi D h}\right) = \frac{D^2 h}{2D^2 + 4DH}$$

$$\left(\frac{V}{A}\right)_1 = \frac{dh}{2d + 4H} = \frac{d^2}{2d + 4d}$$

$$\left(\frac{V}{A}\right)_1 = \frac{d}{6}$$

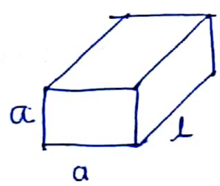
$$V = \frac{\pi d^2}{4} \cdot h$$

$$h = \frac{4V}{\pi d^2}$$

$$A = 2 \cdot \frac{\pi}{4} d^2 + \pi d h \quad ; \quad h = \frac{4V}{\pi d^2}$$

$$\boxed{h = d}$$

square parallelopiped



$$A = 2a^2 + 4al$$

$$V = a^2 \cdot l \Rightarrow l = \frac{V}{a^2}$$

$$A = 2a^2 + 4\frac{V}{a}$$

$$\frac{\partial A}{\partial V} = 0$$

$$\Rightarrow 4a - \frac{4V}{a^2} = 0$$

$$V = a^3 = a^2 \cdot l$$

$$a = l$$

$$V_{cy} = V_{sp}$$

$$\frac{\pi}{4} d^3 = a^3 \Rightarrow \frac{a}{4} = \left(\frac{\pi}{4}\right)^{1/3}$$

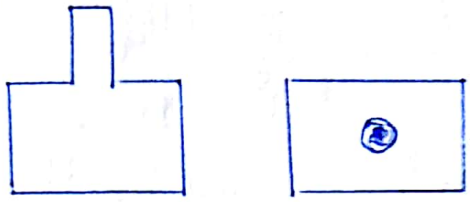
$$\frac{(t_s)_{cy}}{(t_s)_{sp}} = \frac{\left(\frac{V}{A}\right)^2_{cy}}{\left(\frac{V}{A}\right)^2_{sp}} = \frac{(A)^2_{sp}}{(A_{cy})^2}$$

$$= \frac{(6a^2)^2}{\left(\frac{3}{2}\pi d^2\right)^2} = \left(\frac{4}{\pi}\right)^2 \cdot \left(\frac{a}{d}\right)^4$$

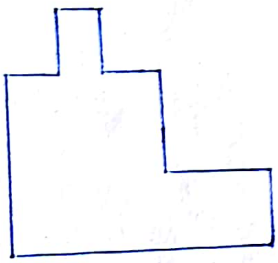
$$= \left(\frac{4}{\pi}\right)^2 \cdot \left(\frac{\pi}{4}\right)^{4/3} = 1.174$$

Position of Riser:-

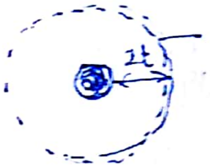
① For uniform thickness

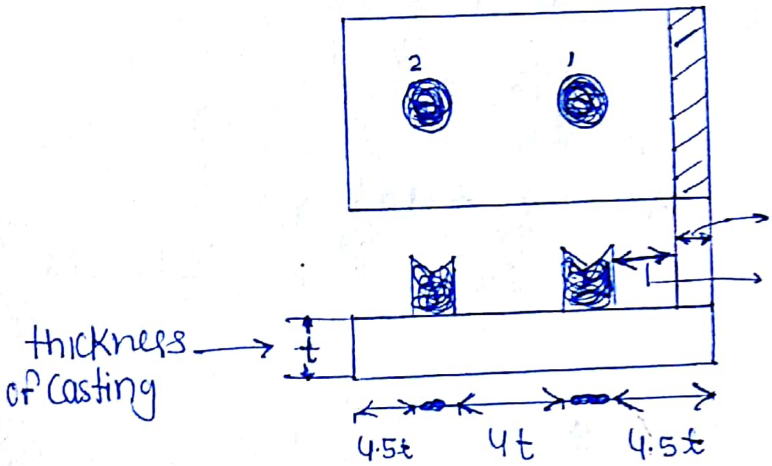


② for non-uniform thickness



③ For min. thickness & max. surface Area.





$L = 13t + d$ ↳ dia of riser but Neglate it

(i) with endwall effect

$L = 13t$ (Two riser)

$L = 9t$ (one riser)

(ii) without endwall effect

$L = 8t$ (Two riser)

$L = 4t$ (one riser)

L - Max. length of casting

t - thickness of casting

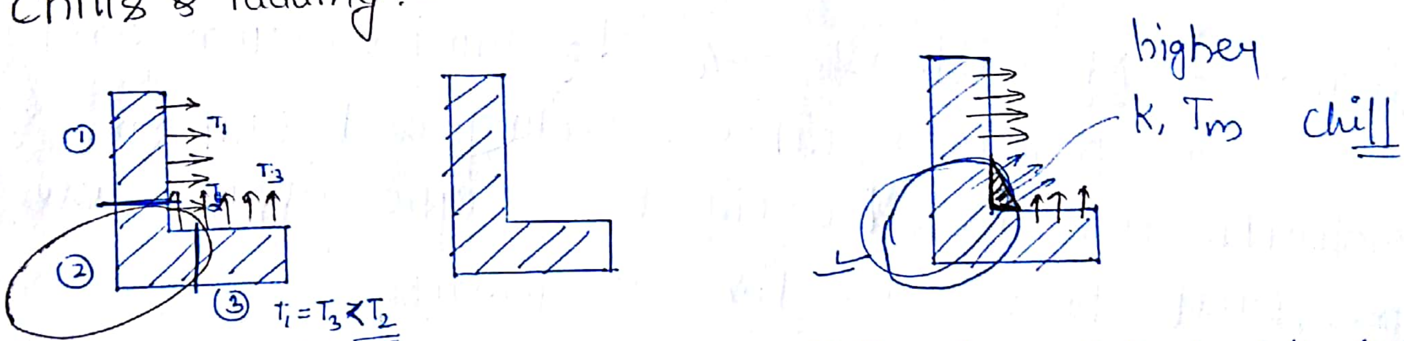
* for uniform thickness and simple shape of casting on riser is sufficient to componset to shrinkage & it is position at the top surface of casting at the center.

* for non-uniform thickness of casting riser is provided higher thickness of casting. ~~for m~~

* for min. thickness & max. surface area of casting due to fast rate of shrinkage of material more no. of riser provided to componset the shrinkage of casting

* In calculation of length of casting diameter of riser can be neglated if given consider.

Chills & Padding :-



* due to cross flow ΔT is low in ~~this~~ x-s/c so less heat transfer takes place so there is non-uniform shrinkage &

$$q = -KA\frac{dT}{dx}$$

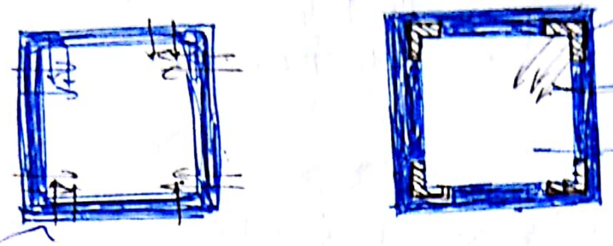
* Due to non uniform heat transfer hot tears/crack will occurs

* In x-s/c ① & ③ material solidify faster.

* Higher thermal conductivity (K) & higher melting point (Tm) material chills are providing for uniform heat transfer

* in that perticular x-S/c

Padding :-



Chanse of erosion at critical x-s/c

After casting remove padding & chills by filing

Chills :- At a min x-s/c in the mould cavity to maximise the heat transfer rate and to provide uniform & direction solidification mettalic objects are provided these are known as chills.

Padding :- At critical x-s/c to mini erosion and to provide uniform cooling and uniform solidification metallic object of higher k, Tm are provided these are know as padding

☆ By providing chill & padding uniform solidification and directional solidification can be possible.

Classification of Casing Technique :-

① **Expendable Moulding:** (Sand Moulds)
- Sand moulding
- shell moulding
- Investment
- Full moulding
- CO_2 moulding

- time consuming
- laborious process
- non uniform cooling & solidification
- less accuracy
- Complex shape and can produce

② **Permanent Moulds:-** (Metallic Moulds)
- Centrifugal
- Die casting
- Slush casting
- Squeeze casting

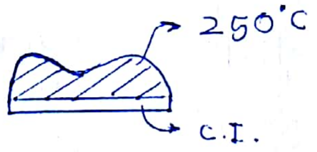
- can use more time & mass production
- surface finish
- Fast rate of Heat transfer so fine grain develope so high strength

③ **Continuous casting:-** large length bloom billet produce for high production

→ Gas deffect occurs
- Metal to metal contact possible so solid lubricant require
- low T_m should produce

Shell Moulding :-

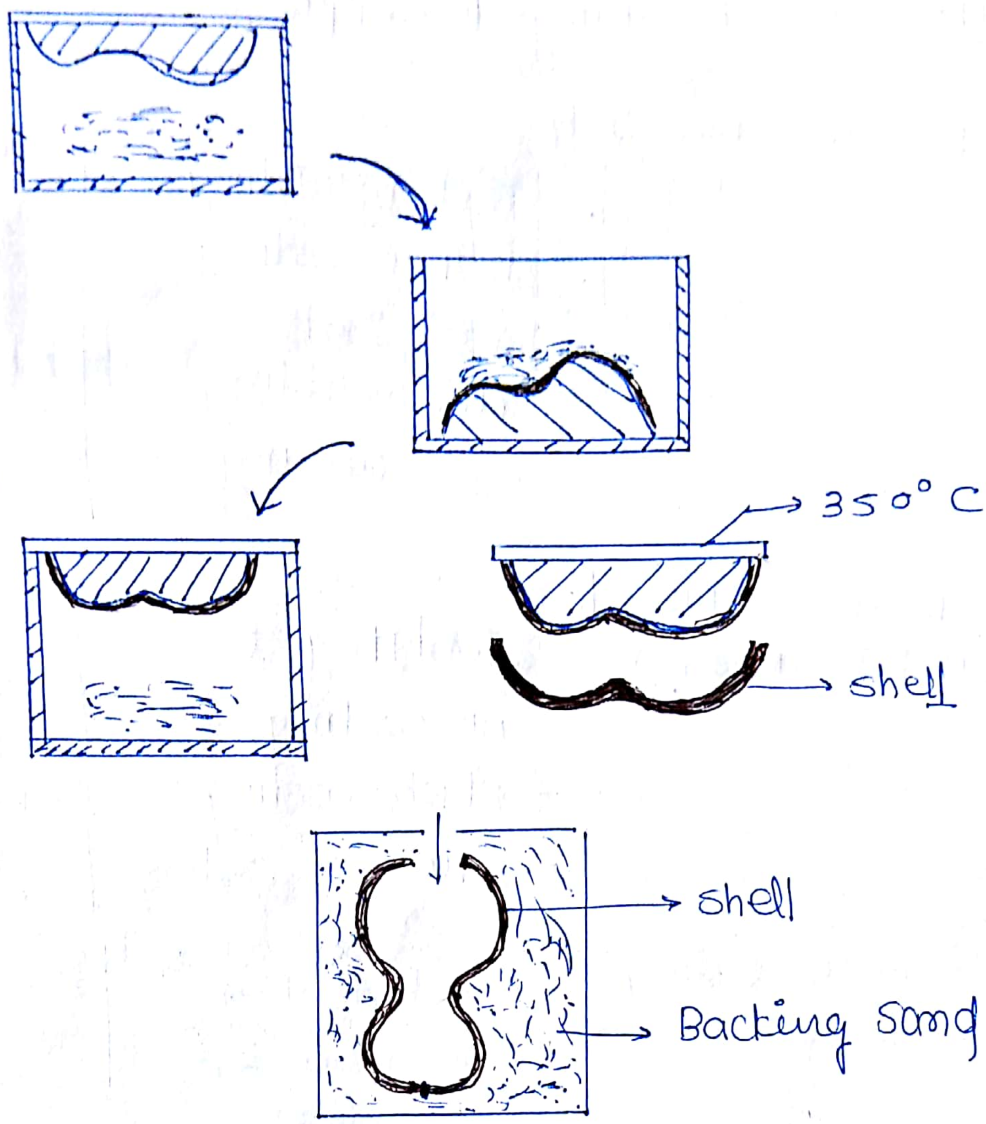
Pattern :



Moulding material : - Fine grain silica
- Phenolic resine — Phenol formaldehyde / Urea formaldehyde
  → Synthetic polymers (Plastic) (made by Rxn of phenol with formaldehyde)
- Alcohol

thermosetting → use only once

thermoplasting ⇒ can re use.



* only shell is wasted
* Backing sand can reuse.

Appications

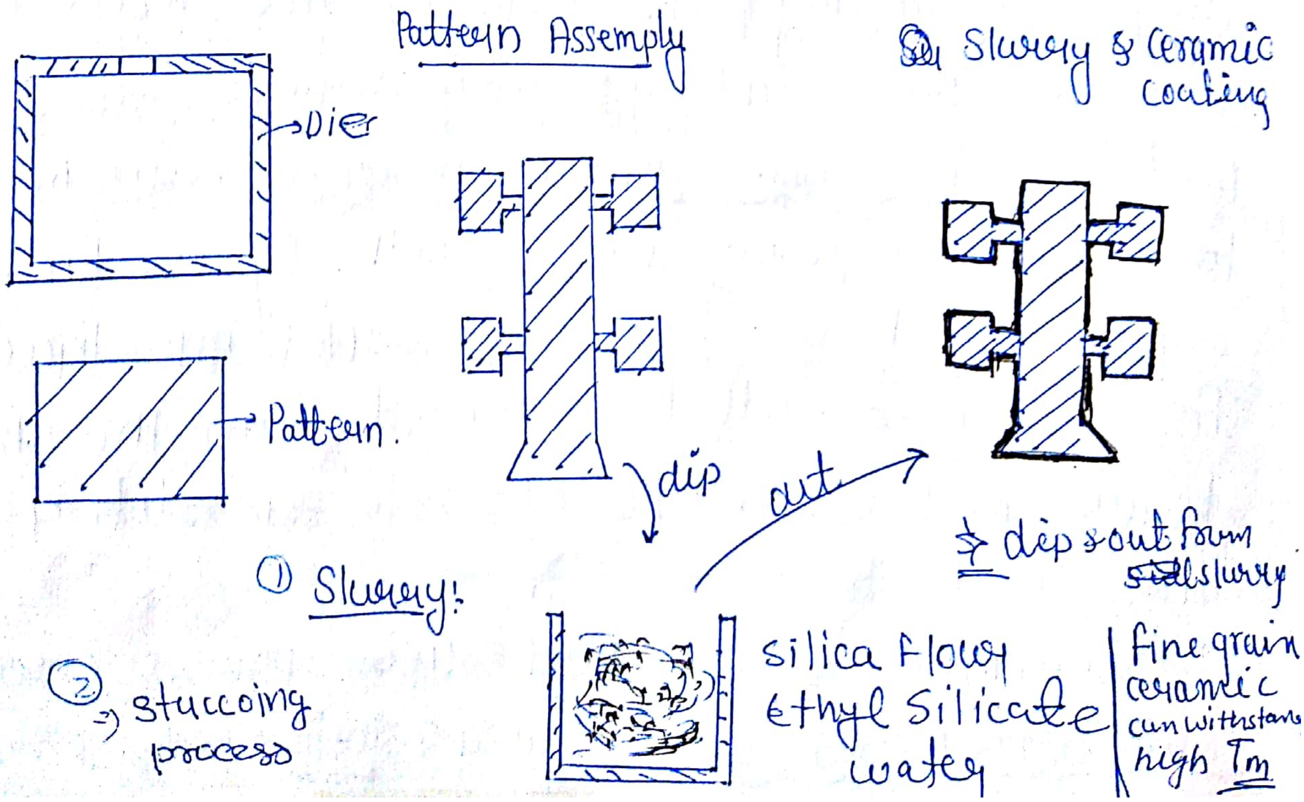
1) Cylinder blocks of Air cooled I.C. engine
2) Rocker arms
3) Valve plates of Refrigerator

⇒ To produce batter surface finish of casting when compare to sand moulding this technique can be used. Pattern is produce by metal and it will be heated upto 250°c

- Moulding materials is contact with heated metallic pattern. Due to heat from the pattern phenollic resins will activate the bonding property and moulding sand will be stick to the surface of pattern in the shape of shell. Thickness of shell will depand ~~by~~ on Contact time between pattern & Moulding material is know as dwell time.

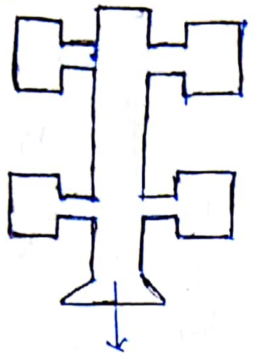
Pattern & shell will be seprated from mould and ~~they will seprated from~~ and they will be heated upto 350°. To increase the strength of the shell. Shell will be seprate from pattern by providing no. of shell they will be added to get the required cavity. It will be seprated by braking sand. Liquid material will be allow to solidify inside the shell cavity.

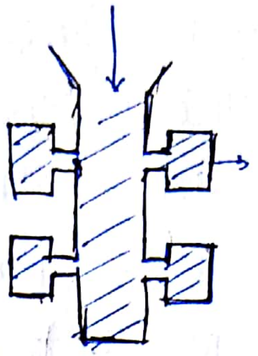
Investment casting:-



Dewexing

Heating





- pattern use only once
- prefferecd for high T_m

Ceramic shell

- Batter surface
- complex shape
- Mass production
- possibility of gas defect so done under vaccum
- costly,

Application:- Gas turbine blades, Jet engine part, Medical implants, dentures (equipment) Gold ornament etc

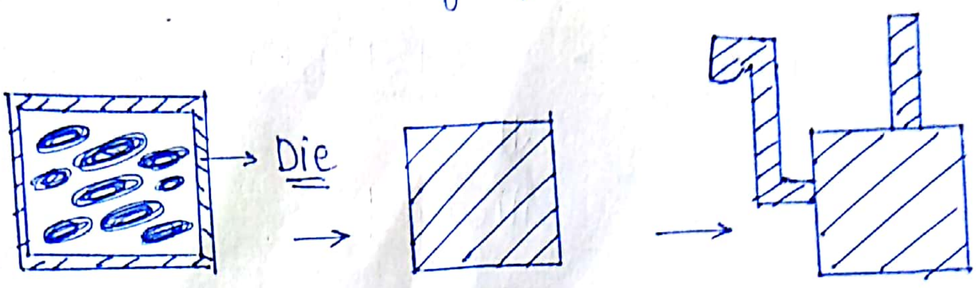
⇒ Pattern use only onke so it called
- Expandable pattern & expandable mould
- lost wax process

Pattern is produced by wax material. it can be produced by Die. No. of patterns will be added along with gating element to produce pattern assemply. By providing slurry coating around the pattern fine grain ceramic particle will be added to produce required ceramic shell. By heating ceramic shell wax can be converted into liquid form and it will be removed from the shell. Liquid metal will be allow to solidify in the shell.

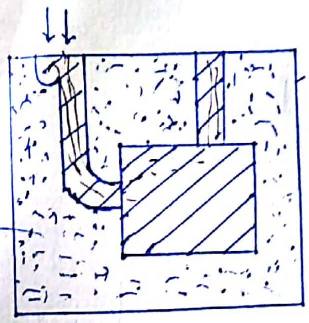
To minimise gas defect this process carried out under vaccum. Accuracy & surface finish of object are high

Full Moulding :- or (Evoprate pattern casting) (EPC) or or (Cavity less moulding) or (lost foam process)

Pattern :- plastic :. Polystyrene, Foam, PVC, Thermocole.



- Complex shape, low cost
- Used for low T_m



- * pattern evoparated in the form gasses.
- * After solidify all gasses escape.
- * prefferd for low T_m

Application: Motor casing, lock component, filling etc.

Pattern is produced by plastic and by adding the slurry coating on the pattern silica sand will be added to produce the require shell by providing inside the mould box backing sand will supported liquid metal will be directly filled on the pattern. Due to high temp of liquid metal pattern will start evaporation and a evopareted gasses can be allowe to escape from the mould to produce cavity into which liquid Metal will be allow to solidify. After Solidification by bracking the mould object can be removed. ~~Brom casting~~ Cost of process is less.

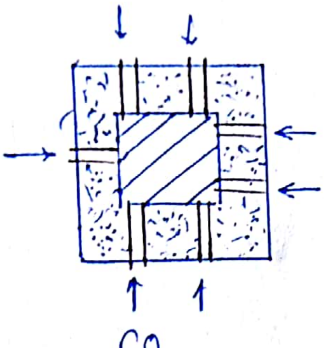
CO_2 Moulding :-

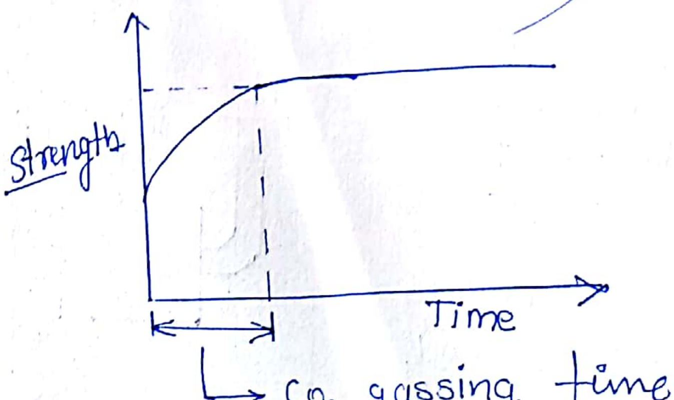
Na_2SiO_3 → 2-6 % (Sodium silicate)

$Na_2SiO_3 + CO_2 \rightarrow SiO_2 + Na_2CO_3$

⇓

Silicagel



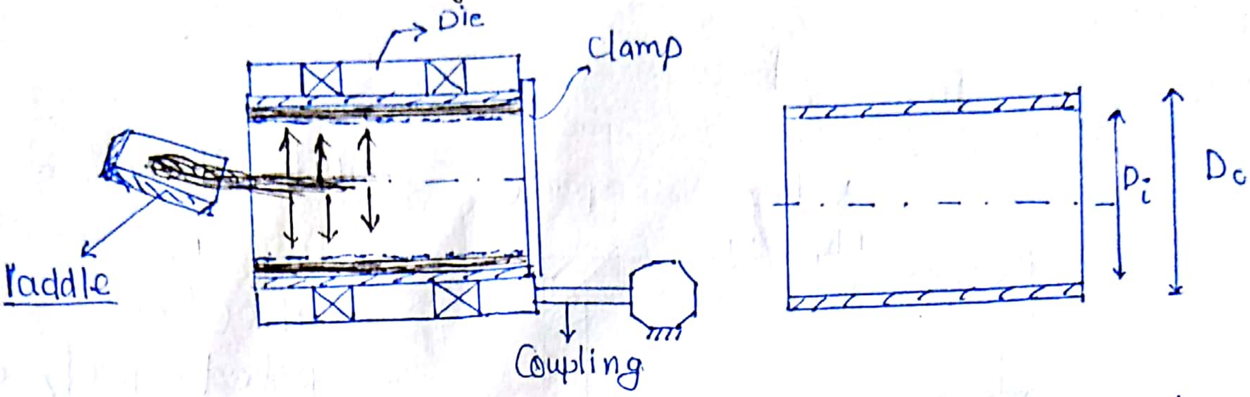


To increase the strength and hardness of large size of mould and core this technique can be used Mould is prepared by adding Na_2SiO_2 binder. CO_2 gas is supplied to mould for sufficient time it will react with Na_2SiO_2 and produce silicagel which is having better bonding property due to this strength and hardness of mould can be increase strength of mould will depand on time of supplying CO_2 gas to the mould known as CO_2 gassing time.

Application :- Preparing of large size Mould like machine tool beds, turbine houshing, Engine block etc.

Centrifugal casting:-

① True centrifugal:- (only centrifugal force)



Application:- Hollow cylindrical pipes, Gun barrels & large size bushes, propelle shaft etc.

* voids remove (due to high centrifugal force) so density increase & fine grains
  - less density impurity comes towards center.
  - No gating element, No riser, Casting Yield 100%; No core
  - batter surface, mass production.
  - Inside surface may have roughness due to impurities.
  - Energy require to rotate more.

How much rotation needed. ?

$$F = ma = m R_m \omega^2$$

R_m - mean radius of mould

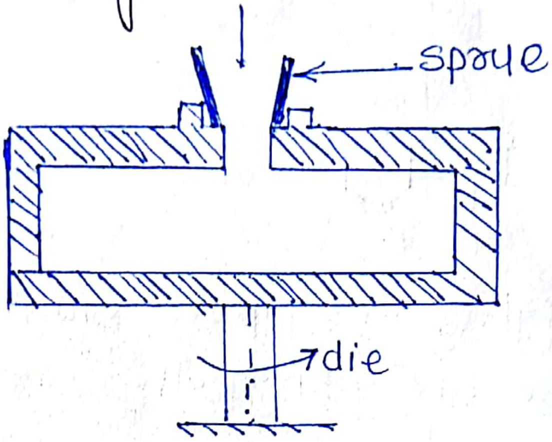
$$a = R_m \cdot \left(\frac{2\pi N}{60}\right)^2$$

a - accⁿ of mould
60-70 times of g

To produce hollow objects without using the core this technique can be used. liquid metal enter into mould which is under rotation due to centrifugal force high density pure metal can be forced away from center and less density impurity collected towards to center. Due to centrifugal force without any gas defect high dense structure with fine grains can be produce.

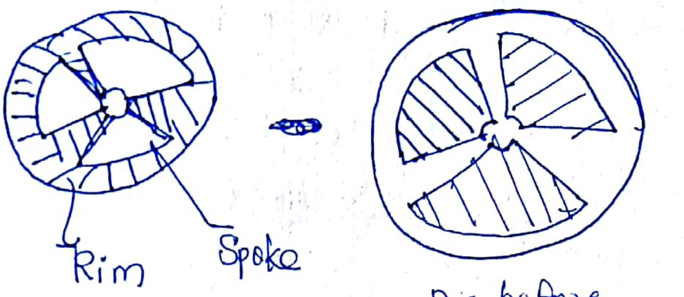
accuracy and ~~better~~ surface finish is very high.
it can be used for mass production.
- It can be used for axis symmetrical cylindrical objects only.

② Semi - centrifugal :-



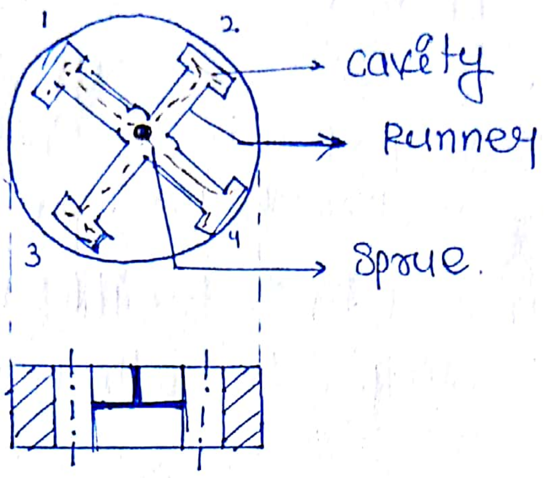
Applications :-
- Pulleys
- wheels
- spoked wheels etc.

· Axis symmetrical objects.
· More material require outside



To produce symmetrical shape of objects which require more material and strength at the outside when compare to inside this technique can be used.
Liquid metal is enter in center of sprue by means of gravity force and it is forced away from the centre by mean of centrifugal force. Liquid metal is solidified first at the outside and it is progressing towards the centre

(c) Centrifuging :-



(object mass)
if $m_1 > m_2$
then we increase size of gating.

To produce unsymmetrical object in mass production this technique can be used. No. of cavity are produced on the die along with gating element. Liquid metal is enter into the centre of the die by mean of gravity force and it is force into the cavities with non uniform Centrifugal force know as centrifuging axes of rotation of mould no coinside with axis of object.

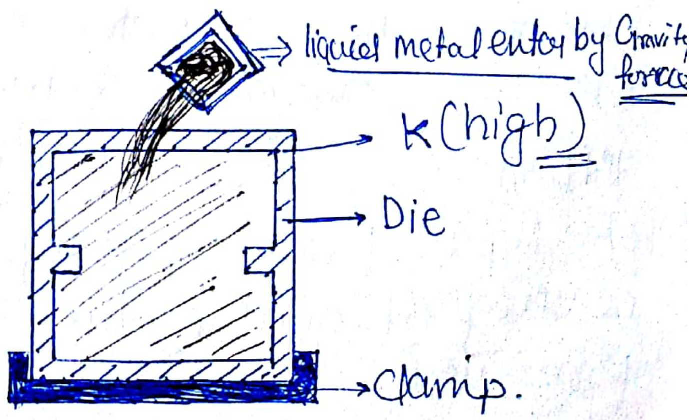
Application :- Pattern used in investment casting made up of wax material

Die Casting

Die casting — Gravity / Pressure

* Gravity Die Casting :→

- Simple object.
- mass prodⁿ
- better surface, finegrain
- High strength
- Cooling rate higher (higher K)



Liquid metal is enter into cavity by means of gravity force only. It is used to produced simple shape of object only.
Surface finish and accuracy of objects are very high.
it can be used for mass production.

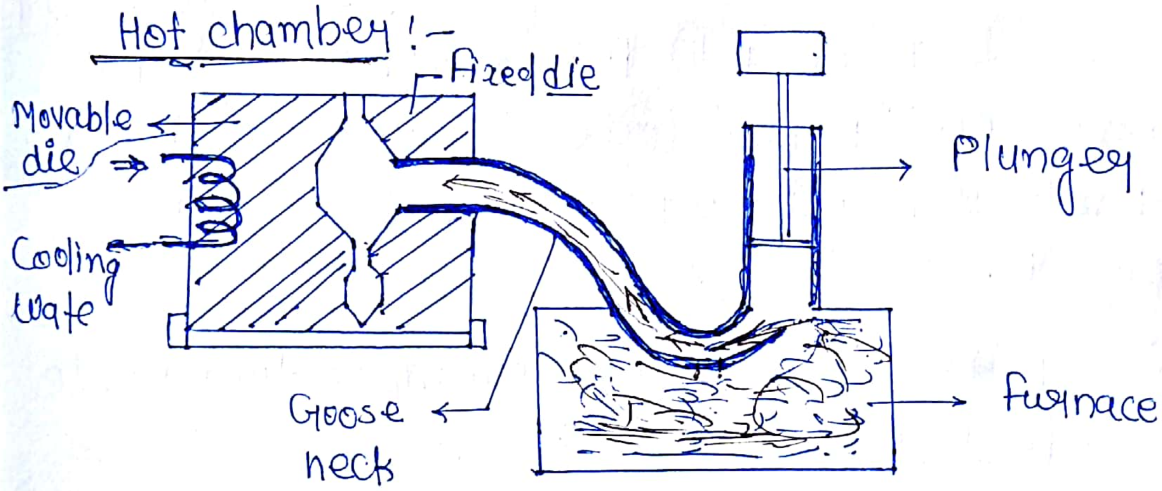
Applications:- Piston used in automible made up of Al, & it alloys. And other simple shape of the objects.

Pressure Die Casting :-

- Hot chamber
- Cold chamber

Pressure required 100 - 200 MPa

Hot chamber :-



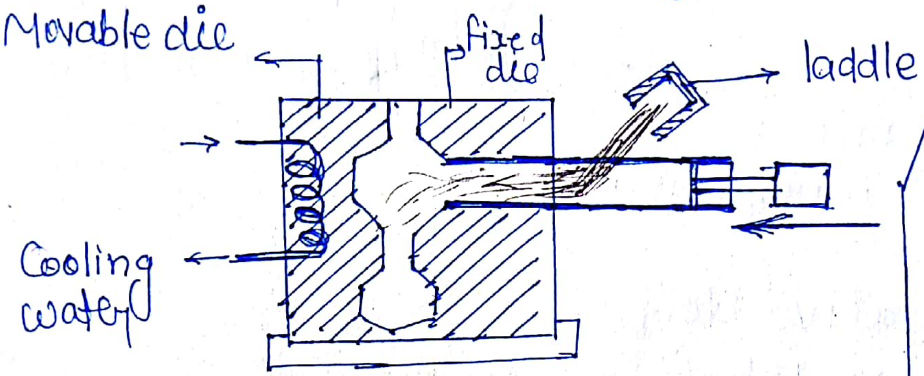
- mass production
- preffer for low T_m eg led, Tin, Zn
- due to sticking property of Al it not used in it

Liquid Metal is forced in the cavity under external plunger force. It can be used to produce complex shape of the object which are made up of low ~~mot~~ melting material like Led, Tin & Zinc.
Furnace is integrated with die. Heat transfer losses of liquid Metal are ~~g~~ negligible. Production rate is very high. Liquid metal is gating solidified under pressure.

mechanical properties of the object are superior. Thin section of casting can be produced.

* Due to sticking tendency of Al, life of Goose nack will be reduce it is not used in this technique.

Cold chamber Die Casting



- Fast rate
- Complex shape
- Less contact time with chamber
- low T_m material
- ✩ Al, Cu, Brass etc. (Non-ferrous)
- ✩ Not used for Ferrous Material
- Small size object (< 20 kg) casting.

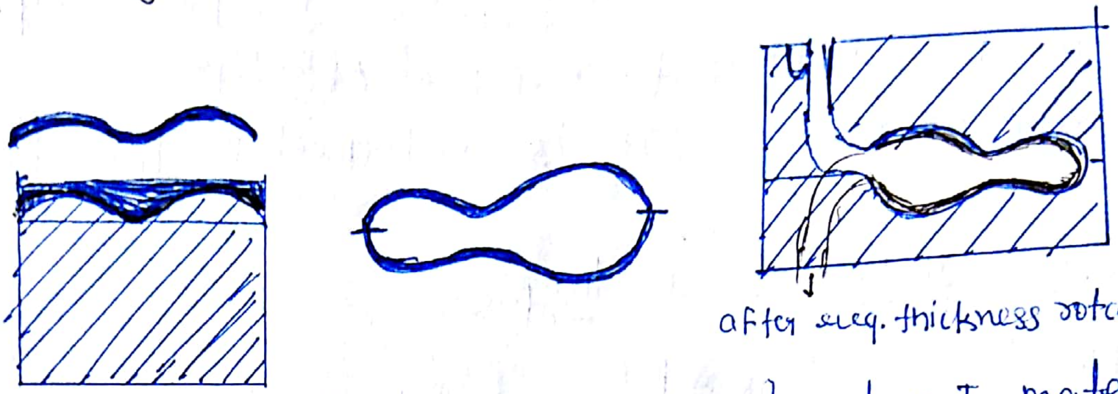
Furnace is seprated from the die. It is used to produced object made of Al, Cu, Brass etc. it is not used for ferrous material. Due to rapid cooling better mechanical properties can be possible. Contact time of liquid metal at the inside surface of chamber is less it life is not getting offected size of casting are limited to 20 kg only. High production rate is possible.

Application:- carburator, Valve bodies, Crack cases, Fuel injection pump part, toilet fixtures

Question: Compare die casting and investment casting w.r.t. following.

		Die	Investment
① production rate	→	High	low
② complexity of object	→	low	high
③ Melting point temp. of Material	→	low	high

Slush Casting :-



- low T_m material
-

Application :- – Thin casting,
- Hollow thing casting
- Toys
- Decorative items
- Hollow statues
- lamp shades
- Thin ornaments etc. ✶✶

$$t_s \propto (V/A)^2 \Rightarrow t_s \propto (t)^2 \Rightarrow \boxed{t = C_1\sqrt{t_s} + C_2}$$

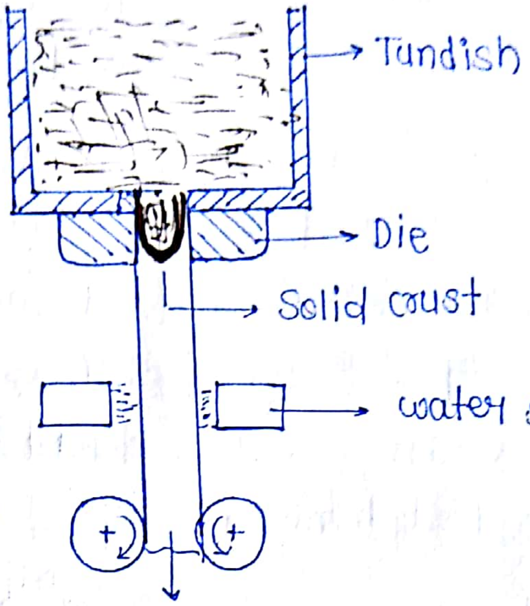
where t thickness of casting

t_s solidification time

C_1, C_2 Constant depends on properties of liquid metal & die material

To produce thin castings and hollow thin castings without using the core this technique can be used Liquid metal will be allow to solidify on the die after getting required thickness of the casting by rotating the die unsolidify metal can be seprated from solidified metal this is know as partial solidification. It is generally used for low melting point, non ferrous material only.

Continuous casting :-



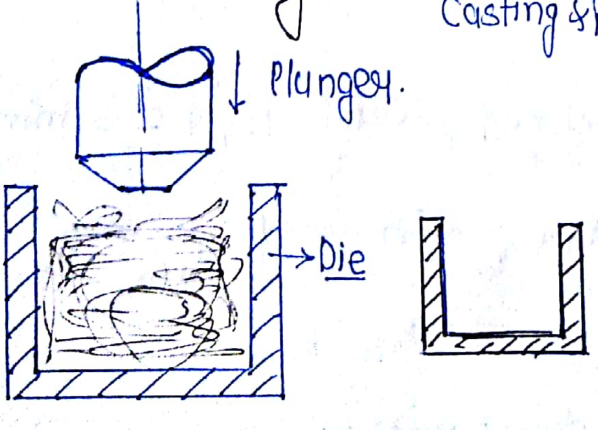
Application

* long length blooms

Liquid Metal will be stored in a tundish it will be allowed through the die opening. The output of die a solid crust on which a water will be sprayed to cool the material at a faster rate depending on the properties required by the object. different cooling rates are provided on the object. Production rate is very high continuously long length metallic object can be produced by using this technique

Squeeze Casting :-

Combination of Casting & forging



* better mech. properties
* No gasses effect.
* Shape depend of shape & size of plunger.
+ better surface finish.

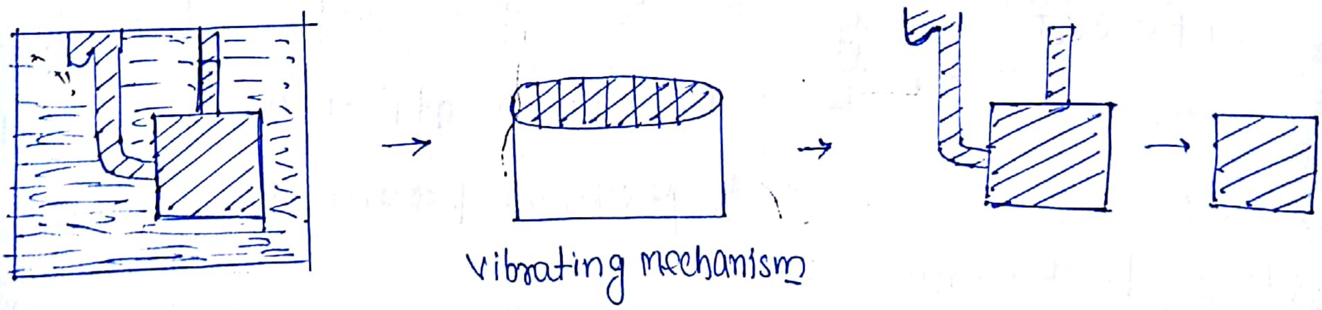
It is a combination of casting and forging liquid metal is allow to solidify in the die by appyeng the plunger force liquid metal can be enter into gap between die and plunger. Liquid metal is getting solidify under pressure from the plunger due to which, high dence better mechanical properties of the object can produced.

shape and size of casting will depand on shape and size of die and plunger.

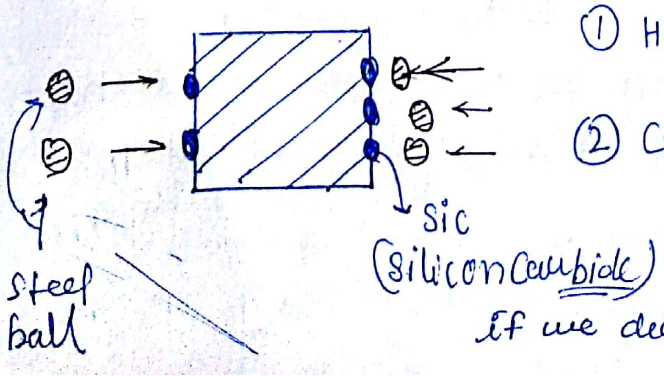
Application :- Al brakes shoes, Bushes made up from brass & bronze.

Cleaning of casting.

① Fettling :-



② shot/sand blasting :- when (silica particle fused on surface on casting



① Hardened steel balls ϕ 2-3 mm.

② Coarse grain sand

if we did direct machen

Fettling

It is a processes of breaking the mould by providing vibrating mechanism and sepration the gating element from the casting is know as fettling

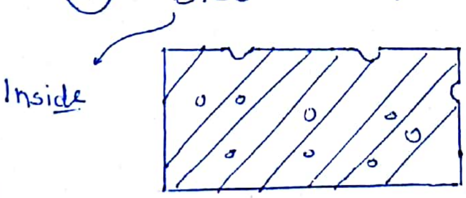
Shot/sand blasting:

To seprate the silica sand particle which are fused on the surface of casting steel ball will be forced on the surface of casting along with air pressure is know as shot blasting. If the cores grain sand will be used for cleaning of casting then it is called sand blasting.

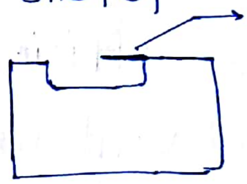
Casting Defects:-

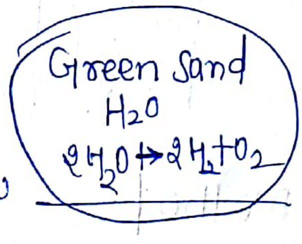
① Gas Defects:-

ⓐ Blow holes & open blows:-

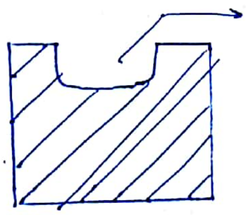


ⓒ Blister

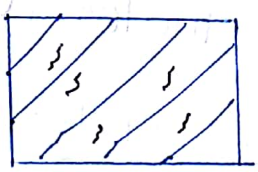




ⓑ Scar:-



ⓓ Pinhole porosity



ⓐ Gas defect which are formed inside the casting or blow hole and which are fromed on the surface of casting are open blow.

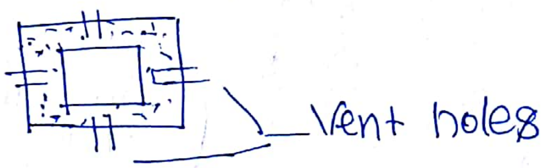
(b) A shallow blow which is form on the surface of casting is scar.

(c) It is a scar covered by thin layer of metal & is called blister

(D) Small size gas holes which are formed due to Hydrogen gas is know as pin hole porosity.

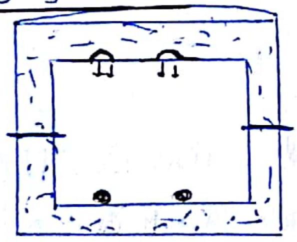
Remedies :-

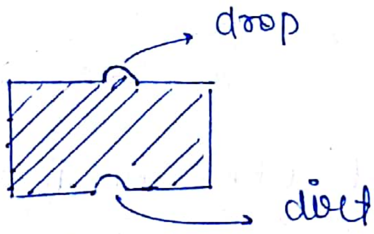
1. Heat the liquid metal in furnace upto pouring temp
2. Convert green sand mould in Dry sand Mould before filling of metal in cavity.
3. Select the moulding sand such that it is having sufficient permeability
4. Provide vent holes.



(2) Moulding material & method

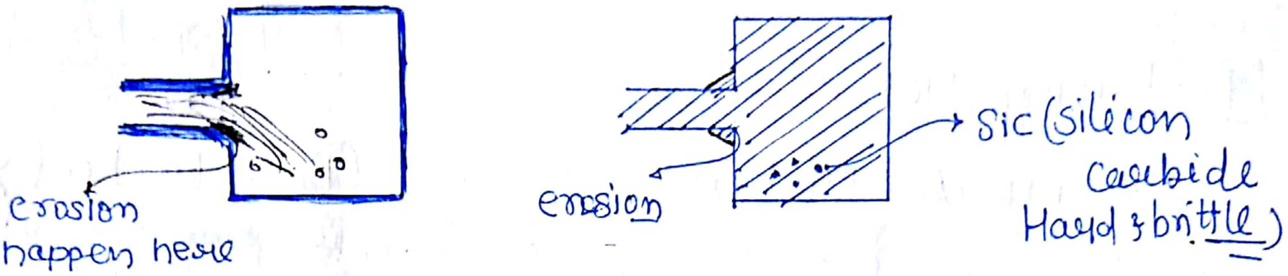
(a) Drop & Dirt :-





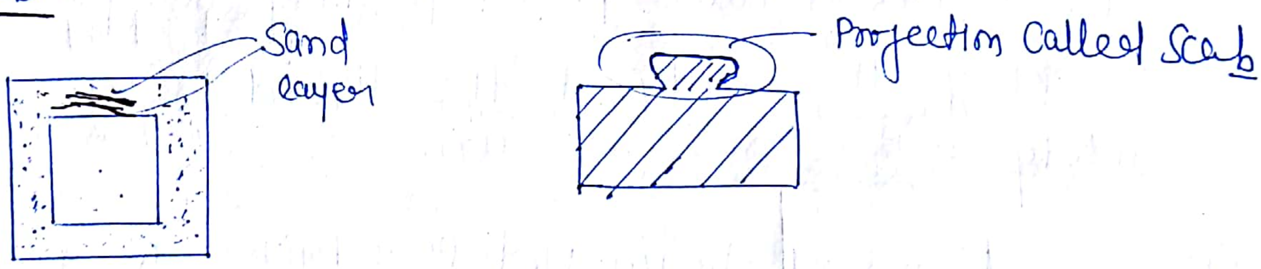
Due to improper ramming moulding sand sand will droped from cope box to drag box. will form a projection on the surface of casting know as drop and a cavity on the bottom surface of casting know as dirt

(b) Cuts and washes :-



At min. x-S_c due to lack of hardness and high velocity of the liquid metal moulding sand will be eroded will produce cuts and washes.

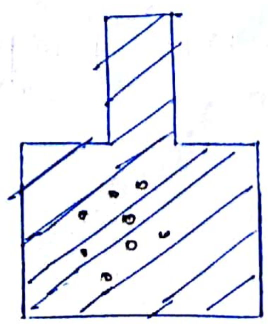
(c) Scab :-



Due to improper ramming i.e if the liquid metal can be penetrated into loose sand layer will form a project on the surface of casting know as scab

(3) Gating Design:-

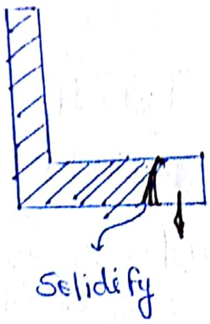
(a) shrinkage cavities



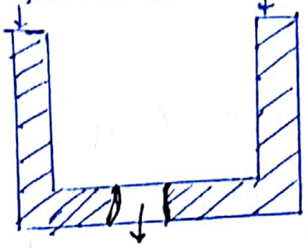
Due to improper riser design cavity form due to shinkage of metal is know as shrinkage cavity.

(4) Pouring Metal:-

(a) Misrun



(b) Cold shuts



(a) Due to lack of fluidity and pouring temp. before reaching the cavity of the liquid metal is solidify will form misrun.

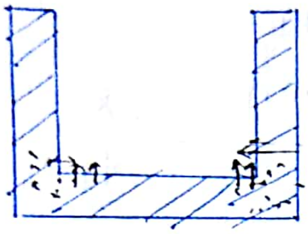
(b) Two stream of liquid metal which are not fushed properly will ~~form~~ form a discountinity in casting

Remedies

1. Heat the liquid metal in the furnace upto pouring temp.
2. Increasing the surface finish of caveity.
3. Desing the gating element properly

⑤ Metallurgical Defects:

Hot tears/ cracks :-

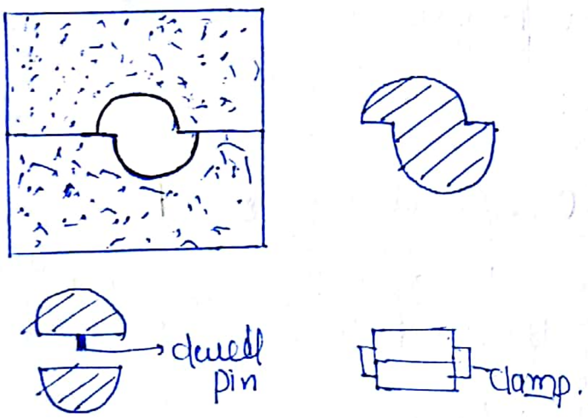


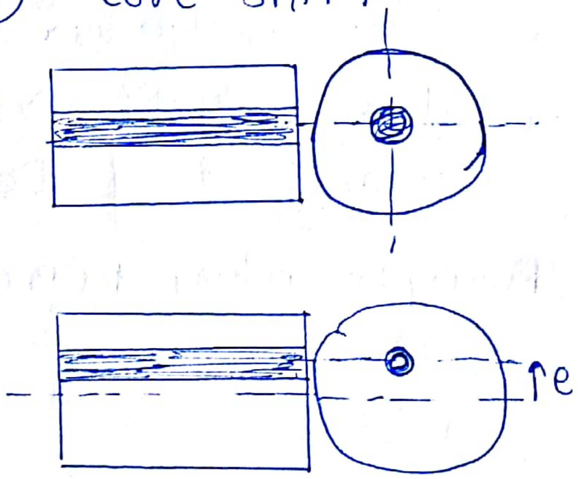
Due to non-uniform Cooling internal stress can be develope in casting if the stress can be more then the strength of the material cracks can be formed to overcome this chills and padding is provided

⑥ other defects:-

ⓐ Mould shift

ⓑ Core shift





ⓐ Due to improper positioning of Cope box on the drag box will produce the miss match along the parting line in the casting this cane be overcome by providing dwell pins & clamps

ⓑ shifting of the core from its origional position due to bouncy force this can be overcome by providing core points & chapletts.

Types of furnace (only ESE) (Prefer Note)

Crucible furnace :- Non-ferrous

Charge — ORE + Flux + Coke

Cupola furnace :-

input → Pig iron
output → Cast iron

operating temp 1650°

ORE - pig iron
Flux = $CaCO_3$
coke -

if furnace have preheating called Hot blast cupola → high temp (temp. higher than cupola.)

* operating temp in hot blast cupola is higher then conventional cupola.

Electric arc furnace :- Non Consumable electrode

Strikes arc.

Induction furnace - Heat generation due to edy current (Mutual induction)

- ✓ small & large quantity possible
- ✓ Can Use Ferrous & Non ferrous,
- ✓ operating temp (1700°C)
- — High Cost, Fast process.

Reverberatory furnace :- (Coal + gas fuel) burn in burner then heat transfer through burner to heat metal.

- ✓ low Cost
- ✓ low polution
- ✓ Heat transfer looses max.
- ✓ Ferrous & Non ferrous both Can melted
- ✓ operating temp (1700°C)
- ✓ High space require

Cupola:-

Charge (Fe_2O_3 & Fe_3O_4)
↓
Blast Furnace
↓
Pig iron
↓
Cupola
↓
Cast iron

* Blast furnace output is pig iron
* Pig iron is output of blast furnace
* cast iron is output of Cupola.

Melting Ratio/ charge Ratio:-

It is a ratio of metal to the fuel.

Metal : fuel ⇒ 4:1 → 12 : 1

* it represent the efficiency of furnace
* In cupola furnace ⇒ 10 : 1 (Metal : fuel)