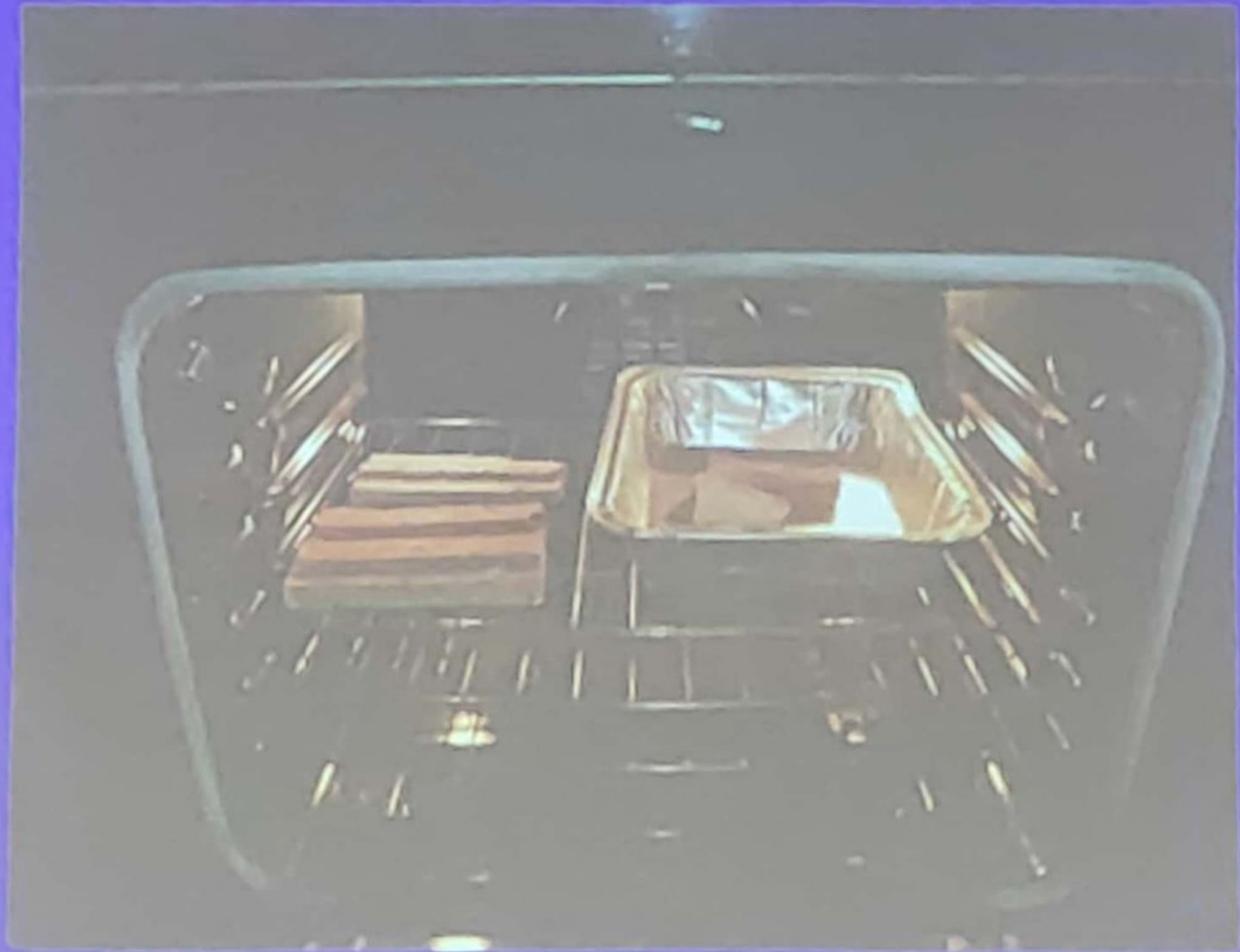
IMPORTANT MOULDING SAND TESTS

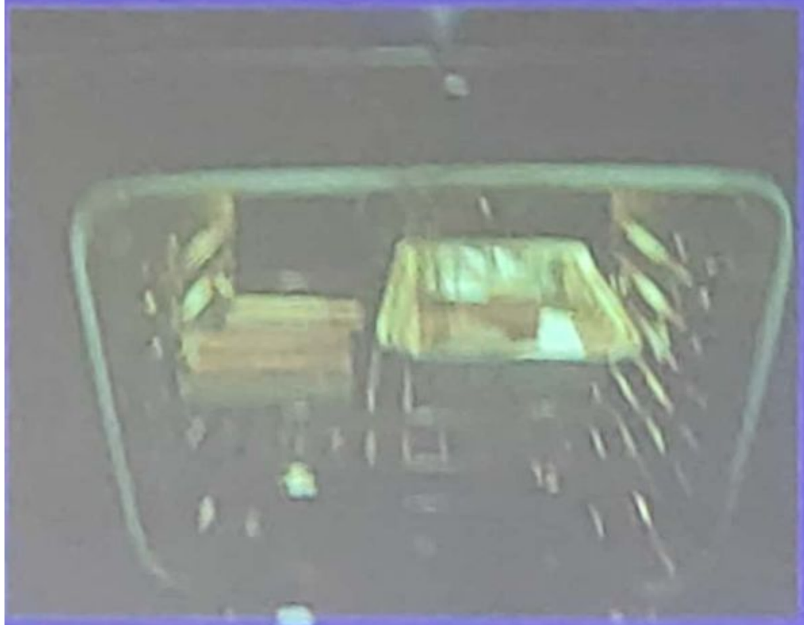
1. Moisture content test
2. Clay content test
3. Grain Fineness test
4. Permeability test
5. Compactibility test
6. Strength tests
   a) Green compression strength
   b) Green shear strength
   c) Dry compression strength
   d) Hardness

Moisture content test



Infrared heater

MOISTURE CONTENT TEST



1. Place 50 gms of prepared sand in the pan and heat it in an infrared heater for 3 minutes (W_1).
2. The moisture in the moulding sand is thus evaporated.
3. Weigh the moulding sand again (W_2).

Percentage of moisture = $(W_1 - W_2)*100/(W_1)$

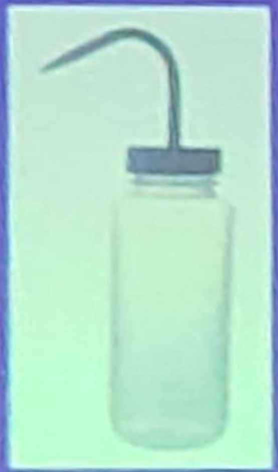
MOISTURE CONTENT TEST

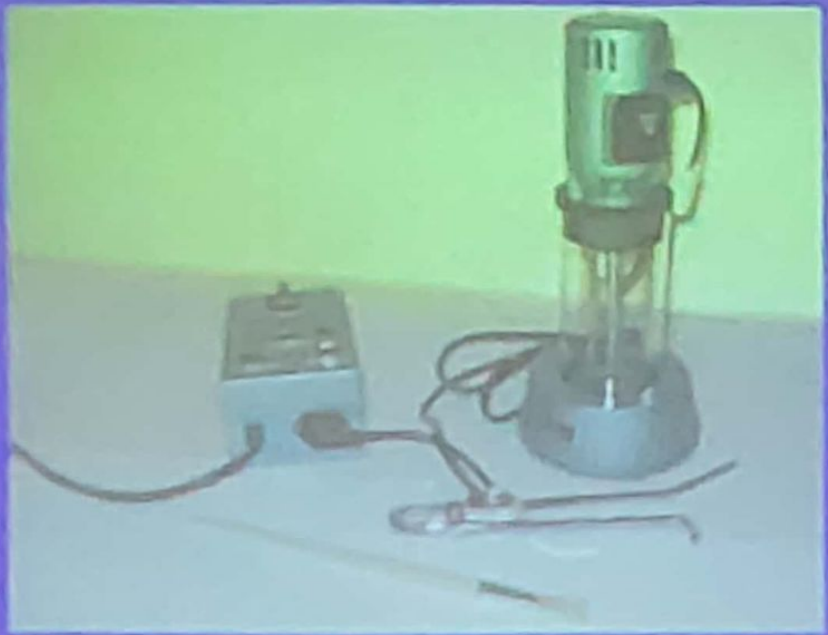
RAPID MOISTURE TELLER

When calcium carbide comes in contact with moisture, acetylene gas is generated. This principle is used in the Rapid Moisture Teller.

CLAY CONTENT TEST

(Total clay)



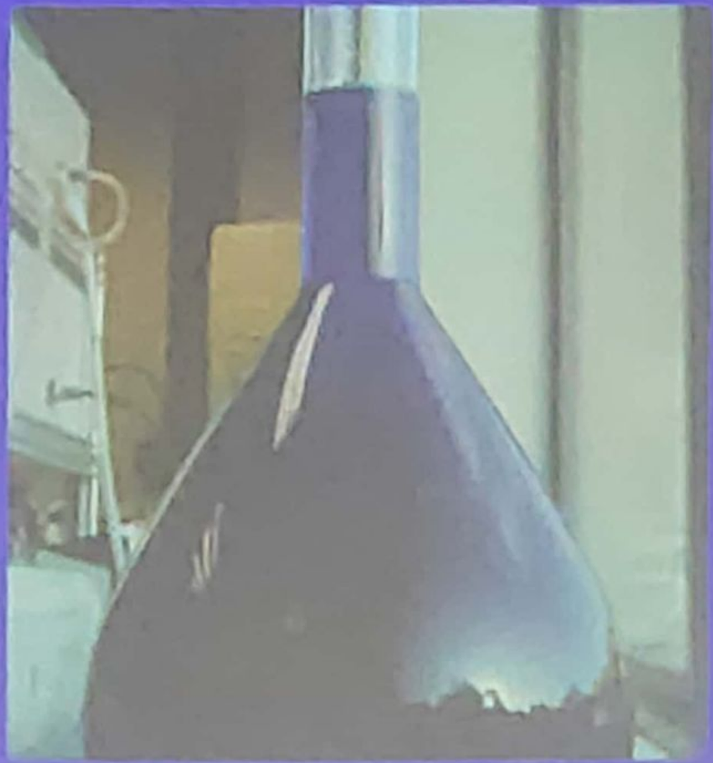


- Separate 50 gms of dry moulding sand and transfer to wash bottle.
- Add 475cc of distilled water + 25cc of a 3% NaOH.
- Agitate this mixture for about 10 minutes with the help of sand stirrer.
- Fill the wash bottle with water up to the marker.
- After the sand has settled siphon out the water from the wash bottle.
- Dry the settled down sand.

CLAY CONTENT TEST
(Active clay)

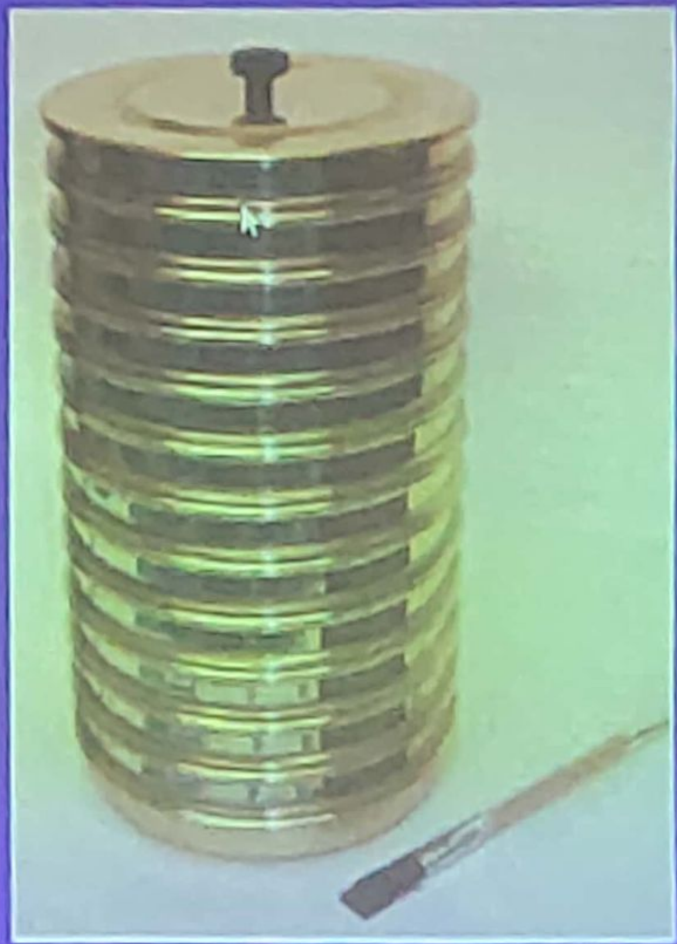
Methylene blue is a heterocyclic aromatic chemical compound with the molecular formula $C_{16}H_{18}N_3SCl$.

Methylene blue is a potent cationic dye.



Methylene blue solution

Grain Fineness test



Sieve shaker used in the grain fineness test

GRAIN FINENESS TEST

Sieves used in the grain fineness test

GRAIN FINENESS TEST

1. Place the sample of dry sand (clay removed sand) in the upper sieve.

2. Vibrate the sieve shaker for a definite period.

3. Weigh the amount of sand retained on each sieve.

4. Compute the percentage distribution of grains.

Sieve No. (1)	% Weight of sand in pan (2)	Multiplication factor (3)	Product of columns 2 & 3 (4)
6	x_1	3	
12	x_2	5	
20	x_3	10	
30	x_4	20	
40	x_5	30	
50	x_6	40	
70	x_7	50	
100	x_8	70	
140	x_9	100	
200	x_{10}	140	
270	x_{11}	200	
Pan	x_{12}	300	

$$\text{GFN} = \frac{\text{Sum of products}}{\text{Sum of \% weights of sands retained}}$$

Principles of Metal Casting
Heine & Rosenthal

Foundry Technology
O.P. Khanna

PROBLEM:

A sample of 50 grams of a moulding sand was sieved through a sieve shaker. The quantities of sands collected in different sieves were recorded.

Determine the AFS Grain Fineness Number (GFN) of the said sand.

USA sieve series No.	Sand retained on each sieve (gm)
6	none
12	none
20	none
30	none
40	0.20
50	0.65
70	1.20
100	2.25
140	8.55
200	11.05
270	10.90
Pan	9.30
Total	**44.10**

USA sieve series No.	Sand retained on each sieve (gm)	Percentage of sand retained (A)	Multiplier (B)	Product (A×B)
6	none	0.0	3	0
12	none	0.0	5	0
20	none	0.0	10	0
30	none	0.0	20	0
40	0.20	0.4	30	12
50	0.65	1.3	40	52
70	1.20	2.4	50	120
100	2.25	4.5	70	315
140	8.55	17.1	100	1710
200	11.05	22.1	140	3094
270	10.90	21.8	200	4360
Pan	9.30	18.6	300	5580
Total	**44.10**	**88.2**		**15243**

$$\text{GFN} = \frac{\text{Sum of products}}{\text{Sum of \% weights of sands retained}}$$

$$= \frac{15243}{88.2} = 172.8$$

$$\simeq \textbf{173 AFS}$$

AFS Grain Fineness Number of the sand = **173**

PERMEABILITY TEST

The quantity of air that will pass through a standard specimen of the sand at a particular pressure condition is called the permeability of the sand.

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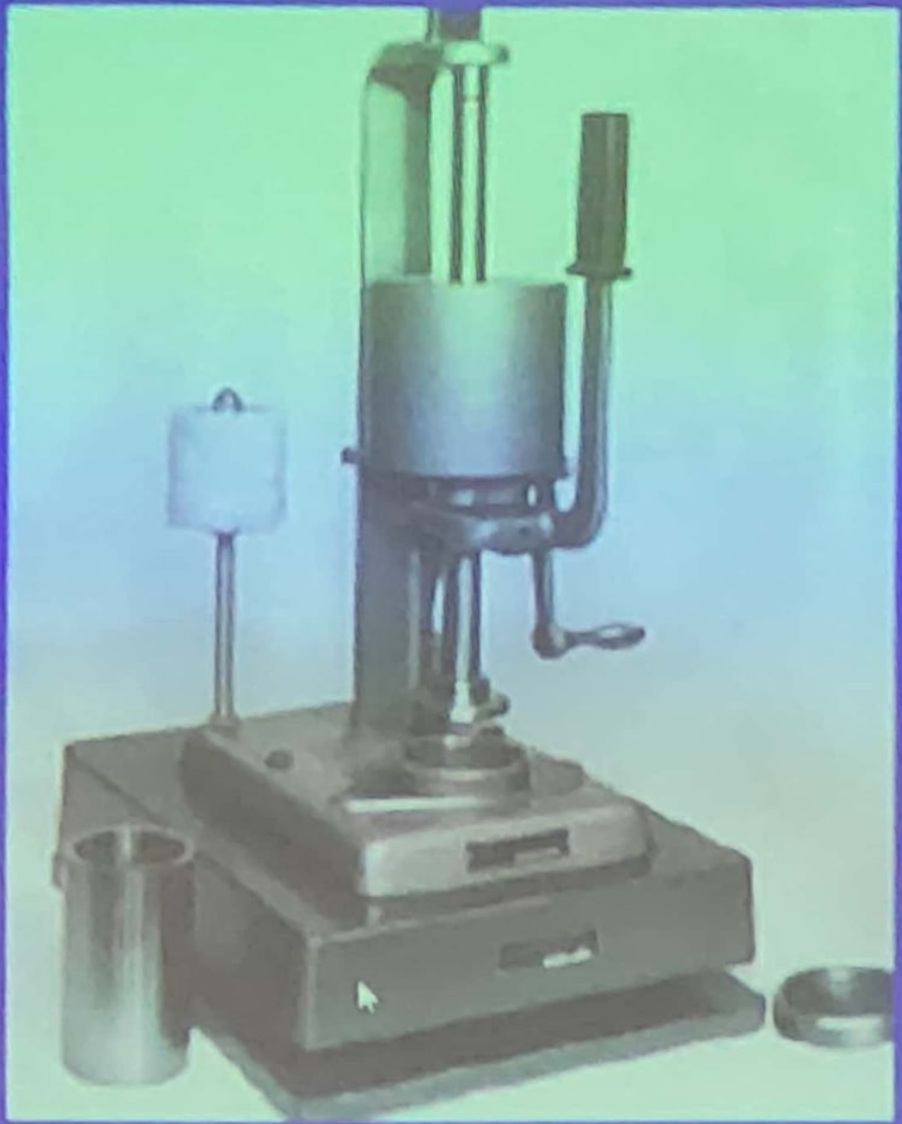
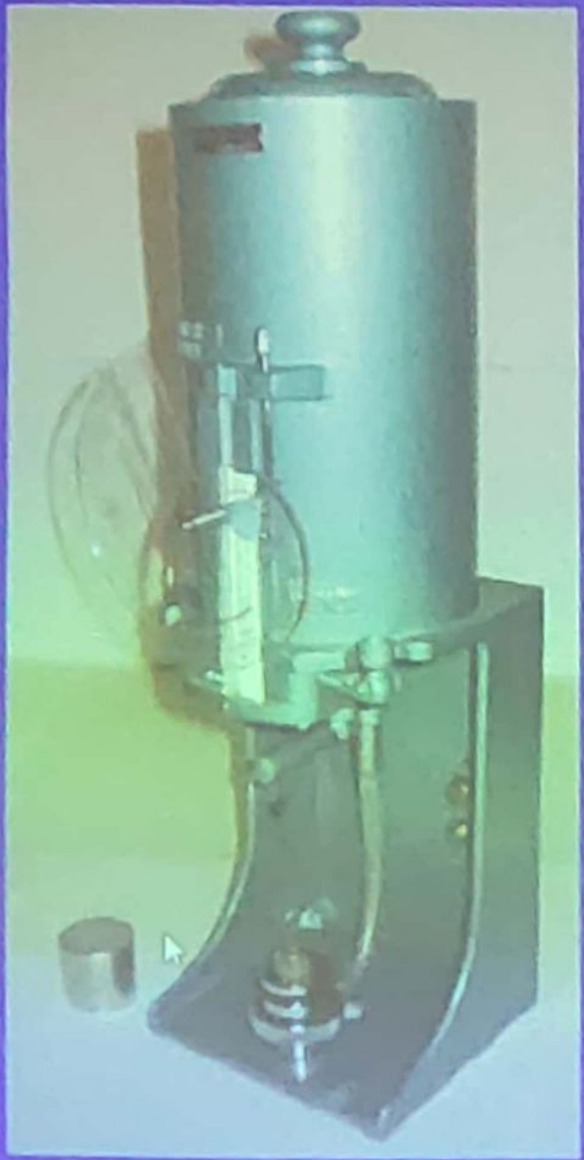


Sand Rammer

Filler accessory for the consistent filling of the specimen tube.



Major parts of a permeability test equipment:

1. An inverted bell jar, which floats in a water.
2. Specimen tube (for holding the sand specimen).
3. Manometer (for measuring the air pressure).

(**COURTESY:** Ridsdale & Co Ltd. ENGLAND)

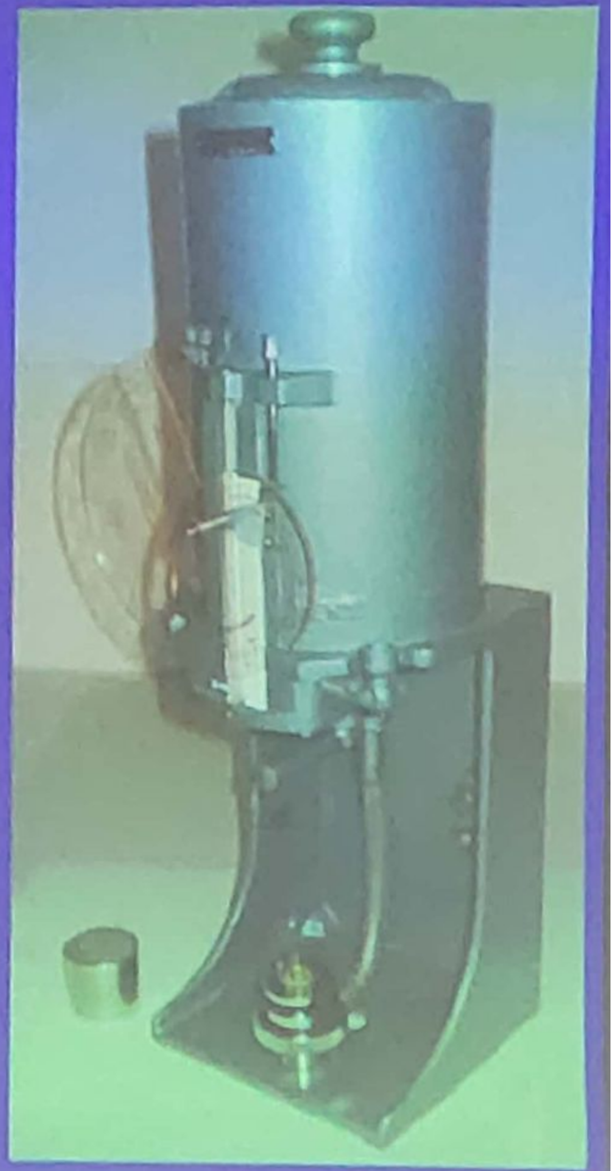
STEPS INVOLVED

1. The air (2000 cc volume) held in the bell jar is forced to pass through the sand specimen.

2. At this time, air entering the specimen is equal to the air escaped through the specimen.

3. Take the pressure reading in the manometer.

4. Note the time required for 2000 cc of air to pass the specimen.



$$\textbf{Permeability number (N)} = \frac{V \cdot H}{A \cdot P \cdot T}$$

Where, V = Volume of air (cc)

H = Height of the specimen (cm)

A = Area of the specimen (cm^2)

P = Air pressure (gm / cm^2)

T = Time taken by the air to pass through the sand specimen (minutes)

PROBLEM:

Determine the permeability a AFS Standard sand specimen of 5.08 cm (2 inches) diameter and 5.08 cm in height. The air drum was raised to take 2000 cm^3 of air into it. The whole air was then allowed to escape through the sand specimen at a pressure of 10 g/cm^2 in a span of 15 seconds.

PROBLEM:

Determine the permeability an AFS Standard sand specimen of 5.08 cm (2 inches) diameter and 5.08 cm in height. The air drum was raised to take 2000 cm^3 of air into it. The whole air was then allowed to escape through the sand specimen at a pressure of 10 g/cm^2 in a span of 15 seconds.

V = Volume of air in cm^3 = 2000 cm^3

H = Height of specimen = 5.08 cm

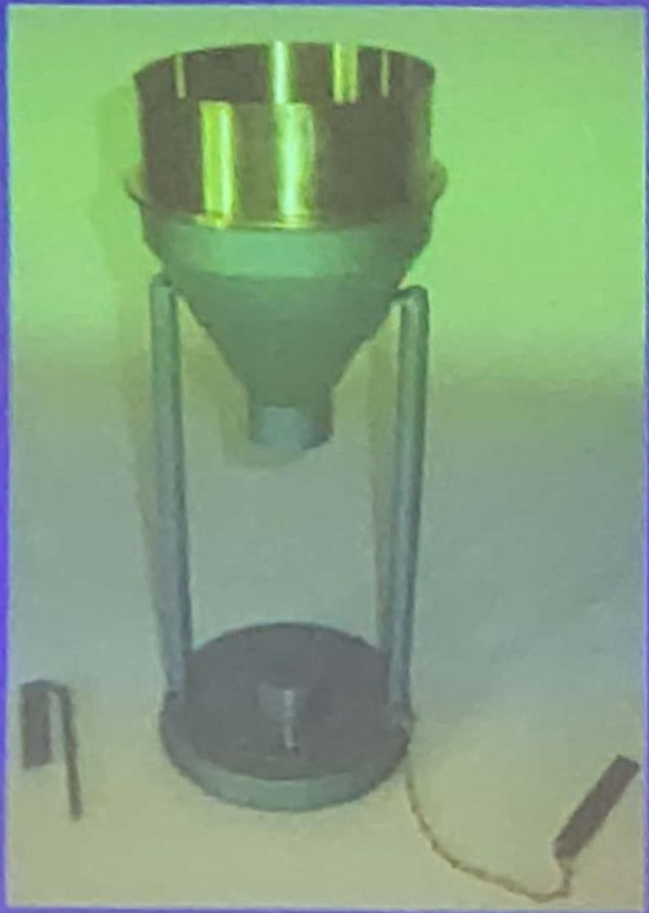
A = Cross sectional area of specimen = 20.268 cm^2

P = Air pressure in g/cm2 = 10 g/cm^2

T = Time = 15 seconds = 0.25 minutes

$$\textbf{Permeability number (N)} = \frac{V \cdot H}{A \cdot P \cdot T} = 200.5$$

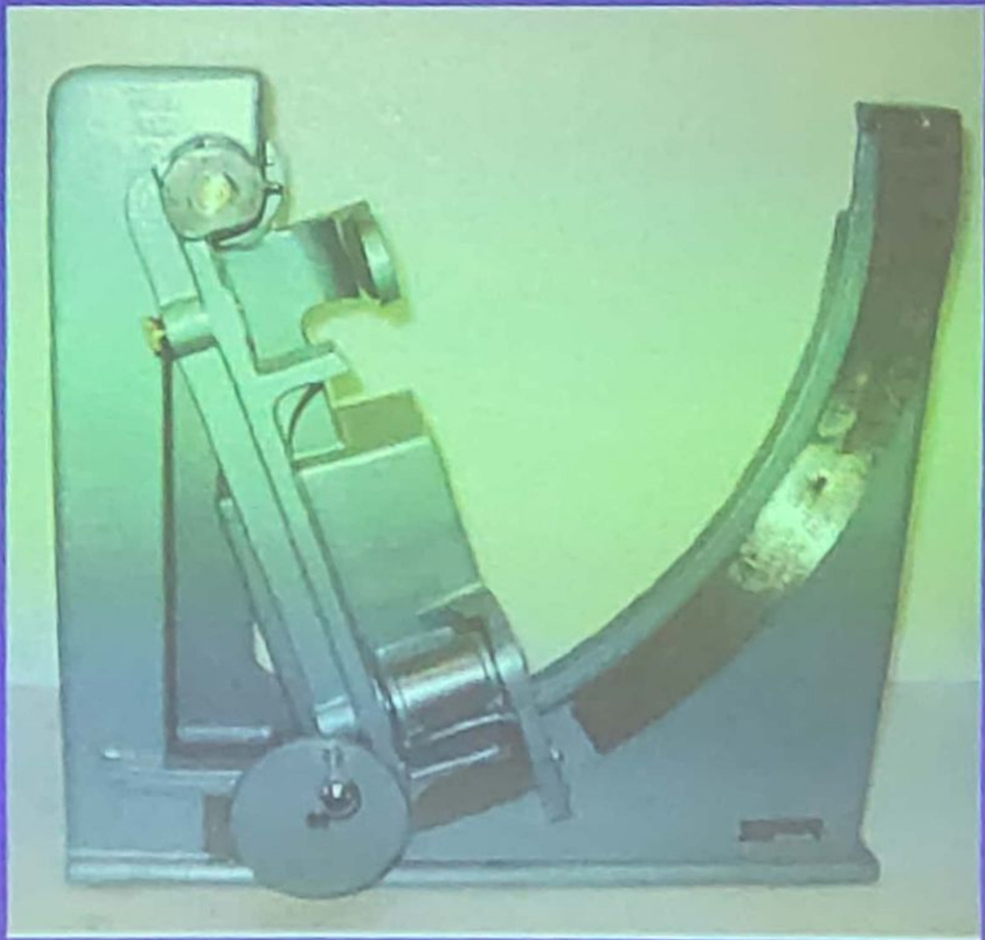
Green Compression Strength



Filler accessory for the filling of the specimen tube.

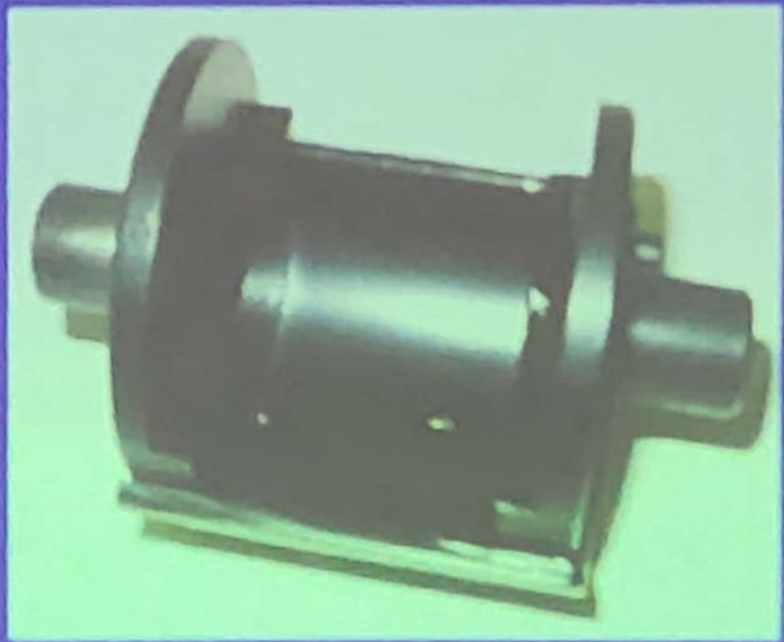
Sand Rammer

Determination of Green Compression Strength using Universal Sand Strength Machine



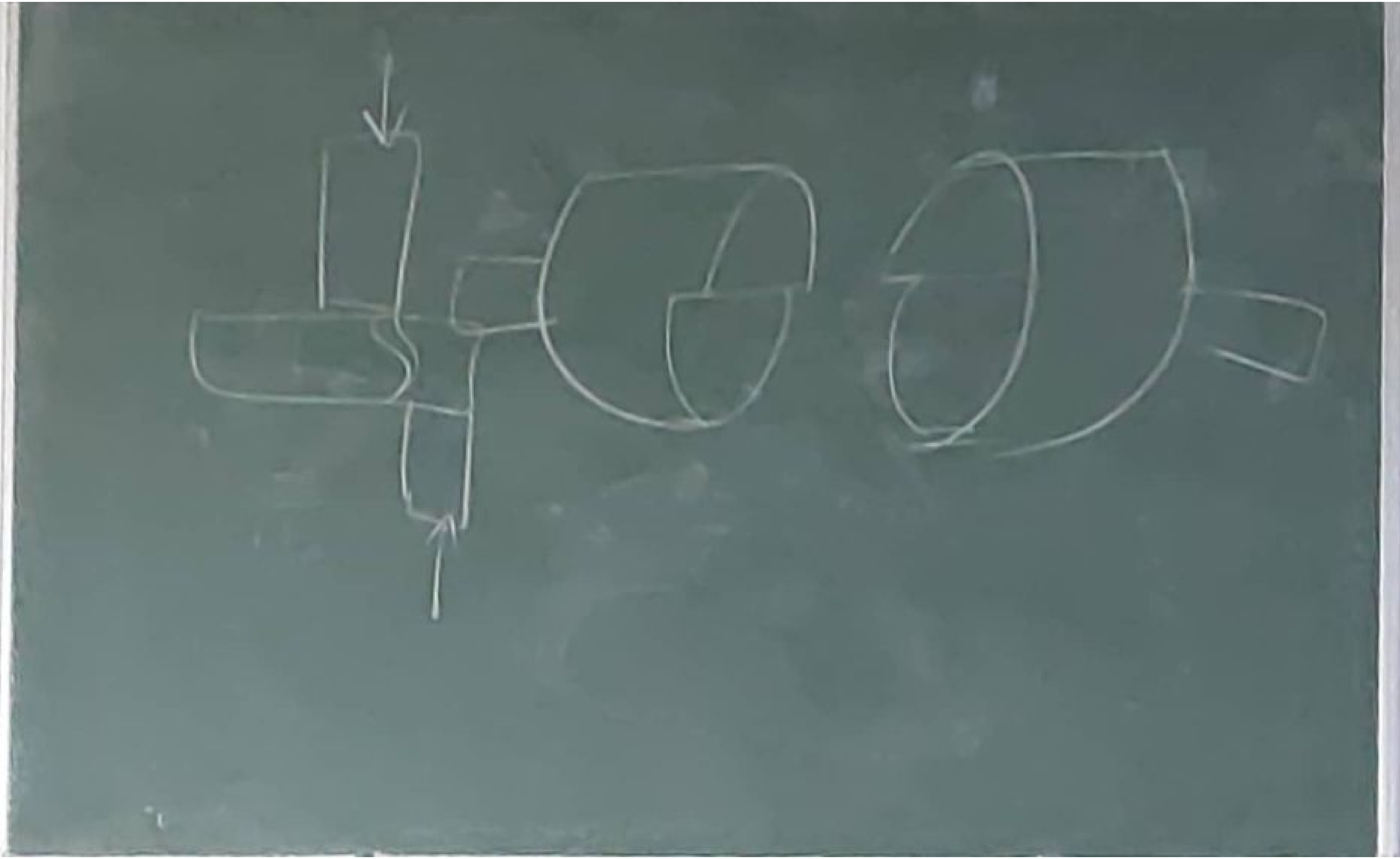
Green compression strength indicates the load bearing capacity of the mould in the presence of moisture.

Determination of Green Shear Strength using Universal Sand Strength Machine



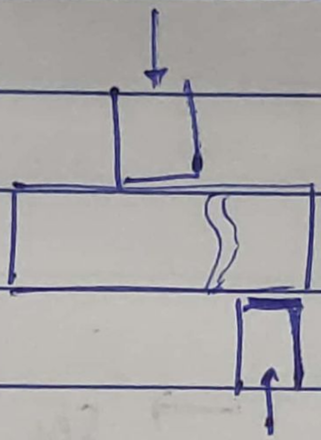
Specimen pads used for shear strength

Green Shear strength indicates the strength of the mould during the removal of pattern or while placing core in the mould.

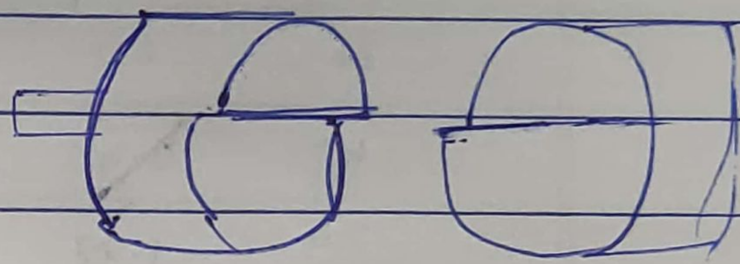


shear :

Change the Pads :

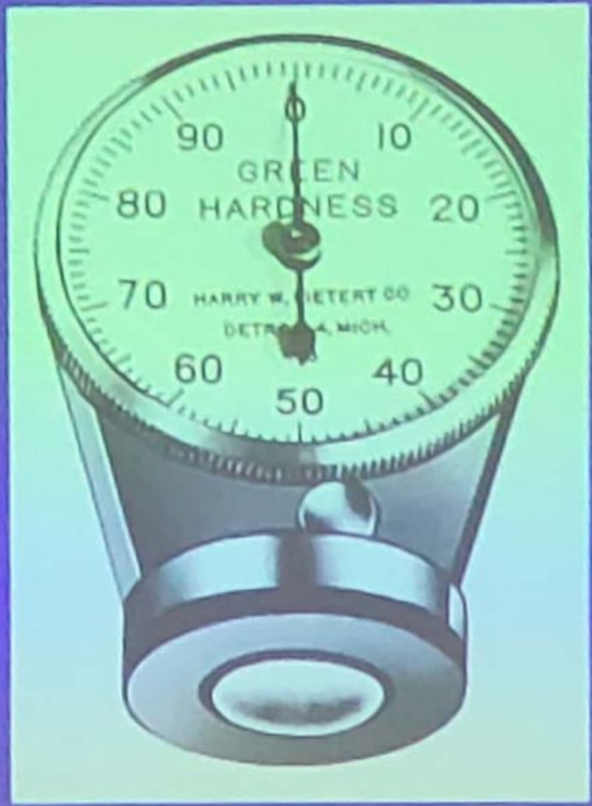


(you need this)



(Pads that are used for shear strength test)

Determination of mould hardness using Hardness Tester



Hardness indicates the resistance of the mould to plastic deformation due to evolution of gases. It also indicates the resistance against erosion due to flow of melt.

CORES & CORE SANDS

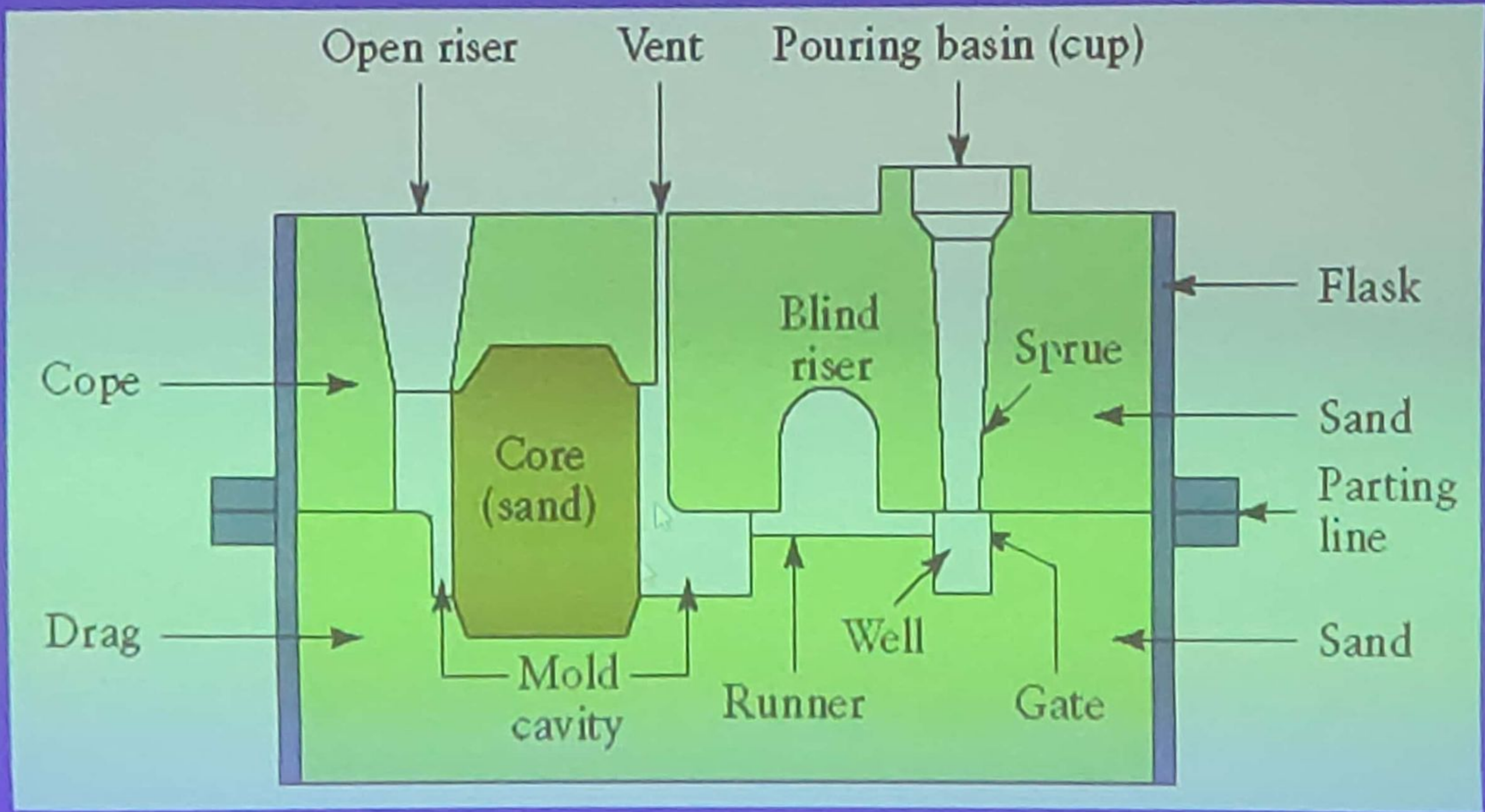
CORES

Cores are the objects that are placed inside the moulds to form internal cavities of the casting.

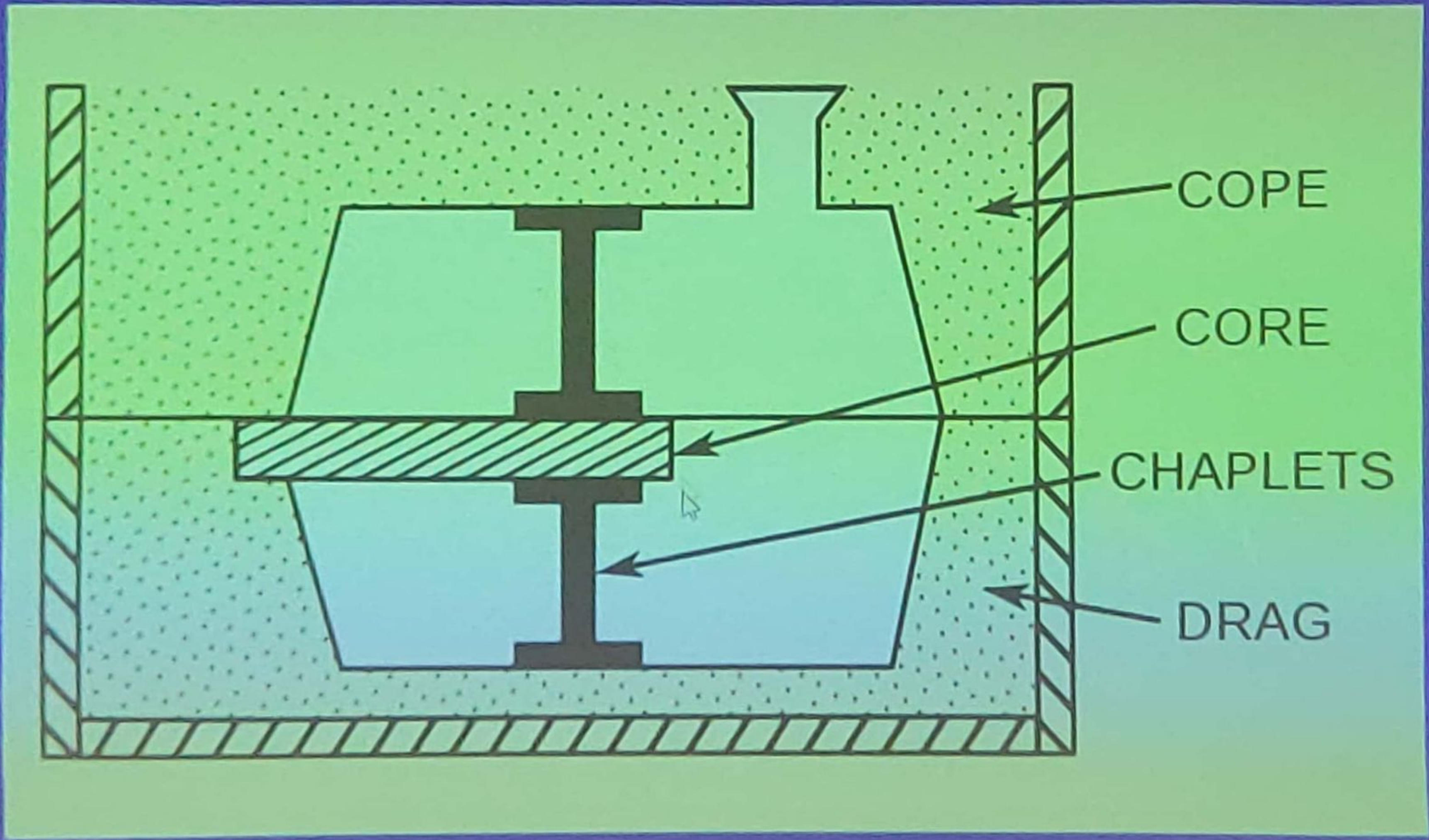
Cores are normally disposable items that are destroyed after solidification.

Cores are normally made up of core sands and are baked before use.

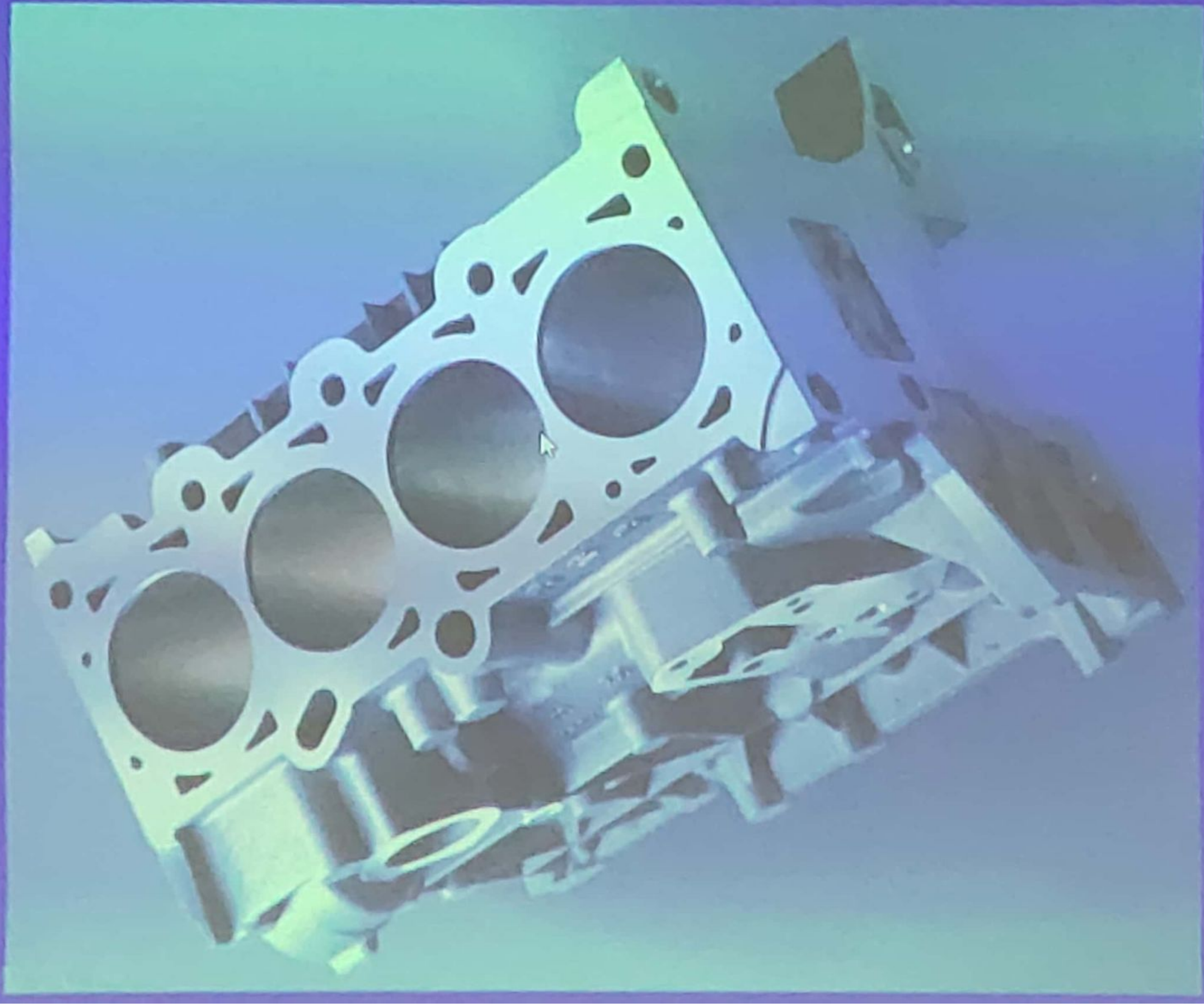
CORE IN A GREEN SAND MOULDING



CORE IN A GREEN SAND MOULDING



ENGINE BLOCK

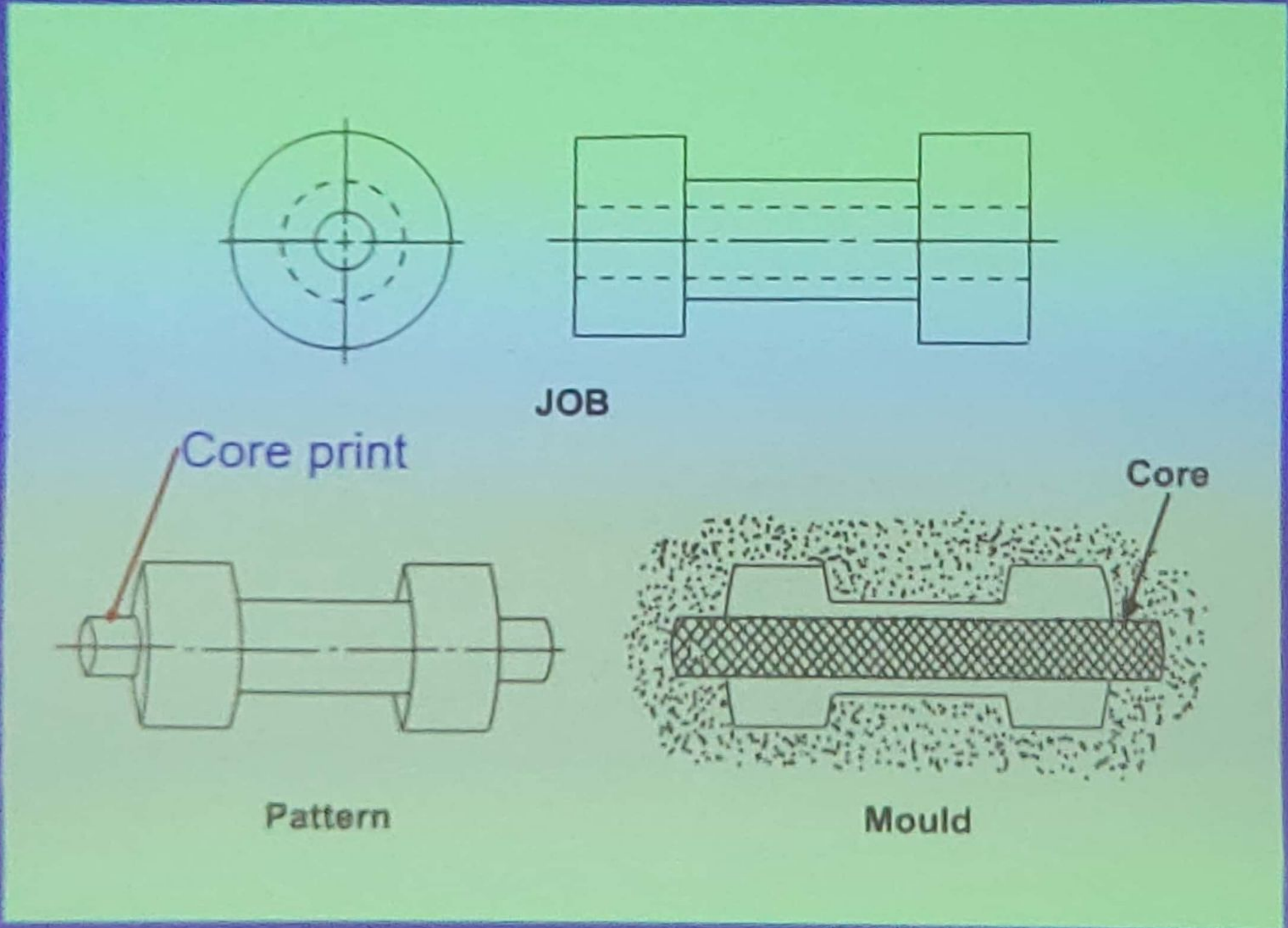


DRY SAND CORES

Core prints hold the cores in the correct position.

They are made by mixing sand with a binder in a wooden or metal core box, which contains a cavity in the shape of the desired core.

TYPICAL DRY SAND CORE



INGREDIENTS OF DRY SAND CORES

TYPICAL INGREDIENTS OF DRY SAND CORES

1. Base sand grains
2. Cereals or clay
3. Organic binders
   a) Vegetable oil
   b) Synthetic oil

BASE SANDS OF CORES

SILICA SAND

Its main constituent is SiO_2.

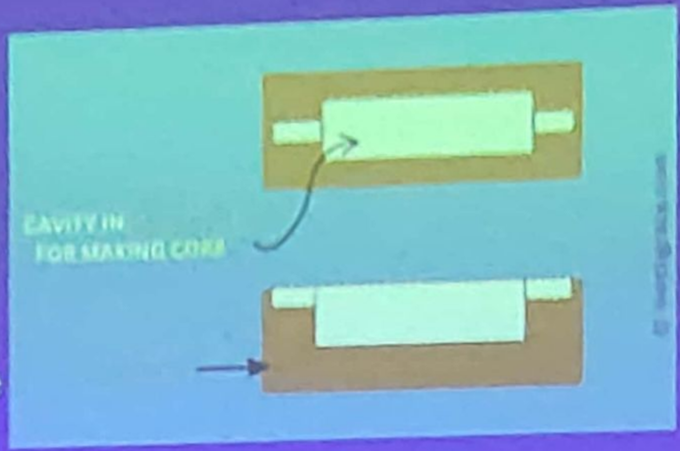
CHROMITE SAND

Its general form is Iron Chromium Oxide ($FeOCr_2O3$)

ZIRCON SAND

Its general form is Zirconium Silicate (ZrO_2 SiO_2)

SEQUENCE OF MAKING CORES



1. Mixing of the ingredients
2. Packing of core sand in the core box
3. Curing (Cold box, Hot box and No-bake types)

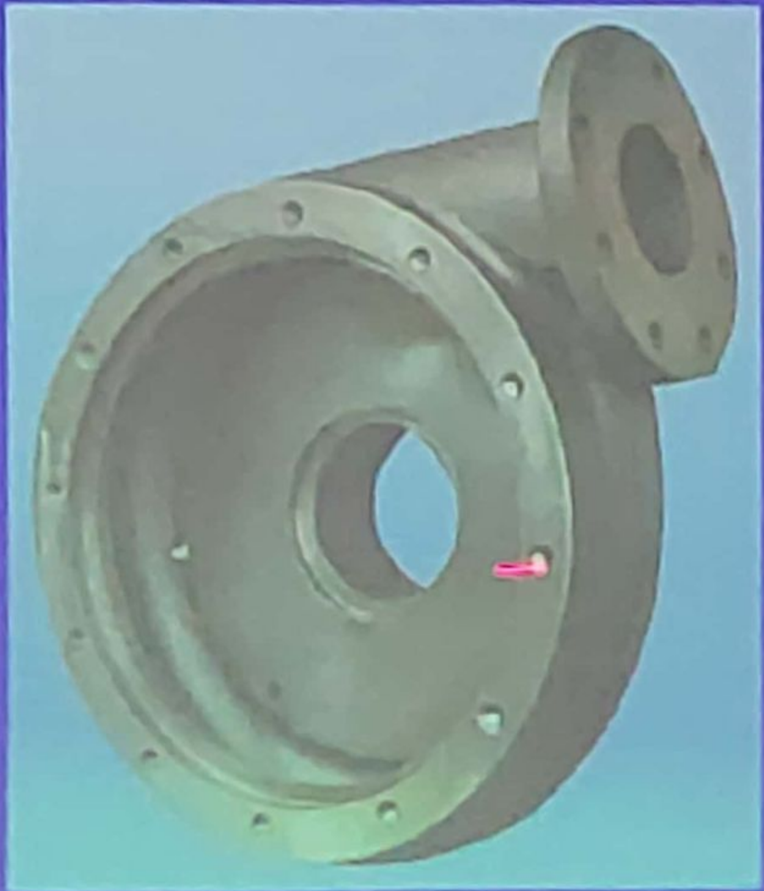
Generallly, curing is done by hardening the binder by passing special gases.

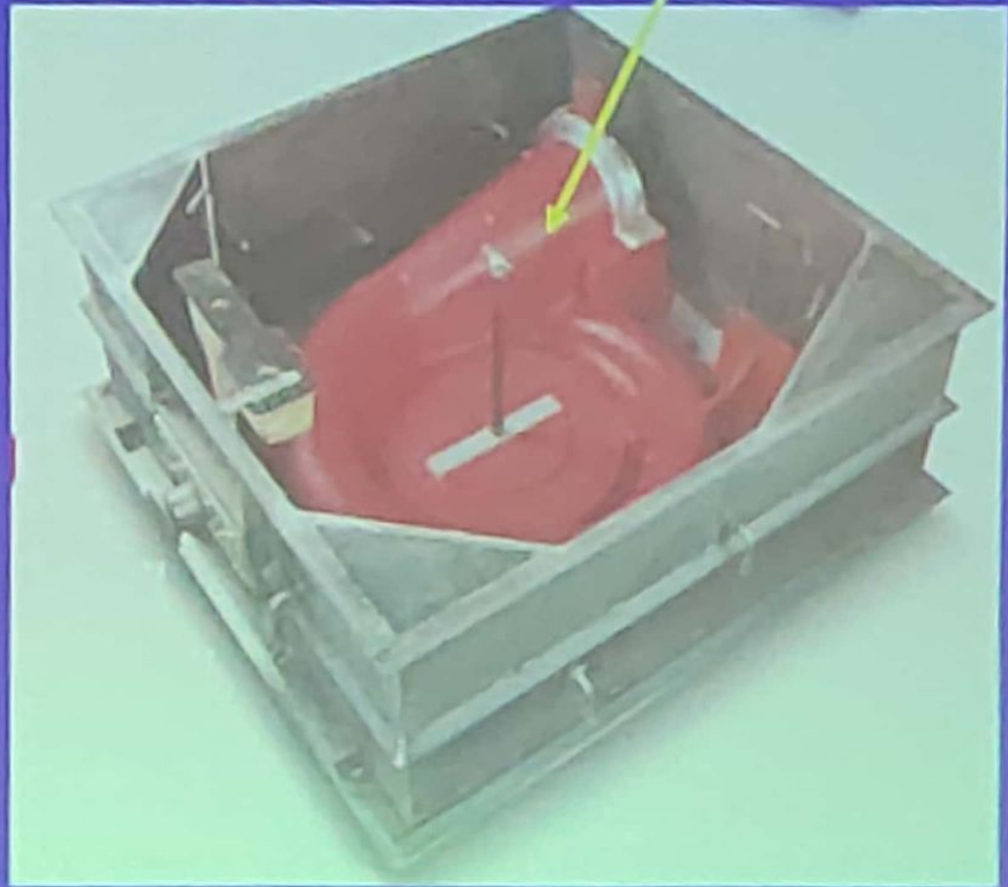
PATTERNS & ALLOWANCES

PATTERN

The pattern is the principal tool during the casting process.

It is the replica of the object to be made by the casting process, with some modifications.





Centrifugal pump housing & its pattern

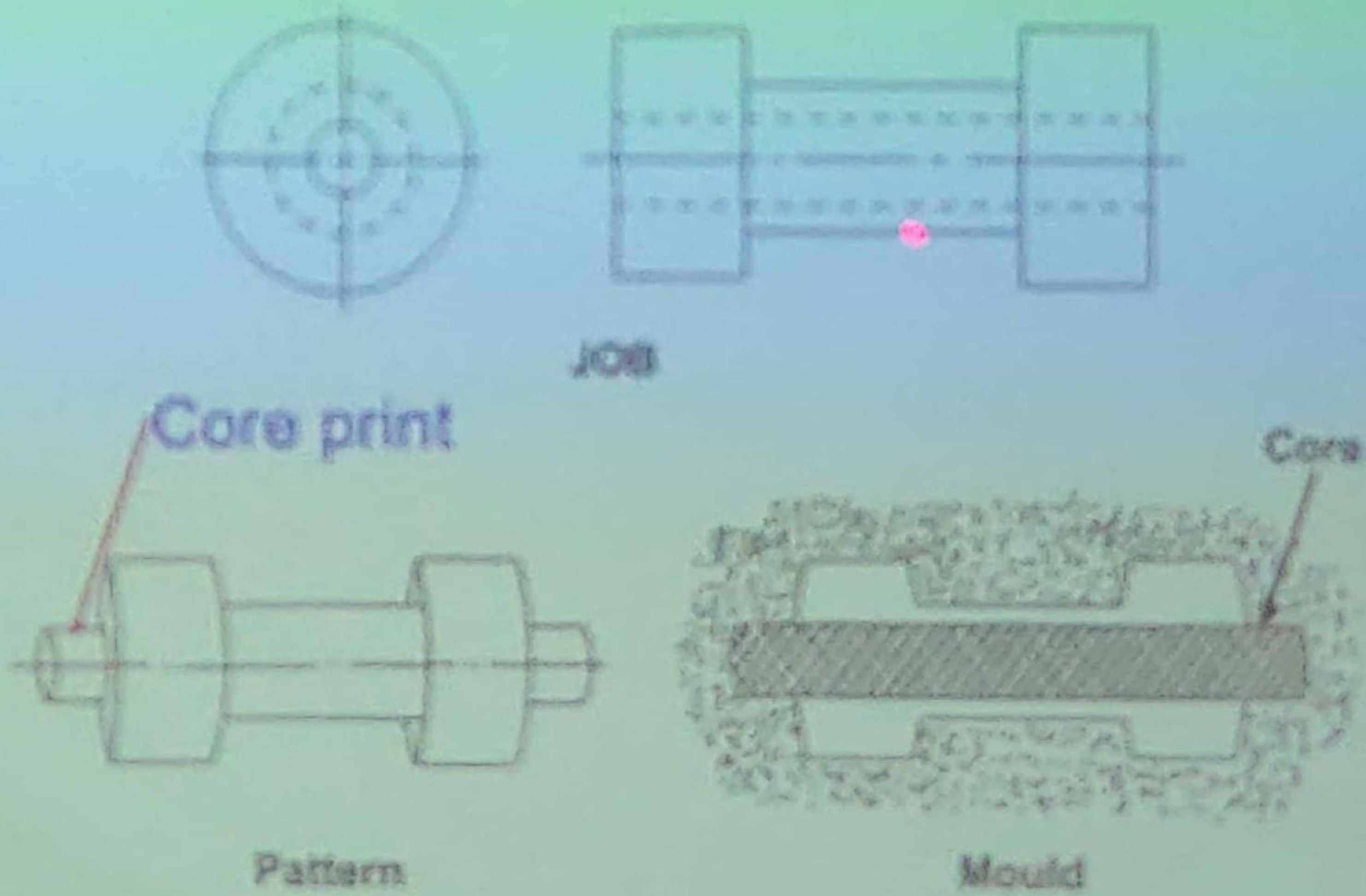
MODIFICATIONS TO THE PATTERN

Pattern is made with some modifications compared to the final cast component.

The main modifications to the pattern are:

1. Pattern allowances
2. Provision for core prints

Modifications to the pattern



FUNCTIONS OF A PATTERN

It prepares the mould cavity.

It enables creation of core prints.

It makes provision for runner, gates, and risers.

Ideal characteristics of a pattern material:

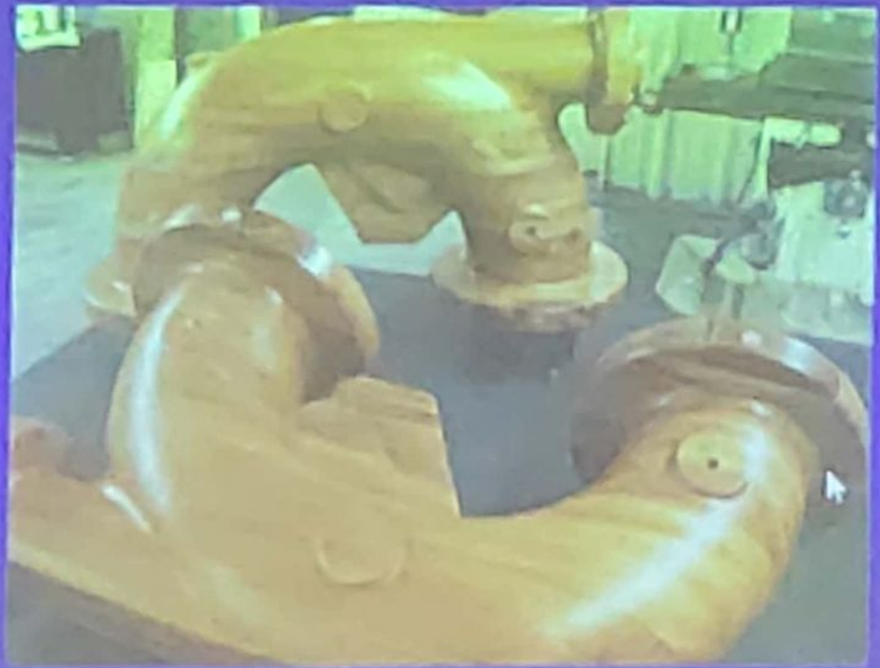
- Easily worked, shaped and joined
- Light in weight
- Strong, hard and durable
- Resistant to wear and abrasion
- Resistant to corrosion, and to chemical reactions
- Dimensionally stable and unaffected by variations in temperature and humidity
- Available at low cost

COMMON PATTERN MATERIALS

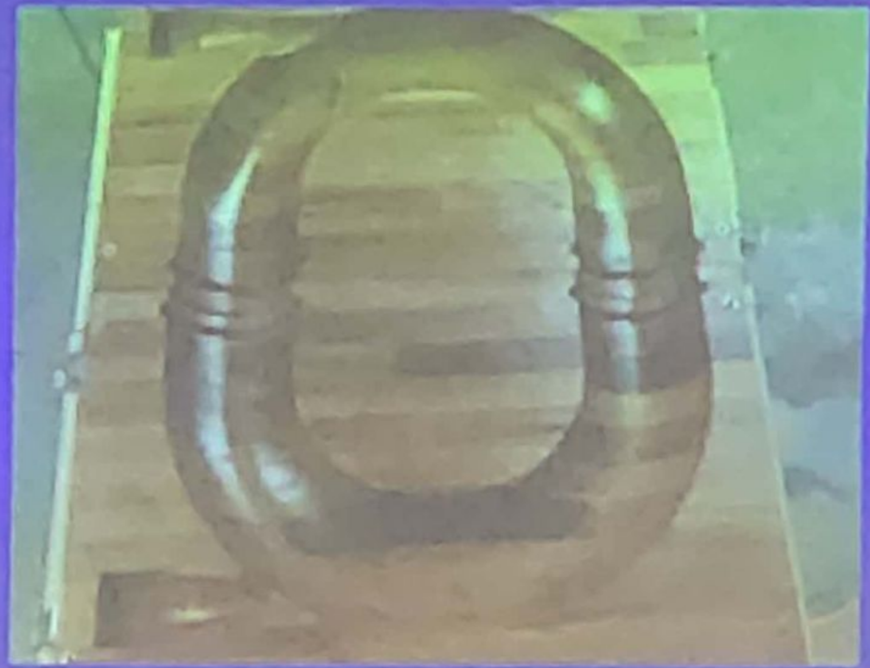
Wood, Metals and alloys, Plastic and rubbers, Wax, etc.

Each material has its own advantages, limitations, and field of application.

WOODEN PATTERNS



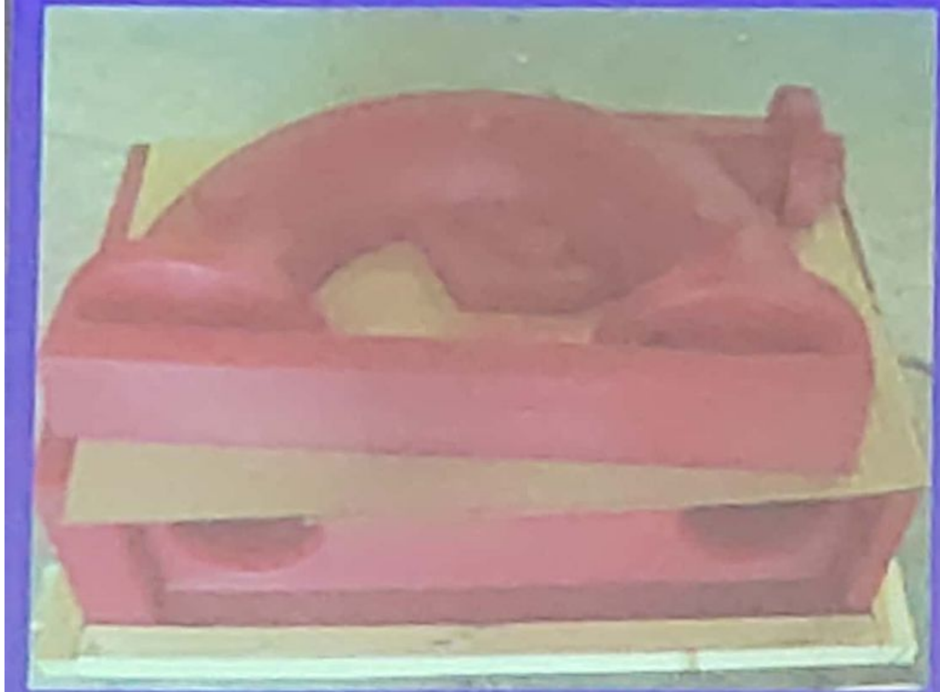
Pattern



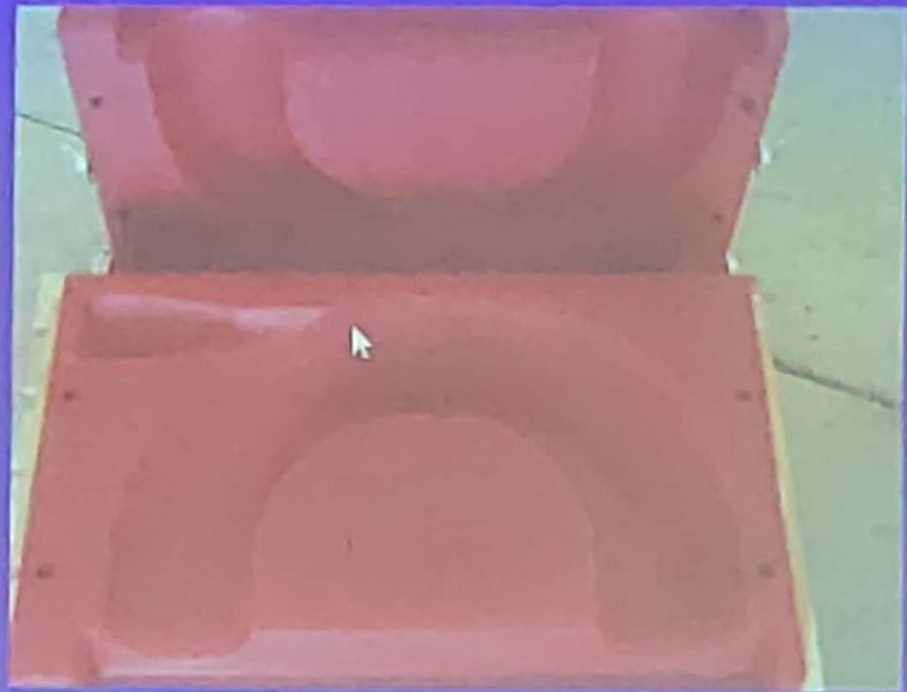
Core box

SOURCE: http://www.precisionpatterns.com

PLASTIC PATTERNS



Pattern



Core box

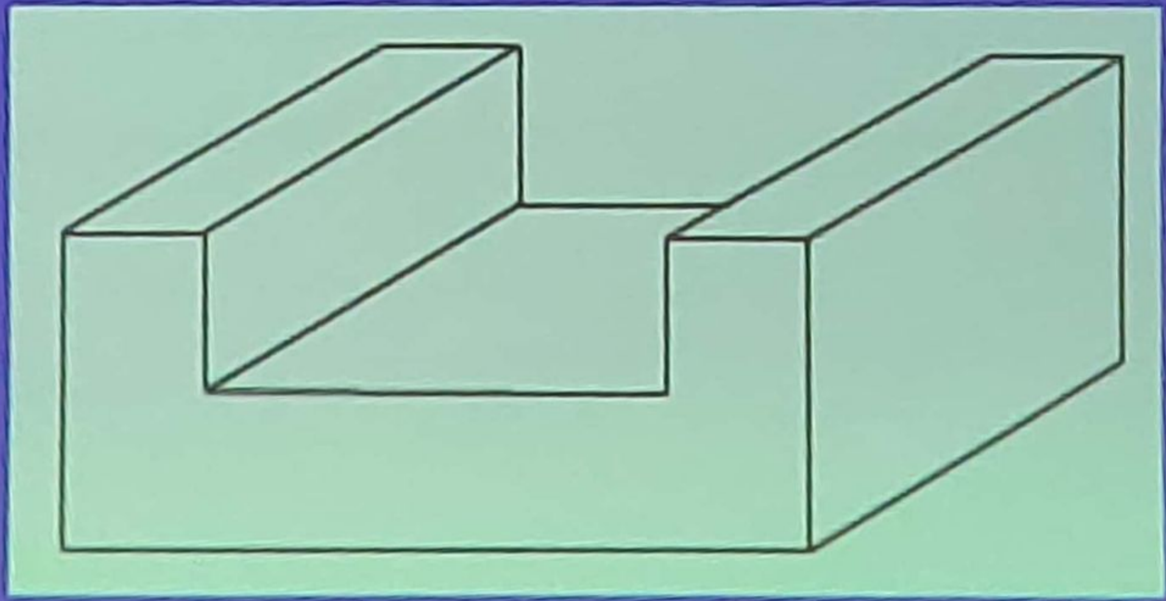
SOURCE: http://www.precisionpatterns.com

TYPES OF PATTERN

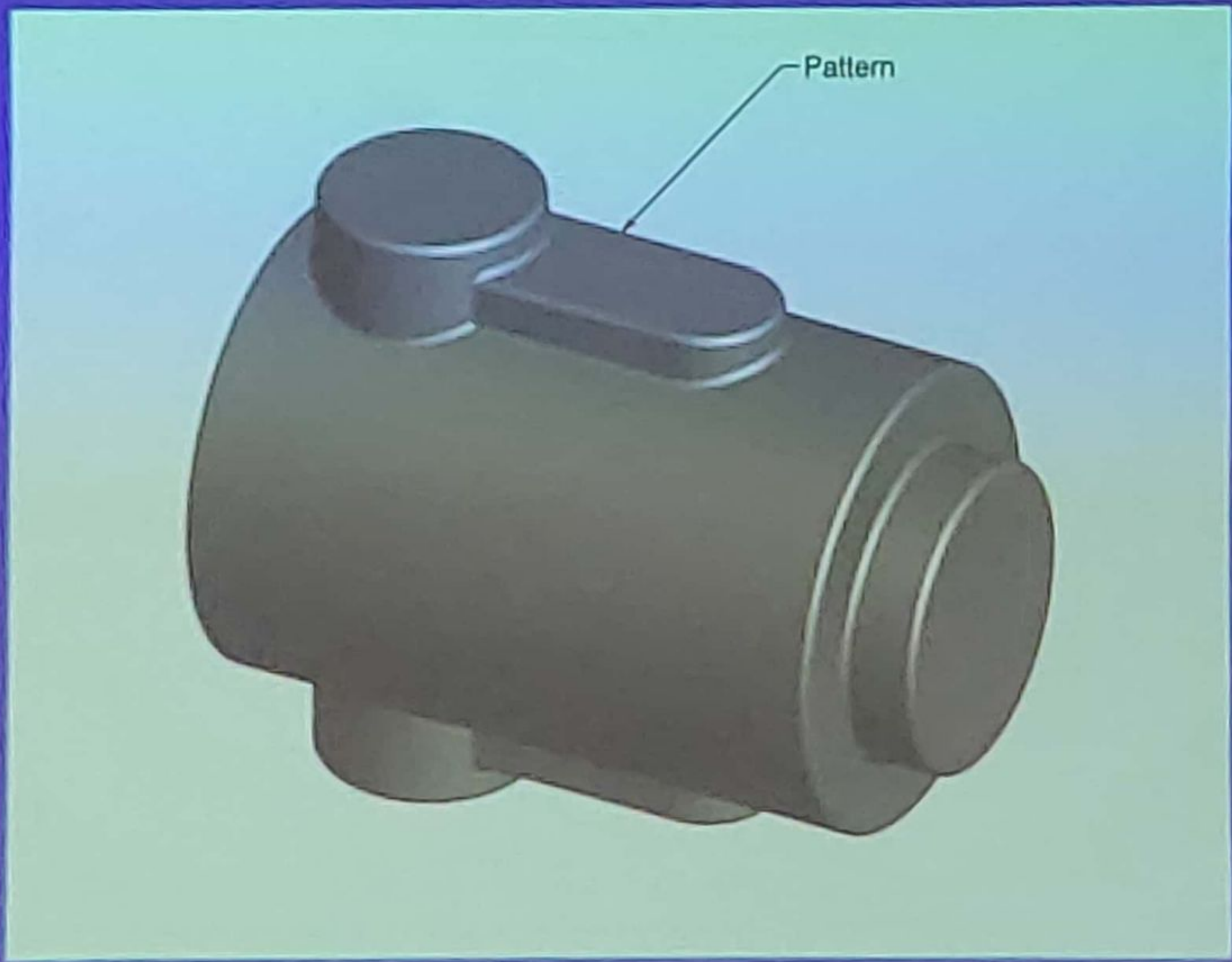
1. Single piece pattern
2. Split or two piece pattern
3. Match plate pattern
4. Gated pattern
5. Sweep pattern
6. Loose piece pattern
7. Skeleton pattern
8. Cope & drag pattern

SINGLE PIECE PATTERN

Used only in cases where the job is very SIMPLE.

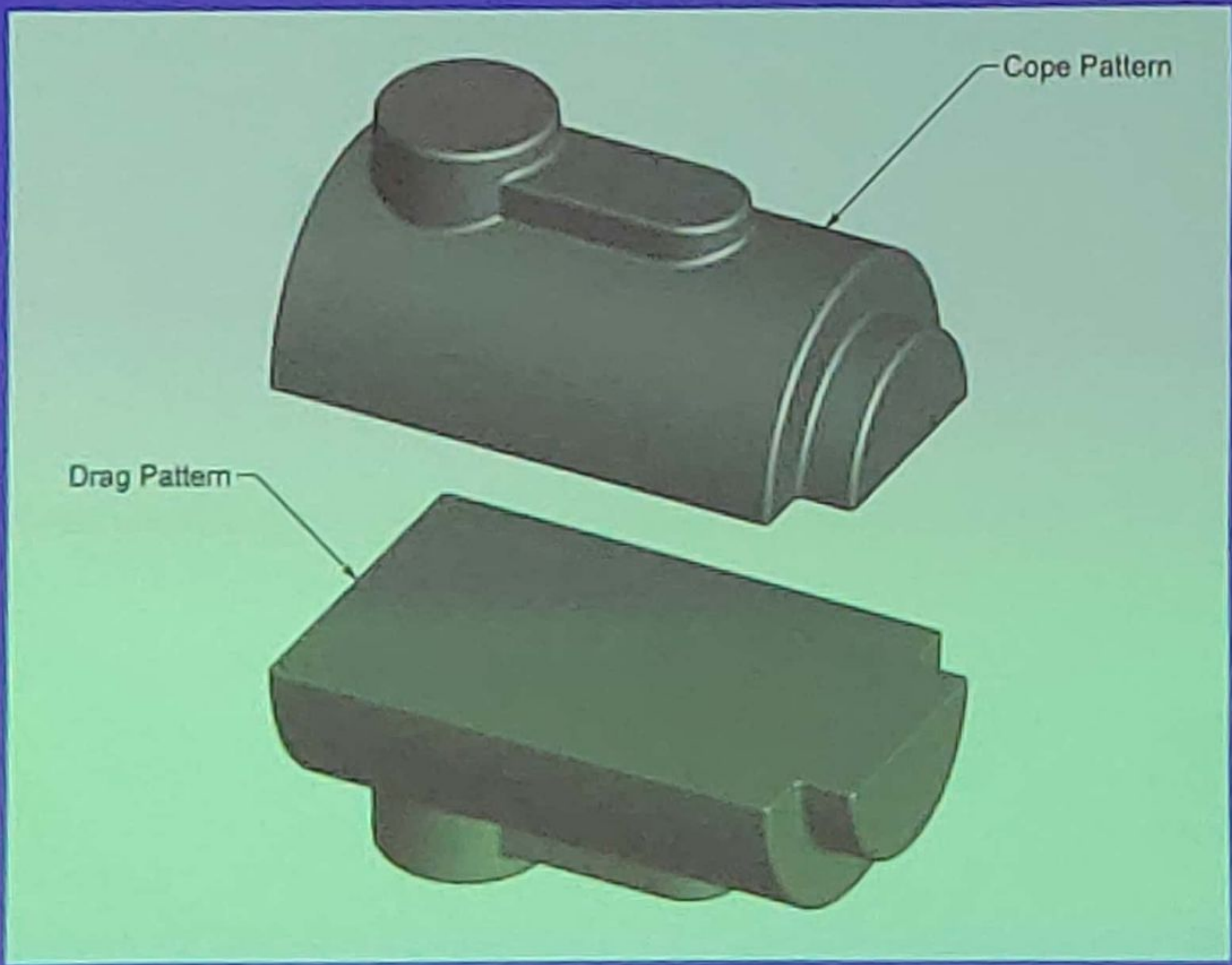


Solid pattern



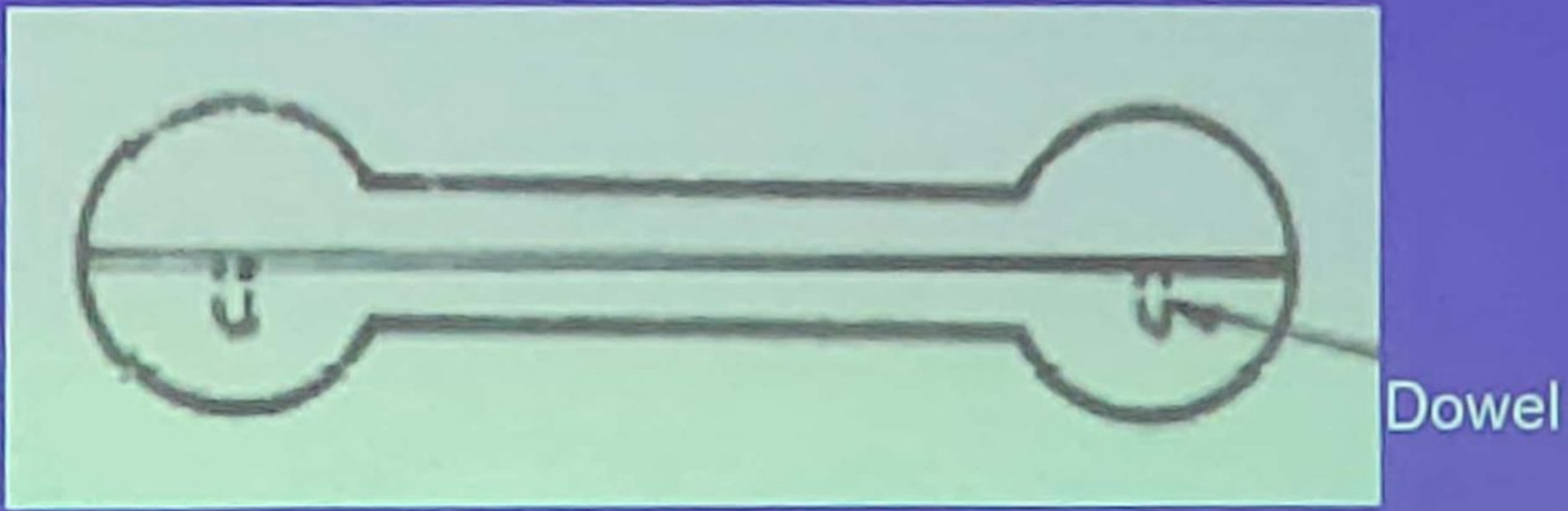
SOURCE: www.custompartnet.com

Split Pattern



SOURCE: www.custompartnet.com

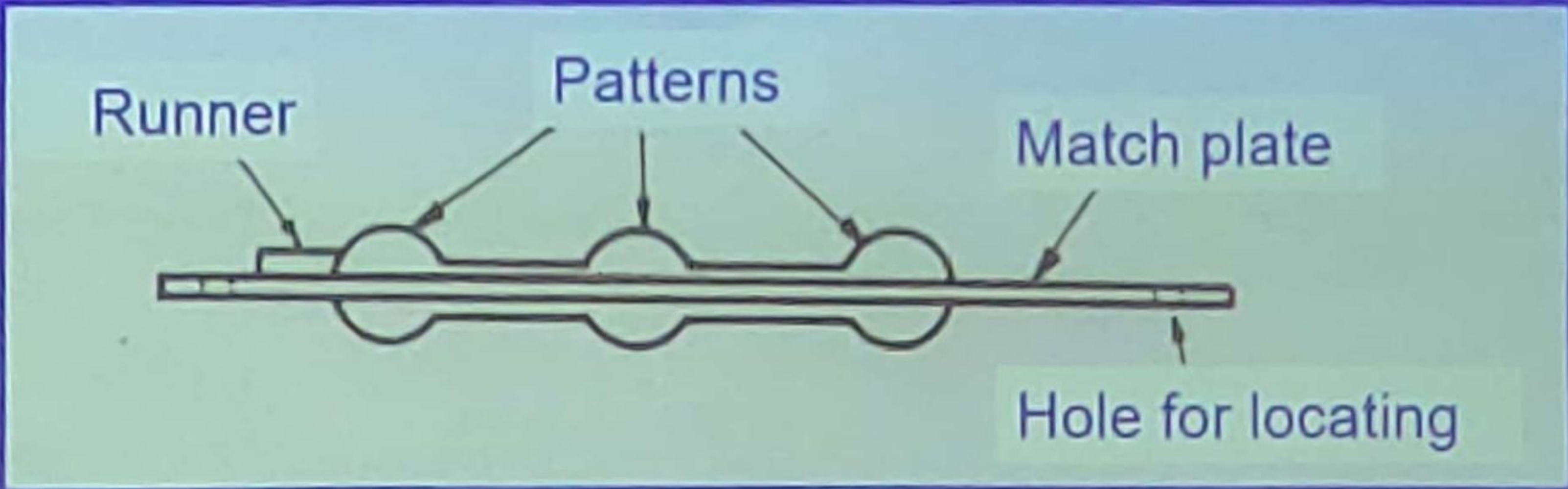
Split Pattern



Match plate pattern

Consists of a match plate, on either side of which each half of a number of split patterns is fastened.

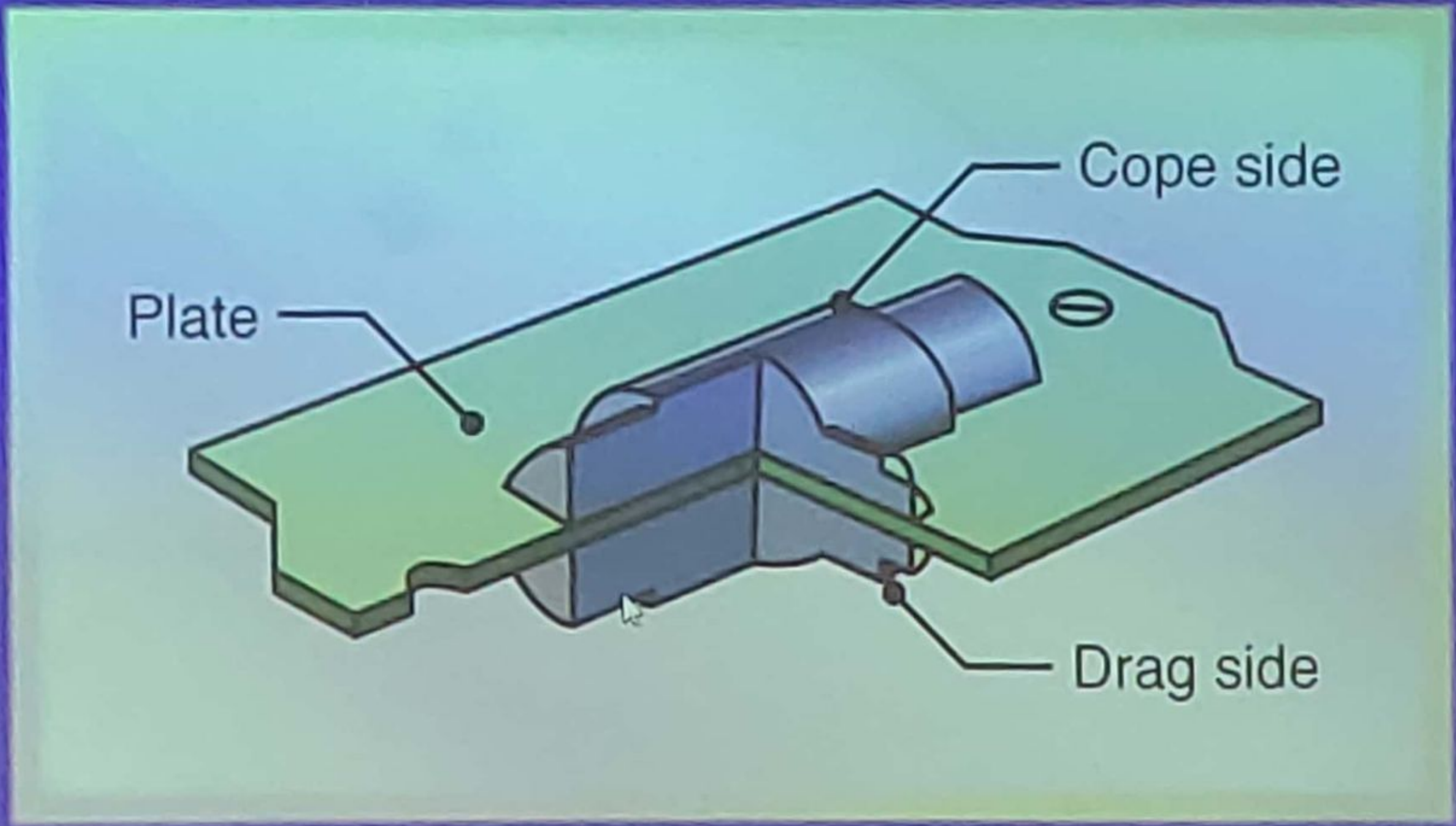
Match plate pattern



Material of the pattern is metal.

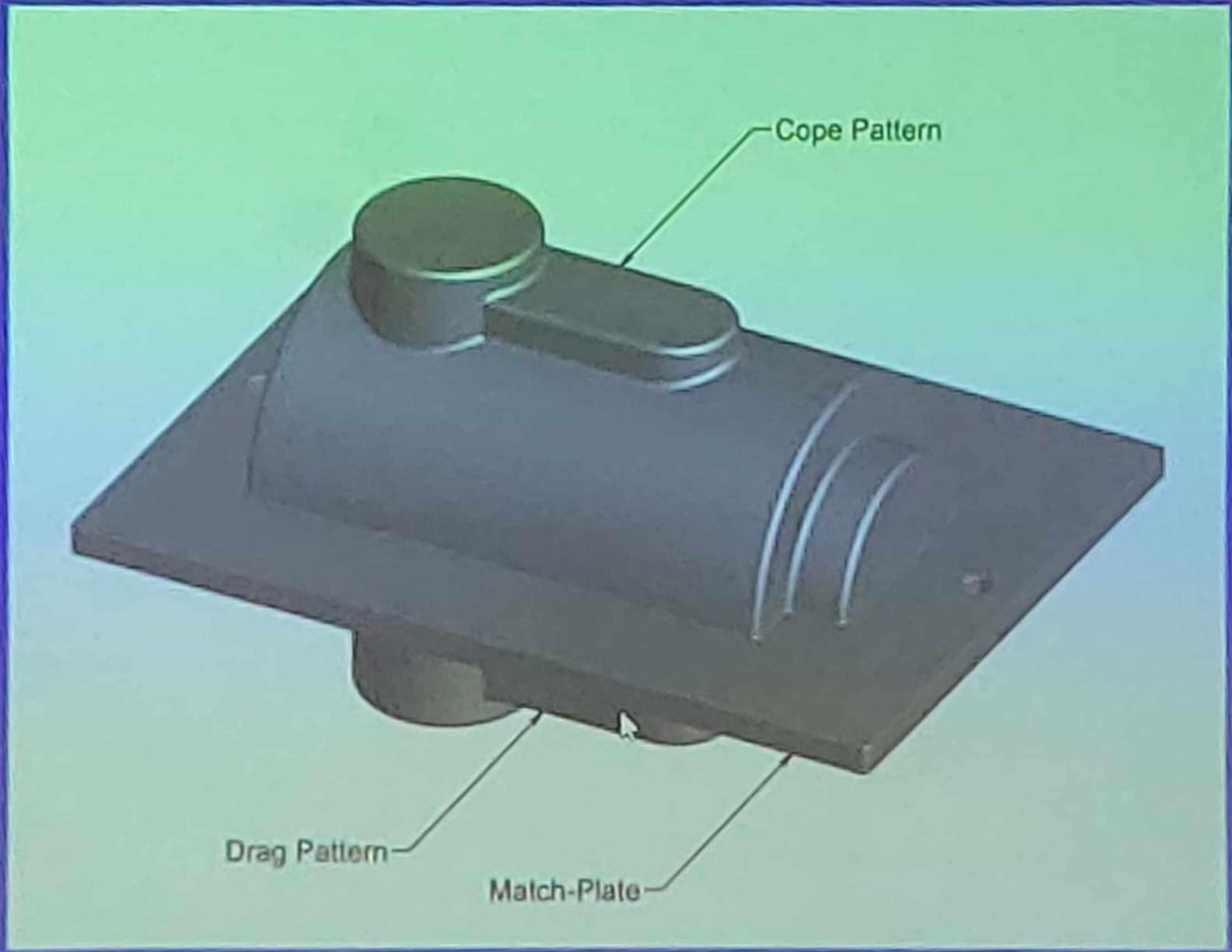
Example: Piston rings of IC engine

Match Plate Pattern



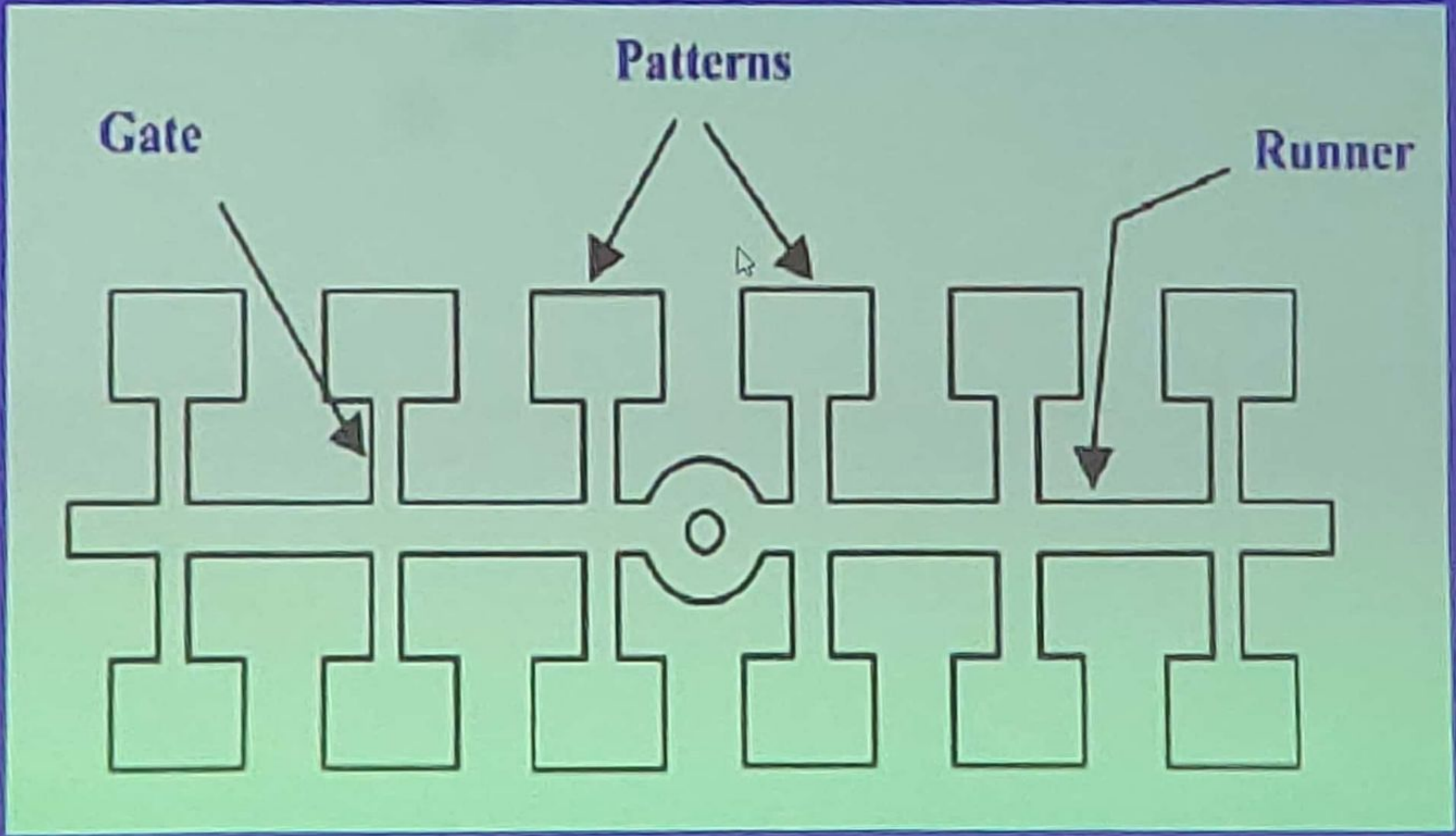
A typical metal match-plate pattern used in sand casting.

Match plate pattern



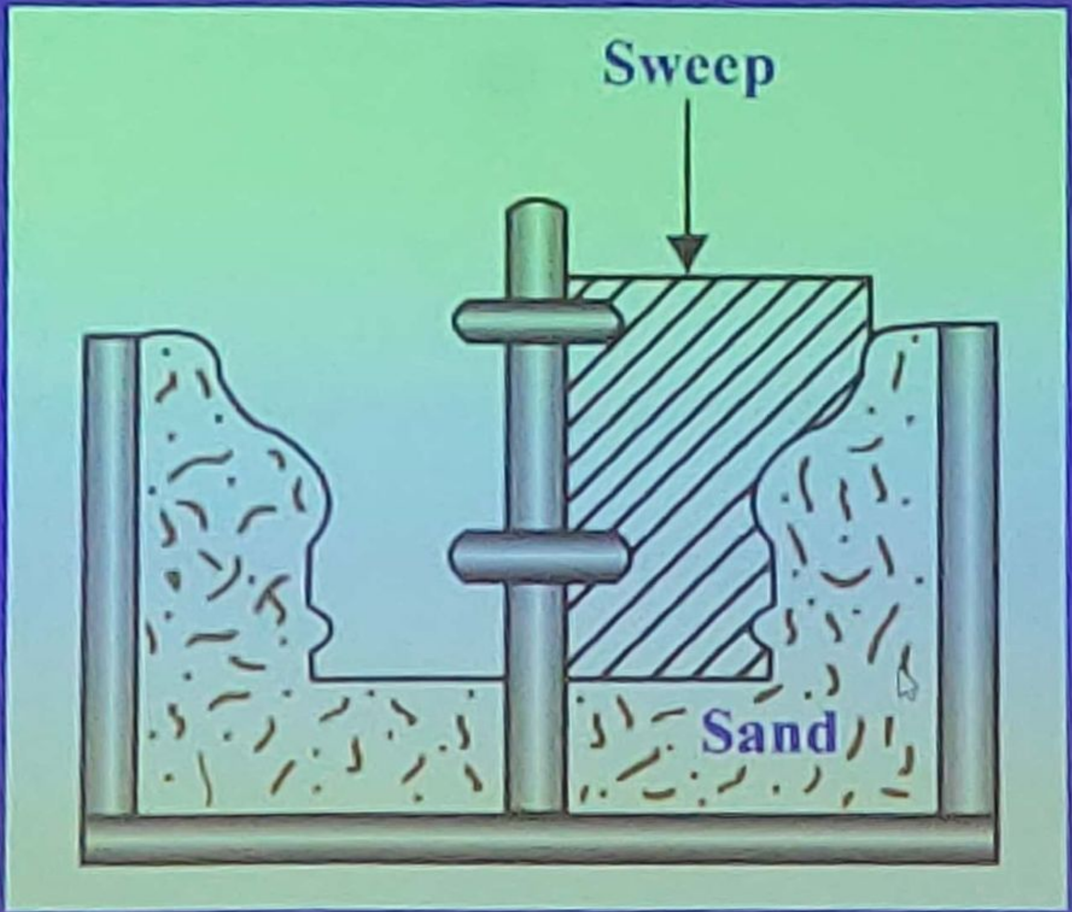
SOURCE: www.custompartnet.com

GATED PATTERN



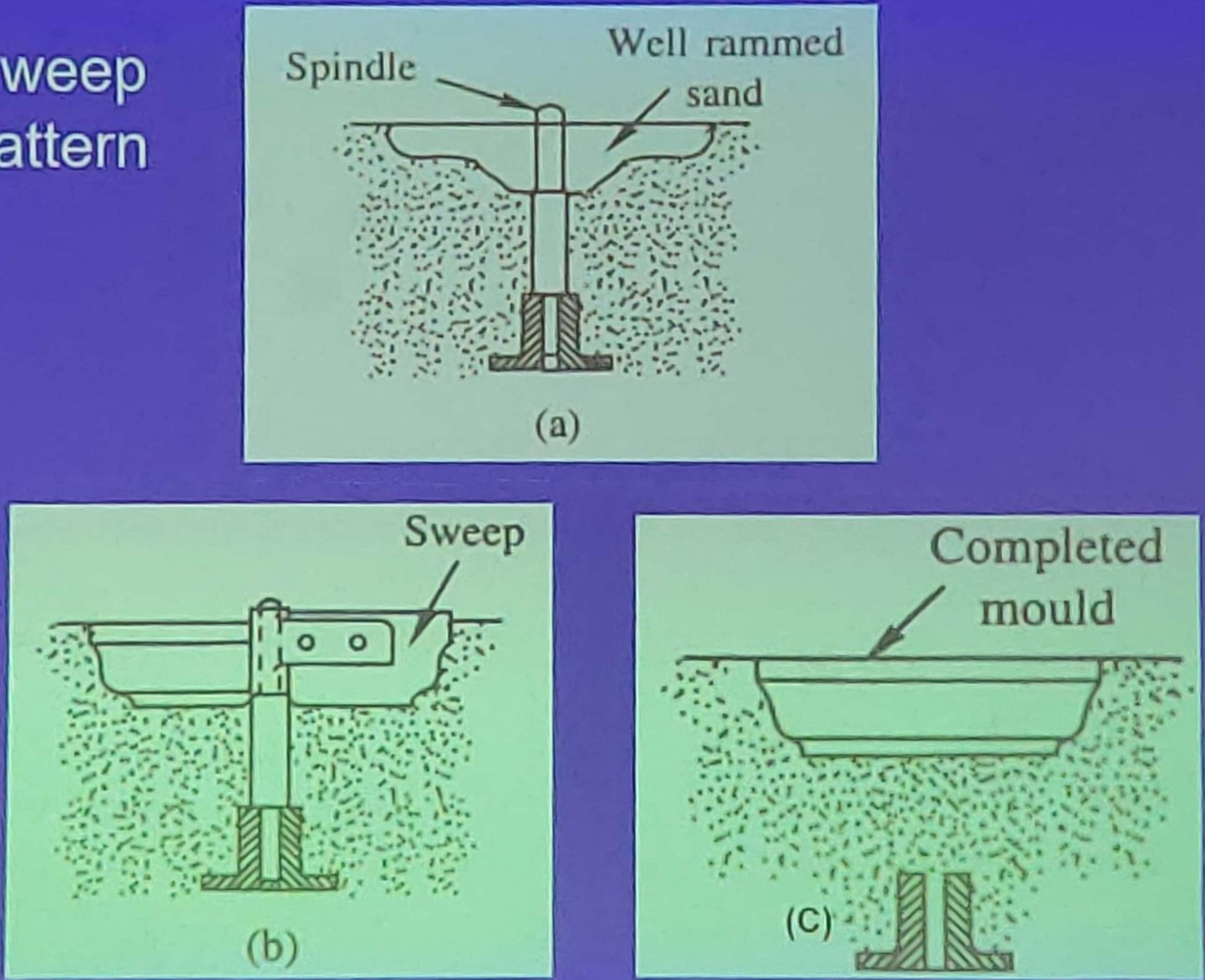
Employed for small castings

SWEEP PATTERN

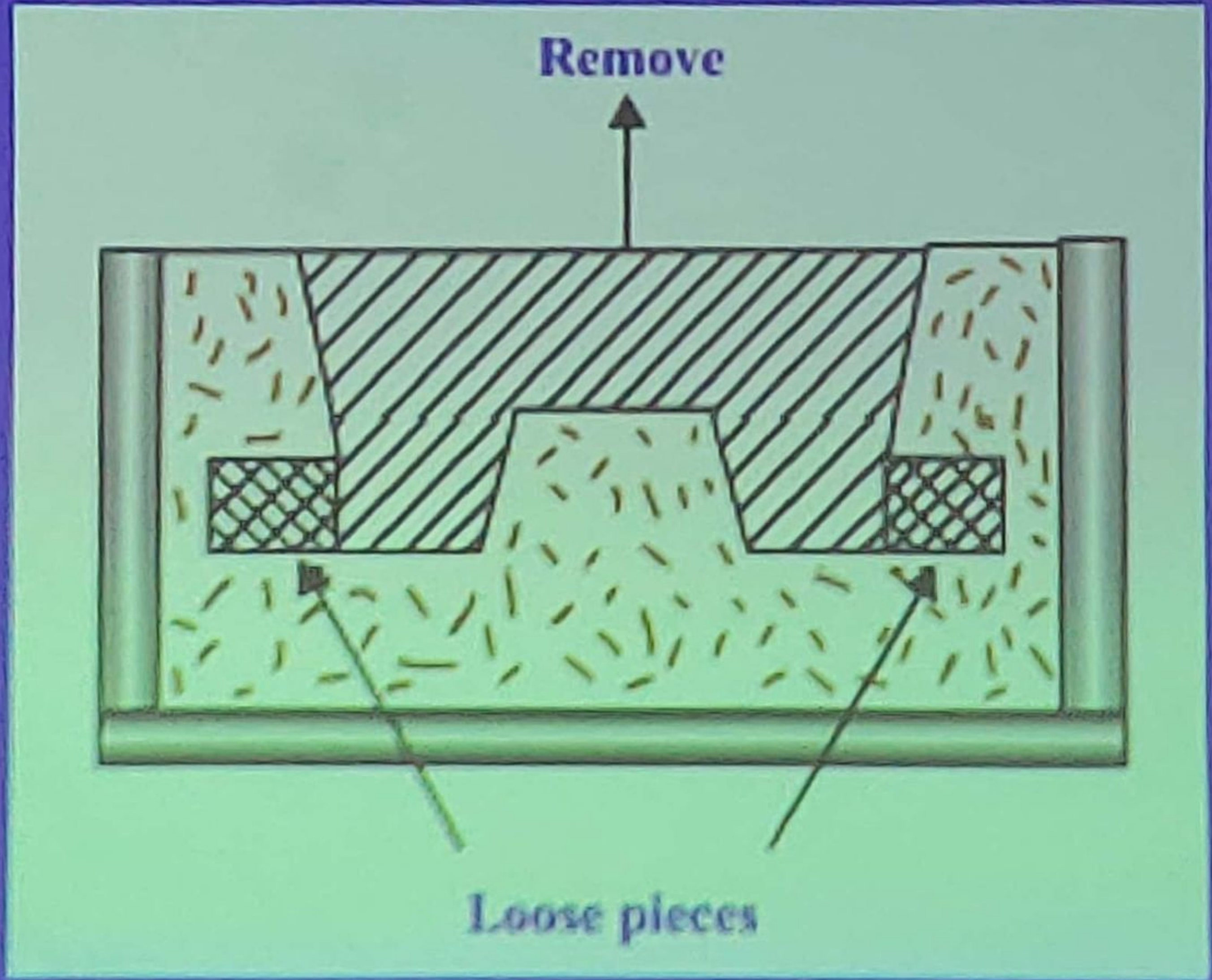


Used for large castings of circular sections and symmetrical shapes

Sweep pattern

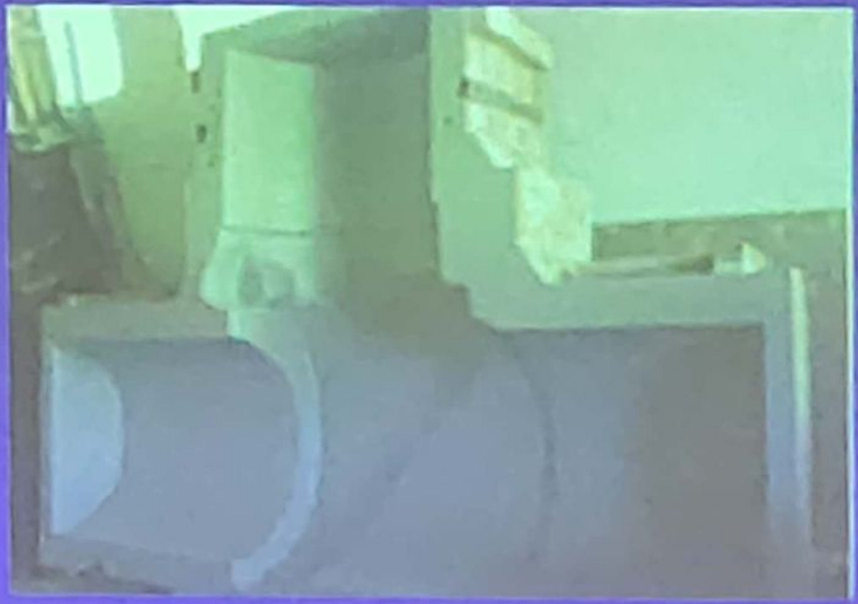


LOOSE PIECE PATTERN

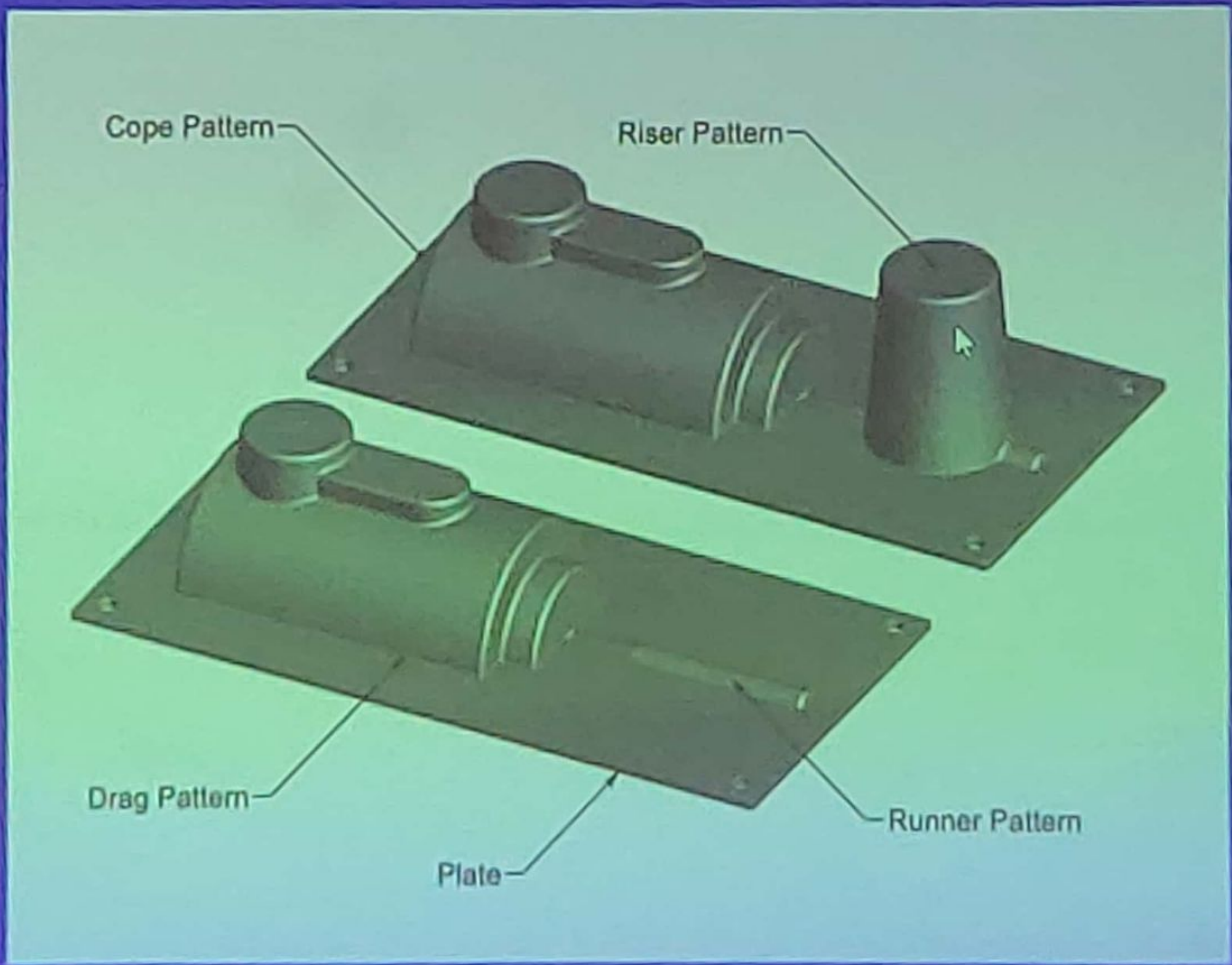


SKELETON PATTERN

Hollow pattern for huge castings



COPE & DRAG PATTERN



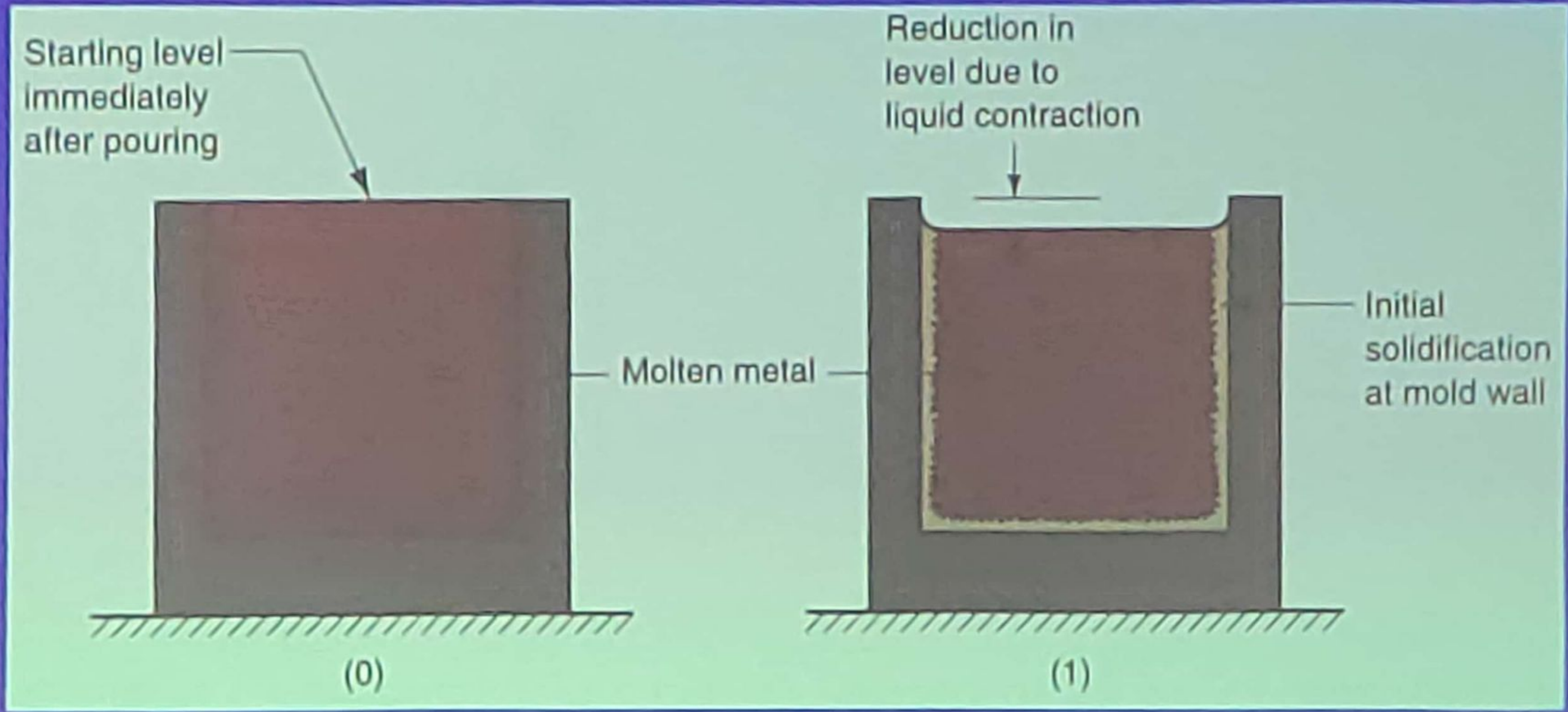
SOURCE: www.custompartnet.com

PATTERN ALLOWANCES

PATTERN ALLOWANCES

1. Shrinkage or contraction allowance
2. Draft or taper allowance
3. Machining or finish allowance
4. Distortion or camber allowance
5. Rapping allowance

FORMATION OF SHRINKAGE CAVITY

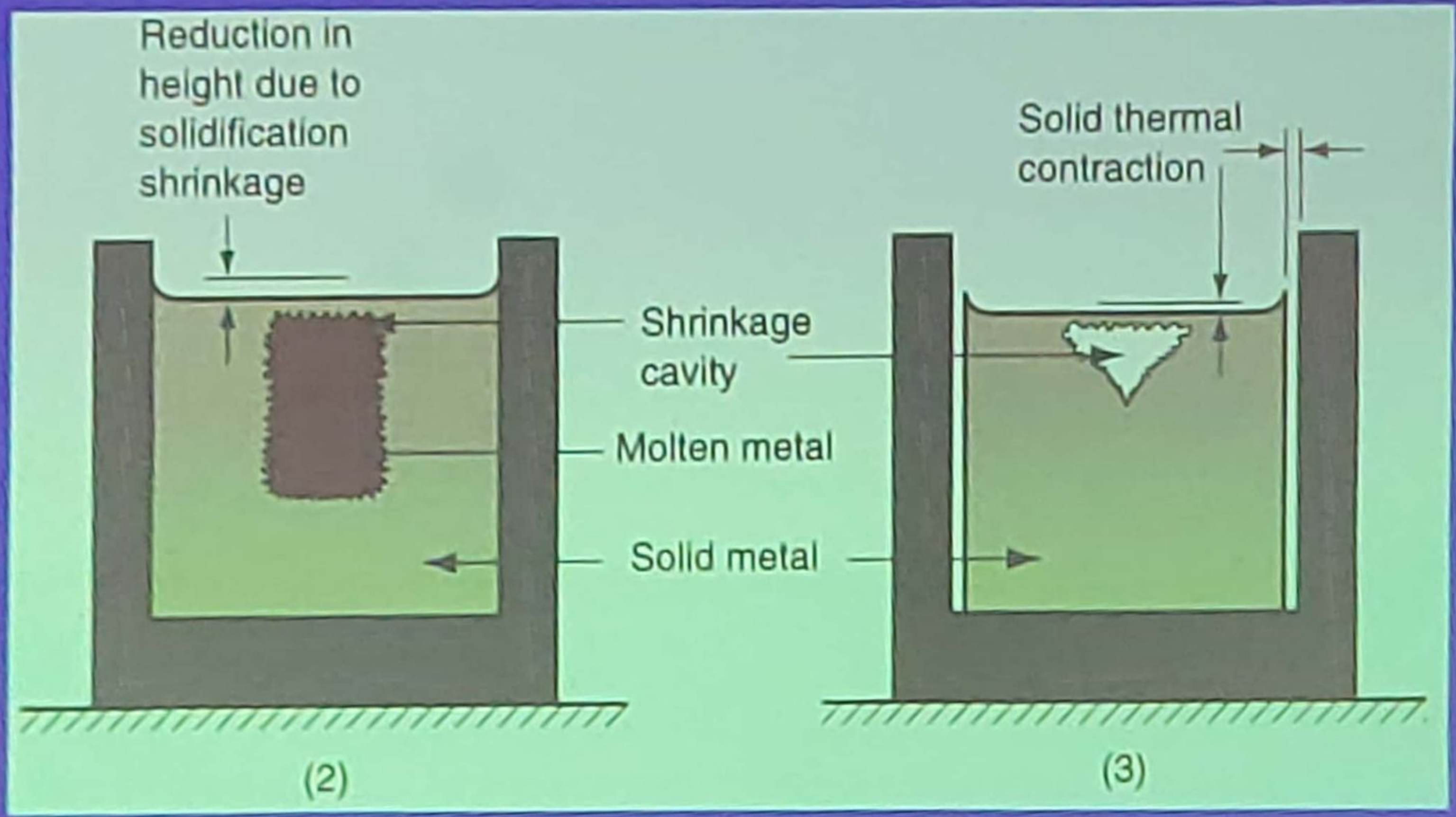


(0) Level of molten metal just after pouring.

(1) Liquid contraction due to cooling.

(Compensated by liquid metal in the riser)

FORMATION OF SHRINKAGE CAVITY



(2) Formation of shrinkage cavity due to solidification.

(Compensated by liquid metal in the riser)

(3) Further reduction in height and diameter due to solid contraction.

(Not compensated by liquid metal in the riser)

PATTERN ALLOWANCES

1. Shrinkage or contraction allowance
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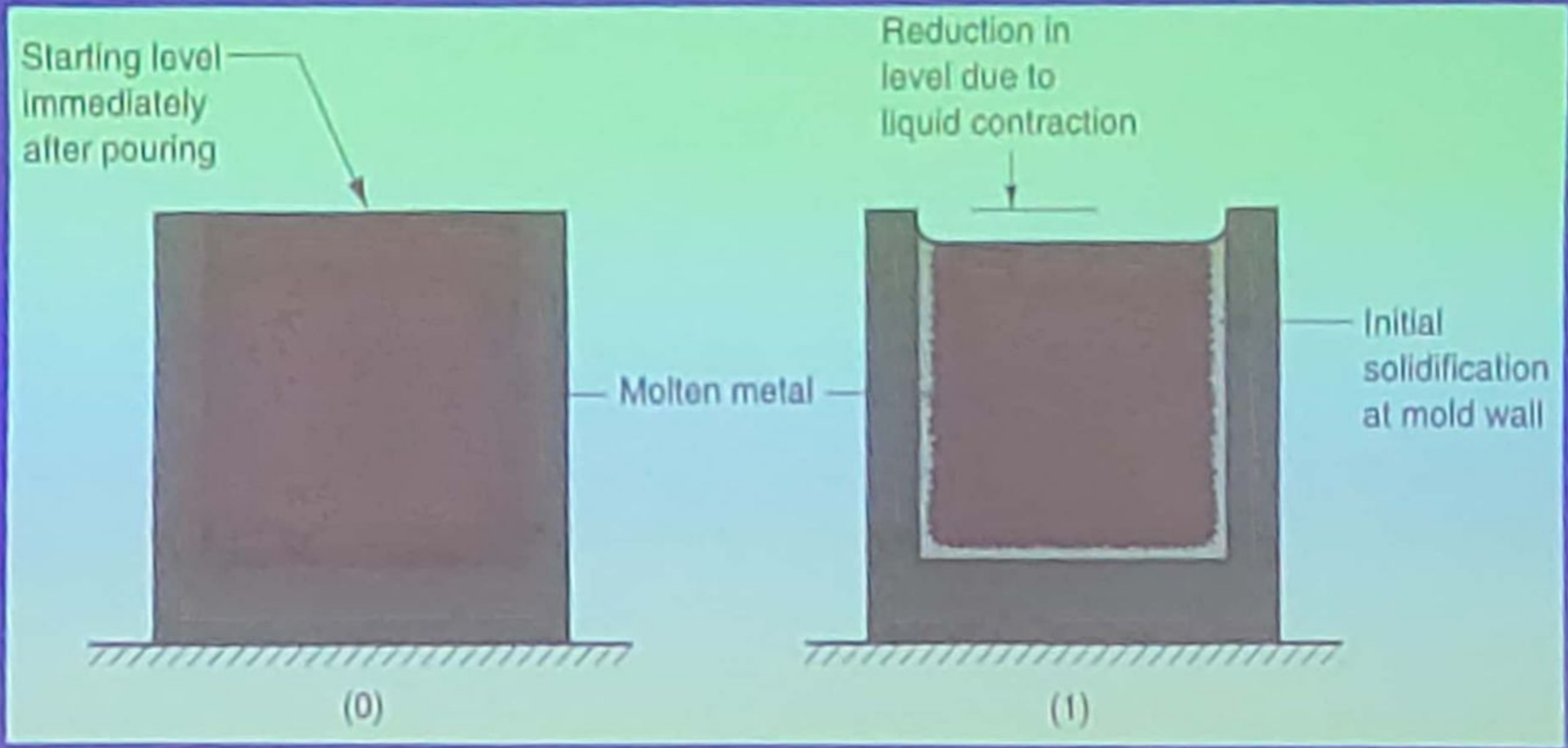
FORMATION OF SHRINKAGE CAVITY



(0) Level of molten metal just after pouring.

(1) Liquid contraction due to cooling.

(Compensated by liquid metal in the riser)

TYPES OF SHRINKAGE OF METALS:

LIQUID SHRINKAGE

-Compensated by the liquid metal in the riser.

SOLIDIFICATION SHRINKAGE

-Compensated by the liquid metal in the riser.

Solid Contraction:

-Reduction in volume caused when the metal loses temperature in solid state. **(Not compensated by the liquid metal in the riser)**

Size of the casting would become smaller.

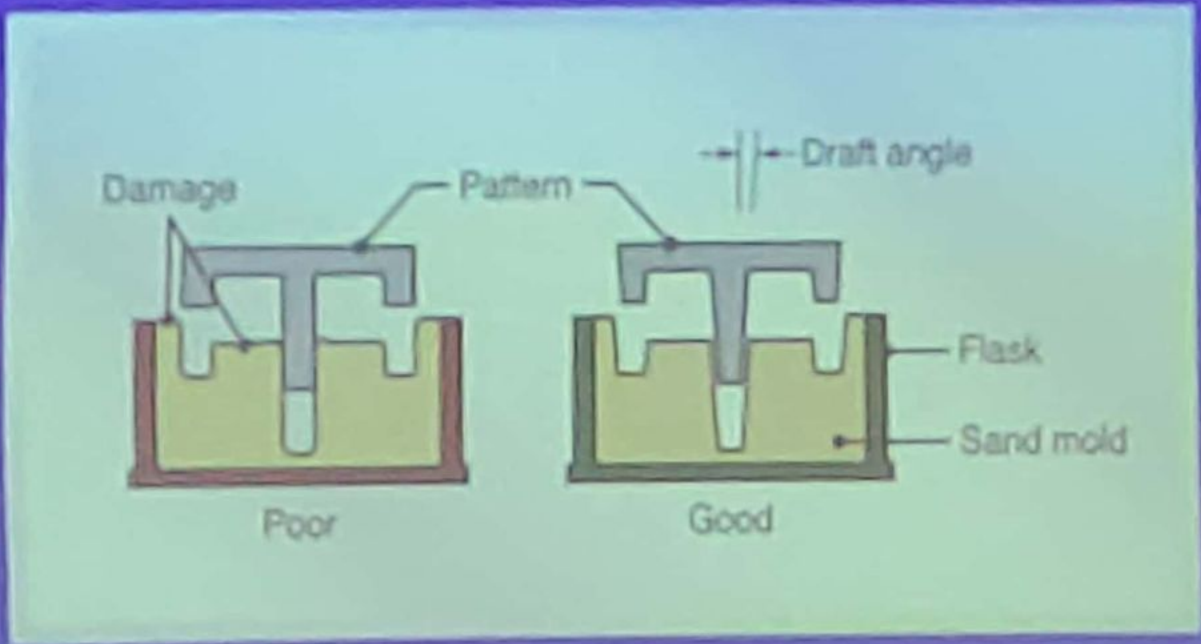
How to overcome this problem?

Make the dimensions of the pattern little larger. This extra dimension is known as '**Contraction allowance**'.

Draft or Taper Allowance

A **TAPER** is provided on all the vertical surfaces of the pattern.

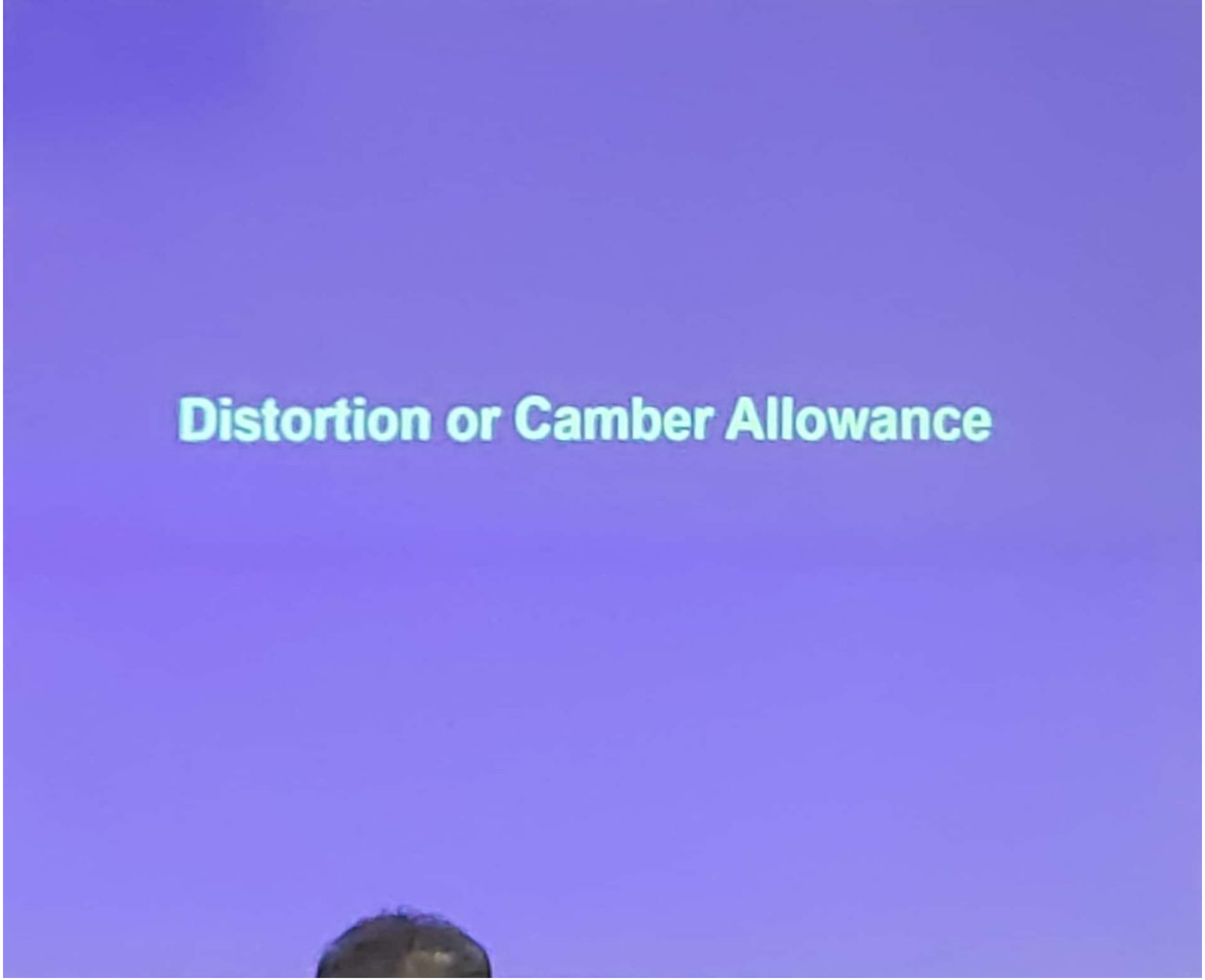
Then it can be removed from the sand without tearing away the sides of the mould.



Machining or Finish Allowance

Need for machining allowance

– poor surface finish


Distortion or Camber Allowance

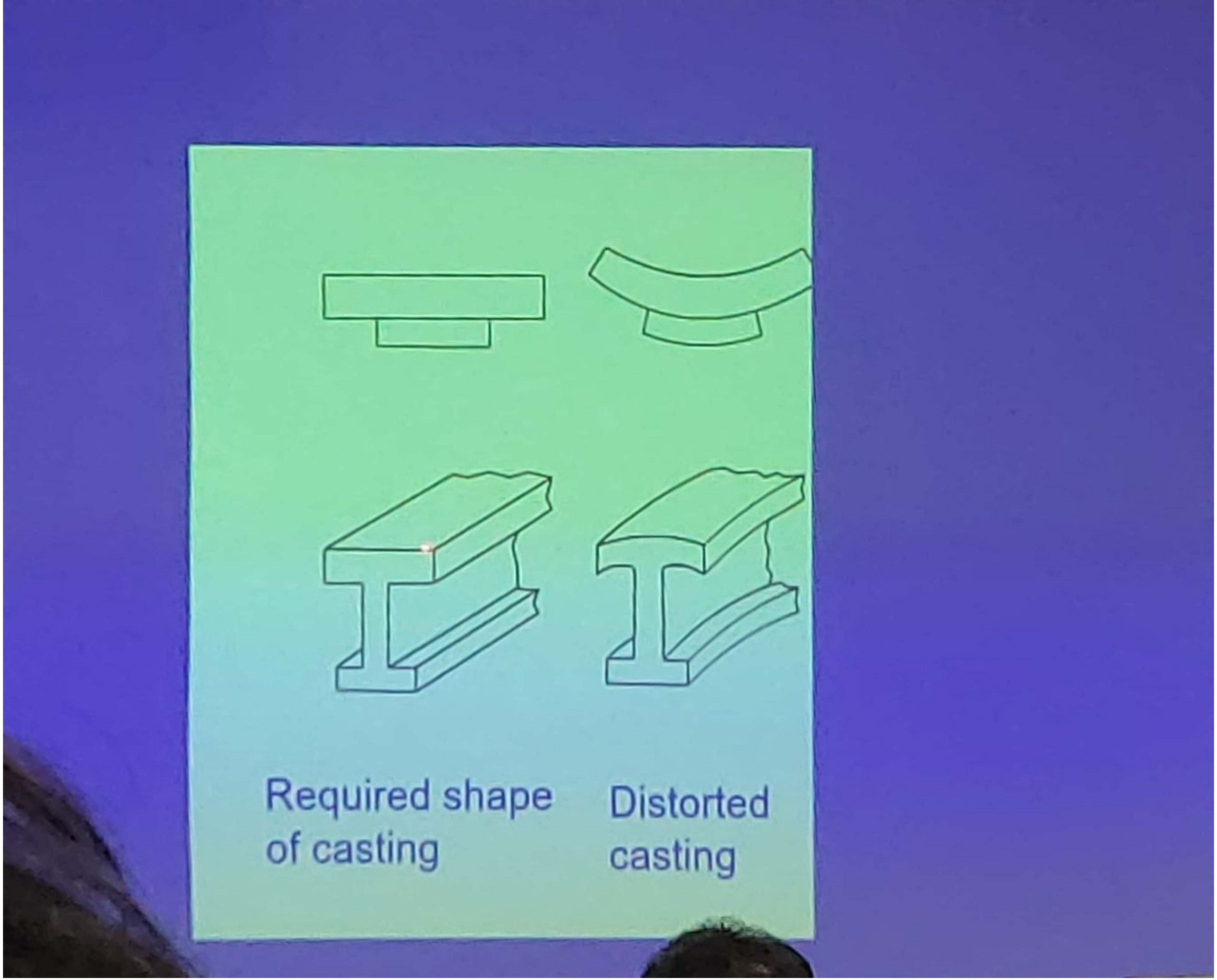
Distortion or Camber Allowance

Sometimes castings get distorted, during solidification, due to their typical shape.

Reasons for distortion:

Internal stresses

Non-uniform cooling of casting


Required shape
of casting
Distorted
casting

Rapping Allowance

Rapping Allowance

Rapping

Effect of rapping on the mould cavity

Rapping Allowance

Negative allowance

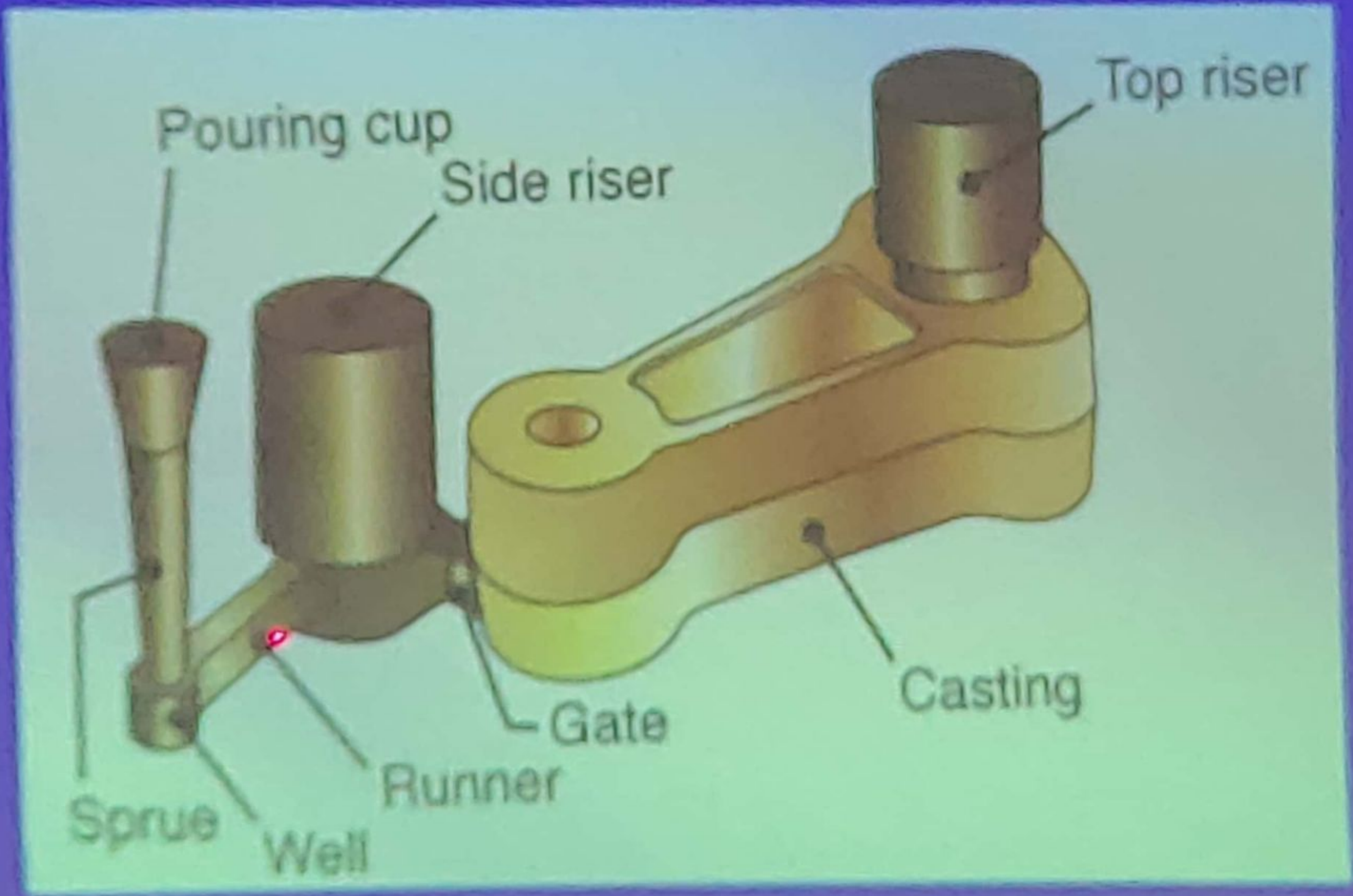
PATTERN MATERIAL CHARACTERISTICS

Characteristic	Wood	Aluminum	Steel	Plastic	Cast Iron
Machinability	E	G	F	G	G
Wear resistance	P	G	E	F	E
Strength	F	G	E	G	G
Weight	E	G	P	G	P
Repairability	E	P	G	F	G
Corrosion resistance	E	E	P	E	P
Swelling	P	E	E	E	E

E- Excellent **G - Good** **F - Fair** **P - Poor**

DESIGN OF RISERING SYSTEM

RISERS OF A CASTING



PRIMARY FUNCTION OF A RISER

- It acts as a reservoir of molten metal in the mould to compensate for shrinkage during solidification.

SECONDARY FUNCTIONS OF A RISER

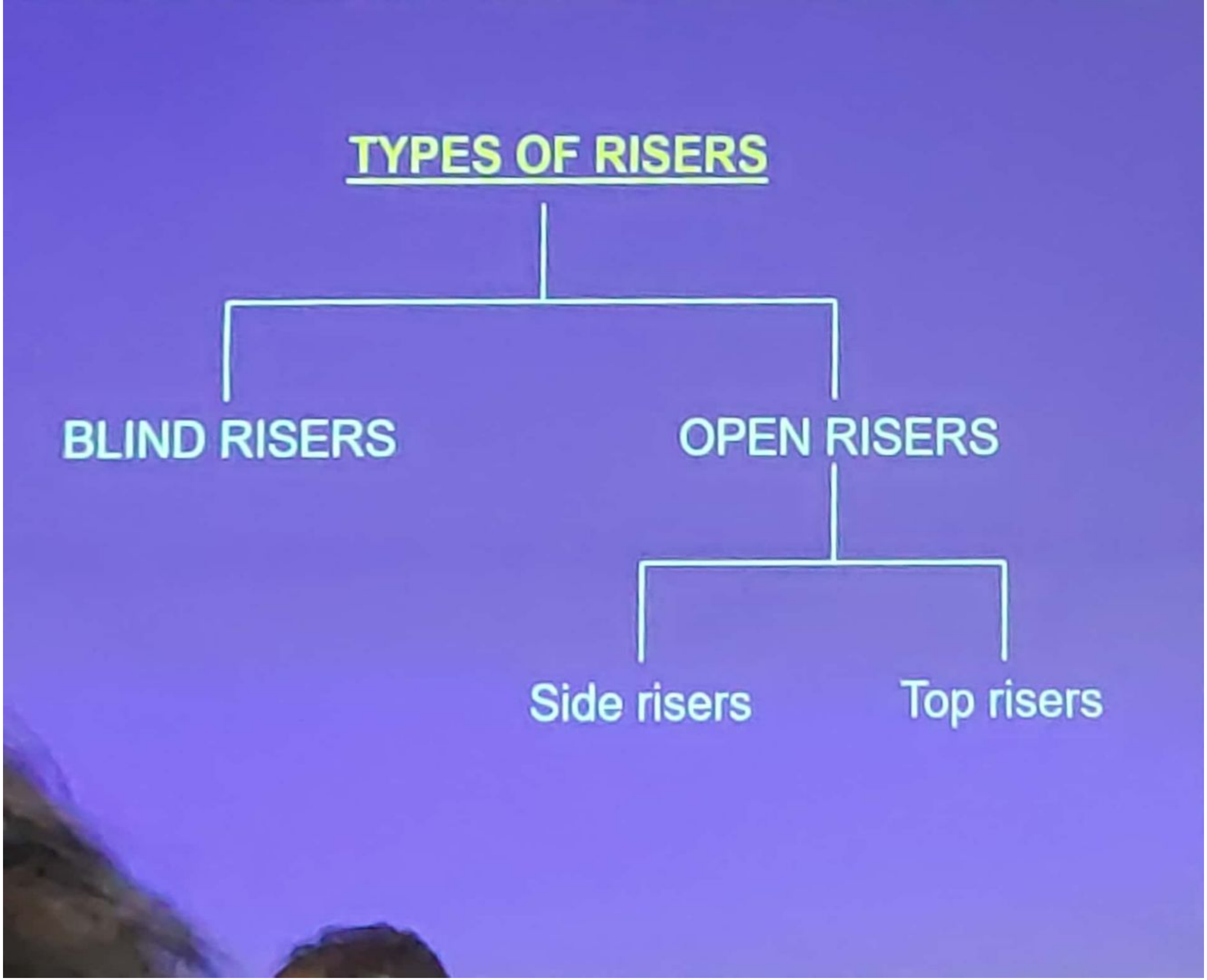
- It gives an indication that the cavity is full with the molten metal.
- It also enables escape of hot gases during pouring of molten metal.

Why Design of Riser?

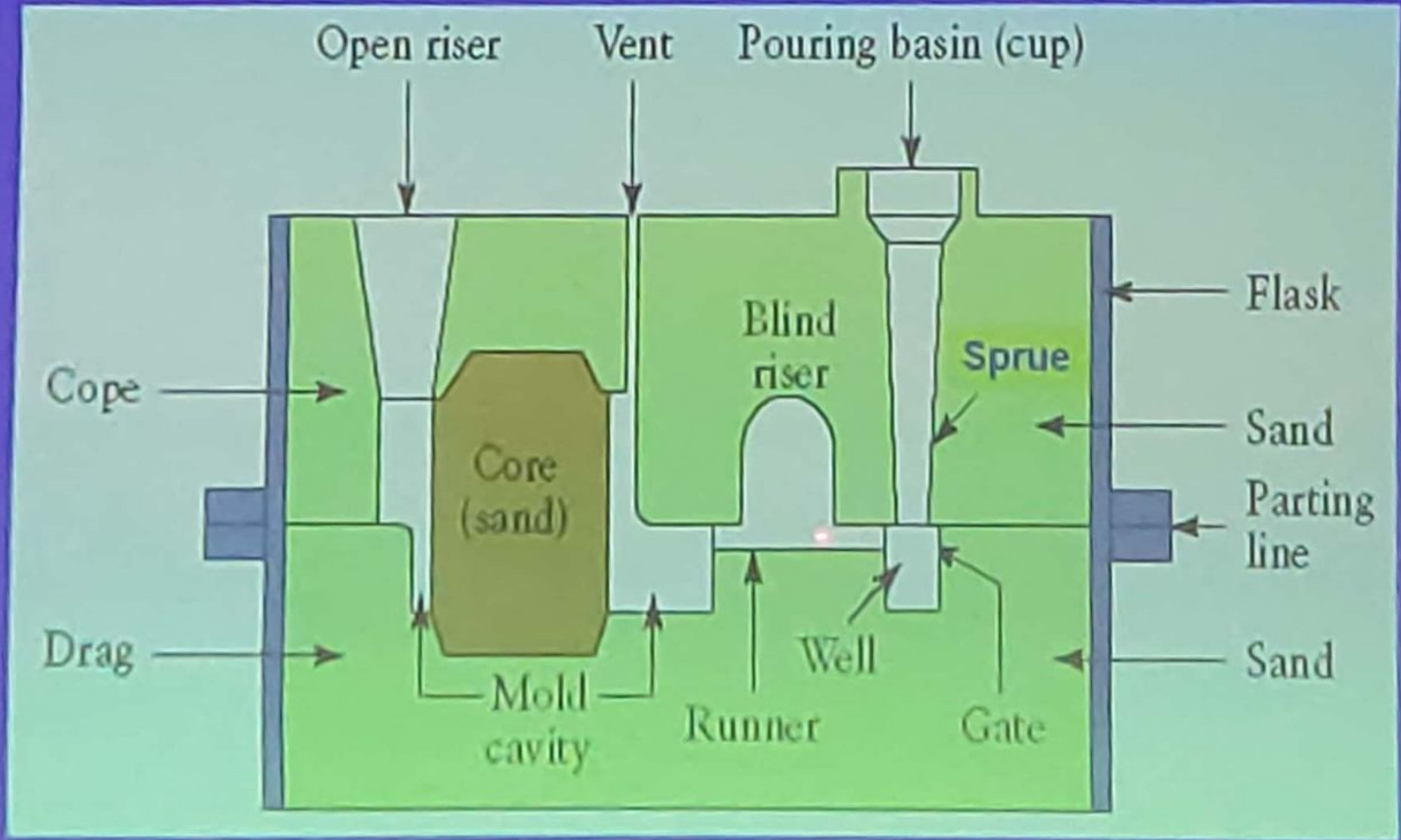
- An undersized riser could lead to shrinkage defects and rejection of the casting.

- An oversized riser requires excess molten metal and results in excess power / fuel consumption.

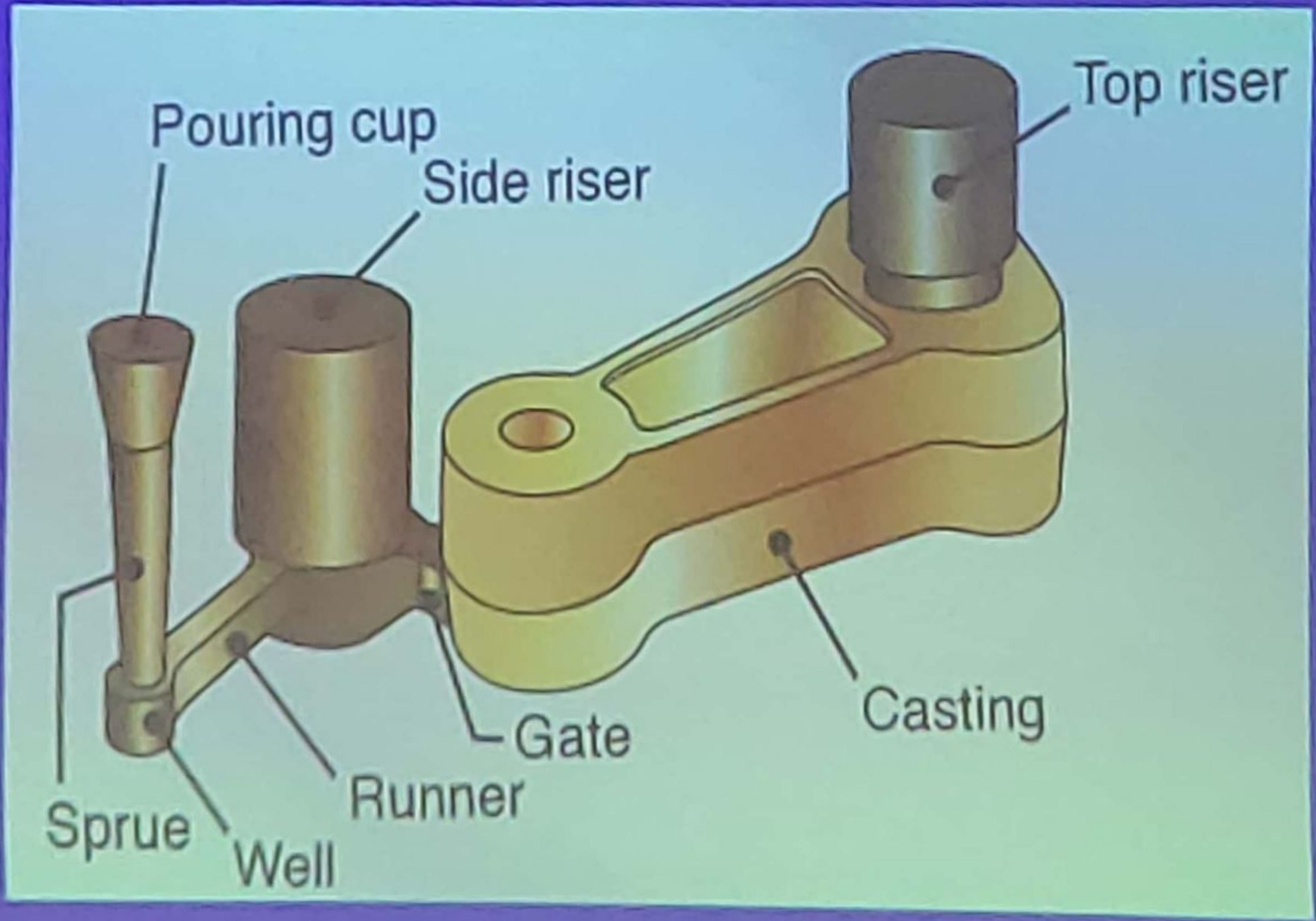
Shrinkage Cavity Defect


TYPES OF RISERS
BLIND RISERS
OPEN RISERS
Side risers
Top risers

BLIND RISER


Open riser
Vent
Pouring basin (cup)
Flask
Blind riser
Sprue
Cope
Sand
Core (sand)
Parting line
Drag
Well
Sand
Mold cavity
Runner
Gate

OPEN RISERS



Pouring cup
Side riser
Top riser
Sprue
Well
Runner
Gate
Casting

IN GENERAL:

FOR SIDE RISER:

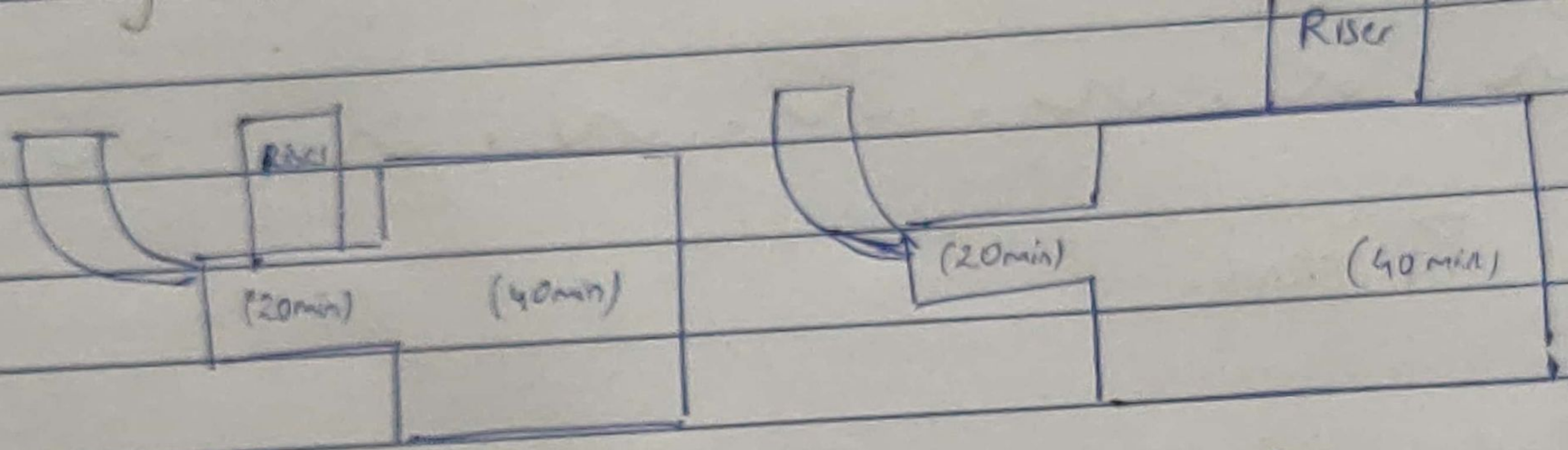
Height is equal to its diameter (H = D)

FOR TOP RISER:

Height is half of its diameter (H = 0.5 D)

GUIDELINES FOR RISER DESIGN AND LOCATION

- The riser (feeder) must not solidify before the casting.
- The volume of riser(s) must be large enough to feed the entire shrinkage of the casting.
- The pressure head from the riser should enable complete cavity filling.
- Riser must be placed so that it enables Directional Solidification.



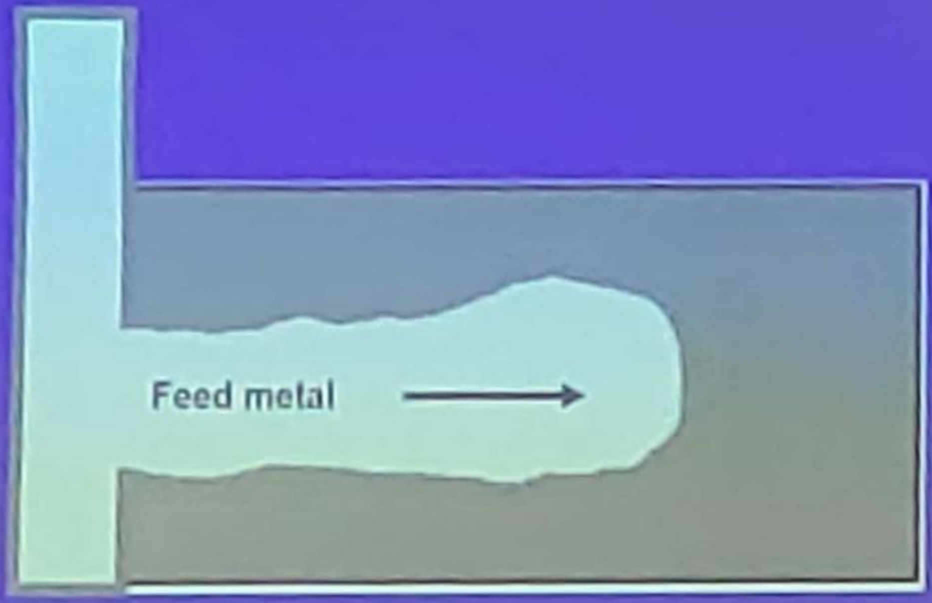
A

B

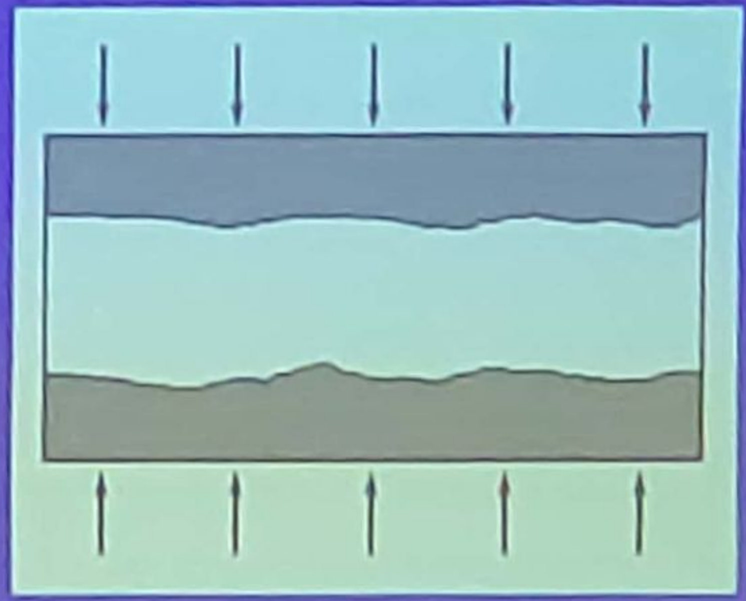
Here, thin portion will solidify in 20min only. So riser should be placed in thicker region so that directional solidification takes places.

Directional ⇒ पहले solidify होने का part should be further away from riser

DIRECTIONAL SOLIDIFICATION

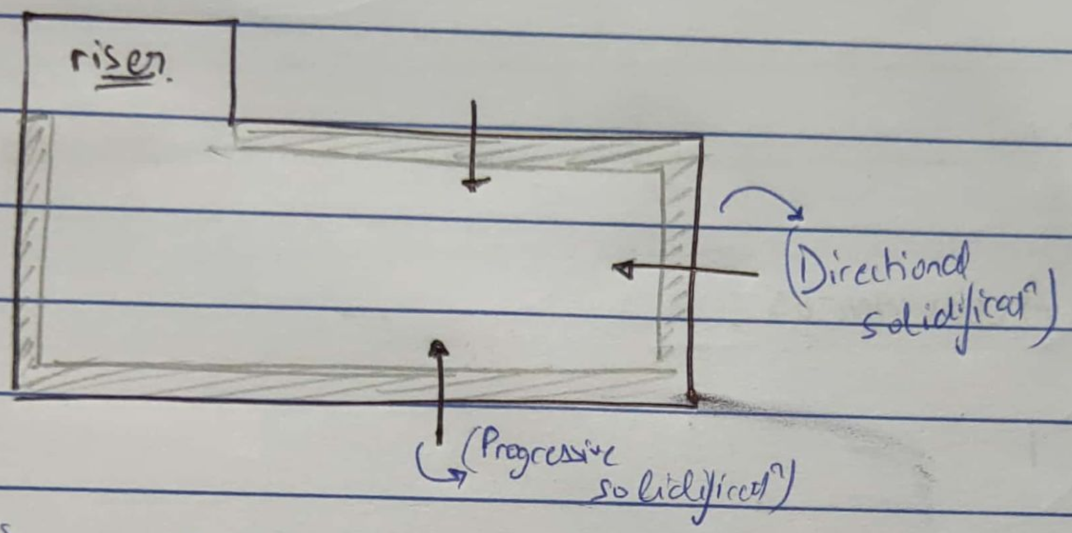


Directional solidification



Progressive solidification

Excessive of progressive solidification leads to shrinkage defect.



(सबसे पहले mould walls area solidify ; fast)

Imagine progressive solidificatⁿ too fast. ⇒ ~~Directional~~ बीच में kuch liquid part रह जाता ! ⇒ shrinkage

⇓

Here, Directional solidificatⁿ should dominate

IMPORTANT METHODS OF RISER DESIGN

1. Caine's Method

2. Modulus Method

3. Naval Research Laboratory Method

CAINE'S METHOD

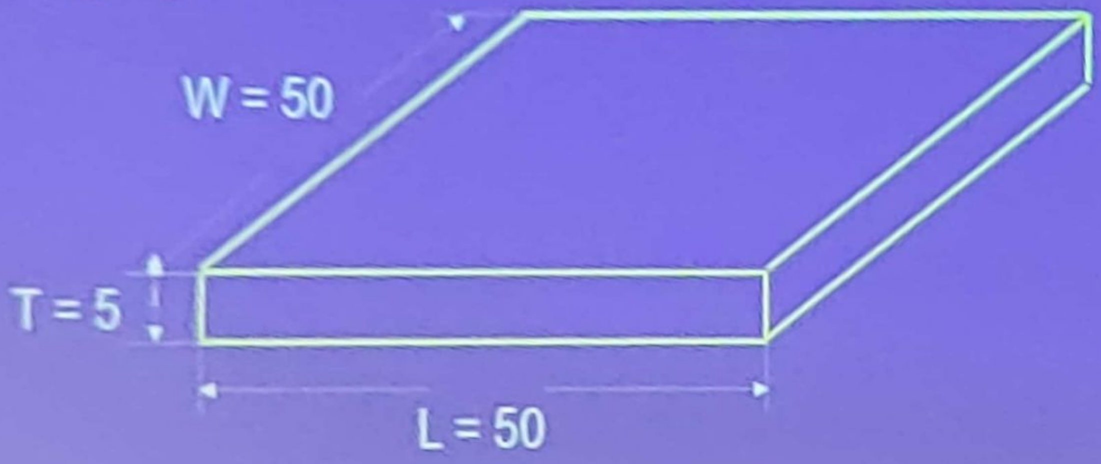
J.B. Caine (1949) conducted extensive experiments on risering.

He examined the presence and absence of shrinkage defects in various castings.

He developed a term called "Freezing ratio", which is defined as follows.

$$\text{Freezing ratio} = \frac{\text{Surface area of casting / Volume of casting}}{\text{Surface area of riser / Volume of riser}}$$

PROBLEM: 3 Design the top riser for a plate like casting whose dimensions are 50 x 50 x 5 cm, as shown in following figure.



MERITS OF MODULUS METHOD

1. The method is independent of the material of the casting (Constants a, b & c don't come into picture).

2. Method is simple and not tedious like Caine's method.

DEMERIT OF MODULUS METHOD

The modulus (V/SA) of the casting depends upon the surface area.

In many cases, determination of surface area of the casting becomes difficult, due to its complex geometry.

NAVAL RESEARCH LABORATORY METHOD (NRL method)

NRL method was developed by **H.F. Bishop** and **his team** at Naval Research Laboratory (US Navy), during 1955.

In their method, the Caine's freezing ratio was replaced by a **'Shape Factor'** for the casting section to be fed.

NAVAL RESEARCH LABORATORY METHOD
(NRL method)

The shape factor was defined by them as follows.

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

Where,

L denotes the length

W denotes the width

T denotes the thickness

(Note: $L > W > T$)

NAVAL RESEARCH LABORATORY METHOD (NRL method)

Once the shape factor for a casting section is calculated, the riser size can be directly determined through an empirical relation (given by a graph).

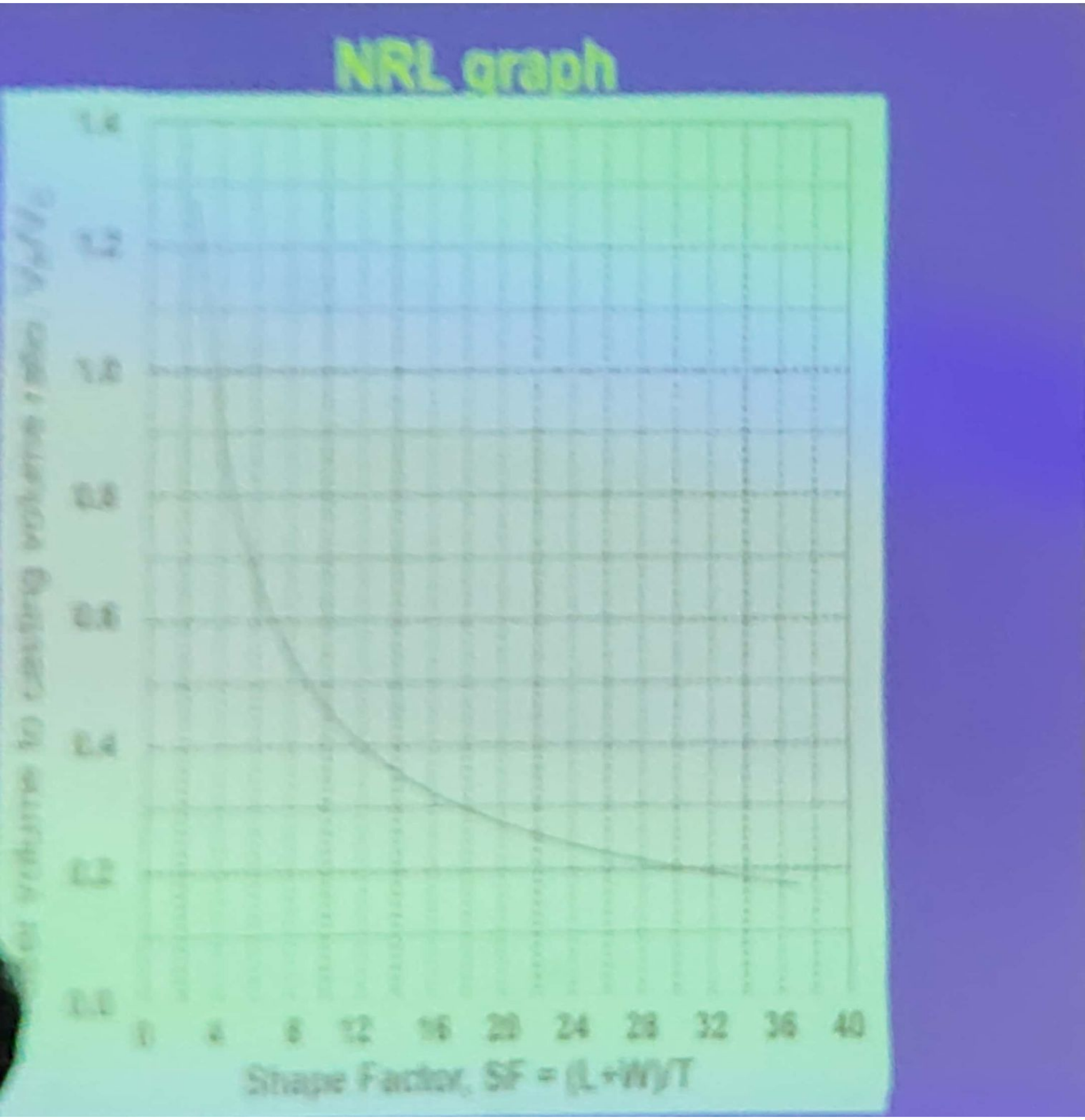
The above method is applicable to **Carbon & Low Alloy (C&LA) Steels**.

STEELS

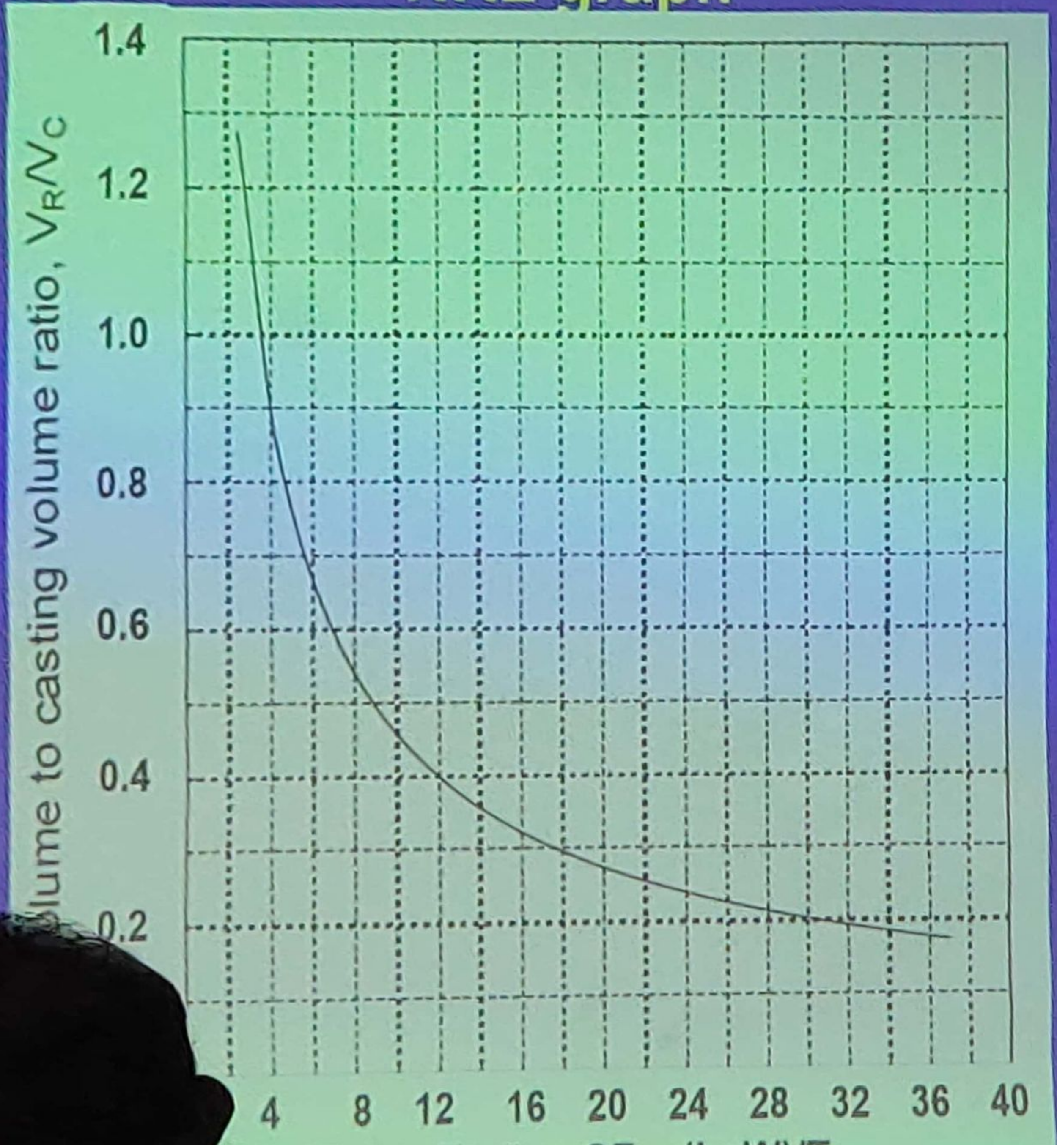
- **Plain carbon steels**
  - Low carbon steels — Carbon: 0.05-0.3%
  - Medium carbon steels — Carbon: 0.3-0.8%
  - High carbon steels — Carbon: 0.8-2.1%
- **Alloy steels**
  - Low alloy steels — Alloy <5%
  - Medium alloy steels — Alloy 5-8%
  - High alloy steels — Alloy >8%

(Carbon content: 0.2 – 1.5 %

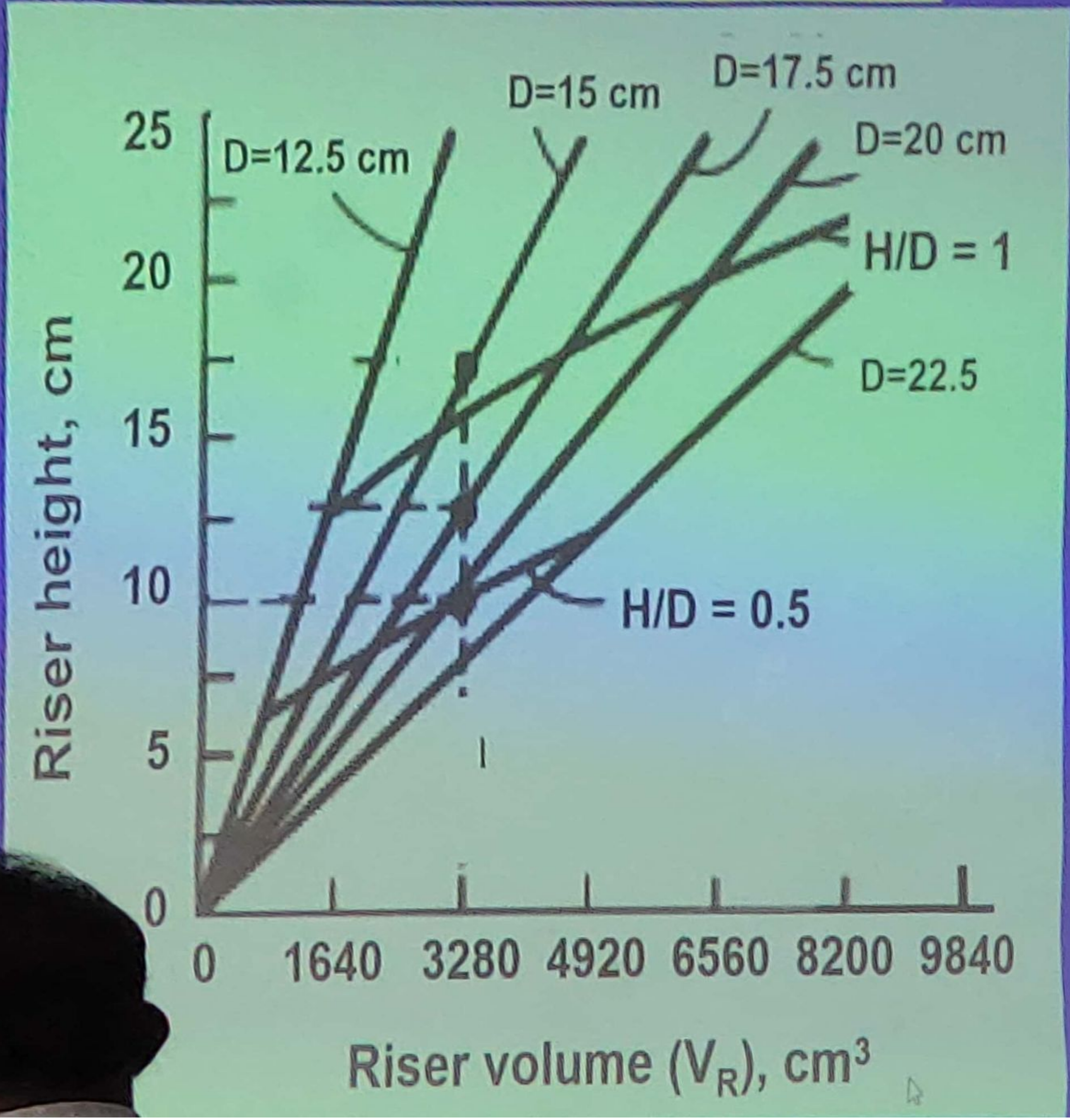
+ Cr + Ni + Va + Mo + W +
Co + Cu + Mn + Si + P + S)


NRL graph
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
4
8
12
16
20
24
28
32
36
40
Shape Factor, SF = (L+W)/T

NRL graph

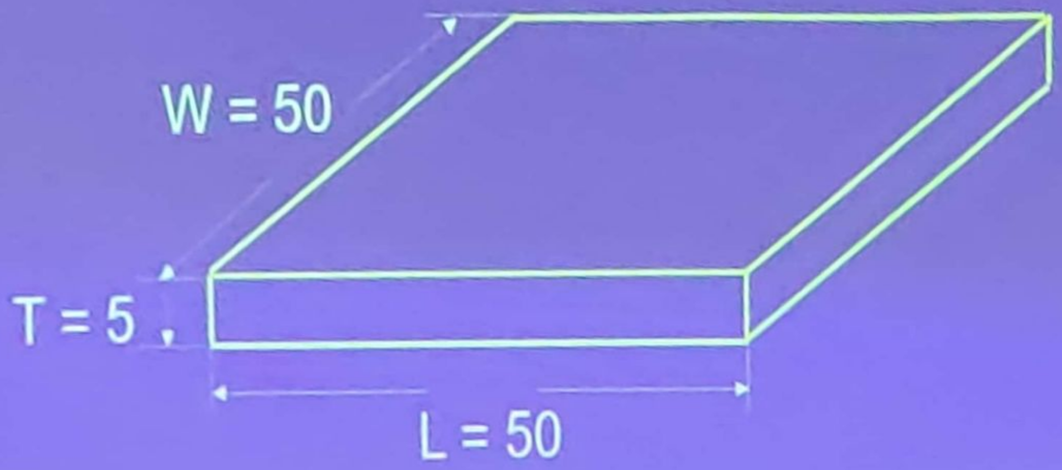

1.4
1.2
1.0
0.8
0.6
0.4
0.2
4
8
12
16
20
24
28
32
36
40
Volume to casting volume ratio, V_R/V_C

NRL RISER SELECTION CHART

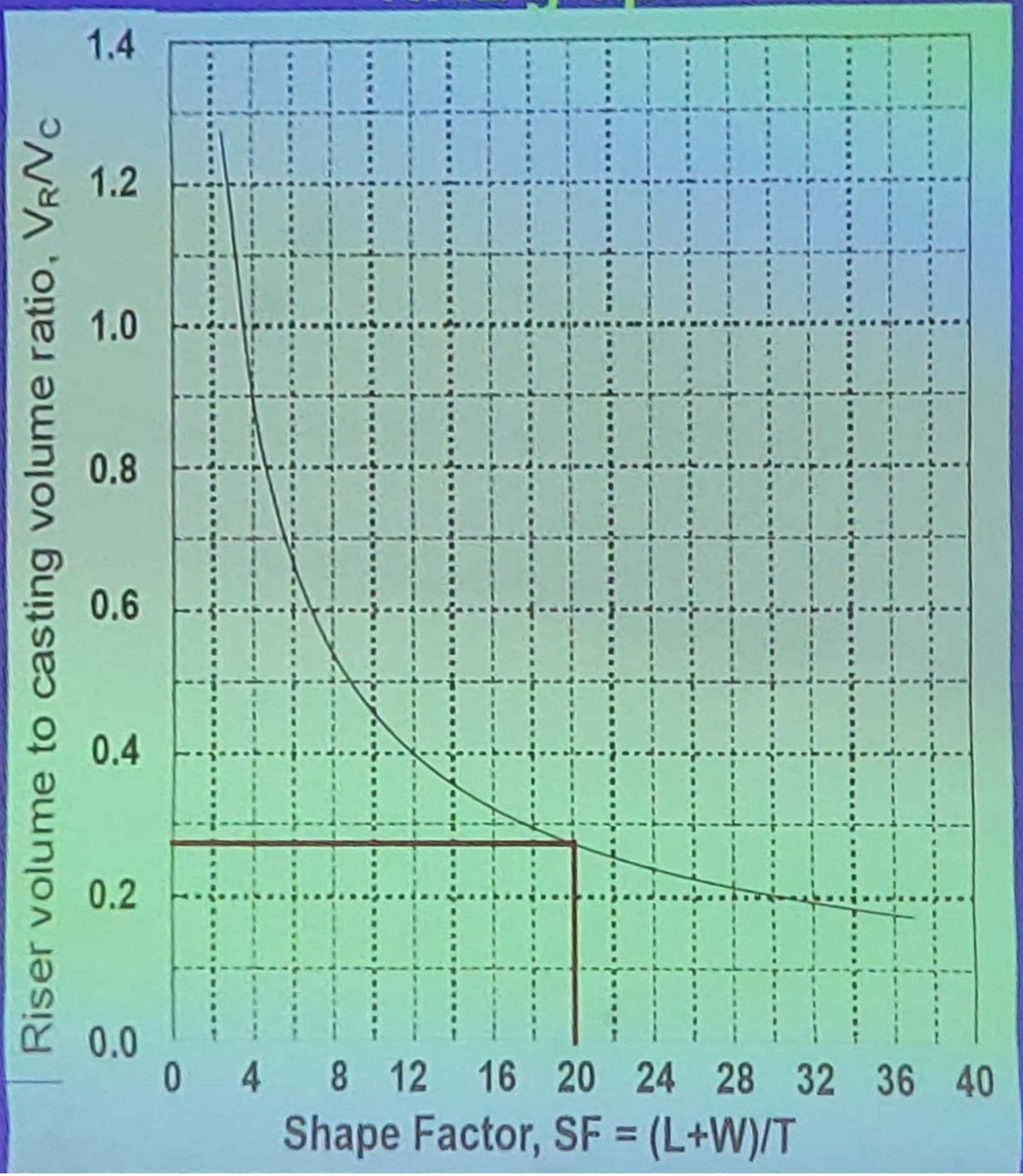


PROBLEM: 4

Design the top riser for a plate like casting whose dimensions are 50 x 50 x 5 cm, as shown in the following figure. The material of the casting is **Low Alloy Steel.**



NRL graph



CamScanner

PROBLEM: 4

Design the top riser for a plate like casting whose dimensions are 50 x 50 x 5 cm, as shown in the following figure. The material of the casting is **Low Alloy Steel.**

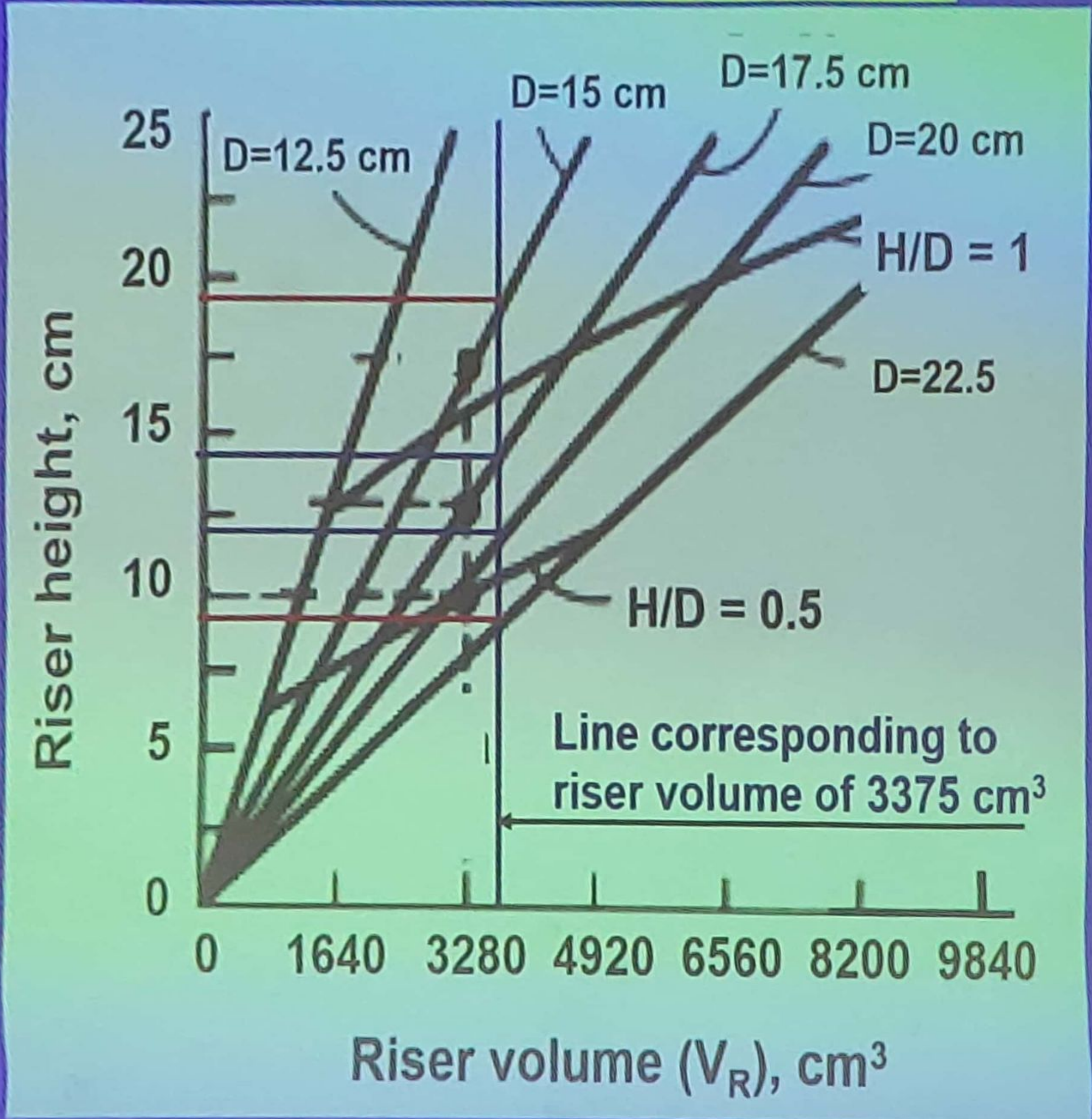
SOLUTION

For a shape factor of 20, ratio of riser volume to casting volume, $V_R / V_C = 0.27$

Casting volume, $V_C = 50 \times 50 \times 5 = 12500\ cm^3$

Riser volume, $V_R = 12500 \times 0.27 = 3375\ cm^3$

NRL RISER SELECTION CHART



also; $\left(\frac{H}{D} = 1\right)$

* In NRC method;

Shape factor $\Rightarrow \frac{V_{Riser}}{V_{casting}} \Rightarrow$ get V_{riser}. $\Rightarrow$ use the fact that "top riser" $\Rightarrow H = \frac{D}{2}$.

$\boxed{OR}$

$\Rightarrow$ if "type" of riser not given; can choose "D" yes; but should be s.t.

$0.5 < \frac{H}{D} < 1$ (i.e; $\cancel{\frac{H}{D}} = D = 17.5$ or 20 here)

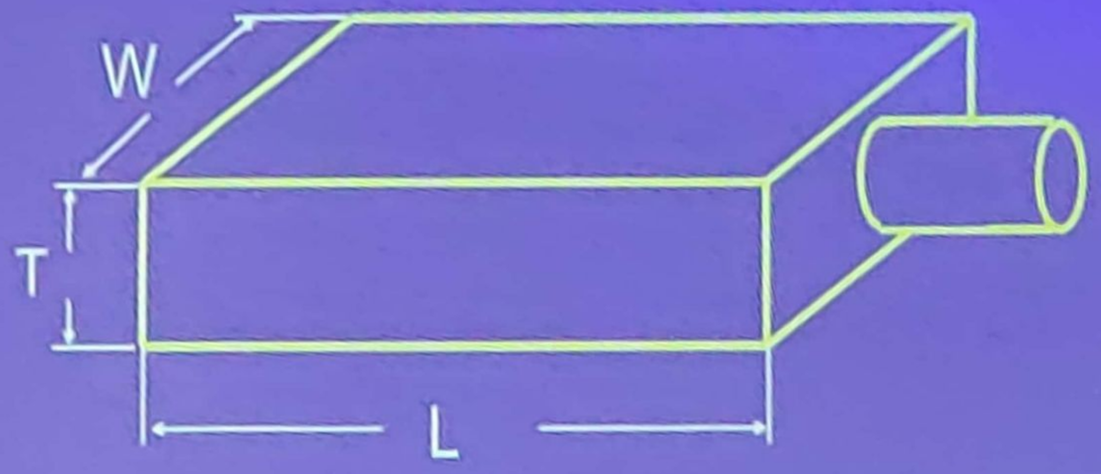
ADVANTAGES OF NRL METHOD

1. The freezing ratio as in the case of **Caine's method** doesn't come into picture.
2. The surface area of the casting need not be calculated, as in the case of **modulus method**.
3. Most of the results can be obtained from the graphs. Very less calculation.
4. The riser dimensions can be selected in different combinations of diameters and heights, as per the convenience (**H/D = 0.5 to 1**).

LIMITATIONS OF NRL METHOD

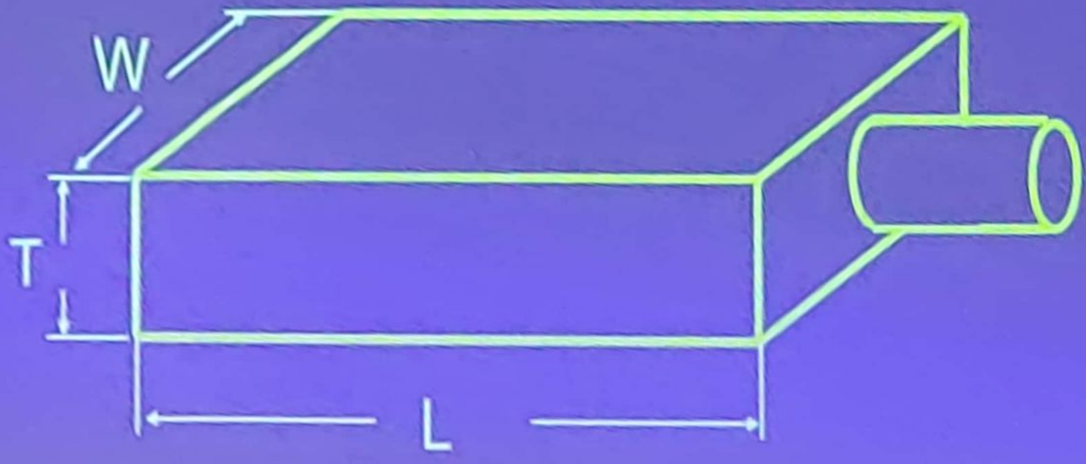
The method is applicable only to **Carbon & Low Alloy (C&LA) Steels**.

PARASITIC VOLUME IN NRL METHOD



The casting is a plate like castings with an additional branch on the right side. This is known as '**Parasitic Volume**'.

PARASITIC VOLUME IN NRL METHOD



Initially, this parasitic volume is to be neglected and the Shape Factor is to be found out.

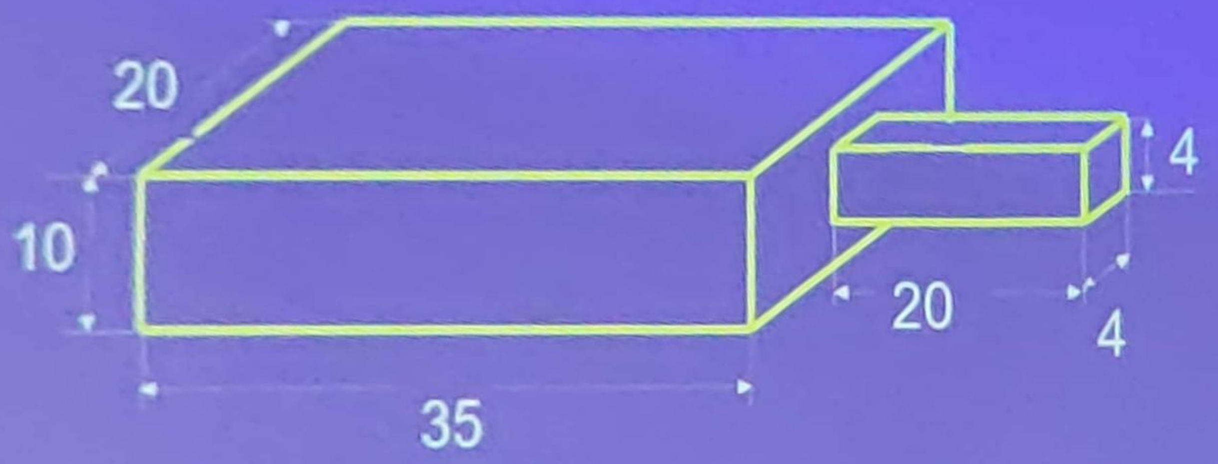
Accordingly, riser volume is to be found out.

Final riser volume = Riser volume (without parasitic volume) + 30% of parasitic volume.

PROBLEM: 5

Design a riser for the casting shown in the following figure.

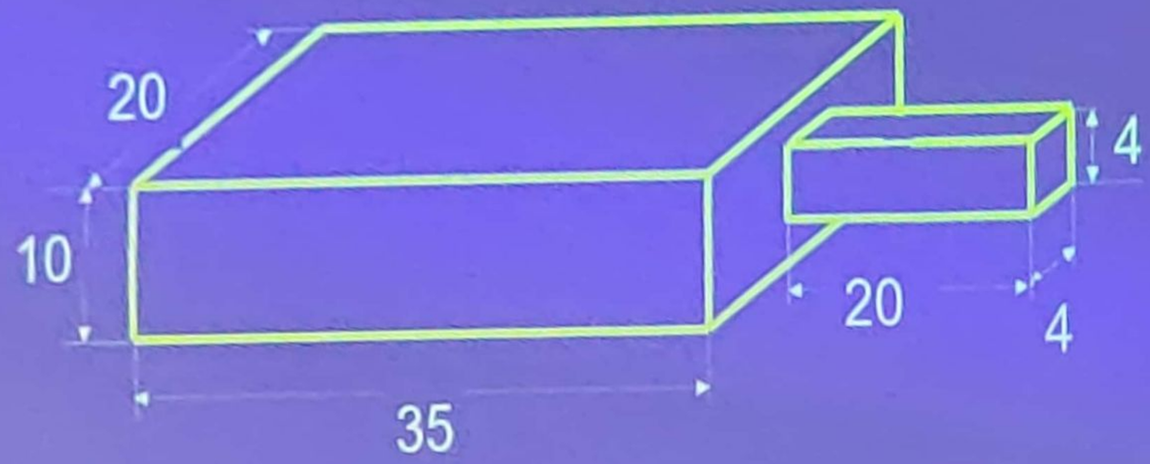
All dimensions in cm



PROBLEM: 5

Design a riser for the casting shown in the following figure.

All dimensions in cm



SOLUTION:

Shape factor = (L + W) / T = (35 + 20) / 10 = 5.5

From NRL graph, ratio of riser volume to casting volume is to be found out.

$\leftarrow$ $V_{R} = 5872$

Vol. of ~~cast~~ riser $= 0.7 \times (35 \times 20 \times 10)$

$= 0.7 \times 7000$

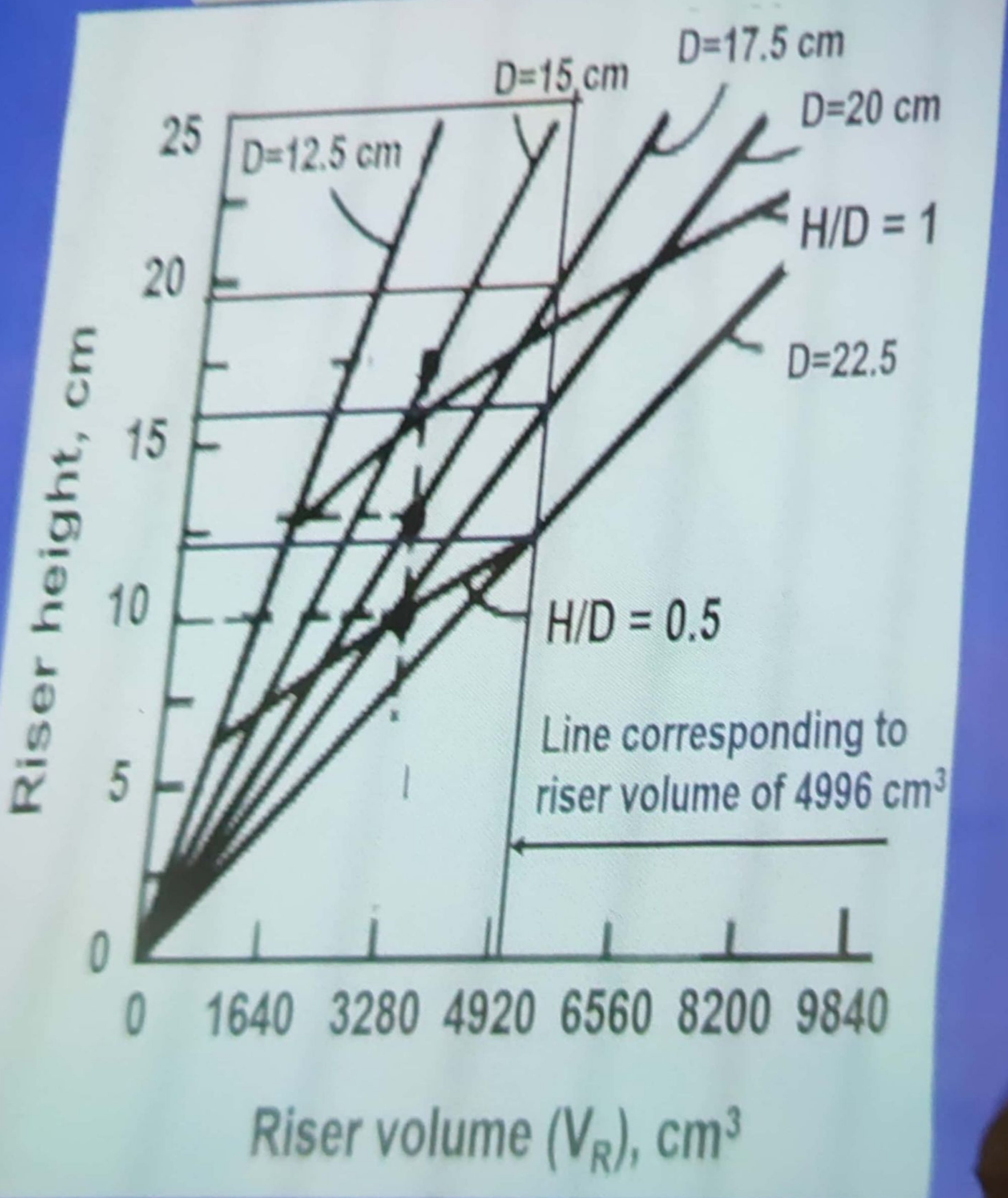
$= 4900$

$\Downarrow$

Vol. of riser (final) $= 4900 + \left(\frac{30}{100} \times 20 \times 4 \times 4\right) = 4900 + 96 = 4996$

Now; can solve by either directly; or by graph.

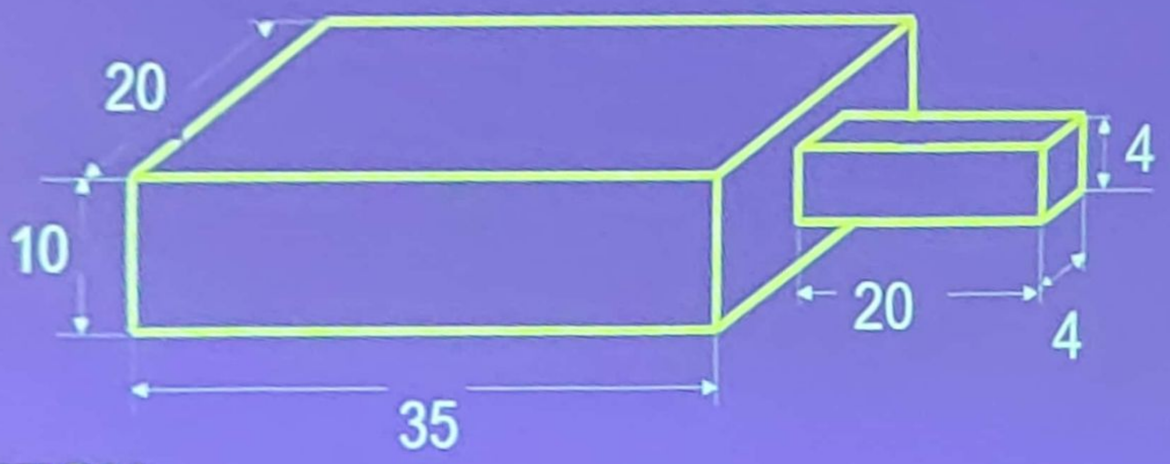
NRL RISER SELECTION CHART



PROBLEM: 5

Design a riser for the casting shown in the following figure.

All dimensions in cm



SOLUTION

Case 1: 22.5 cm Diameter, 12 cm height

Case 2: 20 cm Diameter, 16 cm height

FEEDING DISTANCE

A riser can feed the casting only up to a certain distance. This distance is known as **'Feeding Distance'** of the riser.

Feeding distance has two components:

a) End effect

b) Riser effect

END EFFECT

Consider a casting without a riser.

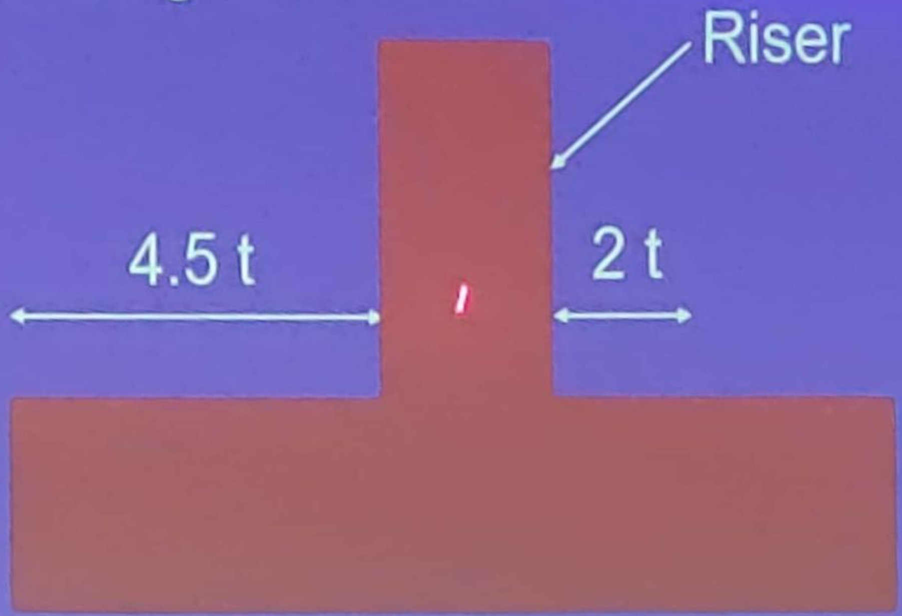
The two ends of the casting have no shrinkage. This is due to the rapid solidification and feeding from the inner portion of the casting. This phenomenon is known **'End Effect'.**

End effect – promotes a distance of **2.5 t**

Here, **t** is the thickness of the slab casting.

RISER EFFECT

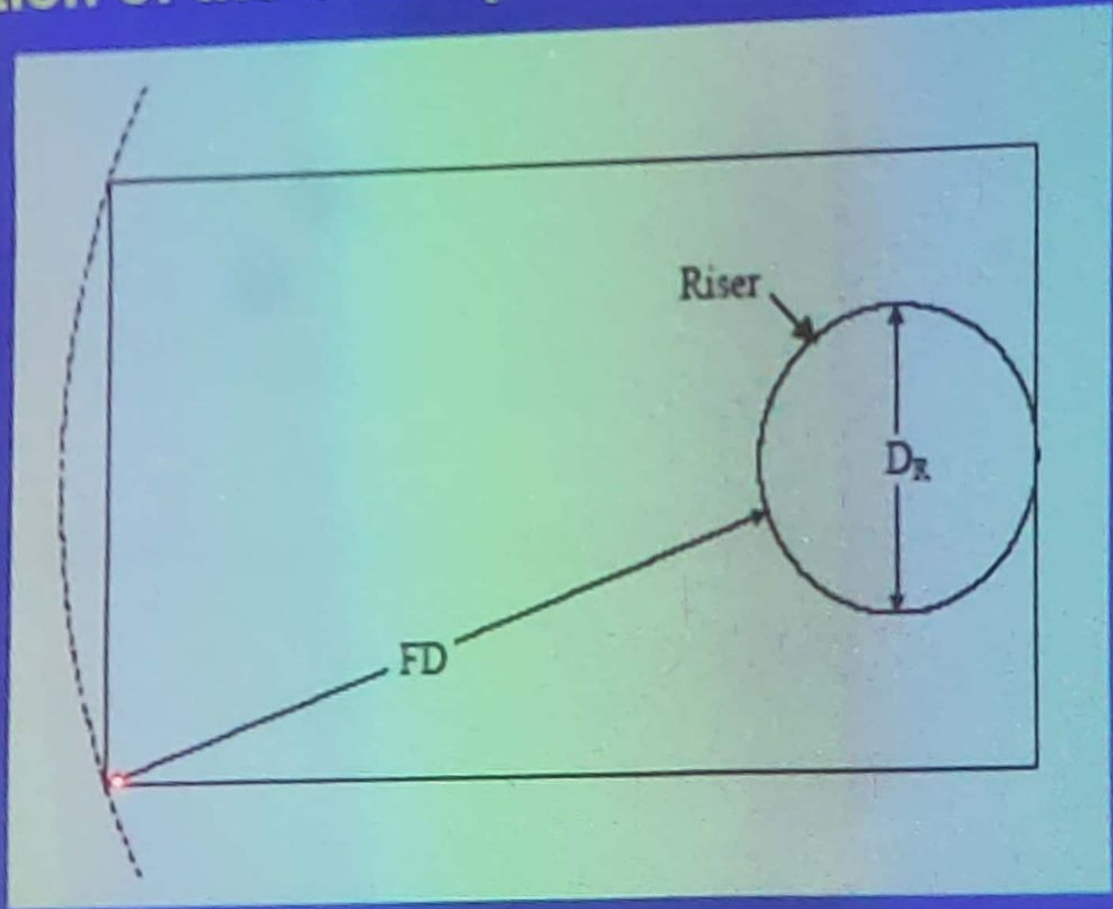
Consider a casting with a riser.



The middle portion of the casting has no shrinkage due to the presence of riser. This is known as **'Riser Effect'**. **Riser effect** – promotes a distance of **2 t.**

Total feeding distance due to end effect and riser effect = 4.5 t

Illustration of the concept of a feeding distance (FD)



The feeding distance is always measured from the edge of the riser to the furthest point in the casting section to be fed by that riser.

PROBLEM 9:

A steel casting of size 40 x 25 x 10 cm is to be fed by a side riser. Calculate the feeding distance of the riser.

PROBLEM 9:

A steel casting of size 40 x 25 x 10 cm is to be fed by a side riser. Calculate the feeding distance of the riser.

SOLUTION:

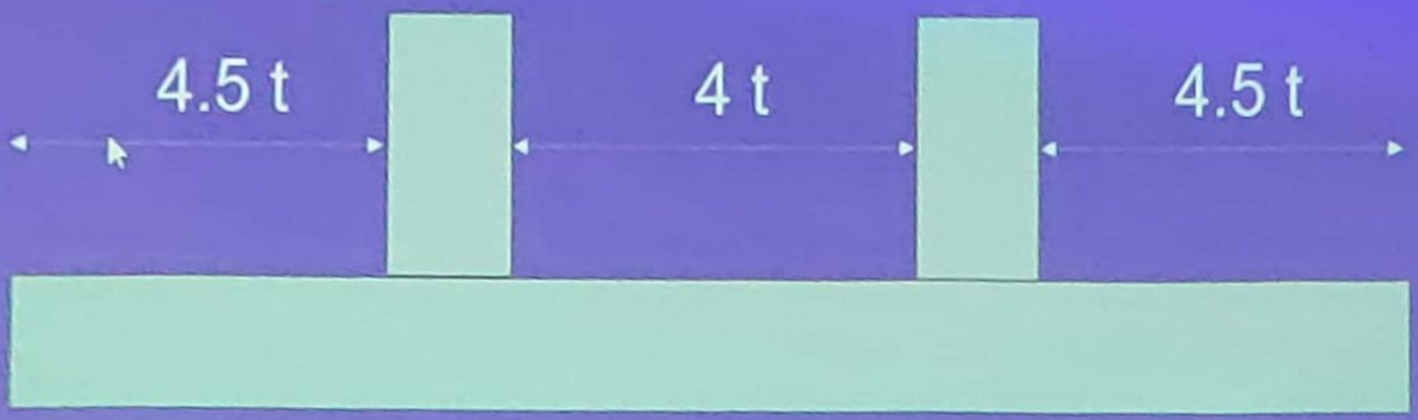
Thickness of casting, $t = 10$ cm

Feeding distance $= 4.5 \times t$

$$= 4.5 \times 10 = 45 \text{ cm}$$

FEEDING DISTANCE WITH 2 RISERS

Influence of **end effect** and **riser effect** for a steel plate casting with two risers.

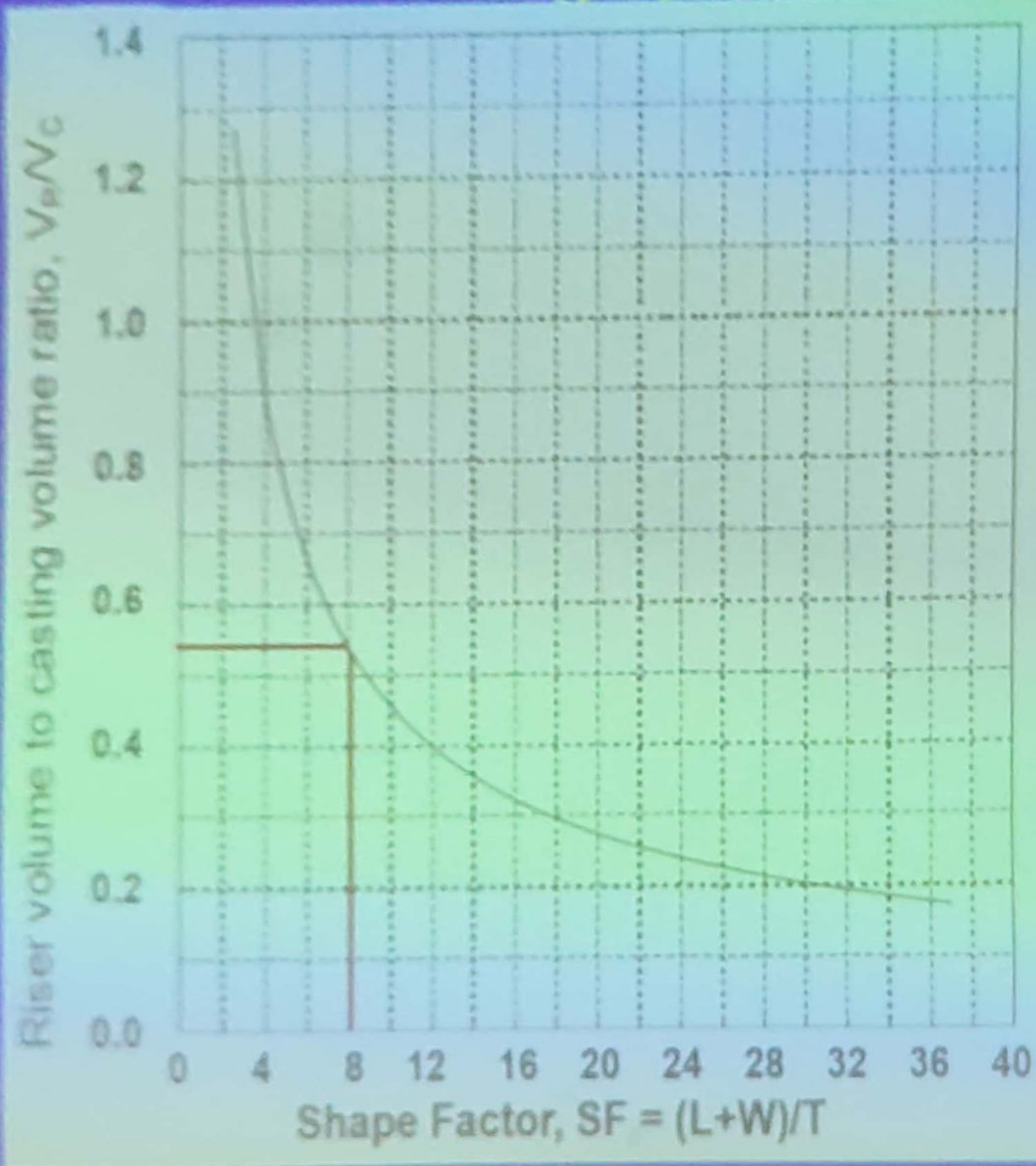


Total feeding distance is about **13 t**.

PROBLEM 10:

Design **top** risering system for a steel slab casting of size 60 x 10 x 5 cm, using NRL method.

NRL graph


1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Riser volume to casting volume ratio, V_R/V_C
0
4
8
12
16
20
24
28
32
36
40
Shape Factor, SF = (L+W)/T

PROBLEM 10:

Design **top** risering system for a steel slab casting of size 60 x 10 x 5 cm, using NRL method.

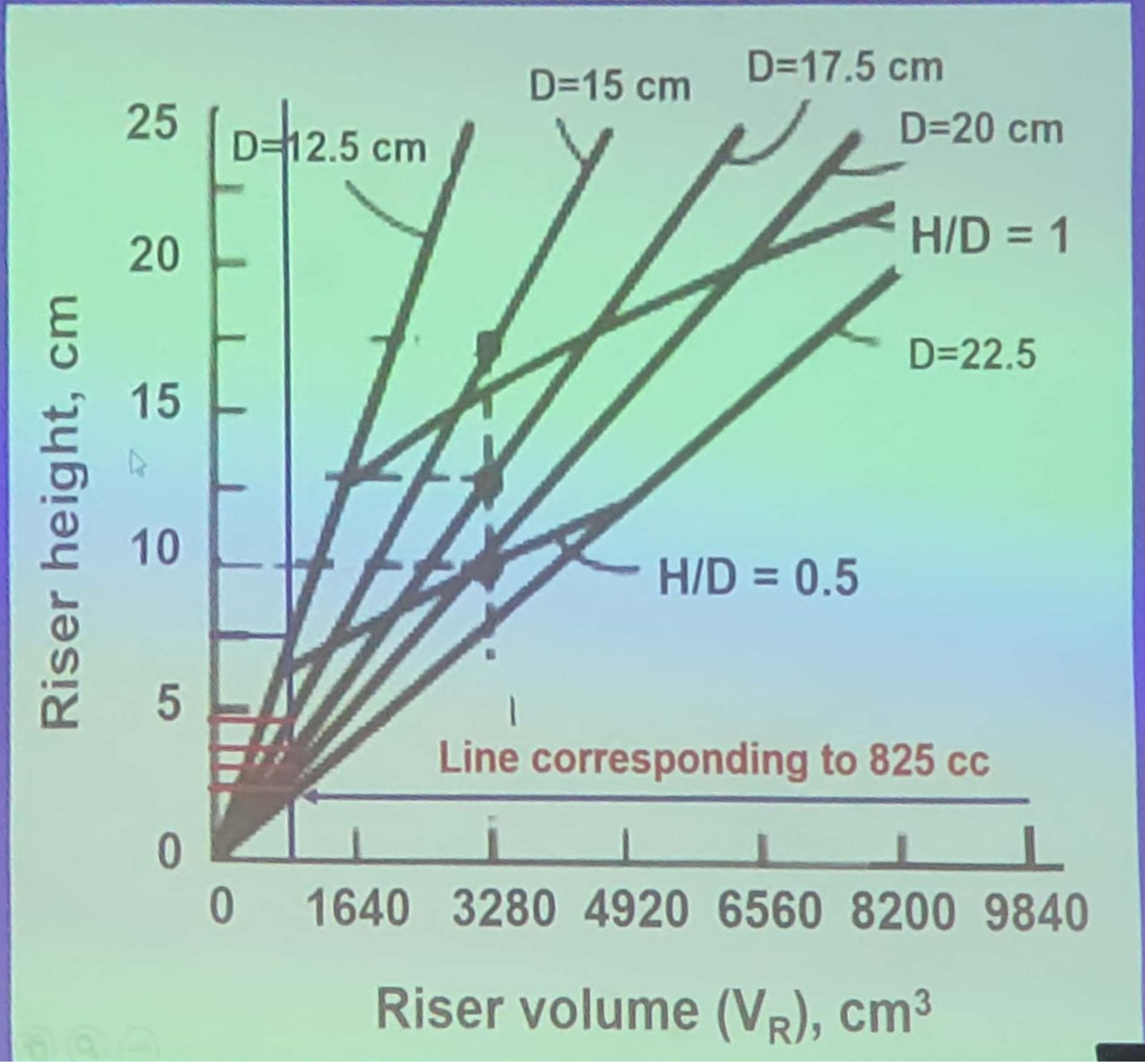
SOLUTION:

V_R/V_c for SF 8 = 0.55

Volume of casting = 30 x 10 x 5 = 1500 cc

Volume of riser, V_R = 0.55 x 1500 = 825 cc

NRL RISER SELECTION CHART



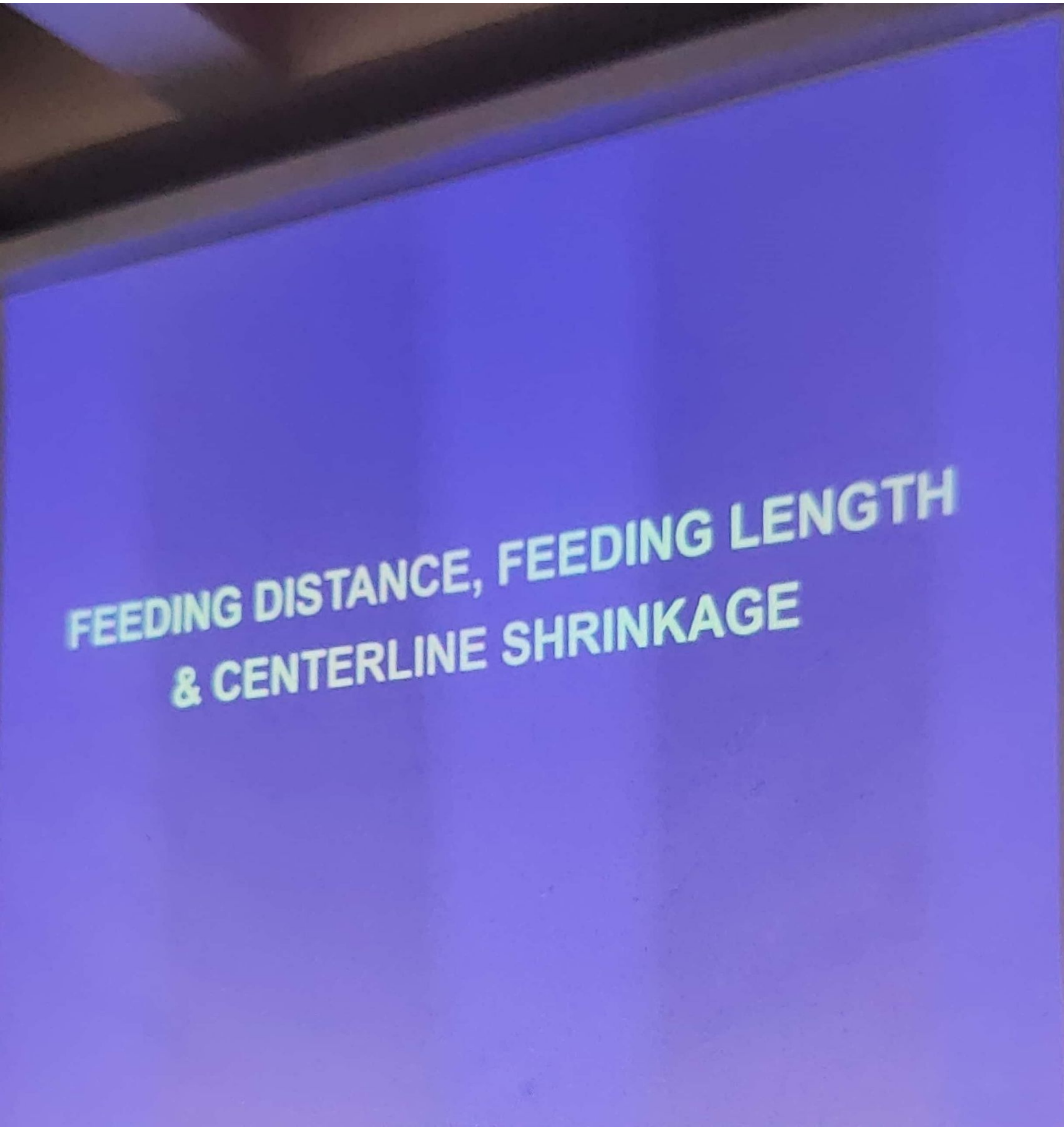
Ans: 12.5 cm dia

7.5cm height.

{If rest diameters won't

fit only ---- aah not

sure }

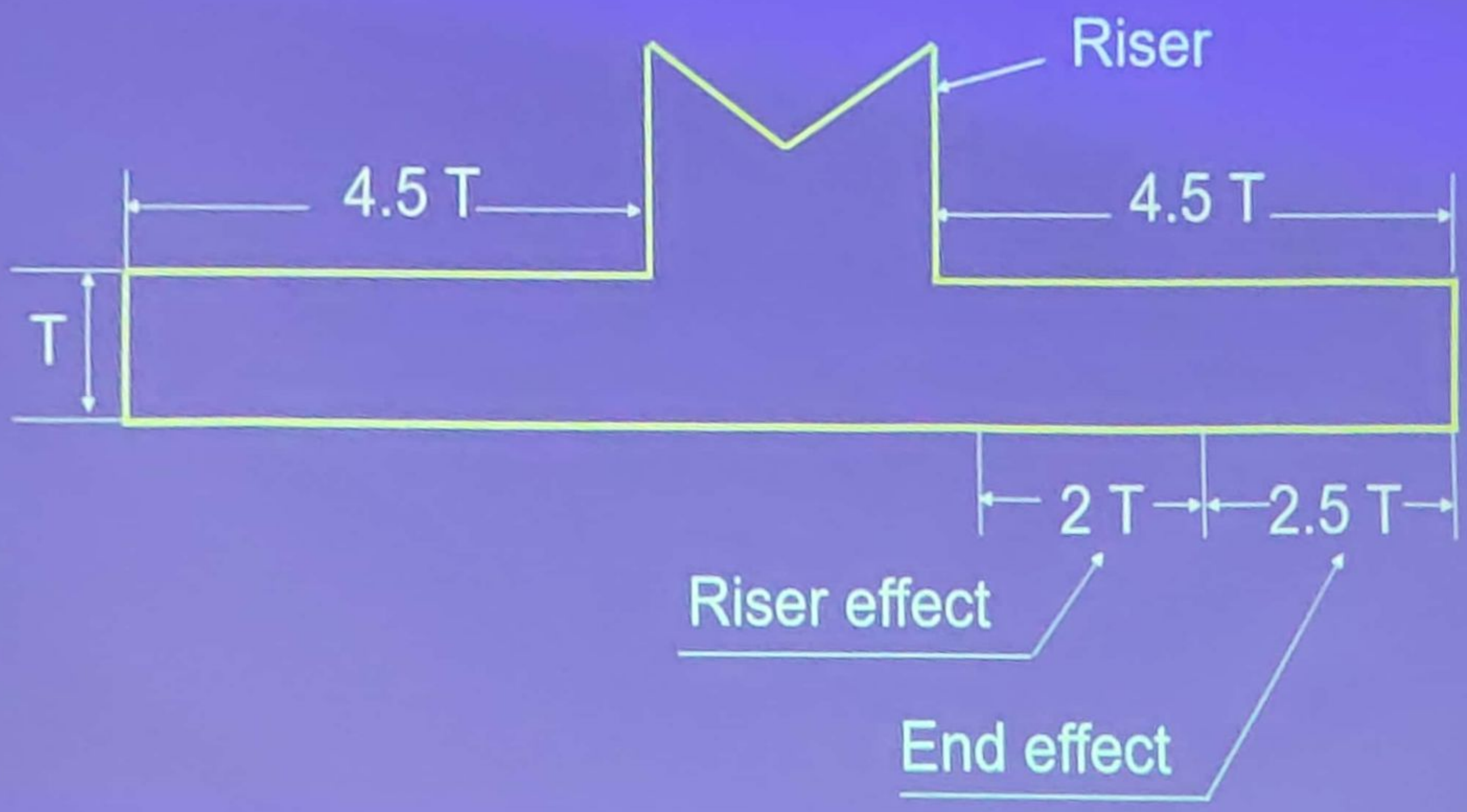

FEEDING DISTANCE, FEEDING LENGTH
& CENTERLINE SHRINKAGE

Feeding distance is the sum of riser effect and end effect.

Feeding length is the actual length which is expected to be fed by the riser including the end effect.

Feeding distance is **equal** to feeding length.

No shrinkage along the feeding length.



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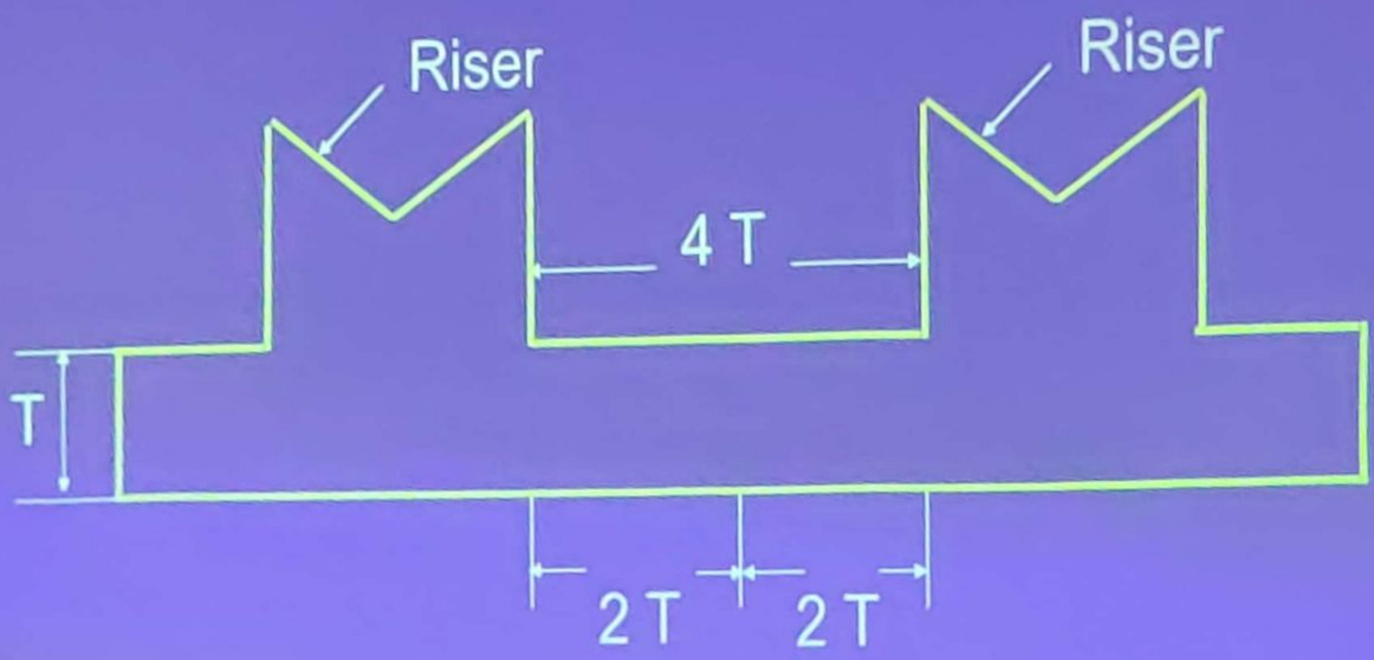
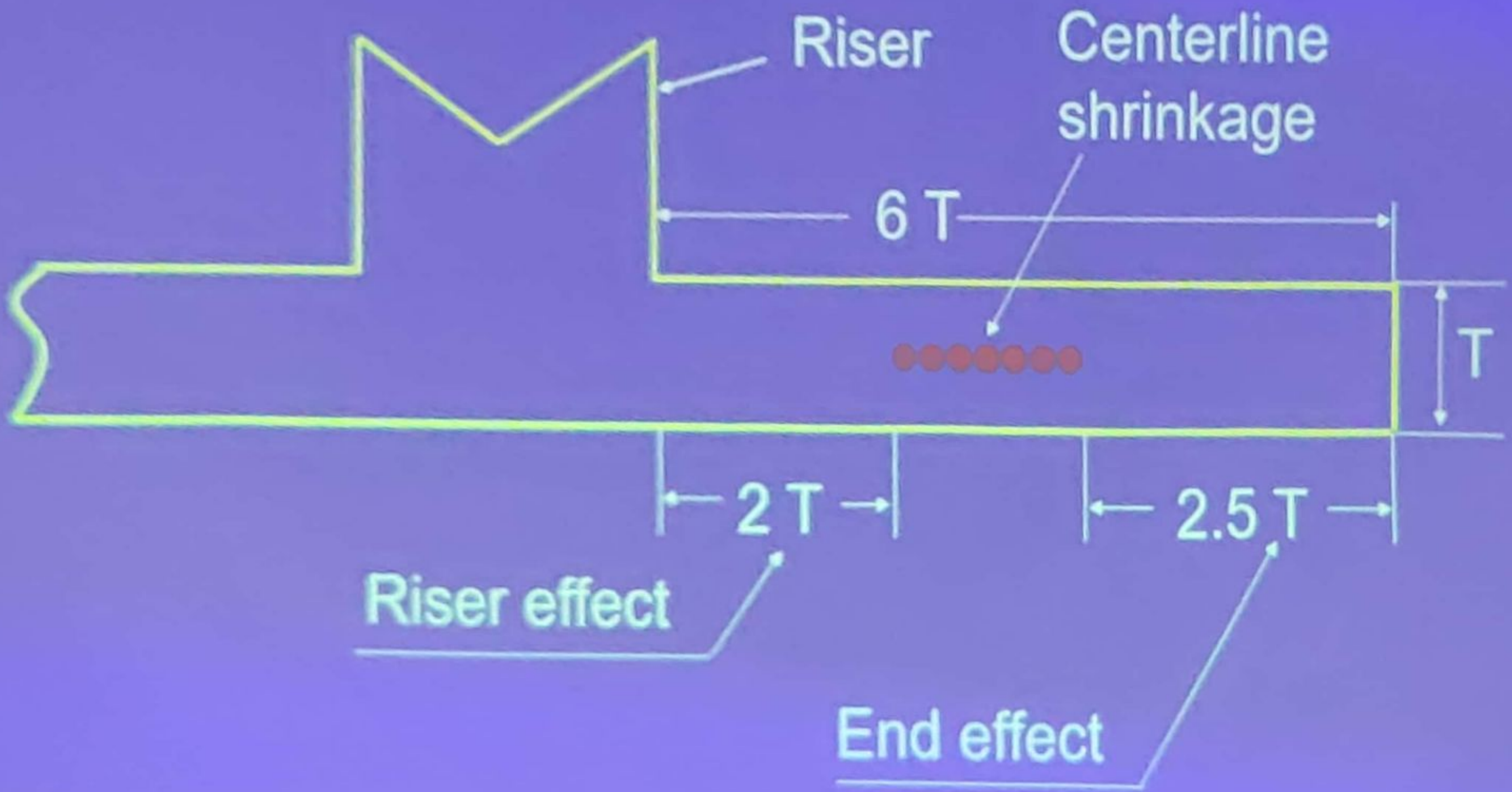
No shrinkage along the feeding length.



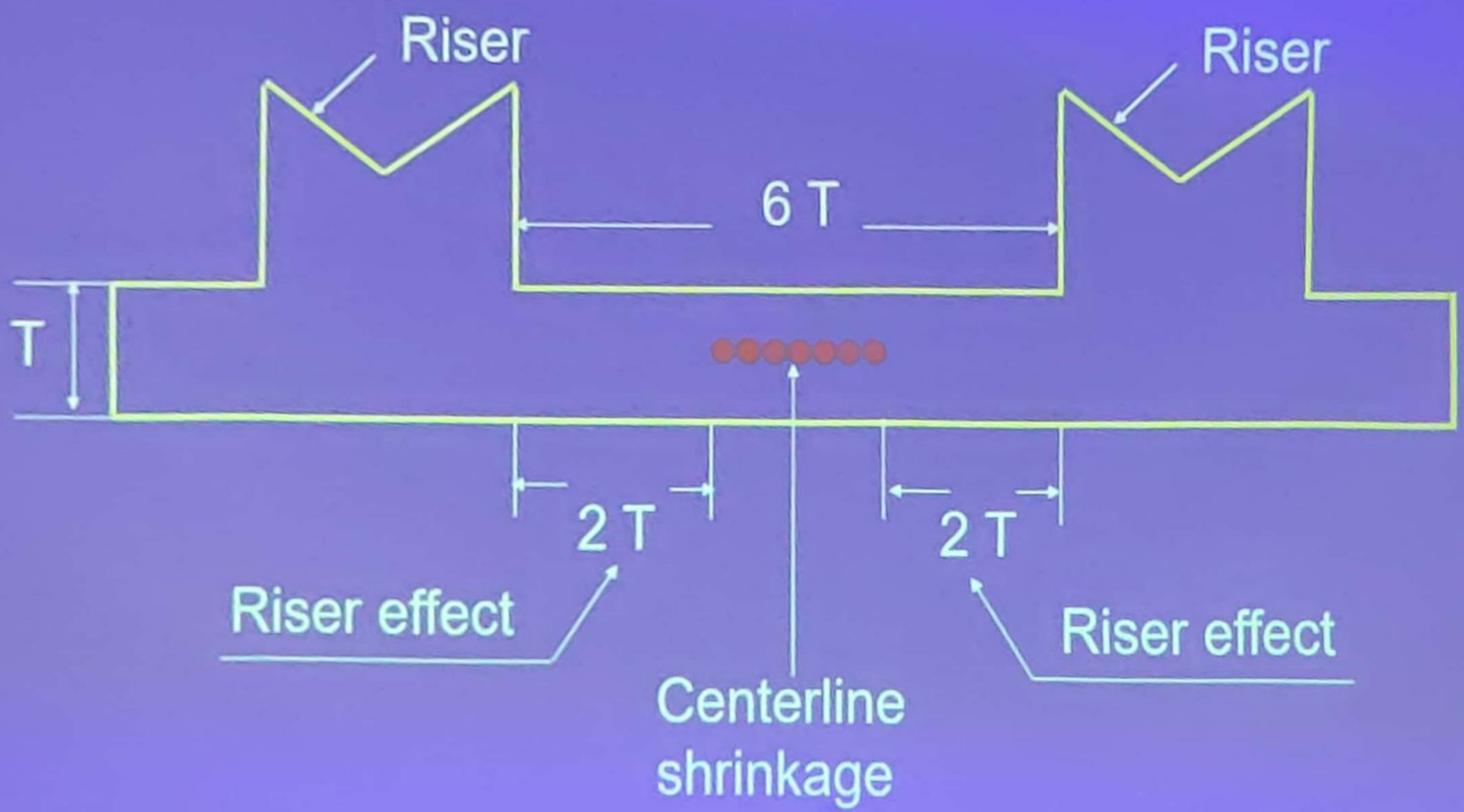
Feeding length is **greater** than feeding distance.

Centerline shrinkage takes place.

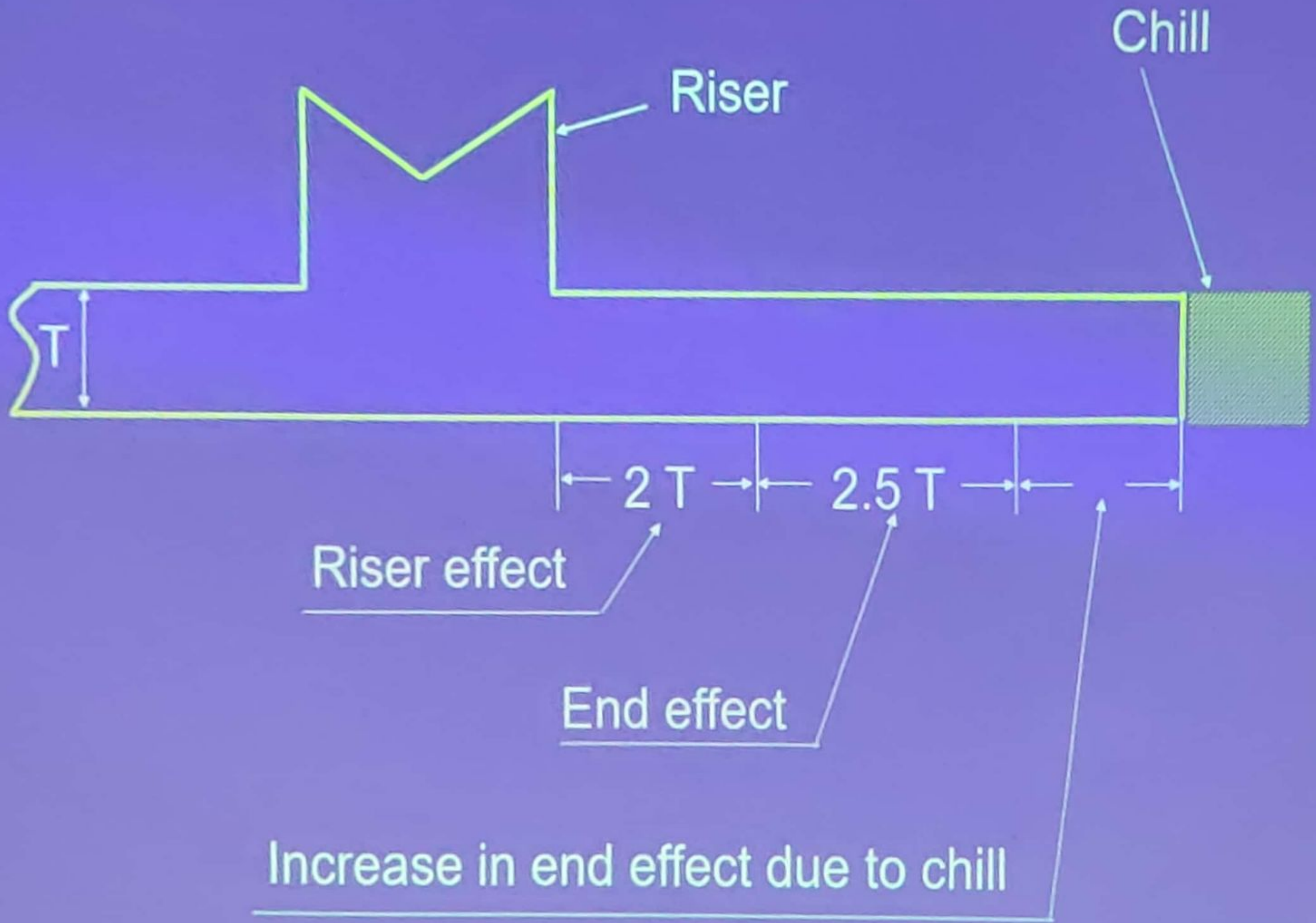


Feeding length is **greater** than feeding distance.

Centerline shrinkage takes place.

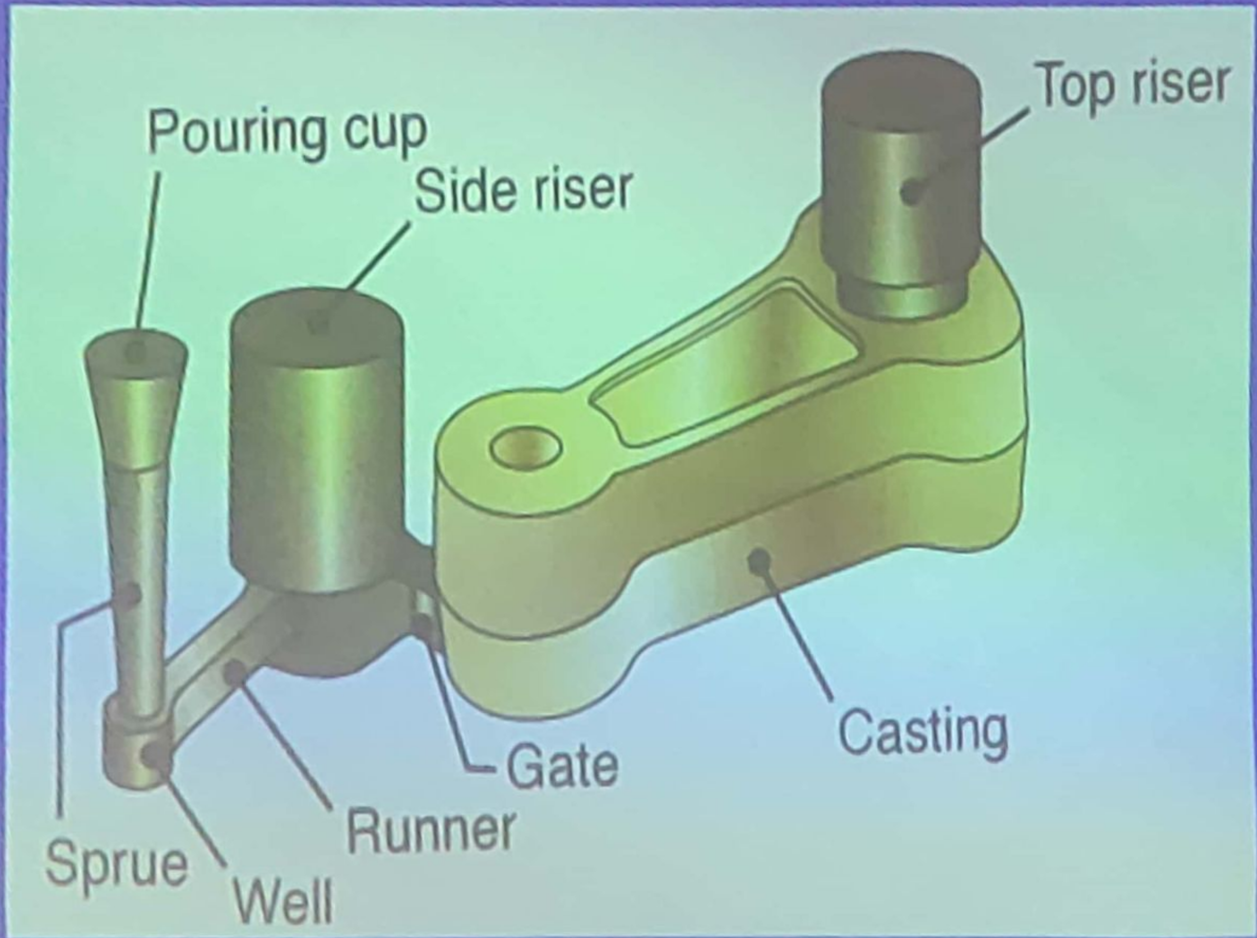


WAYS TO INCREASE THE FEEDING DISTANCE



GATING SYSTEM

It refers to all the sections through which the molten metal passes while entering into the mould cavity.



GATING SYSTEM

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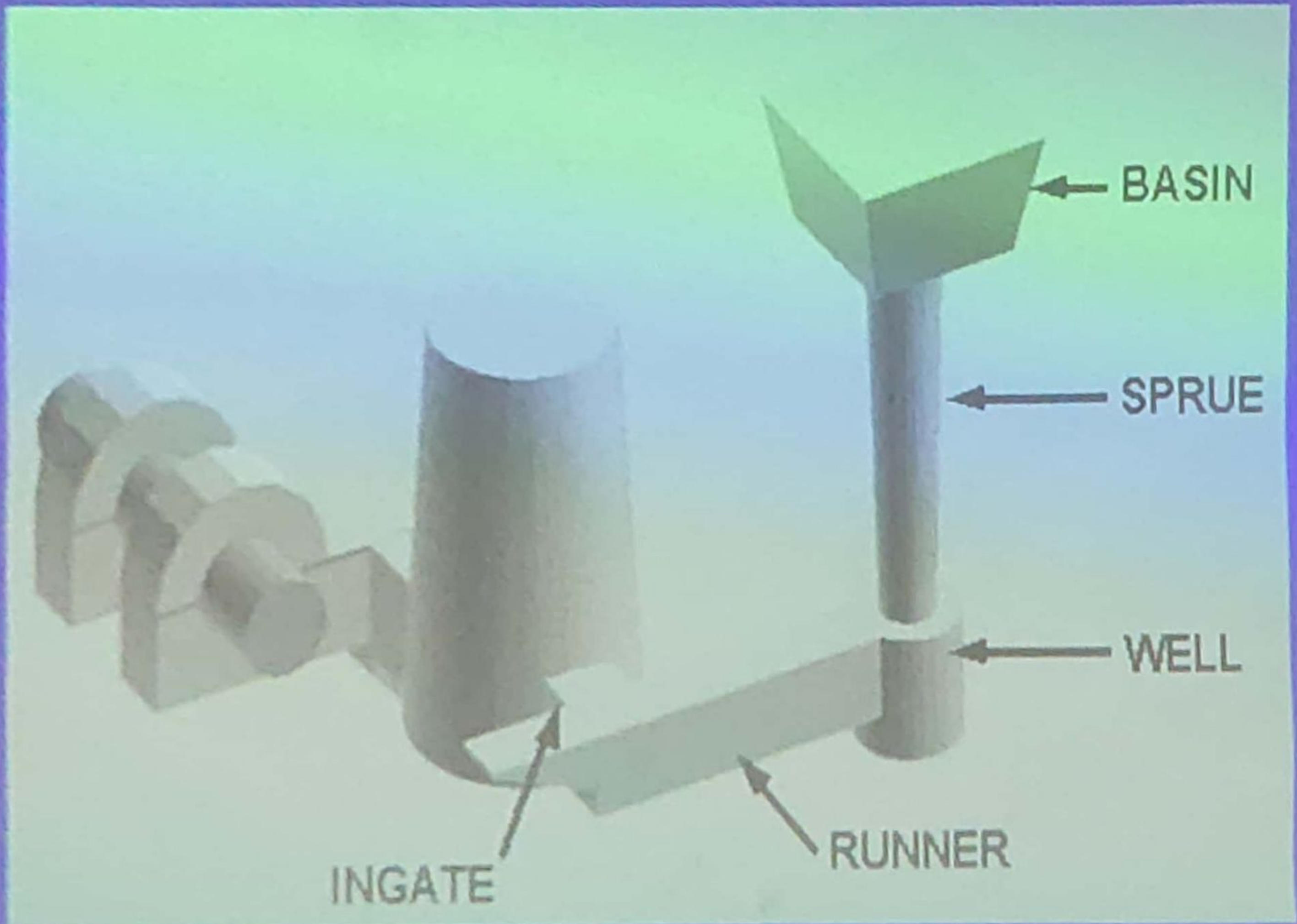
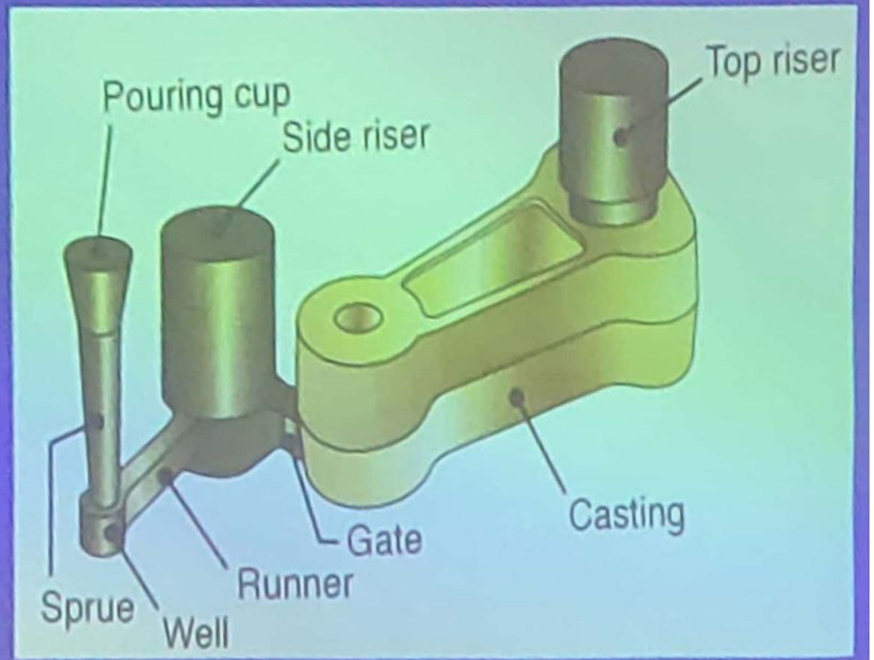


FUNCTIONS OF GATING SYSTEM

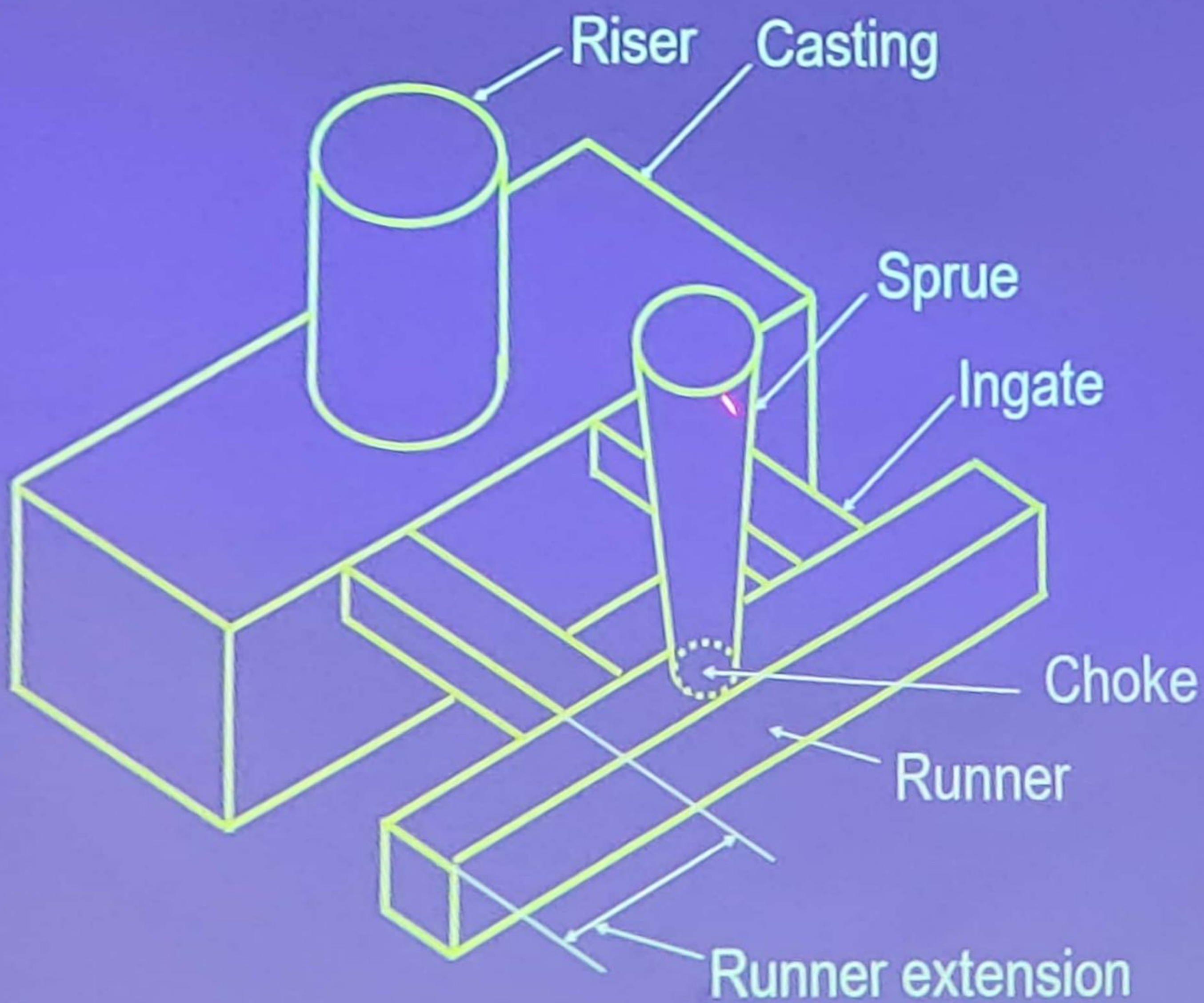
- To fill the mould cavity completely before freezing
- To minimize turbulence
- To avoid sand erosion
- To remove inclusions
- To consume least metal – less scrap
- To establish directional solidification

ELEMENTS OF GATING SYSTEM

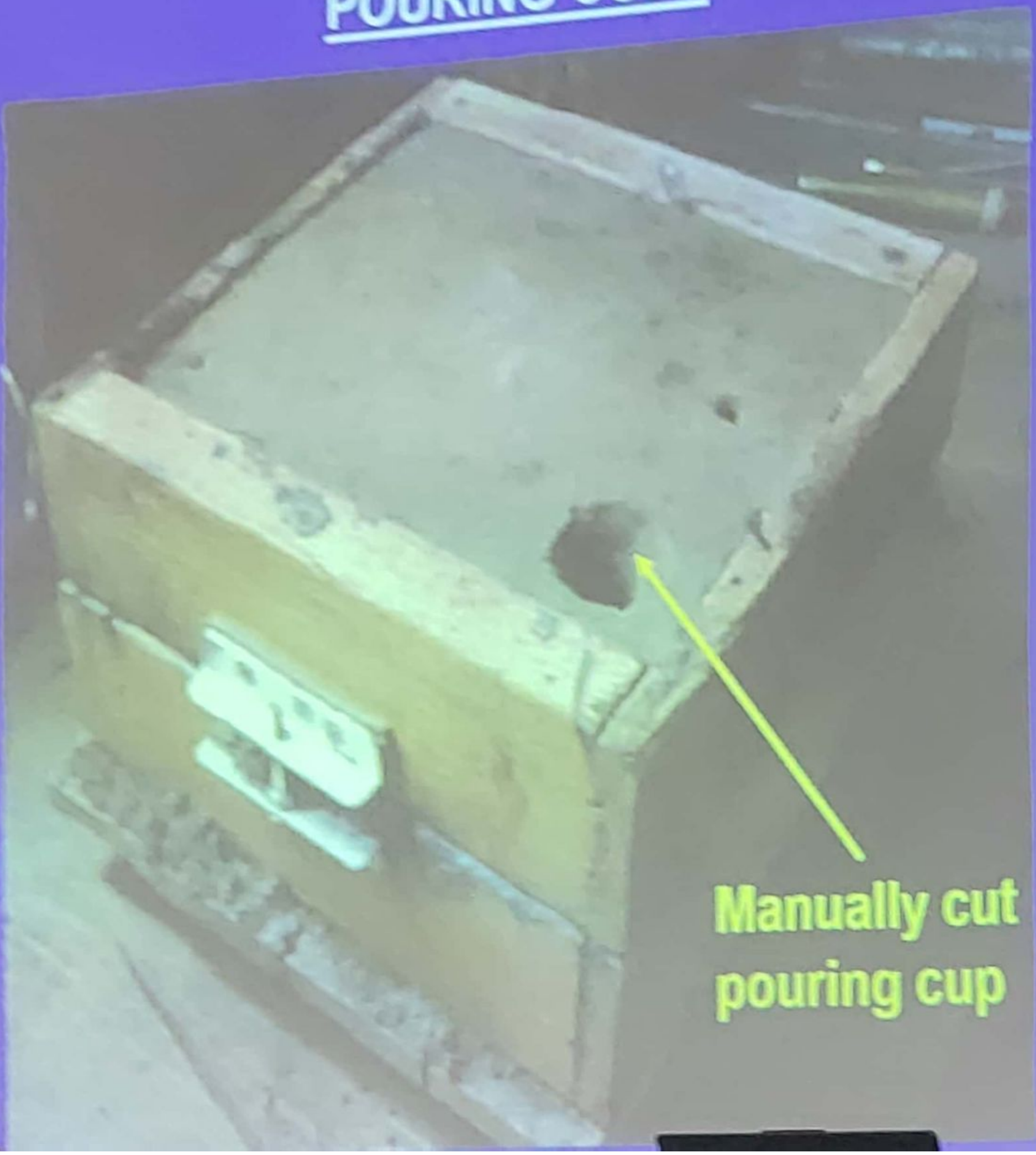
1. Pouring cup
2. Sprue
3. Sprue well
4. Runner
5. Runner extension
6. Ingates (Gates)
7. Riser



ELEMENTS OF GATING SYSTEM



POURING CUPS




CERAMIC POURING CUPS

Anti-swirl bar

these in

ceramic

pouring cup, prevent swirling & turbulence.

Date.

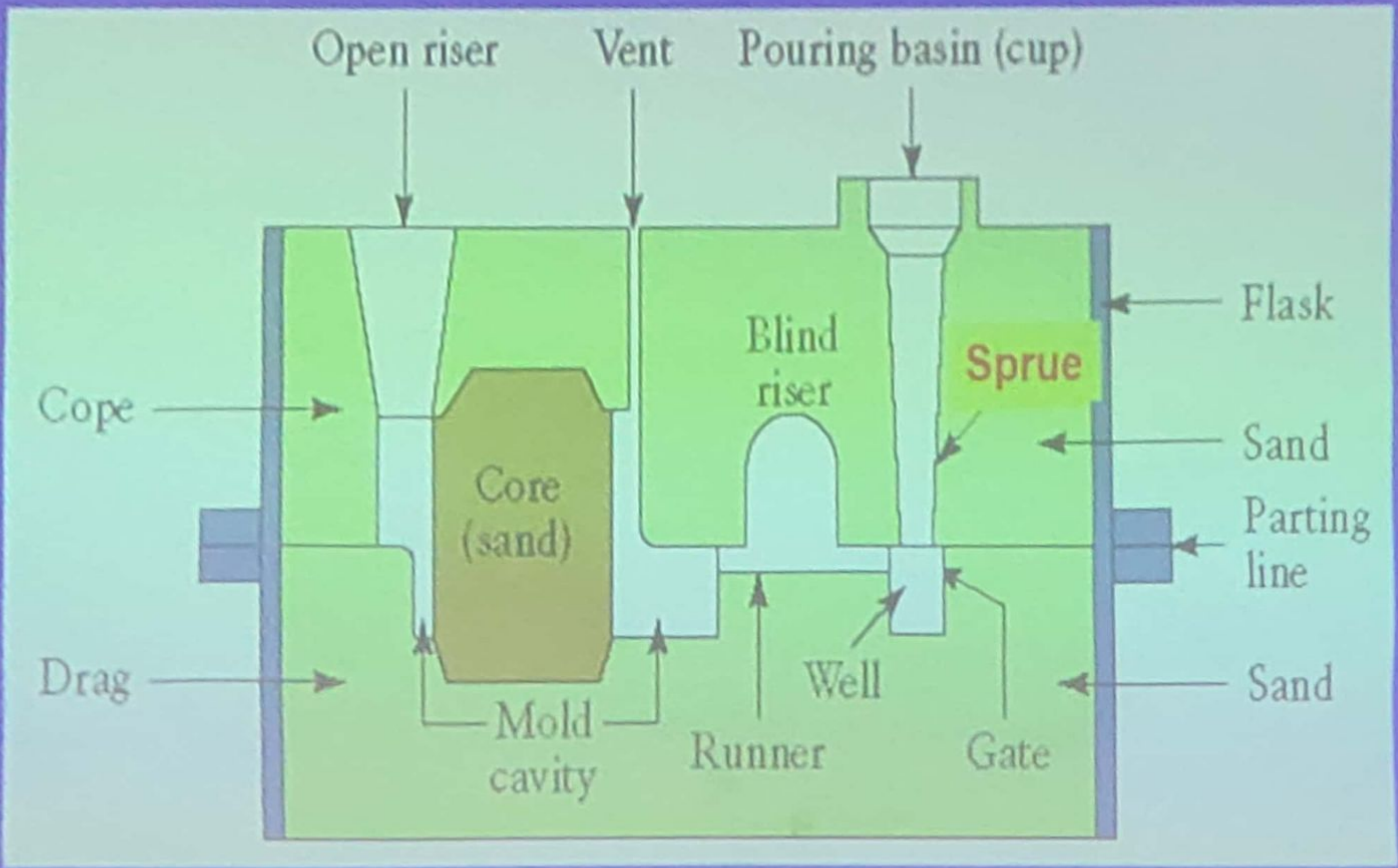
Page No.

(hence erosion ↓↓)

ng system :-

DESIGN OF SPRUE

Sprue is the vertical passage inside the mould through which molten metal (from the pouring basin) reaches the runner and eventually the mould cavity.



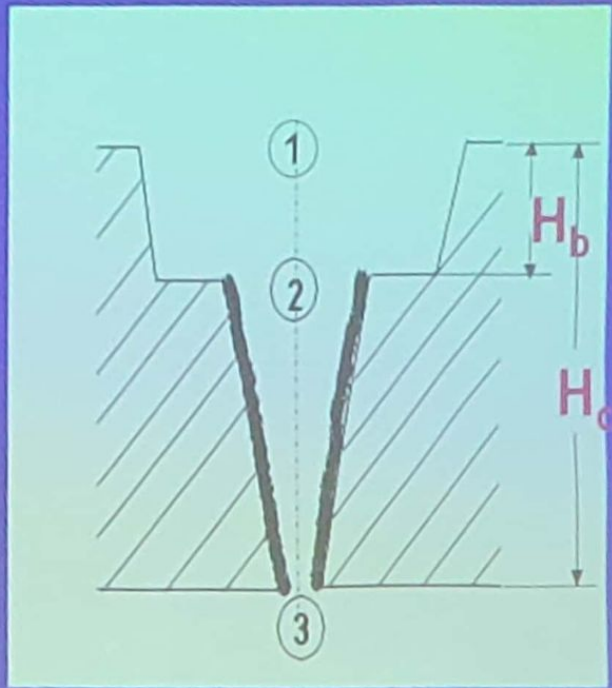
RULES FOR DESIGN OF SPRUE

Sprues should be tapered by approximately 5% to avoid aspiration of the air.

LAW OF CONTINUITY OF MASS

It states that the rate of flow of mass of the fluid is constant at any cross-section.

$$m = \rho A_1 V_1 = \rho A_2 V_2 = \rho A_3 V_3$$



Where, m = rate of flow of mass

ρ = density of liquid metal

A_1= area of cross-section at 1

A_2= area of cross-section at 2

A_3= area of cross-section at 3

V_1= velocity of liquid metal at 1

V_2 = velocity of liquid metal at 2

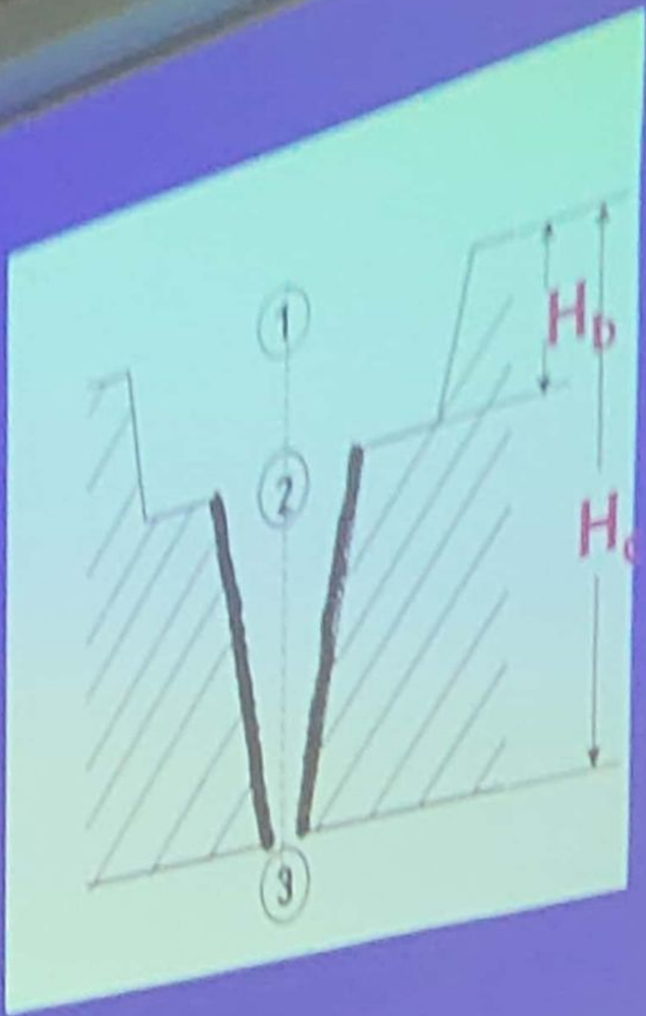
V_3 = velocity of liquid metal at 3

Volume rate of flow , $Q = A_1V_1 = A_2V_2 = A_3V_3$

$$Q = A_1V_1 = A_2V_2 = = A_3V_3$$

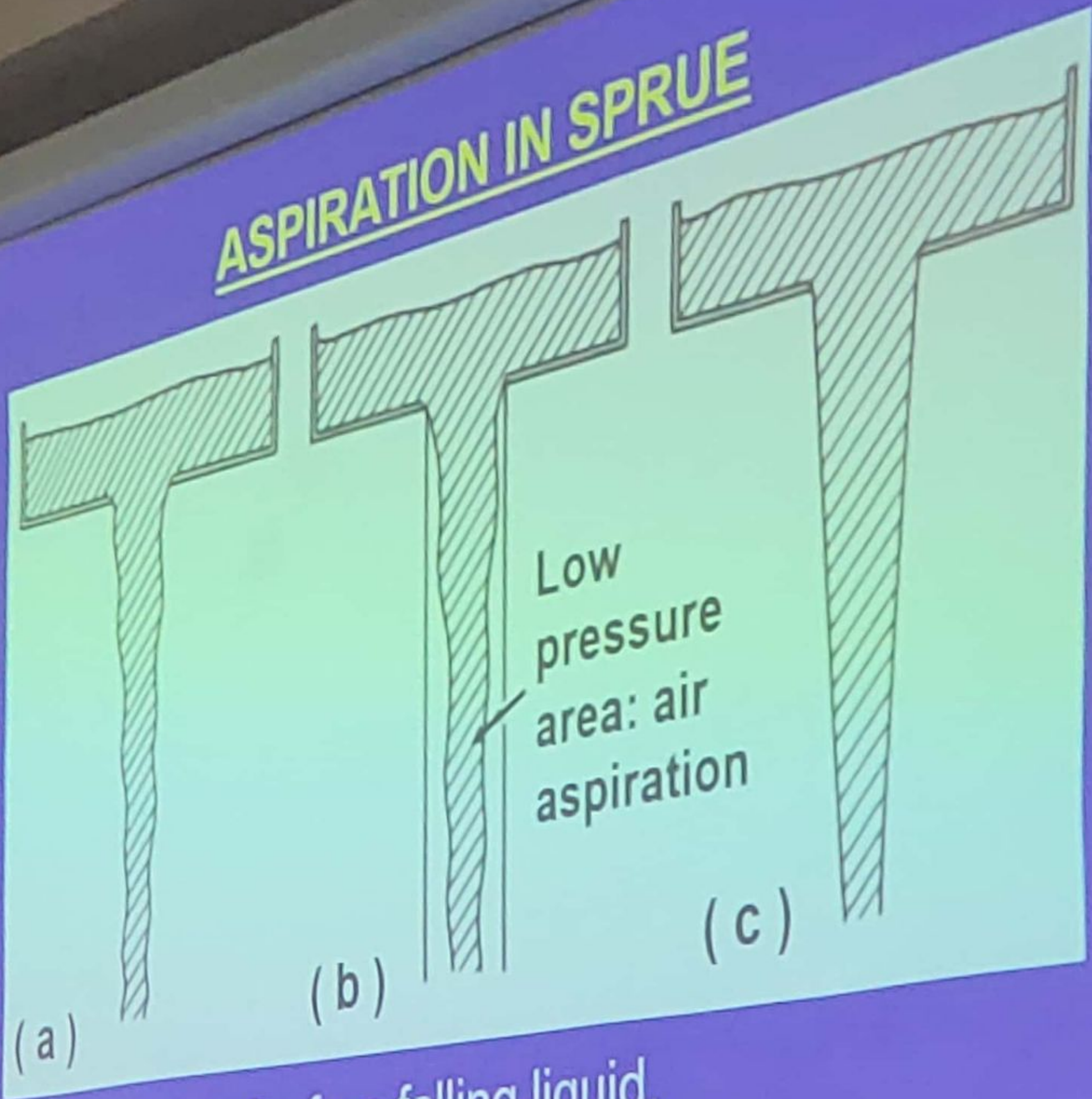
$$V_2 = \sqrt{2gH_b} \text{ and } V_3 = \sqrt{2gH_c}$$

$$\frac{A_2}{A_3} = \frac{\sqrt{H_c}}{\sqrt{H_b}}$$



- As the liquid flows down, the cross section of the fluid decreases. So the taper is provided in the sprue.
- Liquid loses contact if the sprue is straight which could cause '**aspiration**'.

ASPIRATION IN SPRUE

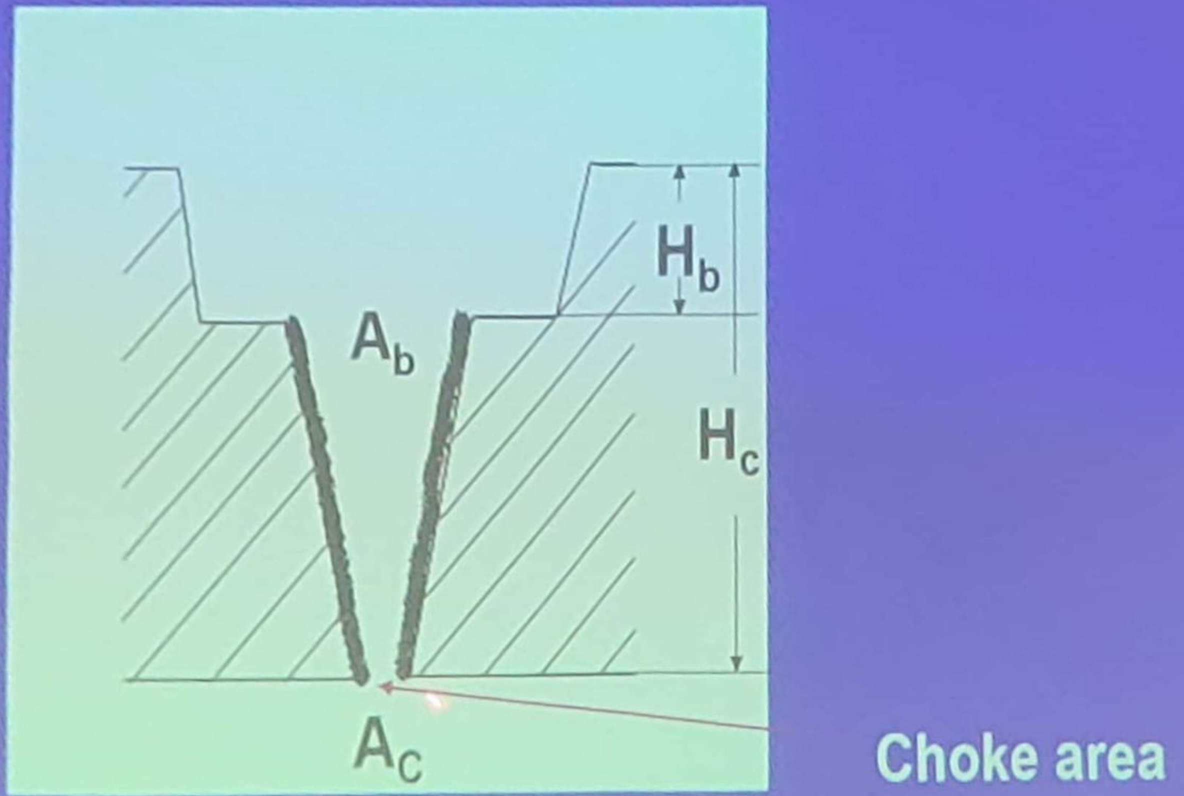


(a) Natural flow of a free-falling liquid.
(b) Air aspiration induced by liquid flow in a straight sprue.
(c) Liquid flow in a tapered sprue.

DESIGN OF CHOKE

CHOKE AREA

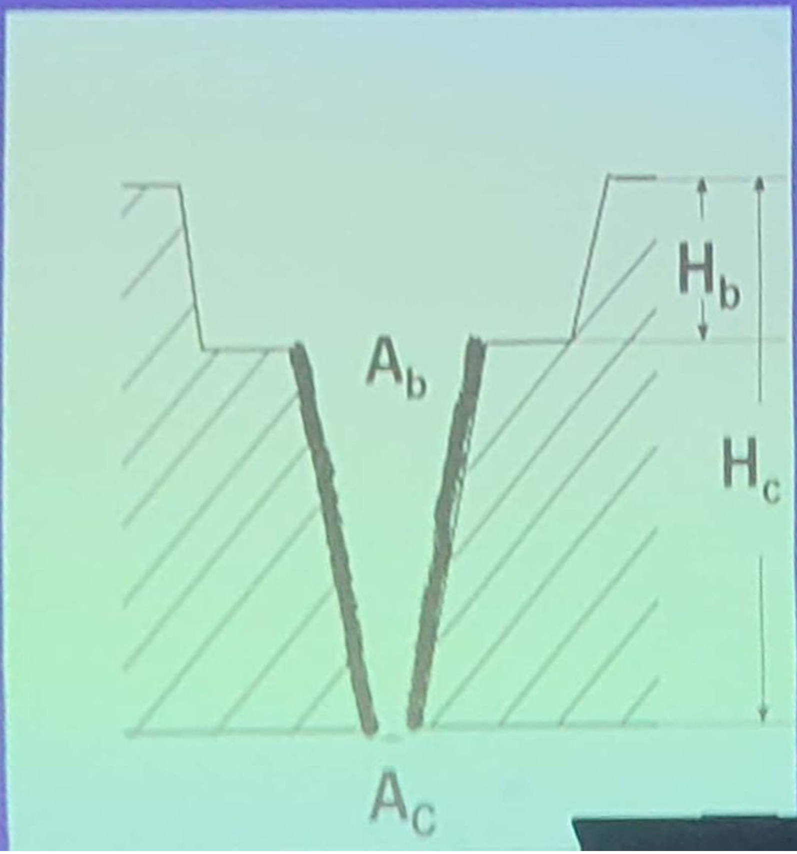
The smallest area that occurs at the bottom of the sprue is known as '**Choke area**'.



Choke area is designed based on Bernoulli's theorem.

BERNOULLI'S THEOREM

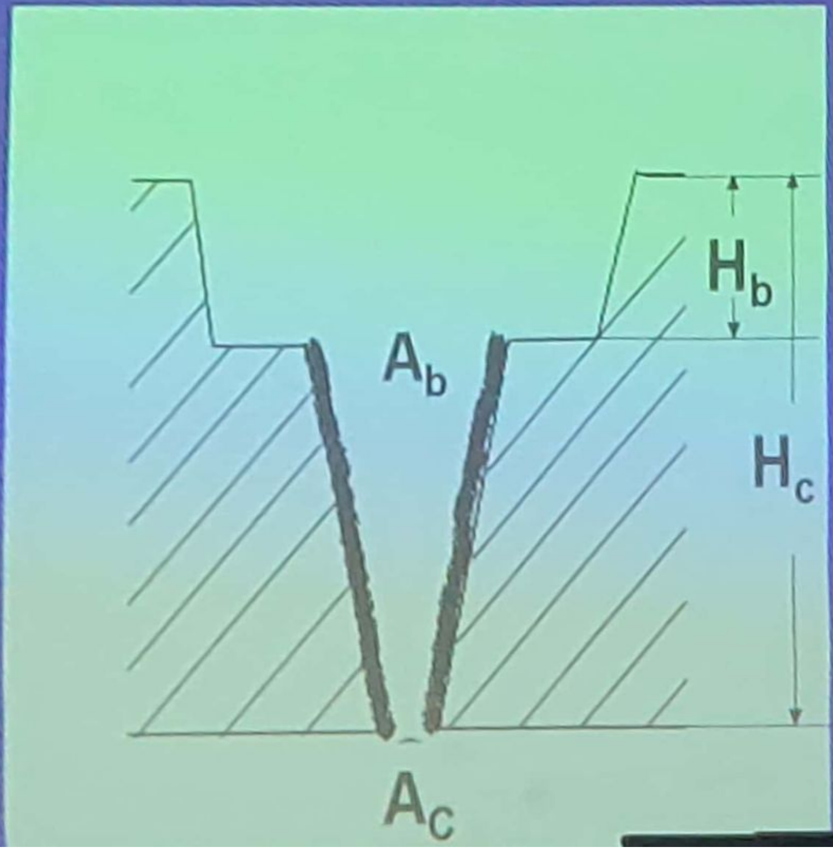
It is based on the principle of conservation of energy and relates pressure, velocity and elevation.

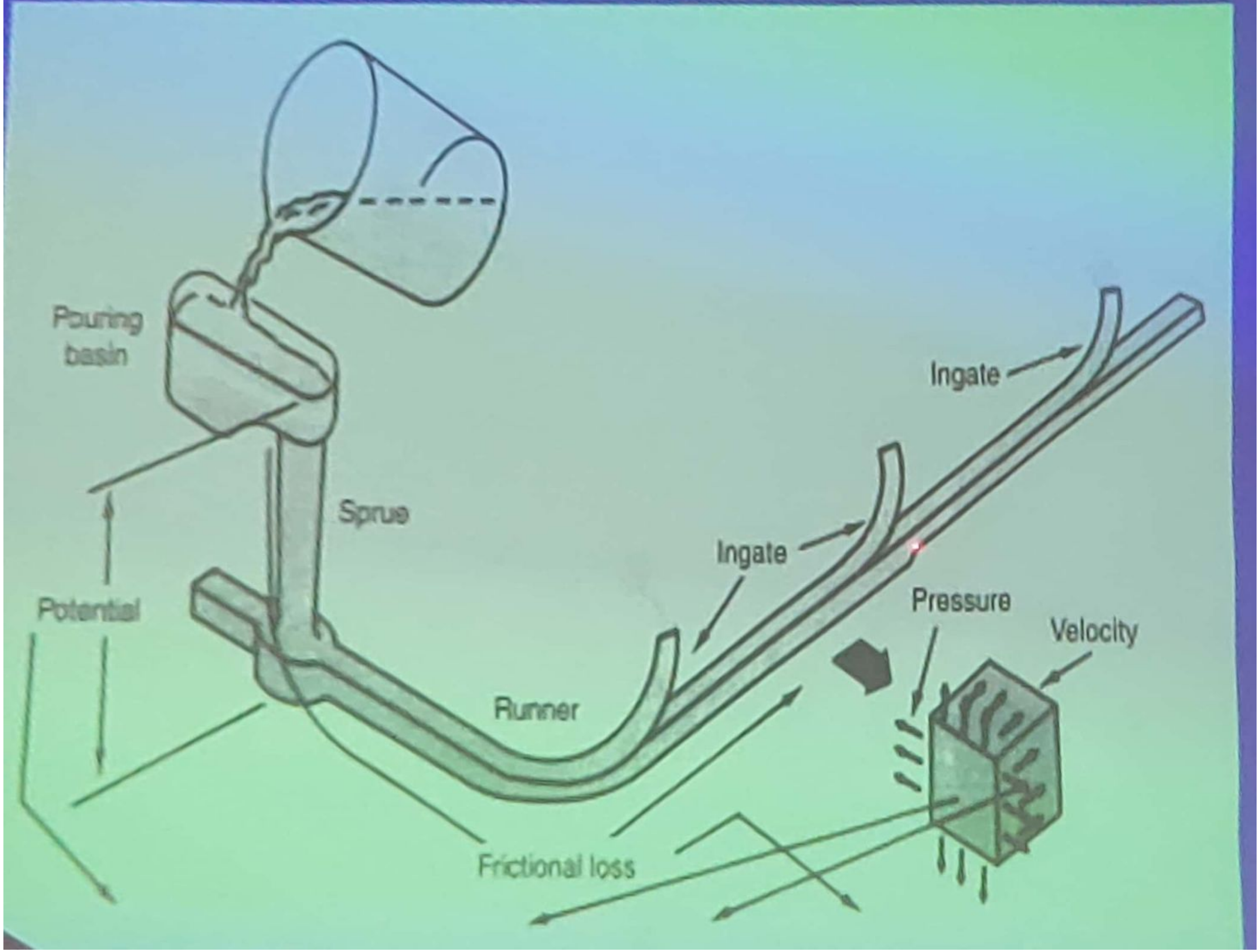


BERNOULLI'S THEOREM

It states that the total energy of unit weight of fluid is constant throughout a fluid system.

Total energy means sum of potential energy, kinetic energy and pressure energy.





Pouring basin
Sprue
Potential
Runner
Ingate
Ingate
Pressure
Velocity
Frictional loss

CamScanner

BERNOULLI'S EQUATION

$$\frac{p}{dg} + \frac{V^2}{2g} + Z - \Delta F = H$$

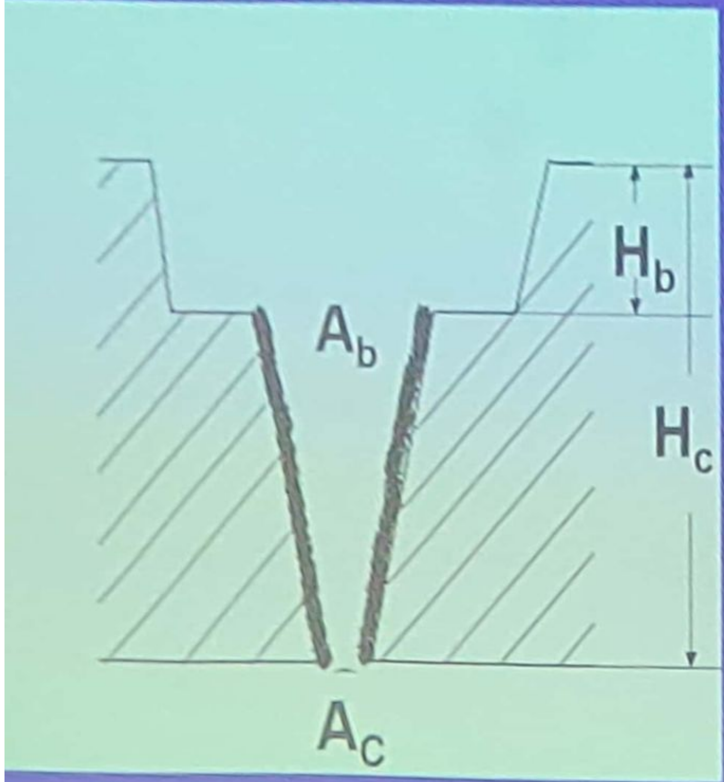
p/dg is the **Flow Energy** per unit weight (p – pressure, d - density).

$V^2/2g$ is the **Kinetic Energy** of the fluid per unit weight.

Z is the **Potential Energy** of the fluid per unit weight.

ΔF is the **Frictional Loss**

H is the **Total Energy** of the fluid per unit weight, which is always **constant** along the same streamline.



Let

A_b = Cross-sectional area of sprue at its top

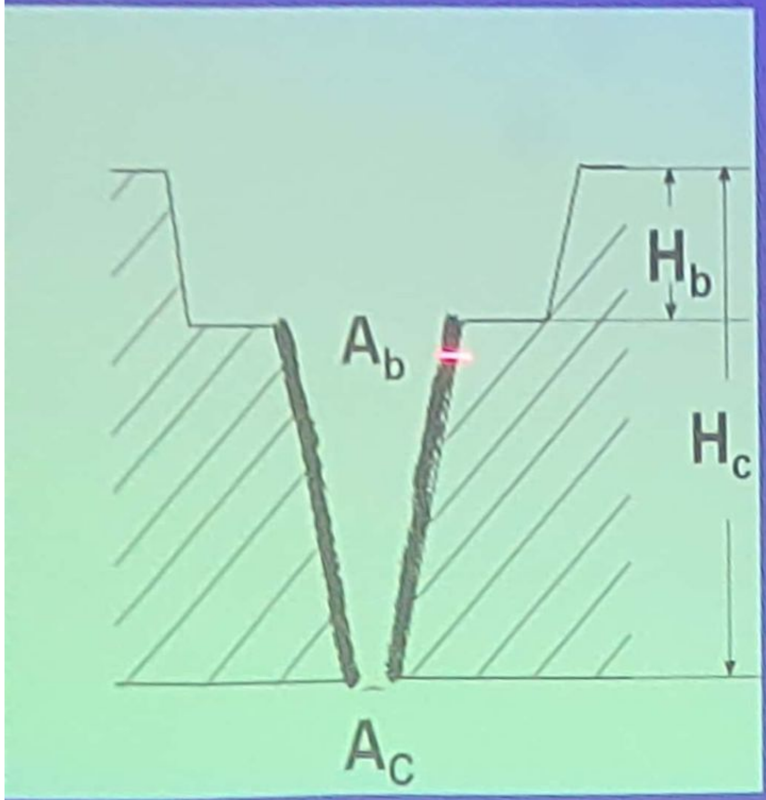
A_c = Cross-sectional area of sprue at the choke

V_b = Velocity of liquid metal at the top of sprue

V_c = Velocity of liquid metal at the bottom of sprue (choke)

H_b = Height of pouring basin

H_c = Height of total metal head above the choke

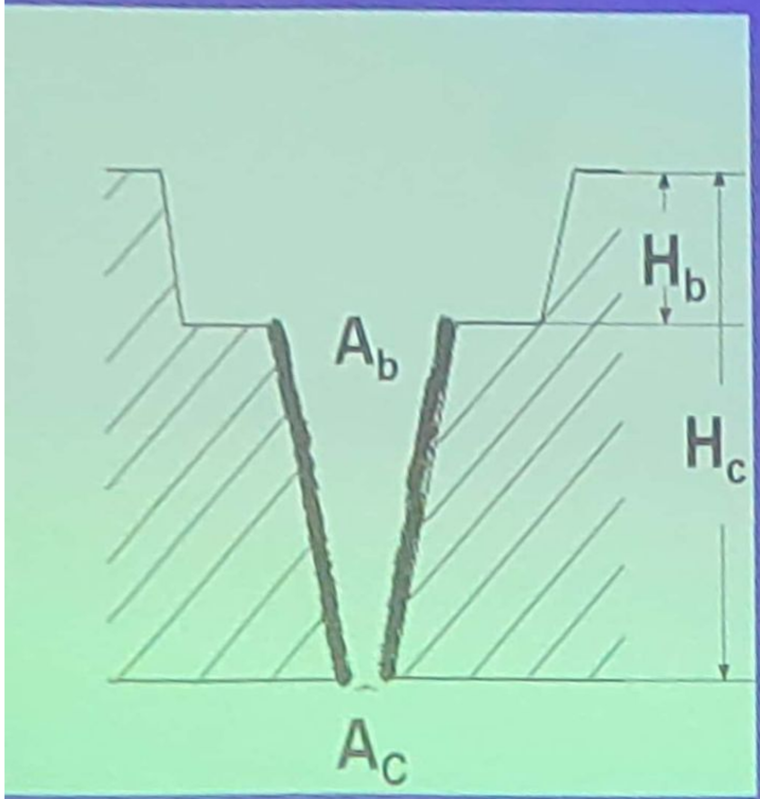


According to the Bernoulli's theorem, velocity of liquid metal at the top of sprue is given by:

$$V_b = \sqrt{2 \cdot g \cdot H_b}$$

Similarly, velocity at the bottom of sprue (choke) is given by:

$$V_c = \sqrt{2 \cdot g \cdot H_c}$$



Volume of flow at choke in a given time $= A_c \cdot V_c \cdot t$

$= W / \rho$

Where,

W = weight of poured metal

ρ = density of liquid metal

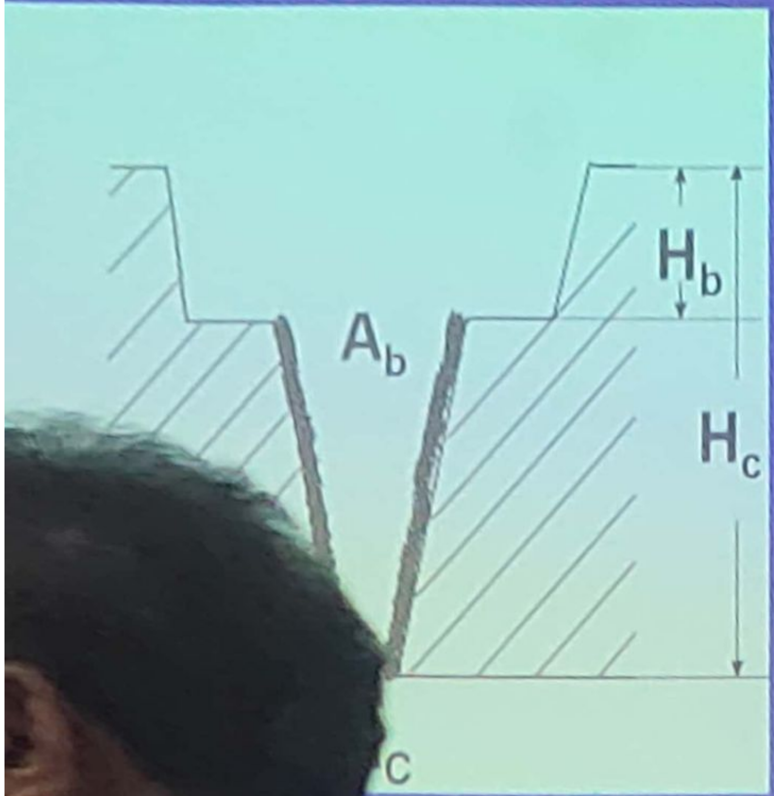
$$\text{Thus,} \quad A_c = \frac{W}{c \cdot \rho \cdot t \cdot V_c}$$

c = coefficient of discharge

$$\text{But} \quad V_c = \sqrt{2 \cdot g \cdot H_c}$$

Hence, the choke area is given by:

$$A_c = \frac{W}{c \cdot \rho \cdot t\sqrt{2 \cdot g \cdot H_c}}$$



Where,

W= Wt. of poured metal **(kg)**

c = coefficient of discharge

ρ = density of liquid metal, **(kg/cm³)**

t = pouring time **(seconds)**

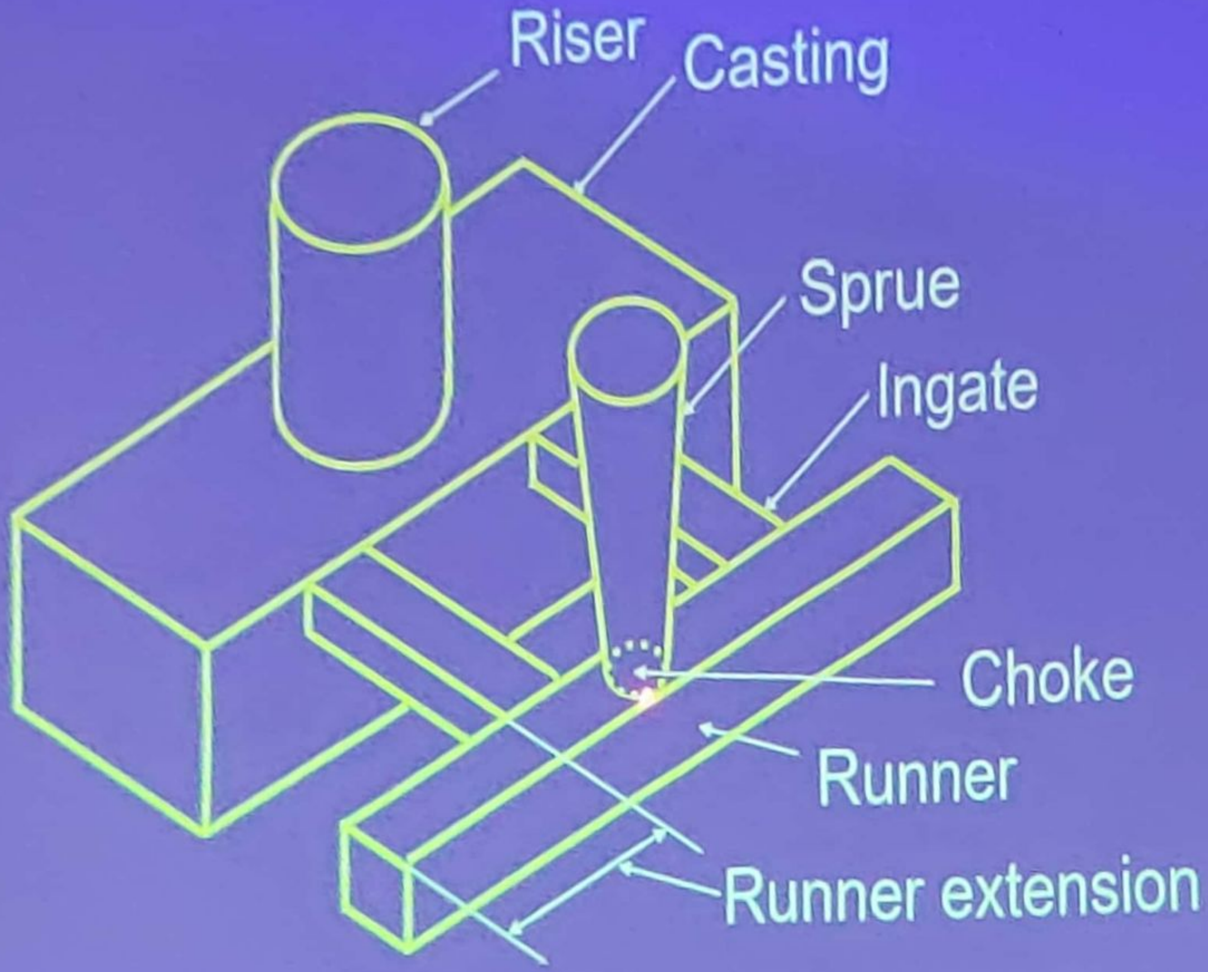
g = acceleration due to gravity **(981 cm/sec²)**

H_c = height of total metal head above choke (cm)

RULES FOR DESIGN OF SPRUE WELL

Sprue well's cross-sectional area is two to three times the area of the sprue exit (choke).

DESIGN OF RUNNER



Runner is the horizontal channel through which the molten metal flows from the sprue to the gate.

RULES FOR RUNNER DESIGN

1. Typical cross-section of a runner is square.
2. The runner's cross-sectional area depends on the gating ratio.
3. Abrupt changes in the direction of runners should be avoided.

poured Metal. (its always > mass of casting)

Runner extension:

Its there so that starting fill slag, impurities etc. doesn't enter your casting.

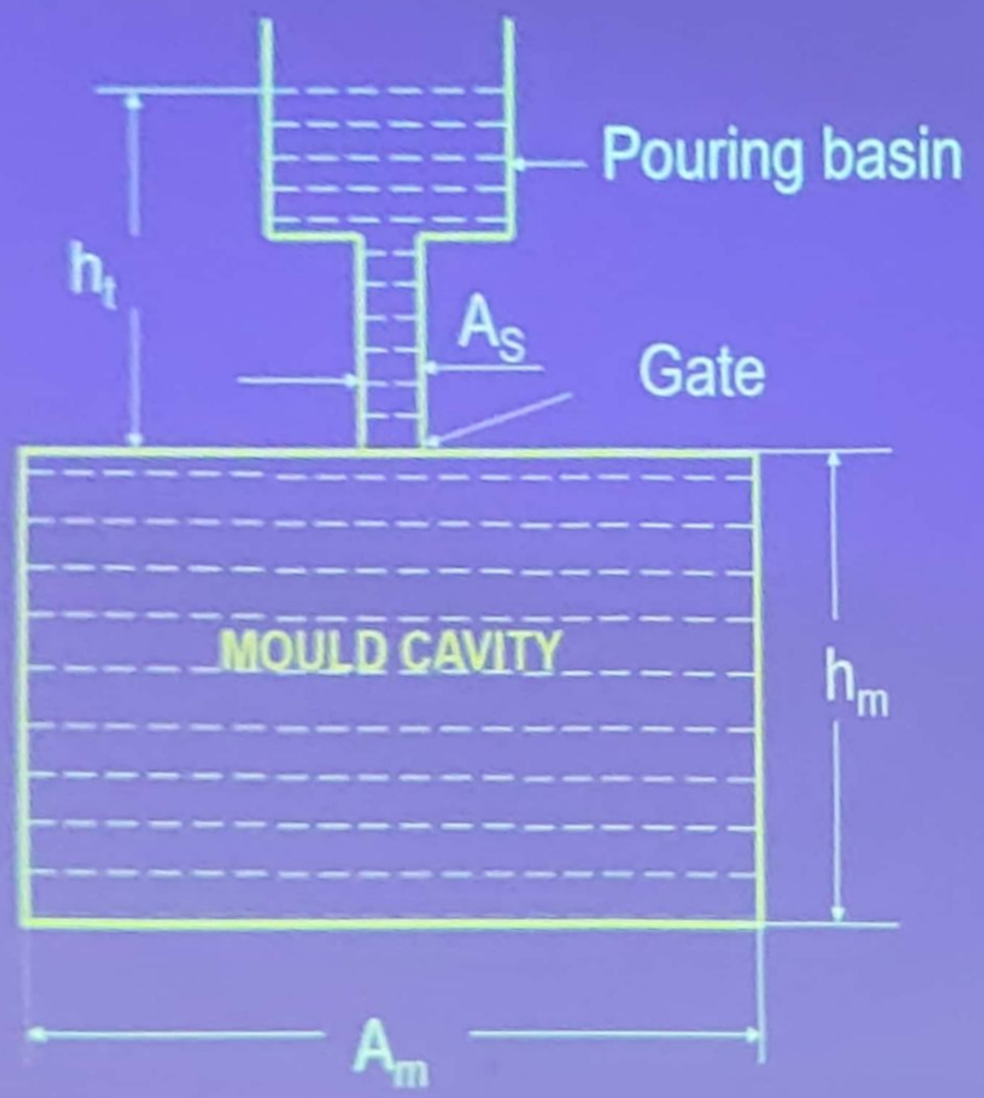
RULES FOR GATES DESIGN

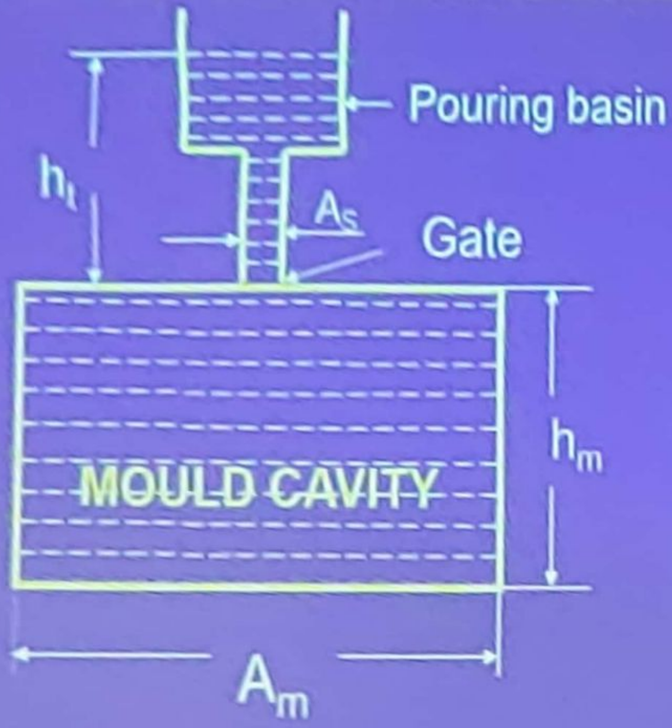
- Multiple ingates often are preferable for large castings.
- A fillet should be used where an ingate meets a casting; - Produces less turbulence.
- The minimum ingate's length should be three to five times the ingate's width, depending on the metal being cast.

TYPES OF GATES

1. Top gate
2. Parting line gate
3. Bottom gate
4. Side gate

1. TOP GATE





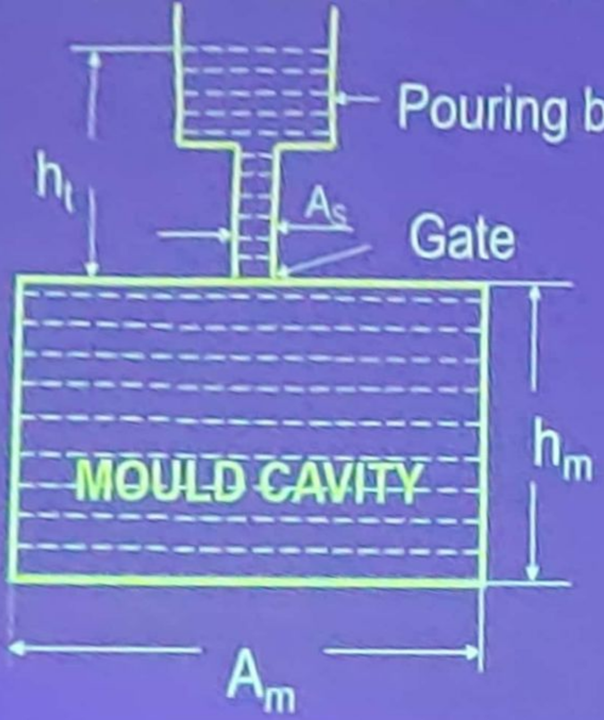
In the top gate, molten metal is poured at the top of the mould.

A_m = Mould cross sectional area (sq. cm)

A_s = Gate cross-sectional area (sq. cm)

h_m = Height of mould (cm)

h_t = Filling (pouring) height (cm)

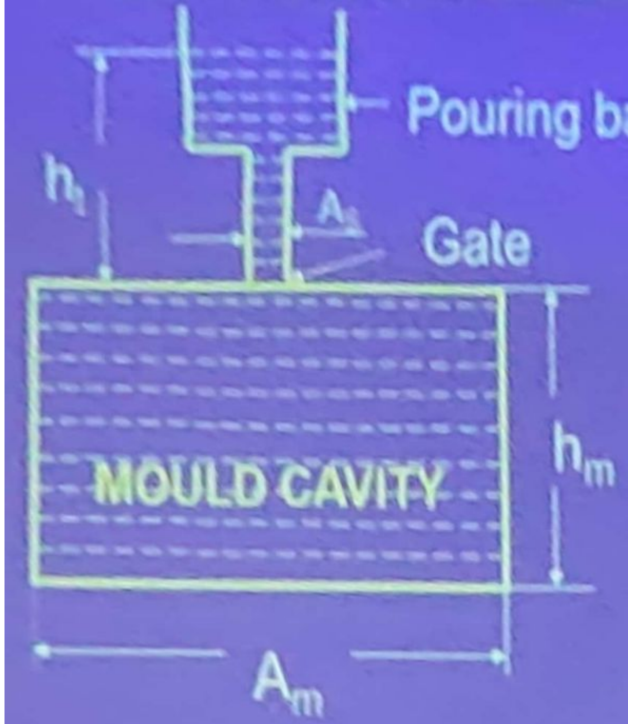


Velocity of liquid metal at gate,

$$V_g = \sqrt{2 \cdot g \cdot h_t}$$

$$\text{Pouring time} = \frac{\text{Volume of mould}}{\text{Gate cross-sectional area} \times \text{Velocity of melt at gate}}$$

$$= \frac{A_m \cdot h_m}{A_S \cdot V_g} \text{ seconds}$$



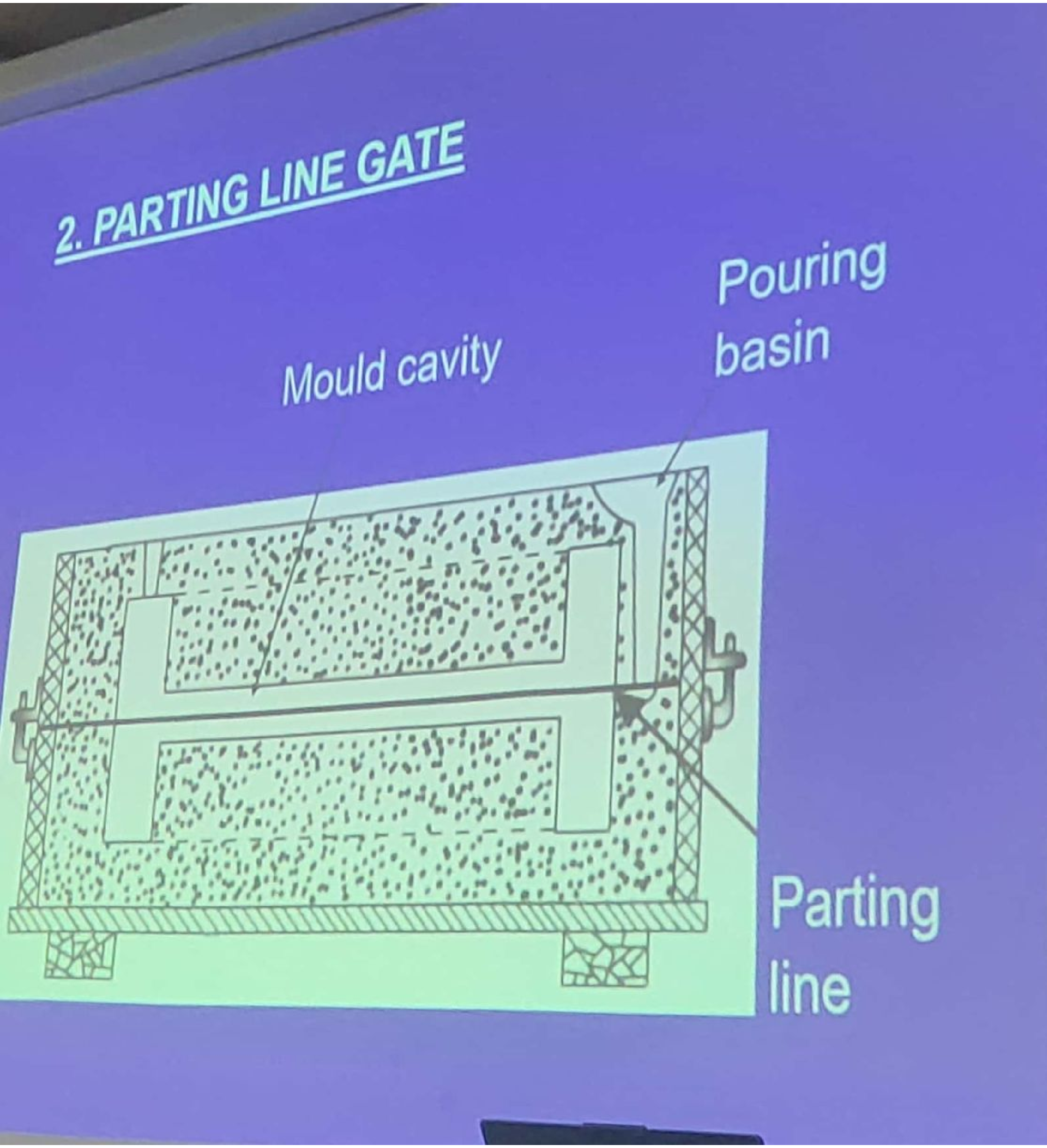
ADVANTAGES:

Simple design.

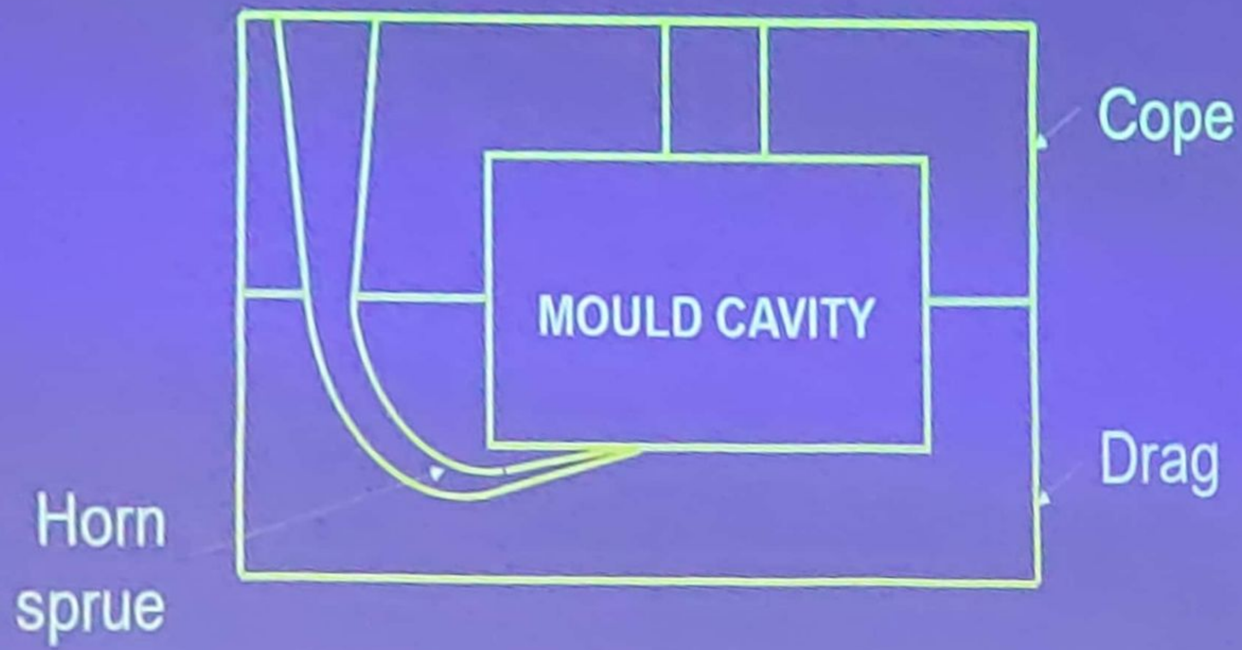
DISADVANTAGES:

Turbulence and erosion is caused in case of large castings.

Can be used where moulds are erosion resistant.


2. PARTING LINE GATE
Pouring basin
Mould cavity
Parting line

3. BOTTOM GATE



Molten metal flows into mould through the bottom of the mould cavity in the drag.

Turbulence and erosion are minimum.

→ Bottom gate doesn't achieve directional solidification; as fresh metal @ bottom [will solidify last]

↓

that's bad.

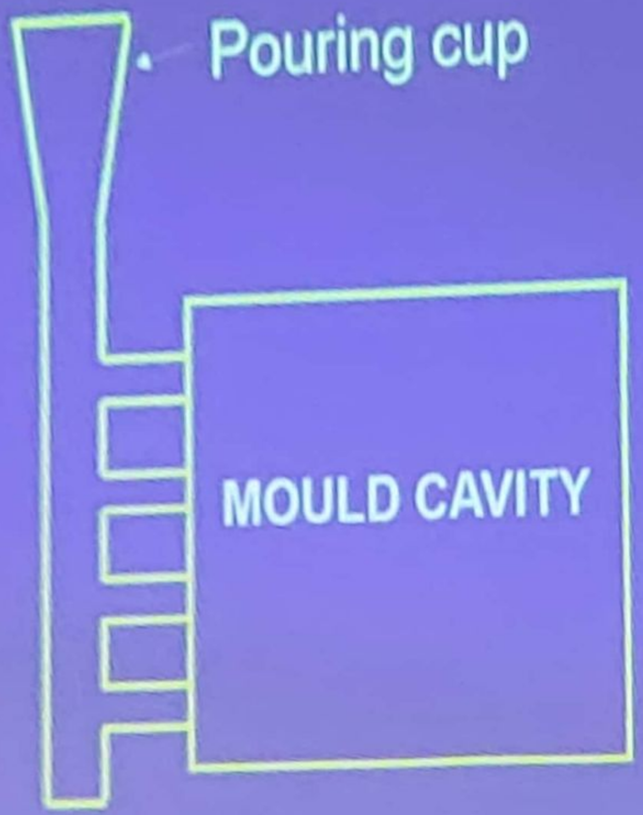
→ But no turbulence ⇒ advantage.

Its th

slag,

cas

4. SIDE GATE



Metal enters into the mould cavity from side through a number of gates.

Solves the problems raised in bottom gate.

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TYPES OF GATING SYSTEMS

1. PRESSURIZED GATING SYSTEM

The total cross-sectional area gradually DECREASES from choke to ingates.

2. UN-PRESSURIZED GATING SYSTEM

The total cross-sectional area gradually INCREASES from choke to ingates.

CALCULATION OF POURING TIMES

1. Gray-iron castings < 450 kg

Pouring time, $t = K\left(1.41 + \dfrac{T}{14.59}\right)\sqrt{W}$ seconds

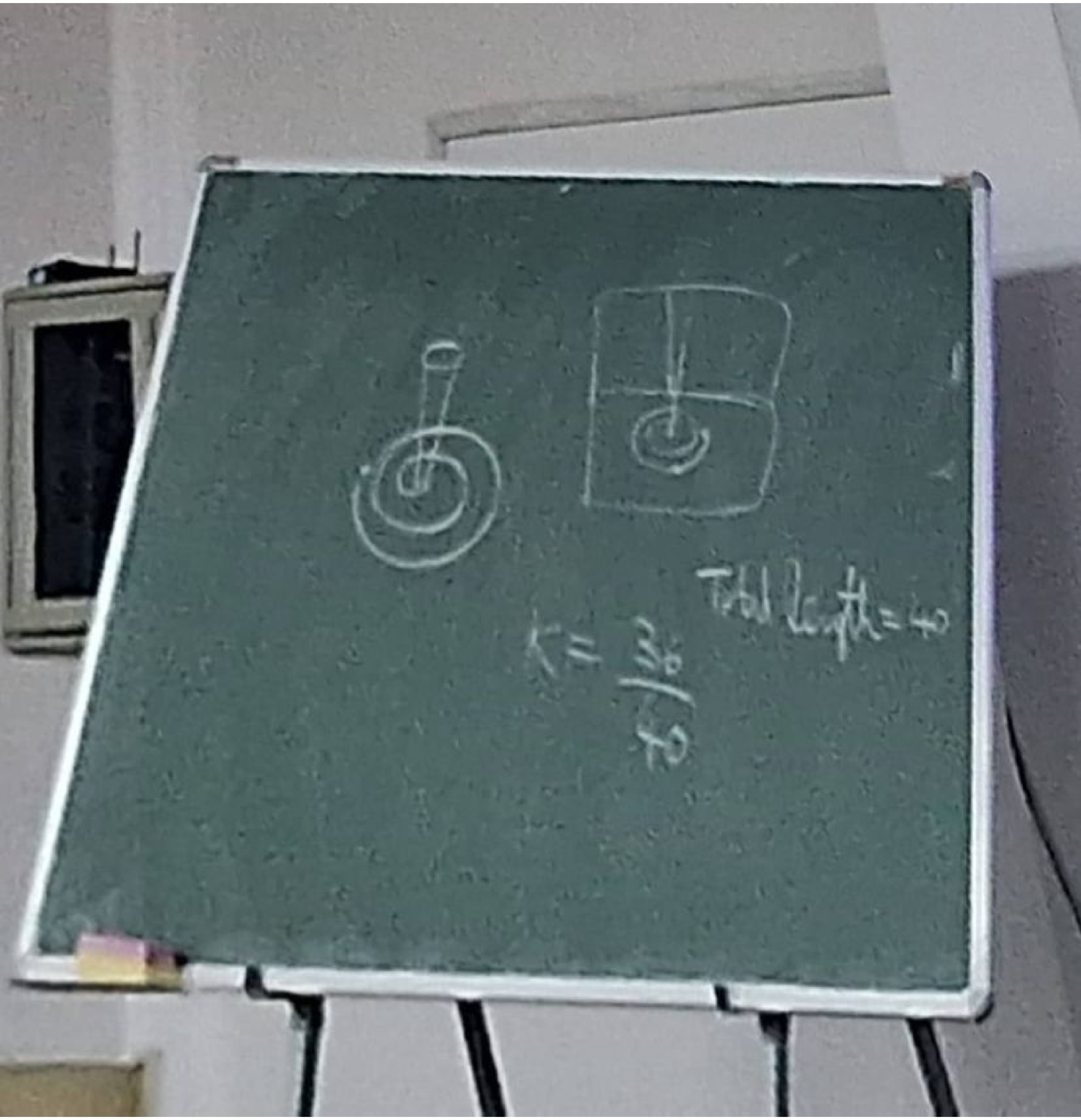
Where,

K is the **fluidity factor** which depends upon **temperature** and **composition** of the molten metal.

K = fluidity of iron in inches / 40

T = average thickness of the casting in mm

W = mass of the casting in kg.


Total length = 40
K = 36/40

LOGICAL APPROACH FOR A PROPER DESIGN OF GATING SYSTEM

SEQUENCE:

- Estimation of optimum pouring time.
- Calculation of sprue-choke area.
- Selection of appropriate gating ratio.
- Selection of gating type and ingate location.
- Calculation of runner/ingate size.

TYPES OF GATES

1. Top gate
2. Parting line gate
3. Bottom gate
4. Side gate

TYPICAL GATING RATIOS

PRESSURIZED GATING SYSTEM

$A_C : A_R : A_G = 1 : 1.3 : 1.1$ (For gray cast iron)

$A_C : A_R : A_G = 1 : 2 : 1$ (For aluminum)

$A_C : A_R : A_G = 1 : 2 : 1.5$ (For steel)

UN-PRESSURIZED GATING SYSTEM

$A_C : A_R : A_G = 1 : 4 : 4$ (For gray cast iron)

$A_C : A_R : A_G = 1 : 3 : 3$ (For aluminum)

$A_C : A_R : A_G = 1 : 3 : 3$ (For steel)

CALCULATION OF POURING TIMES

2. Gray-iron castings > 450 kg

Pouring time, $t = K\left(1.236 + \dfrac{T}{16.65}\right)\sqrt[3]{W}$ sec

Where,

K is the fluidity factor

T = average thickness of the casting in mm

W = mass of the casting in kg

COMPARISON OF GATING SYSTEMS

Pressurized gating	Un-pressurized gating
The total cross sectional area DECREASES towards the mould cavity.	The total cross sectional area INCREASES towards the mould cavity.
More turbulence and chances of mould erosion.	Less turbulence.
Casting yield is more.	Casting yield is less.
Complex and thin sections can be successfully cast.	Complex and thin sections may not be successfully cast.

PROBLEM 3

Design the gating system for a casting made up of cast iron whose dimensions are 500 x 250 x 50 mm

Density of solid cast iron = 7.86 gm/cc

Density of liquid cast iron = 6.9 gm/cc

Fluidity length = 22 inches

Height of cope = 100 mm

CALCULATION OF POURING TIMES

4. Steel castings

Pouring time, $t = (2.4335 - 0.3953 \log W)\sqrt{W}$ sec

Where,

W = mass of casting in kg

CALCULATION OF POURING TIMES

3. Shell moulded ductile iron

Pouring time, $t = K_1\sqrt{W}$ seconds

Where,

K_1 = 2.08 for castings of thinner sections (< 10 mm)

= 2.67 for castings of medium sections (10 to 25 mm)

= 2.97 for castings of heavier sections (> 25 mm)

W = mass of casting in kg

PROBLEM 2

Solve the previous problem if the material is steel.

For Steel castings

Pouring time, $t = (2.4335 - 0.3953 \log W)\sqrt{W}$

W = mass of casting in kg

Pouring time, $t = (2.4335 - 0.3953 \log 20)\sqrt{20}$

$= 8.5825$ seconds

PROBLEM 1

Calculate the optimum pouring time for a casting whose mass is 20 kg and having an average section thickness of 15 mm. The material of the casting is grey cast iron. Take the fluidity of the material as 28 inches.

For Gray-iron castings < 450 kg

$$\text{Pouring time, } t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$$

Where,

K is the fluidity factor

K = fluidity of iron in inches / 40

T = average thickness of the casting in mm

W = mass of the casting in kg.

PROBLEM 3

Design the gating system for a casting made up of cast iron whose dimensions are 500 x 250 x 50 mm

Density of solid cast iron = 7.86 gm/cc

Density of liquid cast iron = 6.9 gm/cc

Fluidity length = 22 inches

Height of cope = 100 mm

SOLUTION:

Volume of casting = $500 \times 250 \times 50 = 6.25 \times 10^6\ mm^3$

$= 6.25 \times 10^3$ cc

Mass of casting = Volume x Density = $7.86 \times 6.25 \times 10^3$

= 49125 gm = 49.125 kg

Assuming casting yield as 70%,

Weight of poured metal = Mass of casting / casting yield

= 49.125 / 0.70

= 70.18 kg

$$\text{Pouring time, } t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$$

$$\text{Pouring time, } t = 22/40\left(1.41 + \frac{50}{14.59}\right)\sqrt{70}$$

$\simeq$ 23 seconds

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DESIGN OF CHOKE AREA

Choke area is given by, $$A_c = \frac{W}{c \cdot \rho \cdot t\sqrt{2 \cdot g \cdot H_c}}$$

Where,

A_c = Choke area = to be found out

W = Weight of poured metal = 70 kg

c = Efficiency factor (varies between 0.7 and 0.9) = 0.8

ρ = Density of liquid metal = 6.9 gm/cc

= 6.9×10^{-6} kg/mm^3

t = Pouring time = 18 seconds

g = Acceleration due to gravity = 9800 mm/sec^2

H_c = Effective height of metal head = 100 mm

PROBLEM 3

Design the gating system for a casting made up of cast iron whose dimensions are 500 x 250 x 50 mm

Density of solid cast iron = 7.86 gm/cc

Density of liquid cast iron = 6.9 gm/cc

Fluidity length = 22 inches

Height of cope = 100 mm

Q) Design a gating system

Casting yield = 70%

Dim^n = 500 × 250 × 50 mm

$\rho_{castiron}$ = 7.86 gm/cc

Fluidity length = 22 inches

$\rho_{liq\ castiron}$ = 6.9 gm/cc

Height of cope = 100 mm

$M_{castin} = \rho_{solid\ cast\ iron} \times V_{cast}$

$= \frac{7.86\ gm/cc}{\cancel{500 \times 250 \times 50 \times 10^{-3}}} \times \cancel{500} \times 250 \times \cancel{50} \times \cancel{10^{-3}}$

= 49.125 kg.

Casting yield = $\frac{M_{casting}}{m_{poured\ metal}}$

$\Rightarrow m_{poured\ metal}$ = 70.17 kg.

$t = \frac{22}{40}\left(1.41 + \frac{50}{14.59}\right) \times \sqrt{70.17}$ ×

$t \simeq$ 23 seconds

$t = \frac{22}{40}\left(1.41 + \frac{50}{14.59}\right)\sqrt{49.125}$

$t \simeq$ 18.6 sec

$A_c = \frac{W_{pourd\ metal}}{c\rho t\sqrt{2gH_c}} = \frac{70.17\ kg \times 10^3\ \cancel{cm^3}}{0.8 \times 69 \times 18.6\sqrt{2 \times 981 \times 10}}$

$= \frac{70.17 \times 10^3}{0.8 \times 6.9 \times 18.6 \times \sqrt{2 \times 981 \times 10}}$

$= 4.87\ cm^2$

Dia $= \sqrt{\frac{4.87 \times 4}{3.14}}$ = 2.49 cm. ≈ 24.9 mm

Cross section

NOTE: ~~cs~~. of runner is always a square. $(a \times a)$

and that of ingate is always $(2a \times a)$ rectangle.

And if 2 ingates, then halve the areas.

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Quest^n : (4)

(i) NOTE → must choose pressurized gating system else metal won't flow into fins.

→ Volume of casting should INCLUDE that of the fins.

→ Height of cope box ⇒ pouring height

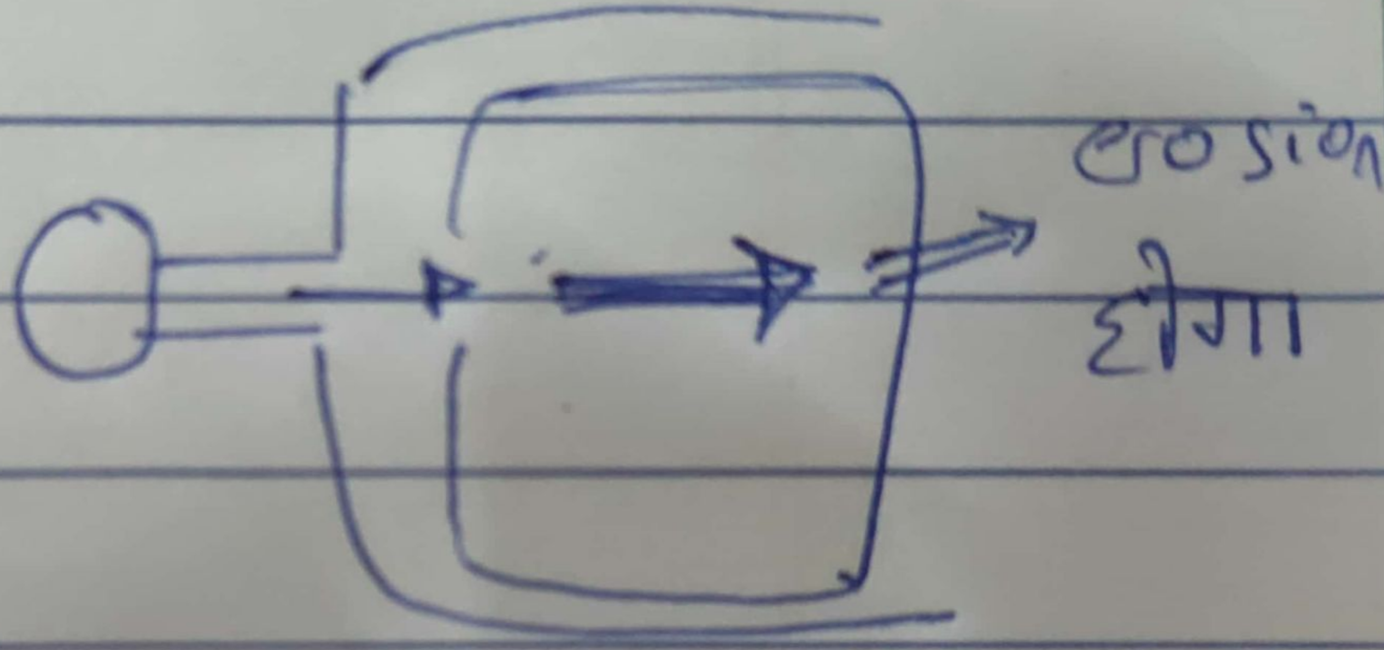
→ इसे ; assume

casting yield = 70%.

→ Assume fluidity factor = 0.8 here. Ideal fluid में ⇒ = 1.

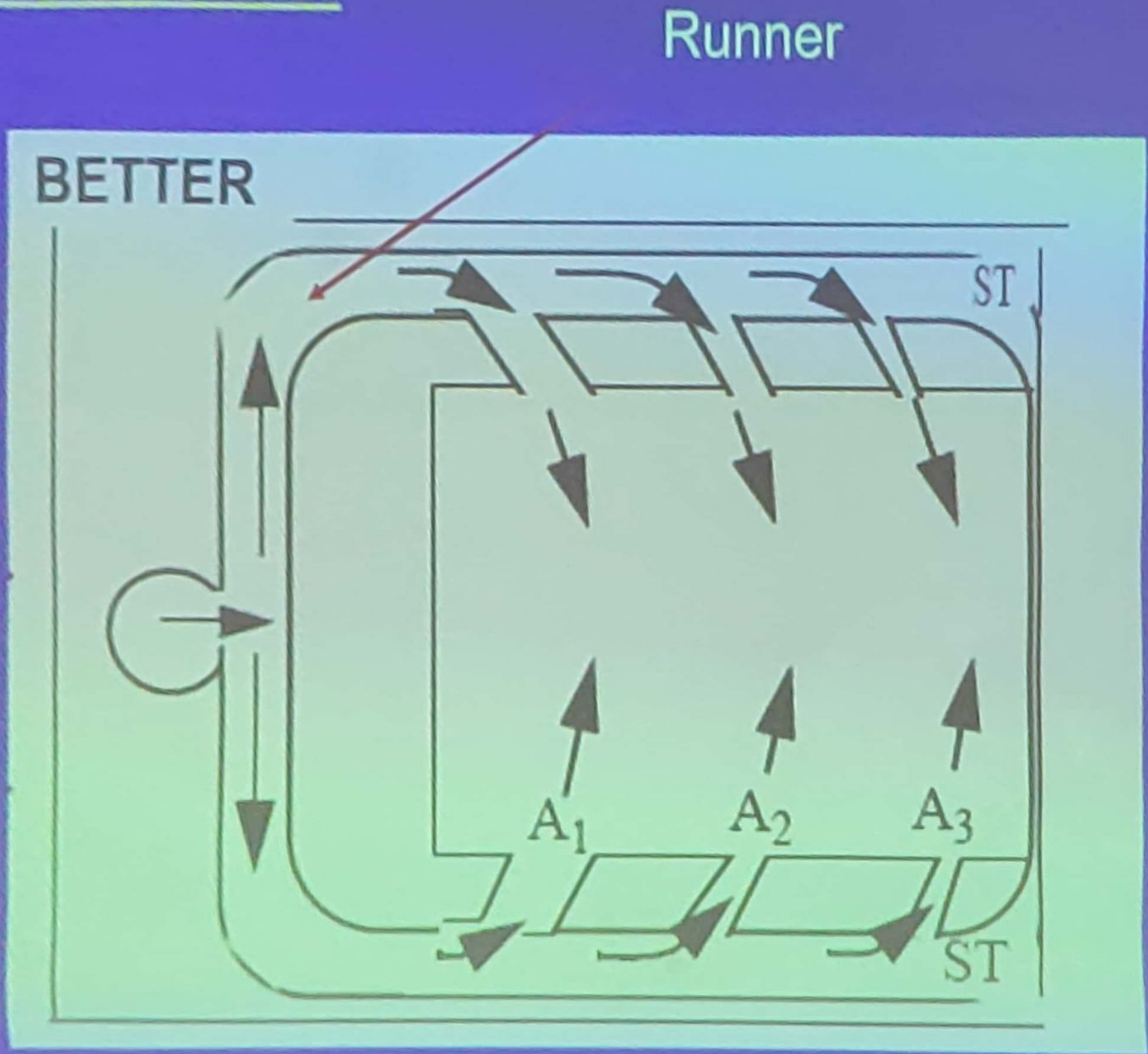
{3275}

OLD:

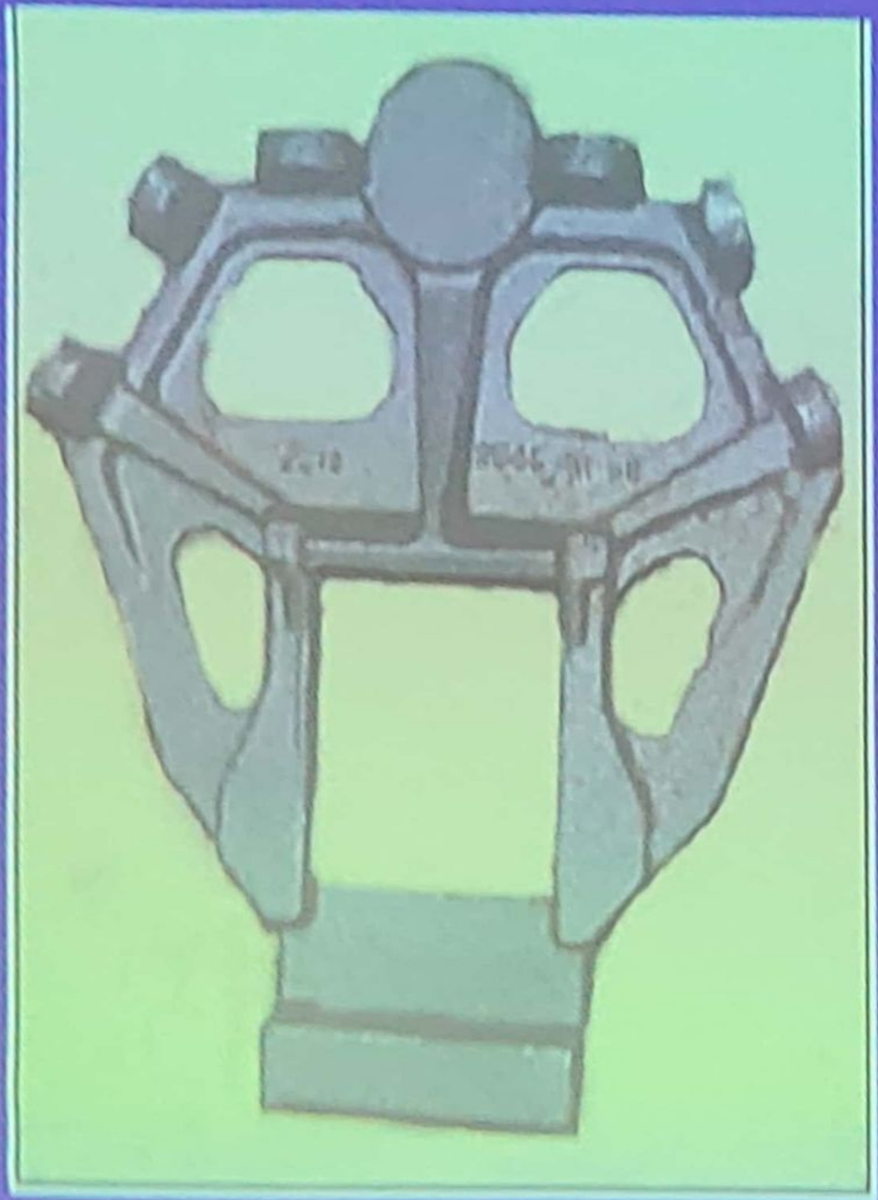


{top-view}

CASE STUDY 1



CASE STUDY 2 Hitch housing



The hitch housing acts as an alignment and locking fixture for connecting the trailer tow hook to the truck tow bar.

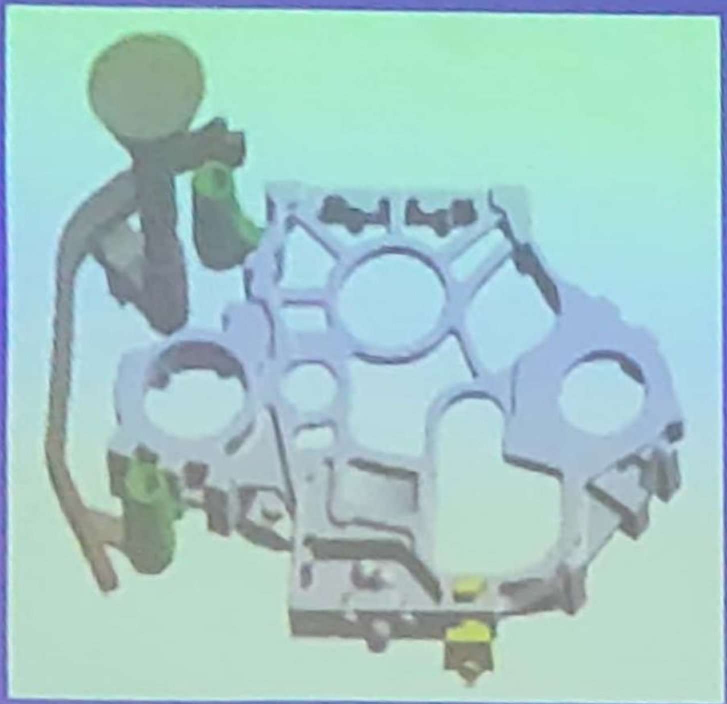
CASE STUDY 2 Hitch housing

PATTERN ORIENTATION

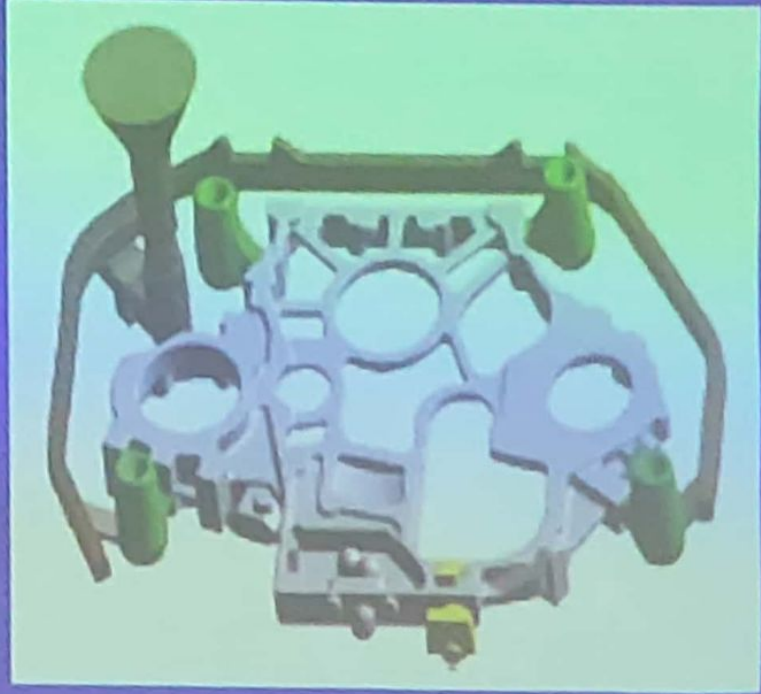
Not preferred | Preferred | Not preferred

CASE STUDY 2

Gating & Runner Option



Not preferred



Preferred

Reasoning

★ CASE-1: thin parts needs हैं ताकि metal goes into them properly

▲ CASE-2 – runner should run through all regions of casting.

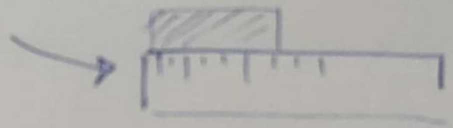
METROLOGY

⇒ Science of precise measurement ; eg. Time, mass, force, Temp, length ---- ✓

(i) Standards of measurement :

→ Line standards : measurement made b/w 2 ∥ lines :

eg : using ruler.



→ End Standards : b/w 2 flat parallel faces.

eg : vernier callipers, micrometer.

★ Drawbacks

of line standard : • Thickness of lines can cause errors.

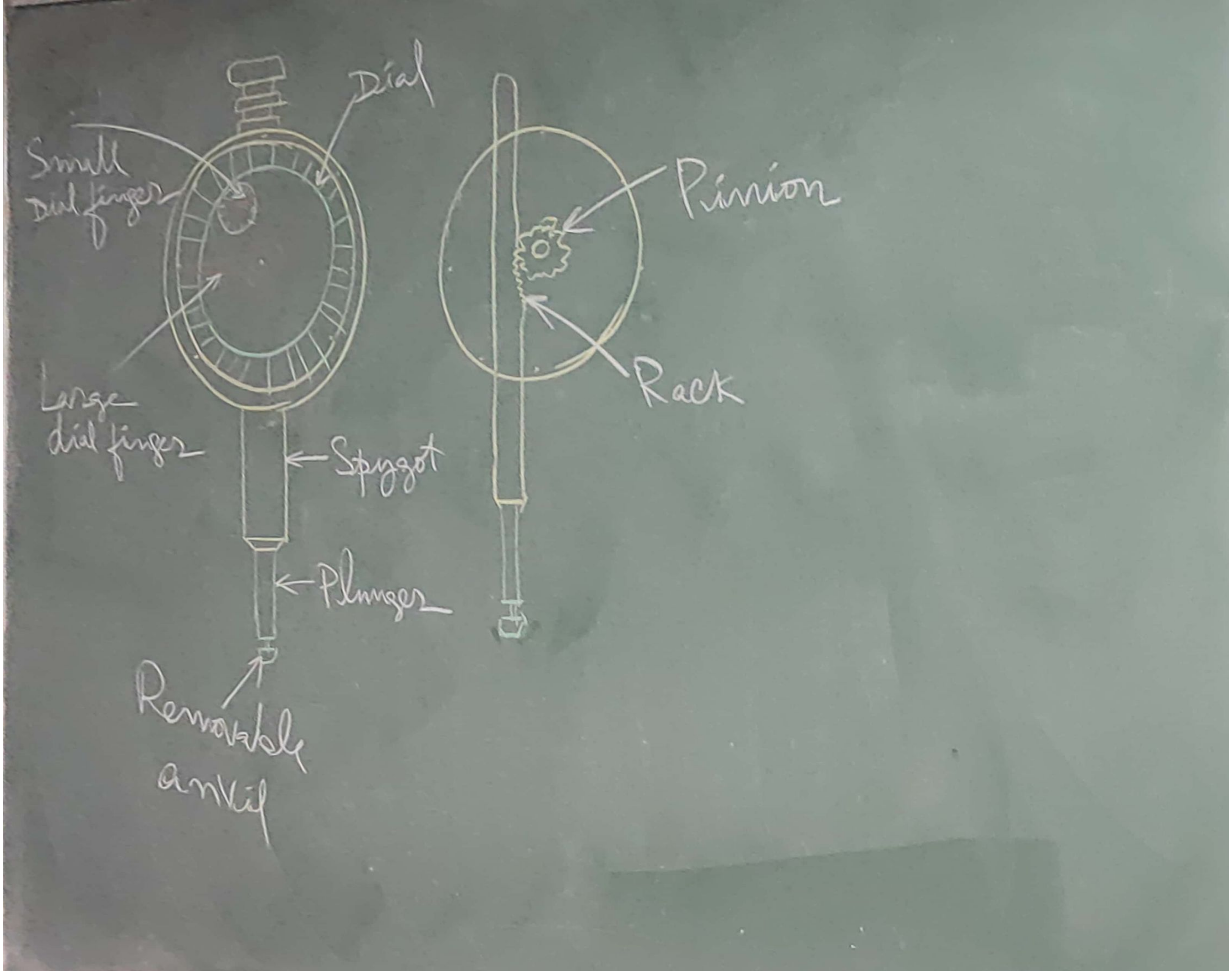
• Parallax error can occur.

•

LINEAR MEASURING INSTRUMENTS

(length)

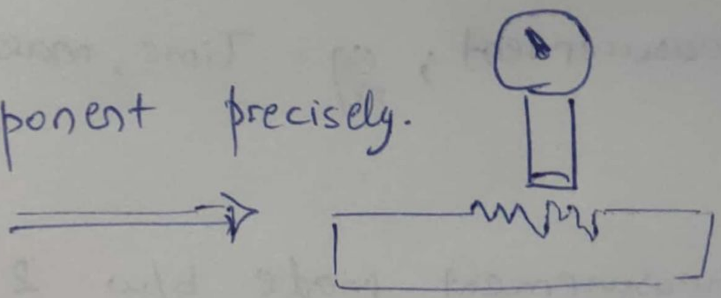
→ ruler
→ vernier caliper
→ micrometer
→ depth gauge
→ vernier height gauge
→ dial gauge
→ Block gauge.
→ limiting gauge.
→ Comparators.


Dial
Small
dial finger
Large
dial finger
Spygot
Plunger
Removable
anvil
Pinion
Rack

Applications of dial gauge:

(i) measure height of component precisely.

(ii) measure deviations.



(iii) measurement of extent of (compression or elongat^n) in testing of materials.

(iv) Checking roundness of shafts, or jobs etc

BLOCK-GAUGES → aka "slip gauges".

→ Simplest measurement of linear dimensⁿ

→ Very accurate.

→ Tolerance ≃ 0.001 to ~~0.008~~ 0.0005 mm.

=

• Slip gauge are available in different sets.

3 block set : 0.5mm, 1.0mm, 1.0005mm.

9 block set : ~~1.01mm~~ 1.001 mm, ~~0.01~~ 1.002 mm, ... 1.009 mm (0.001 increment)

49 blocks : 1.01 mm, 1.02 mm ..... 1.49 mm (0.01 increment)

17 block : 1.5 mm, ~~0.05~~ ~~1.55~~ 2.0 mm ..... 9.5 mm, (0.5 mm increment).

10 block : 10mm, 20mm .... 100mm. (10 mm increment)

★ Applications of Slip Gauge :

→ Precision, experiments & research.

→ inspect finished components.

Material of Gauges.

→ Chrome-plated steel, chrome-carbide, tungsten-carbide.

→ Need abrasion & corrosion resistance.

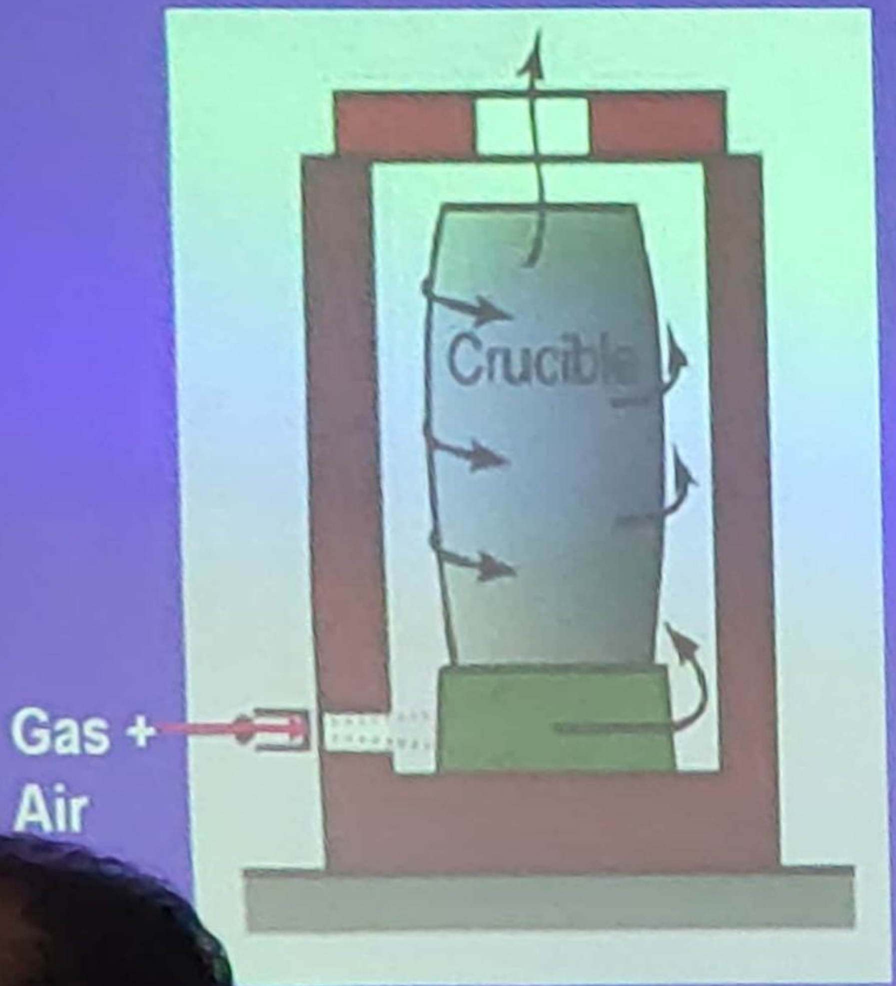
Melting & Pouring Temperatures

S. No	Metal / Alloy	Melting temperature (°C)	Pouring temperature range (°C)
1.	Gray Cast Iron	1370	1510 – 1590
2.	Cast steel	1480	1600 – 1720
3.	Copper	1083	1130 – 1200
4.	Nickel	1453	1500 – 1590
5.	Aluminum	660	700 – 760
6.	Zinc	420	450 – 480
7.	Lead	327	350 – 380
8.	Tin	232	280 – 290
9.	Cu- 4.0 Ni alloy	1175	1220 – 1280
10.	Gun metal (Cu-85%, Sn-5%, Zn-5%, Pb-5%)	1040	1100 – 1180

Important furnaces used in melting

1. Crucible furnace
2. Cupola furnace
3. Electric arc furnace
4. Induction furnace
5. Resistance furnace
6. Rotary furnace
7. Reverberatory furnace

CRUCIBLE FURNACE



CRUCIBLE MATERIAL

Graphite

+ Silicon carbide

+ Clay

+ Resin etc.

FUELS USED

- Coke
- Oil
- Gas

Advantages of Crucible Furnace

1. Low installation costs.
2. Low melting losses.
3. Uniform heating of the charge.

Application of Crucible Furnace

- Useful for melting non-ferrous metals / alloys.

CUPOLA FURNACE

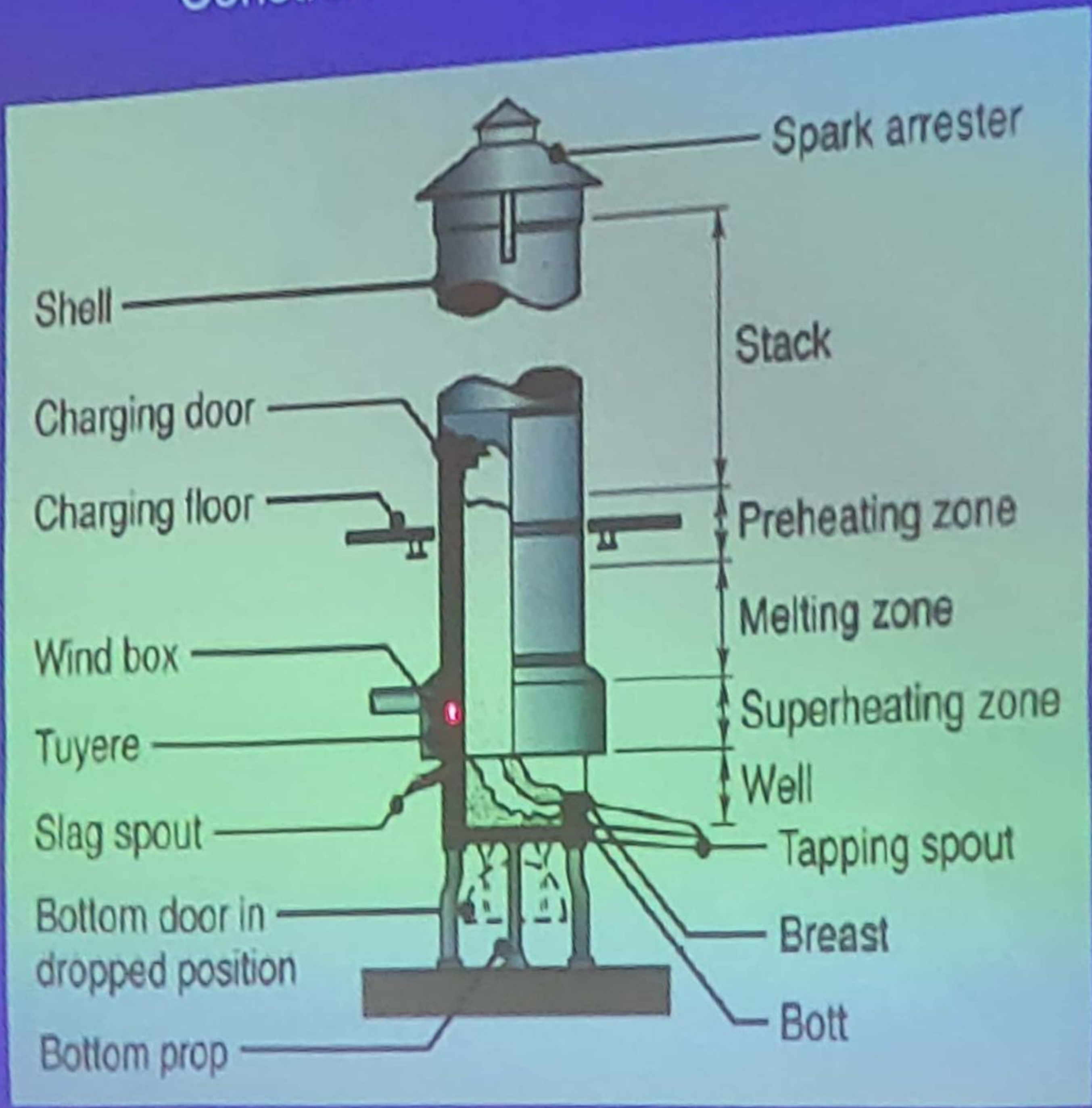
It is the oldest and simplest furnace.

'Cupola' is derived from Latin word 'Cupa', which means cask or barrel.

It is very much alike to a blast furnace.

It is used to melt Cast Iron and Steel.

Construction details of a cupola



Steps in operation of a cupola

1. Preparation / repair of refractory lining.

2. Lighting and burning in the coke bed.

3. Charging (Metal + Coke + Flux).

4. Melting
   - a). Starting the air blast.
   - b). Charging.

5. Tapping and slagging.

6. Dropping the bottom.

Merits of Cupola Furnace

1. Simple construction.
2. Low initial cost.
3. Simple to operate.
4. Relatively very low operating cost.
5. Offers very high melting rate. (1 to 35 tons / hour).
6. It can be operated continually.
7. Electric power is not required.

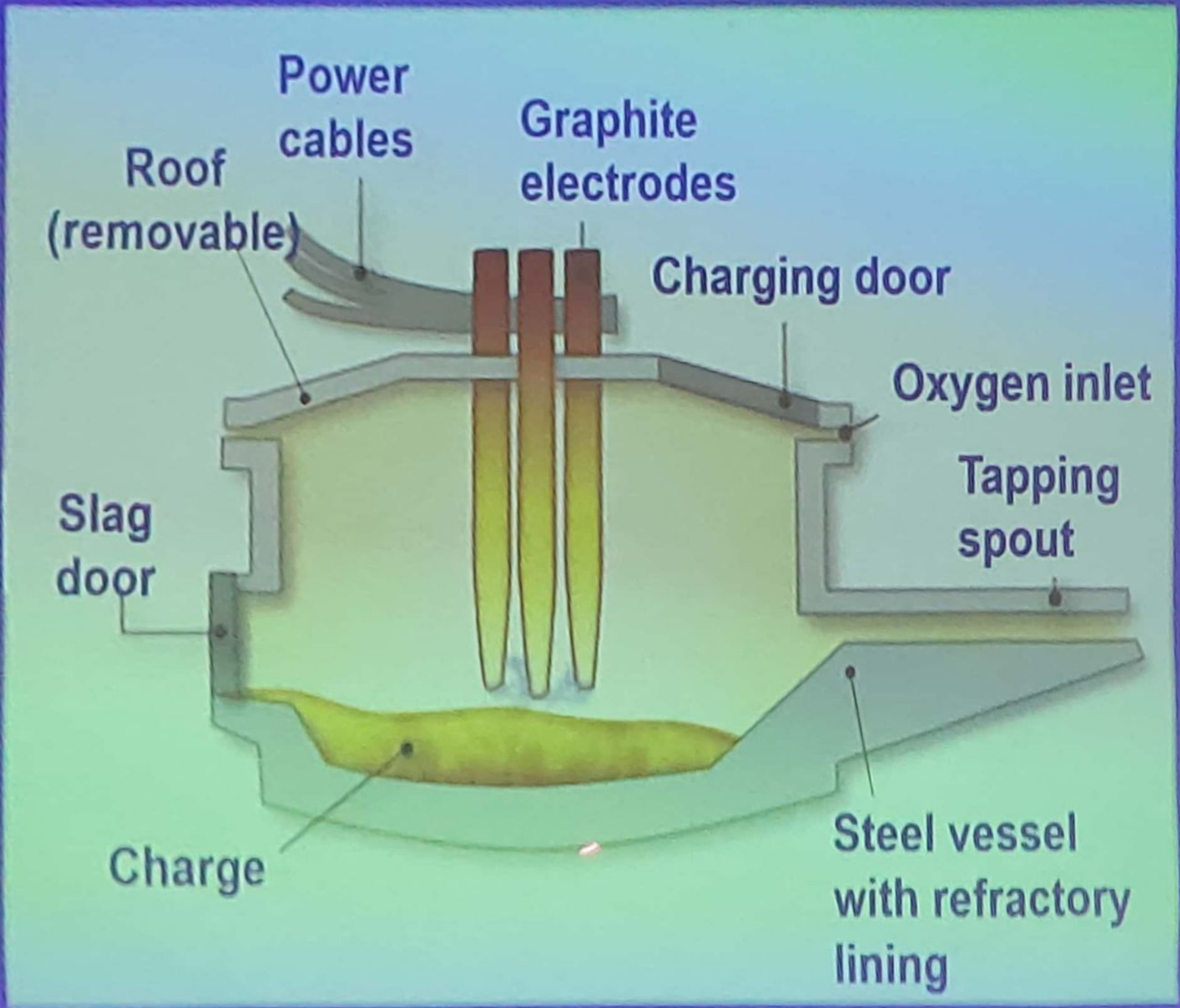
Demerits of Cupola Furnace

1. Close temperature control is not possible.
2. Carbon and Sulfur pickup takes place during melting. (Composition of Cast Iron is affected).
3. Loss of Iron, Silicon and Manganese takes place during melting. (Due to oxidation).
4. Precise control of composition is difficult.
5. Environmental pollution takes place.

Composition of Cast Iron:

ELEMENT	RANGE (%)
Carbon	2.1 - 4.0
Silicon	0.5 - 3.0
Manganese	0.15 - 1.0
Sulfur	0.03 - 0.25
Phosphorus	0.05 - 1.0
Iron	Balance

ELECTRIC ARC FURNACE



Types of Arc Furnaces

1. **SINGLE PHASE** - generally used for melting non-ferrous alloys.

2. **THREE PHASE** - generally used for melting steels.

Advantages of Arc Furnace

1. Precise control of composition is possible.
2. Close temperature control is possible.
3. Higher thermal efficiency.
4. Quality of molten metal is high.
5. Metal can be melted in short duration.

Limitations of Arc Furnace

1. High power consumption. High melting costs.
2. High installation costs.
3. Chances for oxidation of liquid metal.
4. Chances for carburization of liquid metal.

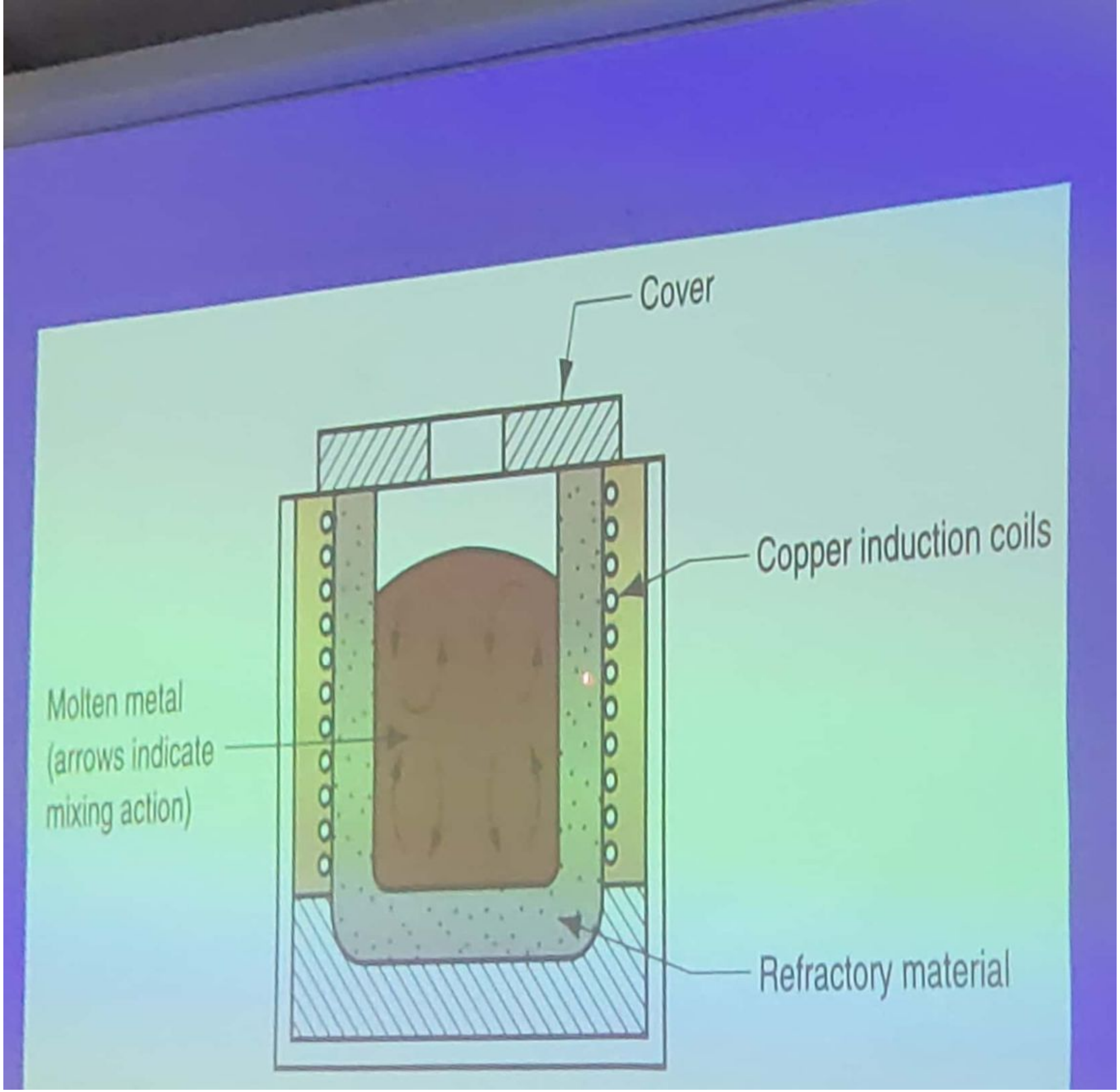
INDUCTION FURNACE

PRINCIPLE: Electromagnetic Induction

High frequency current is passed through water cooled copper coils. (Primary coil).

Secondary currents are induced in the metal charge by electromagnetic induction.

Metal charge offers resistance to the passage of secondary current and develop heat.


Cover
Copper induction coils
Molten metal
(arrows indicate
mixing action)
Refractory material

Advantages of Induction Furnace

1. Narrow melting vessel (Low d/h ratio). Less oxidation.
2. Low crucible wall thickness. Less expensive.
3. Relatively small area of metal in contact with slag.
4. No carburizing during melting down.
5. Magnetic stirring of the melt produces excellent uniformity of the melt composition.
6. Melting takes considerably less time.

Limitations of Induction Furnace

1. Initial cost of the furnace and its auxiliary equipments is high.

2. Not suitable for melting large quantities of metal.

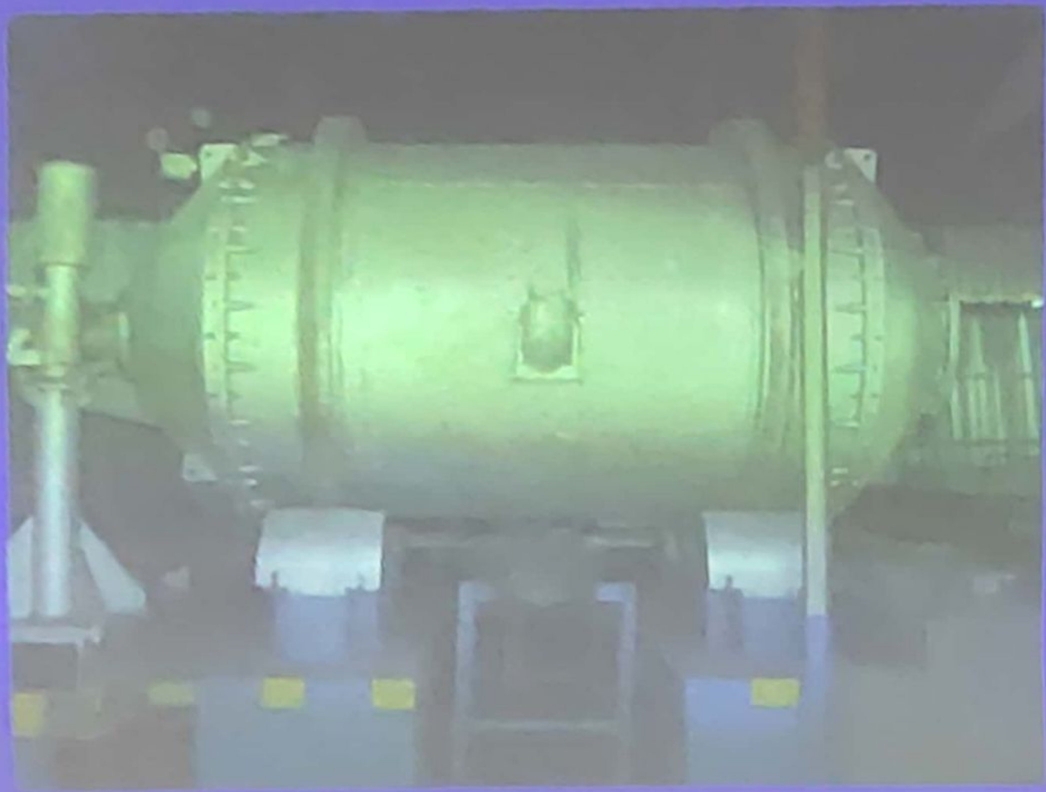
Types of Induction Furnaces

1. **Low Frequency Induction Furnace**
   (Used to melt Non-ferrous alloys)

2. **High Frequency Induction Furnace**
   (Used to melt Steel and Alloy steels)

ROTARY FURNACE

It is a horizontal cylindrical steel shell.



The steel shell is lined with refractory material inside.

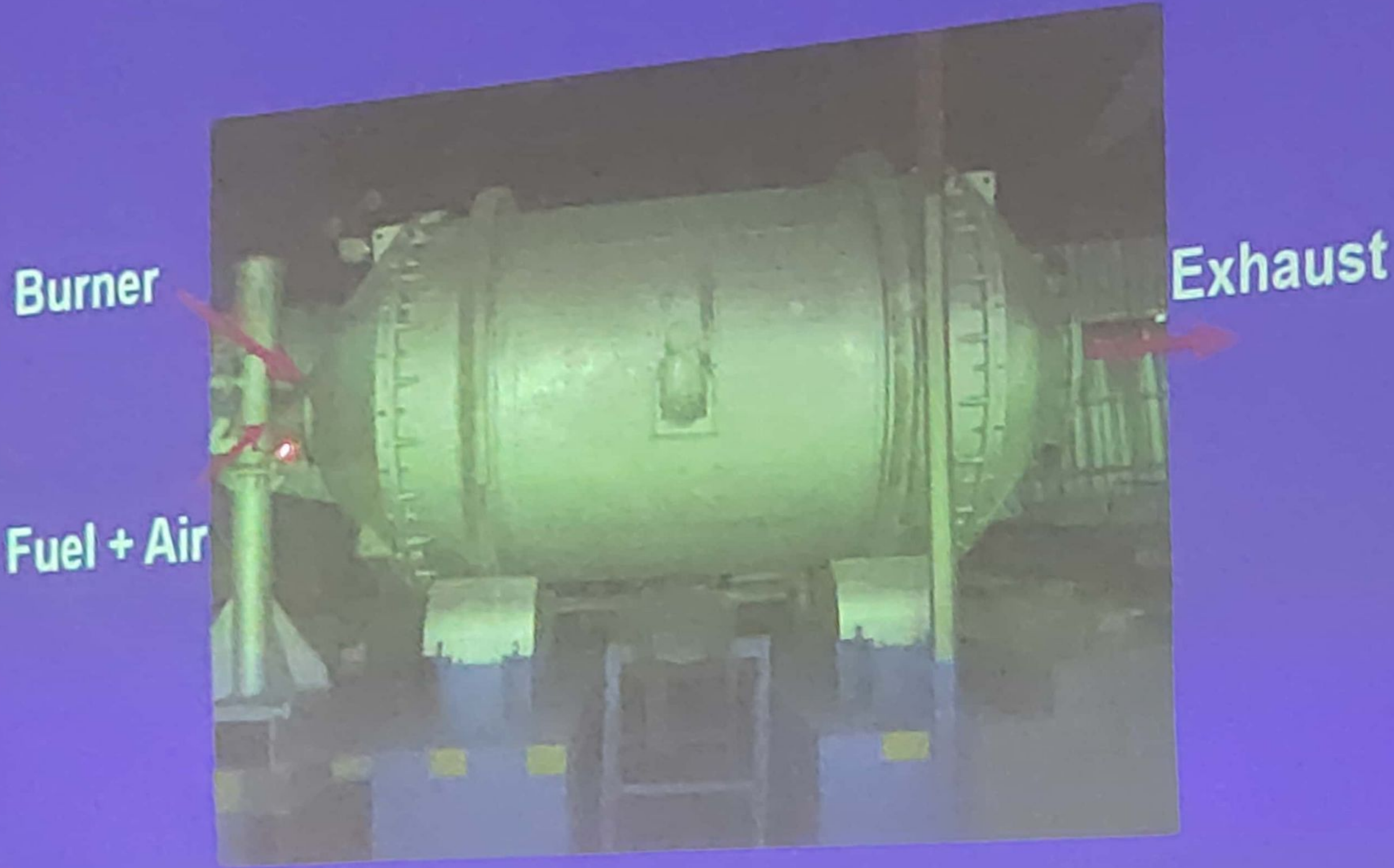
The shell is mounted on rollers.

The cylindrical shell revolves at about 1 RPM.

Rollers

FUEL: Pulverized coal or Oil

Metal to fuel ratio is 5:1 (coal) or 6:1 (oil)



Advantages of Rotary Furnace

1. Molten metal does not come in contact with fuel. Hence no Carbon or Sulphur pickup.

2. Liquid metal from cupola can be super heated in a rotary furnace.

3. Alloying of certain elements like Mo, Ni, Cr etc can be successfully done. (Loss of alloying in Cupola).

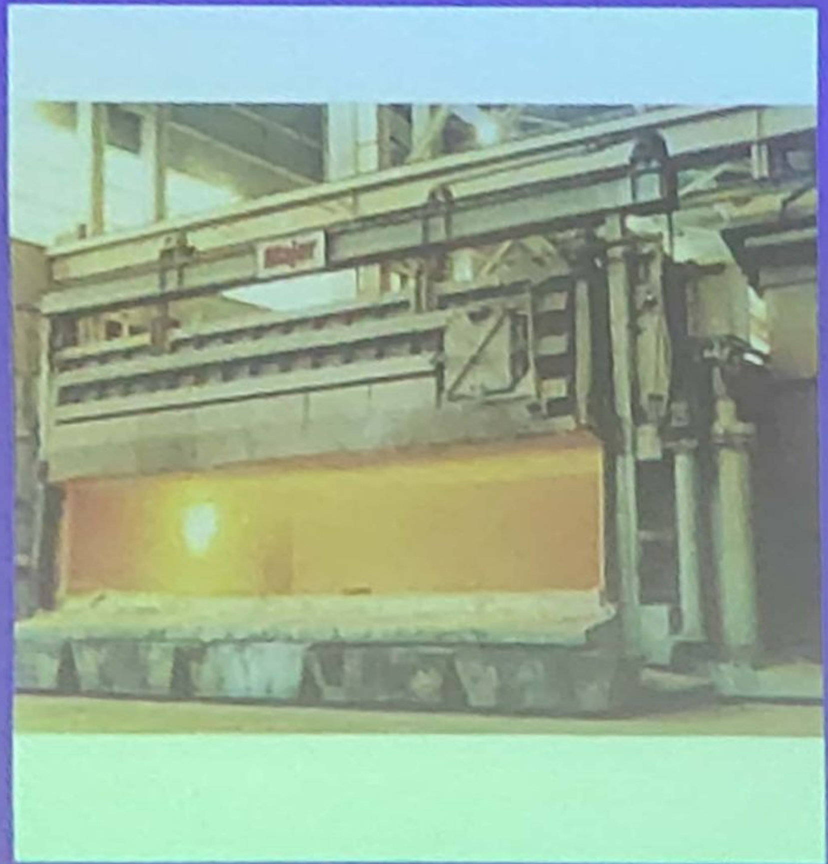
Application

Used to **melt** and **superheat** Cast iron and Non-ferrous alloys.

REVERBERATORY FURNACE

It is a long rectangular structure with removable arched roof.

FUEL: Oil or pulverized coal.



Casting Defects

CLASSIFICATION OF DEFECTS

1. **DEFECTS DUE TO EVOLUTION OF GASES**
   (Blowholes, Pin hole porosity, Dispersed shrinkage, Blister, etc.)

2. **DEFECTS DUE TO POURING OF THE MELT**
   (Mis-run, Cold shut, Inclusion, etc.)

3. **DEFECTS DUE TO METALLURGICAL FACTORS**
   (Hot tears)

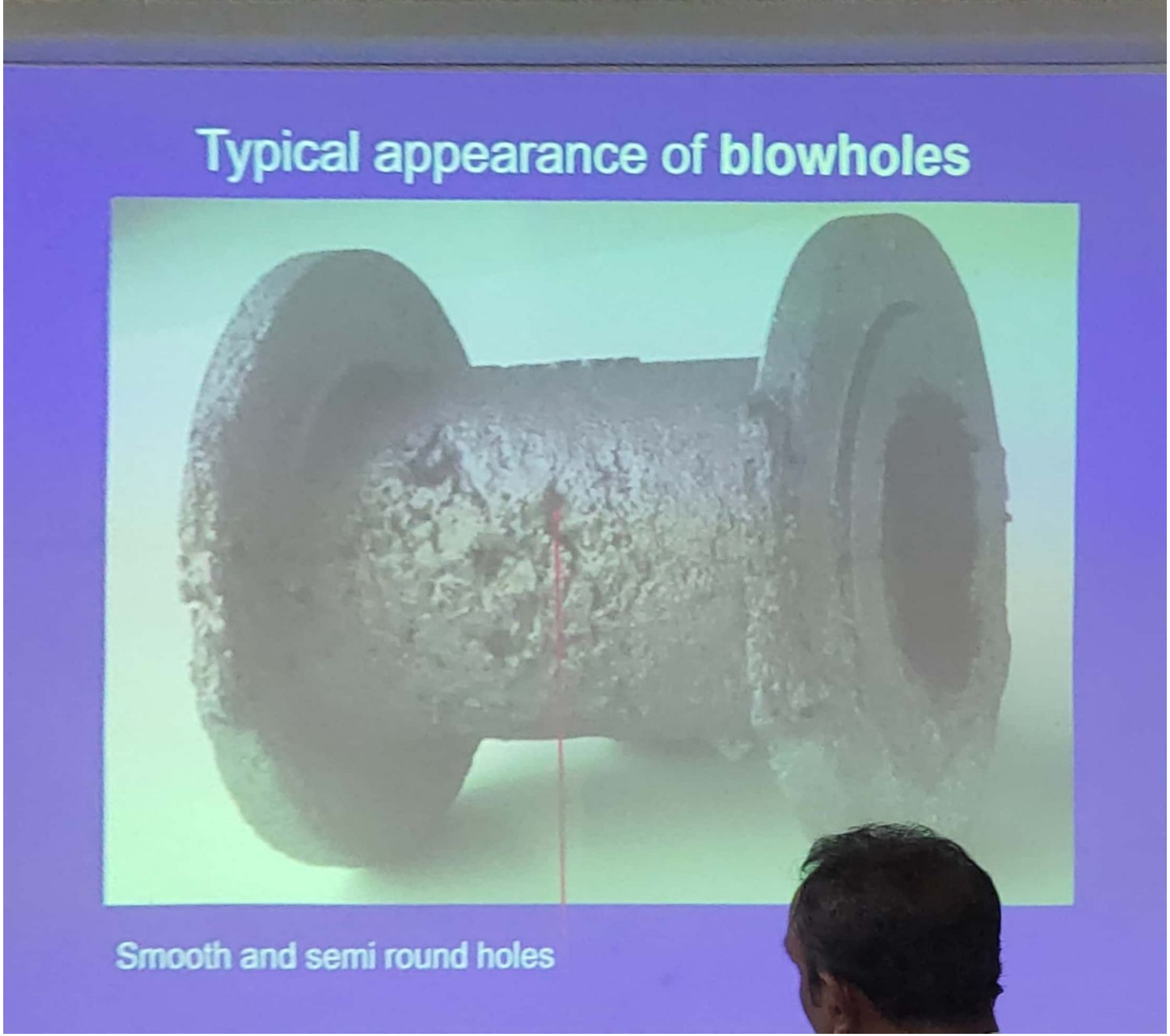
4. **DEFECTS CAUSED BY MOULDING MATERIAL**
   (Scab, Metal penetration, Flash, Run-out, Lug, etc.)

5. **DEFECTS DUE TO SHRINKAGE**
   (Shrinkage cavity)

Defects due to evolution of gases

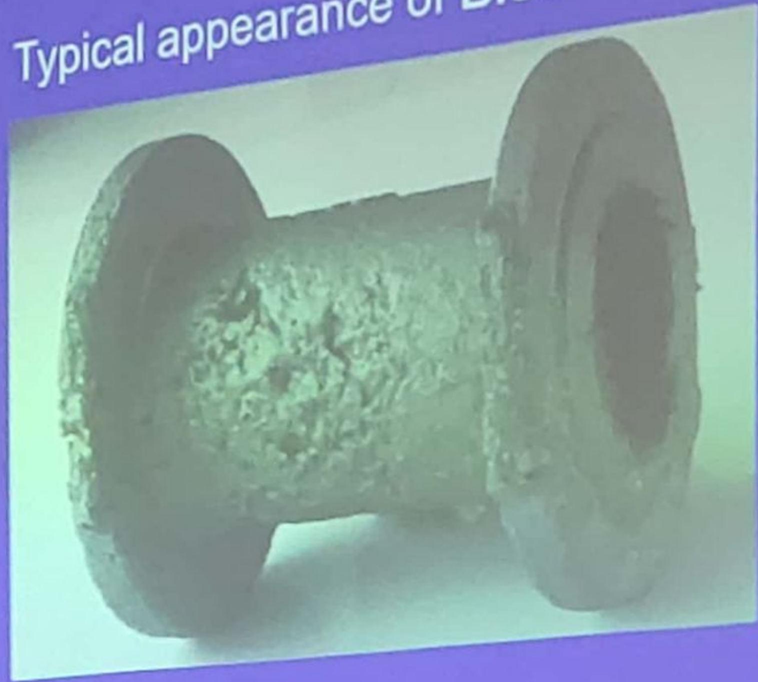
1. Blowholes

2. Pin hole porosity


Typical appearance of blowholes
Smooth and semi round holes

Blowholes

Typical appearance of **Blowholes**



CAUSES

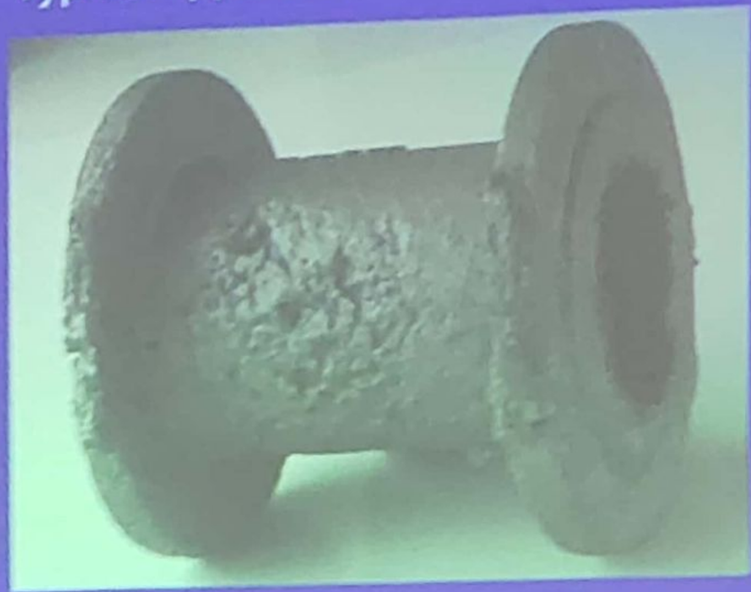
1. Excessive moisture in the mould.
2. Slag in the metal reacts with carbon in the metal and liberates CO.
3. Iron oxide on the mould wall reacts with carbon in the metal and liberates CO.

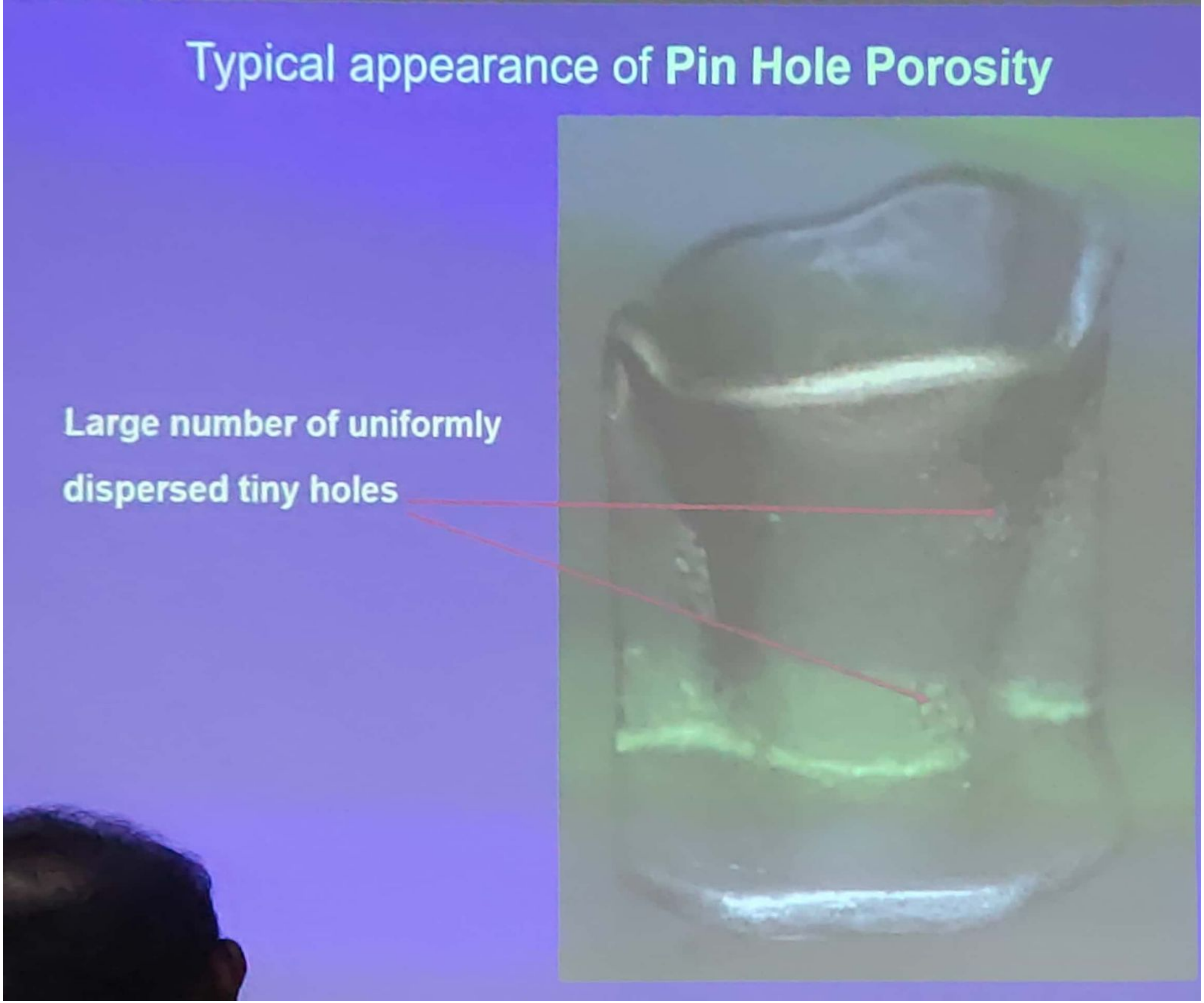
Blowholes

REMEDIAL MEASURES:

1. Provide vent holes.
2. Avoid excessive compaction of mould.
3. Avoid excessive moisture in the moulding sand.
4. Extra care to be taken to segregate slag from liquid metal.
5. Avoid using rusted chills and chaplets.

Typical appearance of **Blowholes**




Typical appearance of Pin Hole Porosity
Large number of uniformly dispersed tiny holes

Pin Hole Porosity

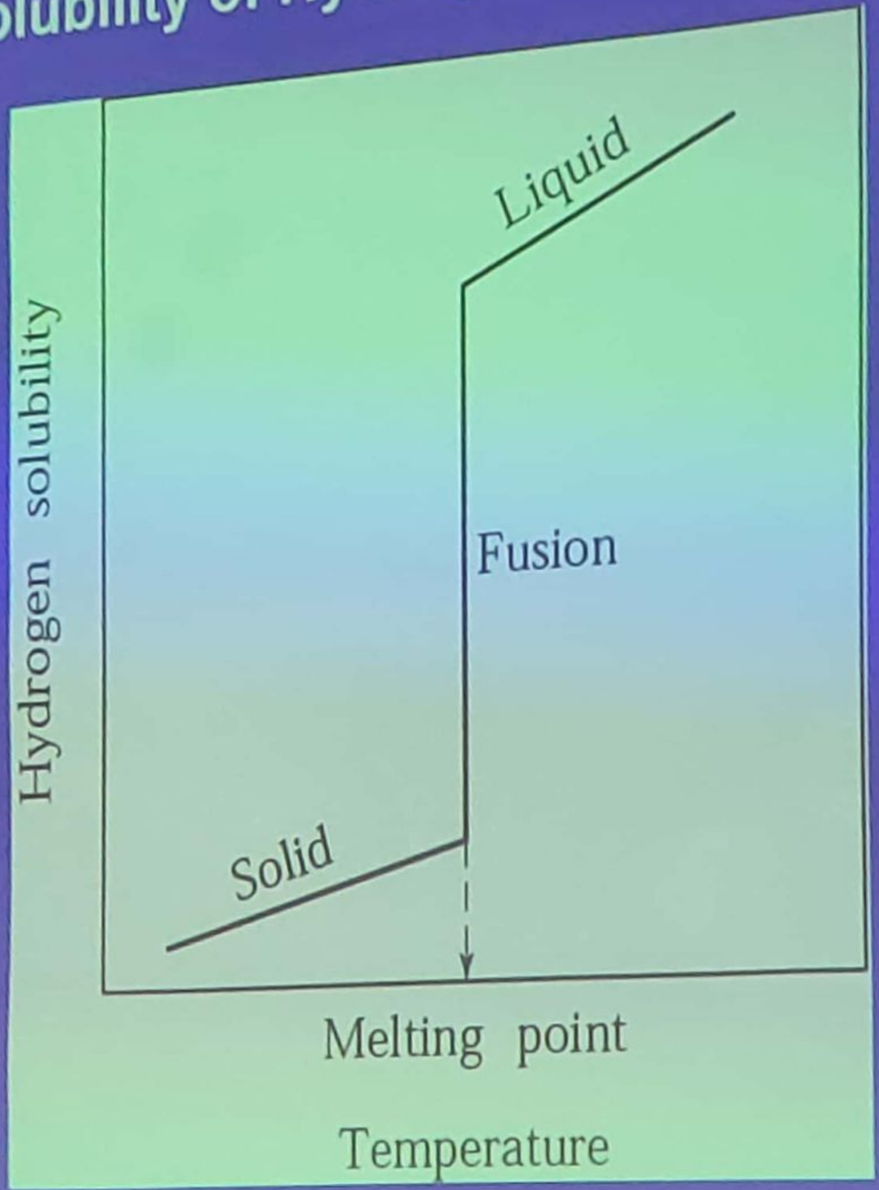
CAUSES:

Hydrogen is absorbed by the molten metal inside the furnace and also inside the cavity.

As the melt gets solidified, it loses the temperature and liberates dissolved hydrogen.

Typical appearance of
Pin Hole Porosity

Solubility of Hydrogen in Aluminum

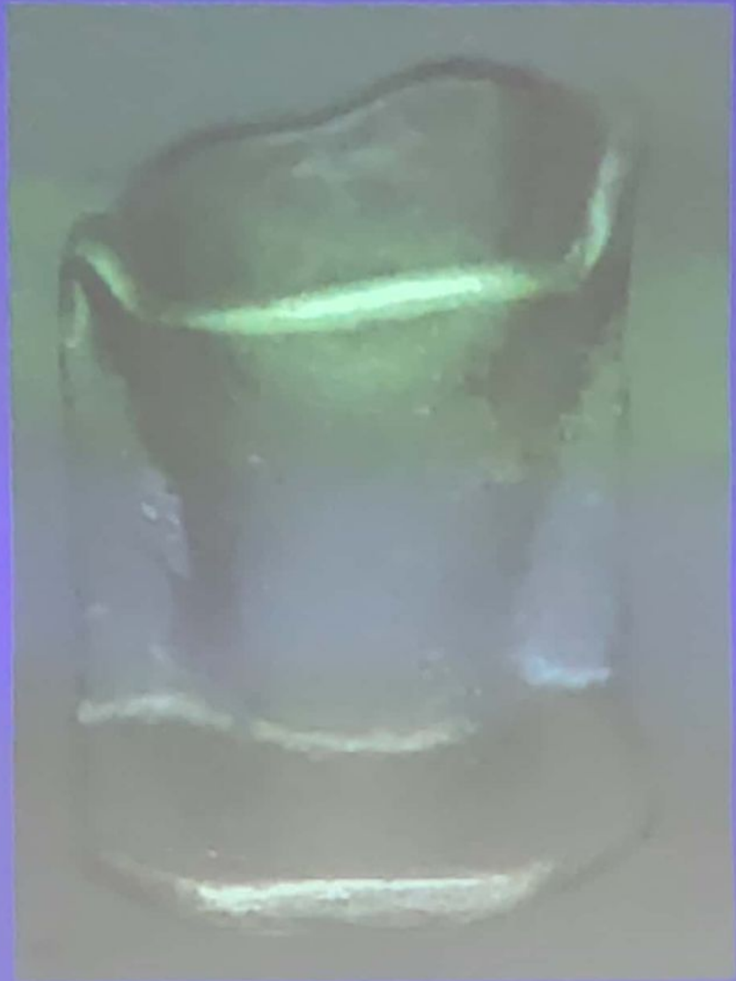


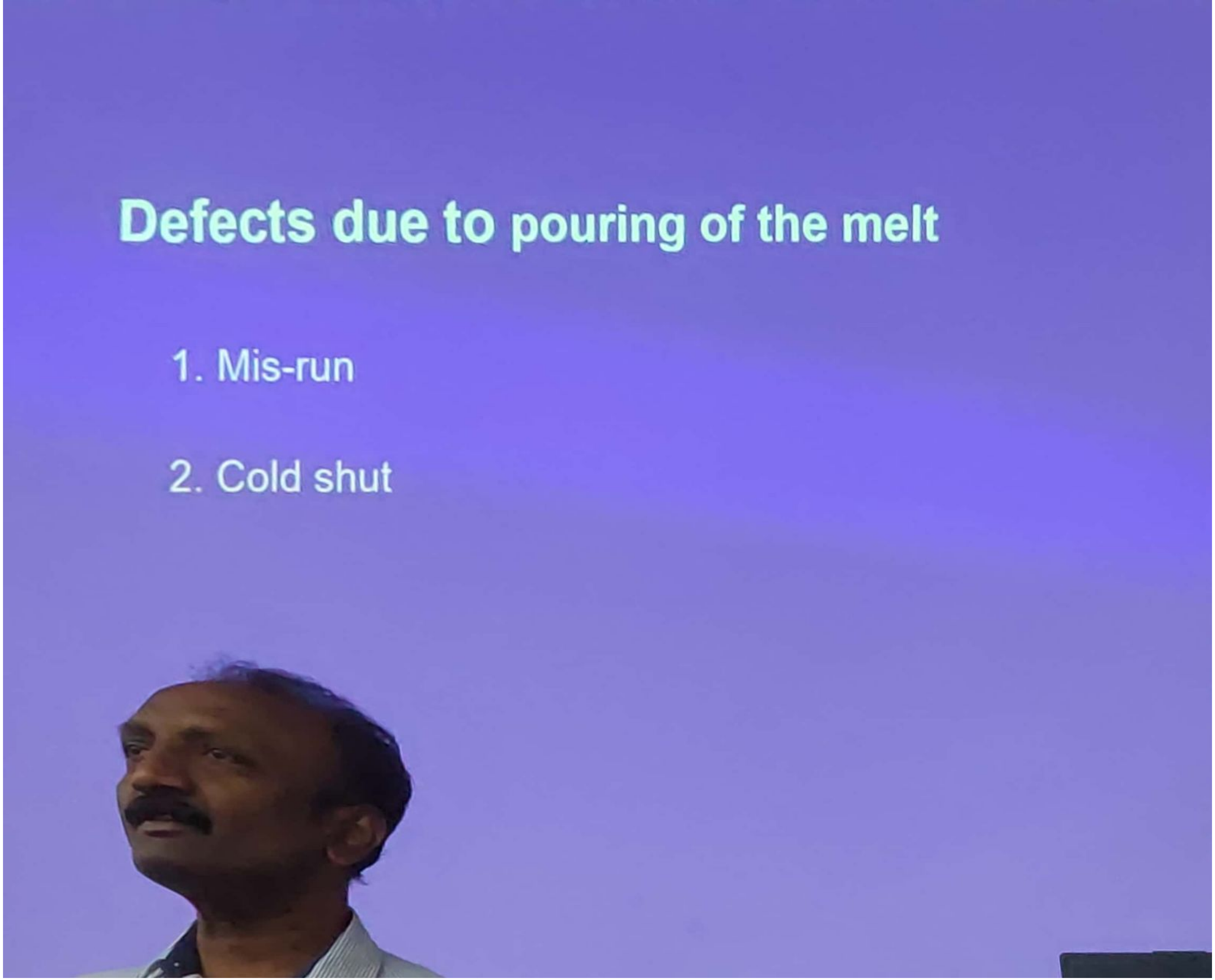
Pin Hole Porosity

REMEDIAL MEASURES:

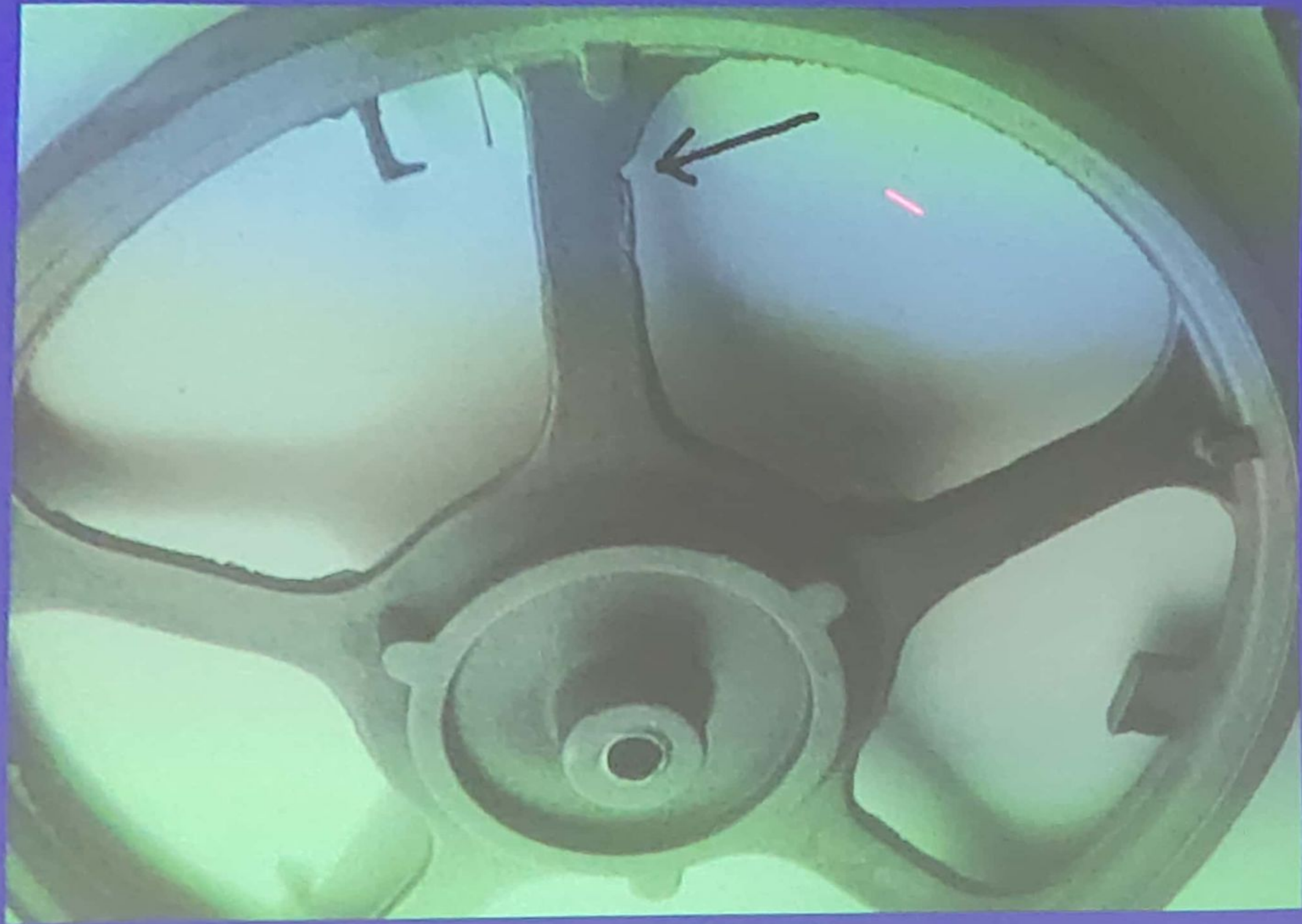
1. Vacuum melting
2. Vacuum degassing
3. Avoid very high pouring temperatures

Typical appearance of
Pin Hole Porosity



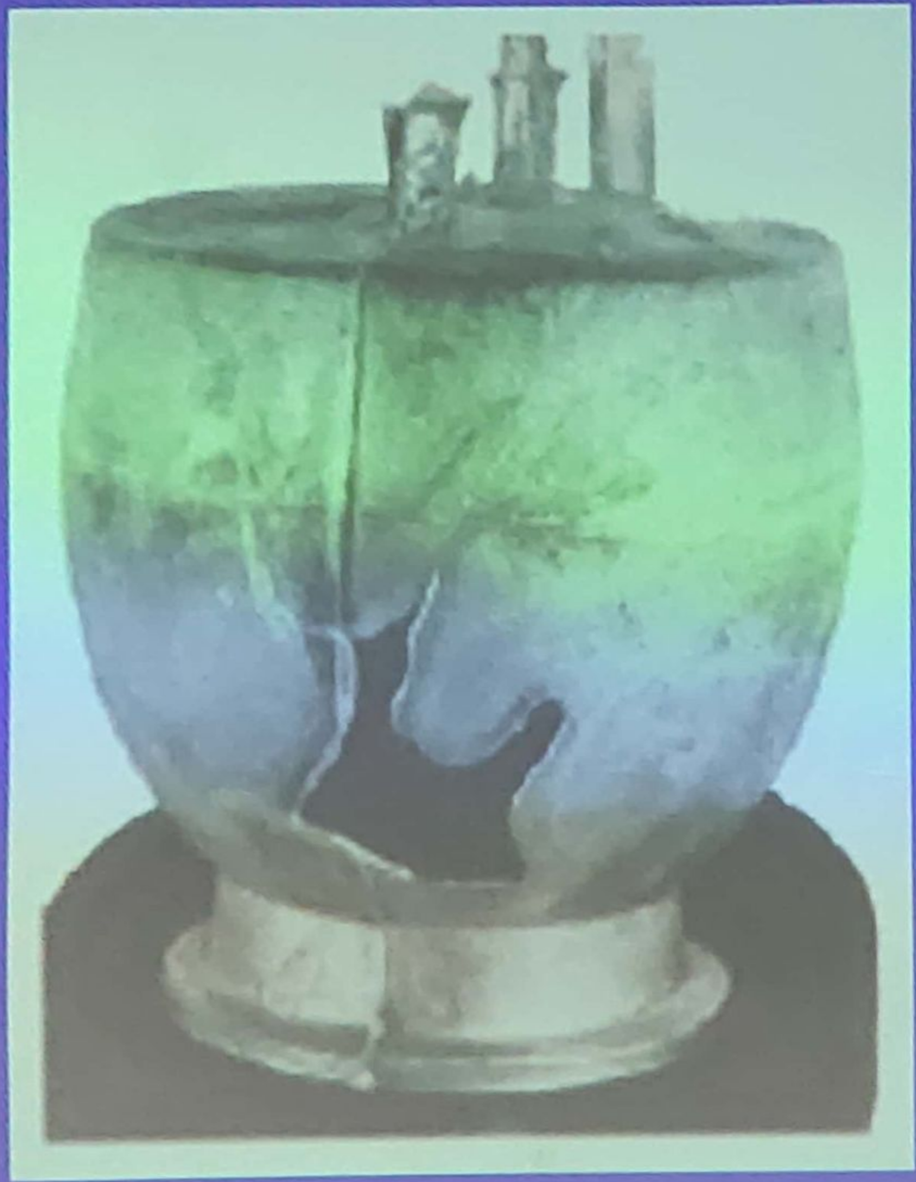

Defects due to pouring of the melt
1. Mis-run
2. Cold shut

Typical appearance of a **Mis-run**



Molten metal could not fill thin section of the mould cavity.

Typical appearance of a **Mis-run**

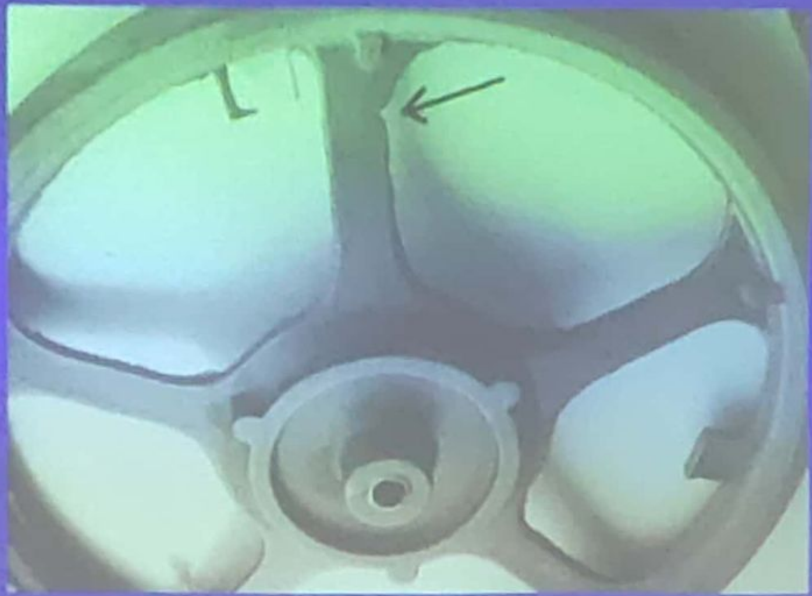


Mis-run

CAUSES:

1. Insufficient fluidity.
2. Low pouring temperature.
3. Too small ingates.
4. Low pouring speed.

Typical appearance of a Mis-run

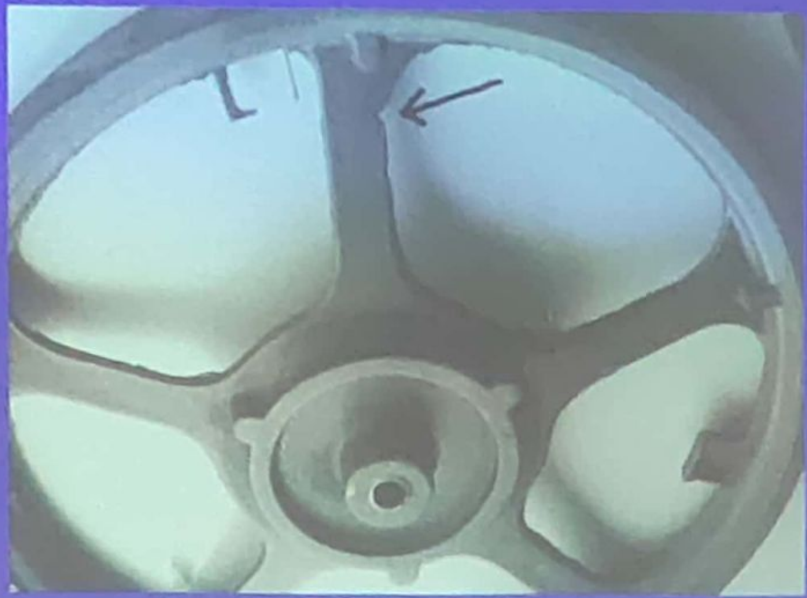


Mis-run

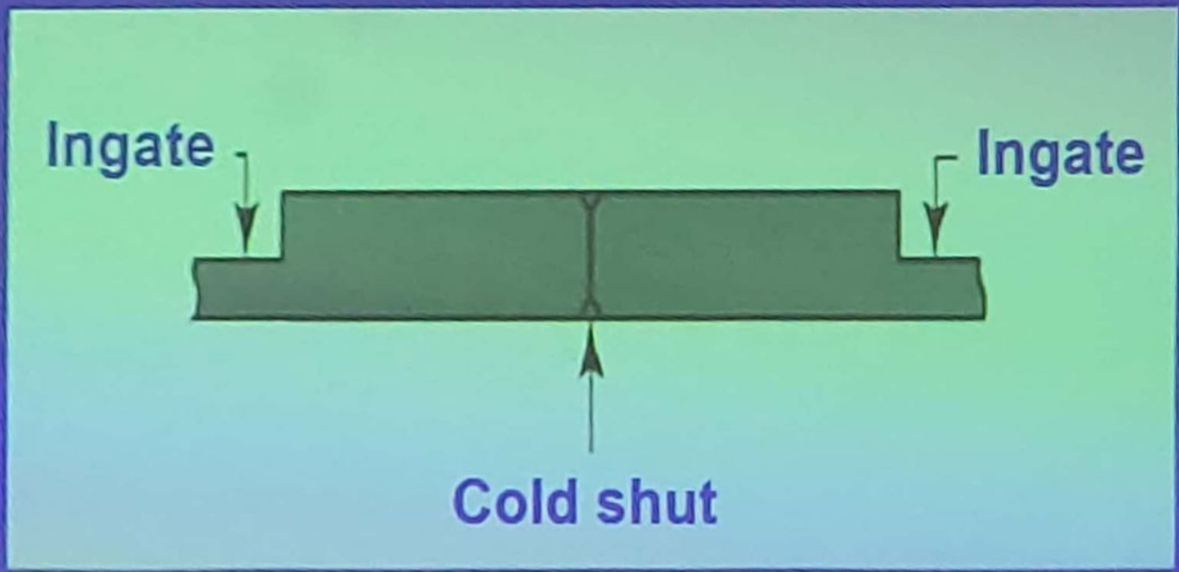
REMEDIAL MEASURES:

- Increase pouring temperature.
- Increase pouring speed.
- Make ingates larger.

Typical appearance of a **Mis-run**



Typical appearance of a **Cold shut**



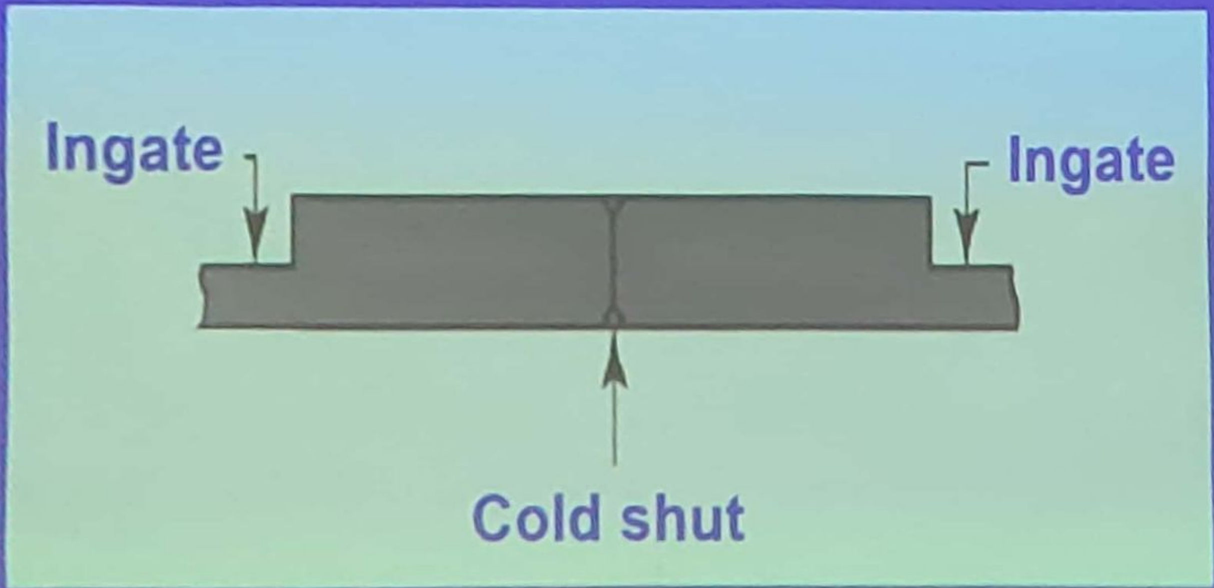
The molten metal streams from different ingates are not fused together properly, causing a discontinuity or weak spot.

Cold shut

CAUSES:

Longer distance between the ingates.

Large surface area to volume ratio.

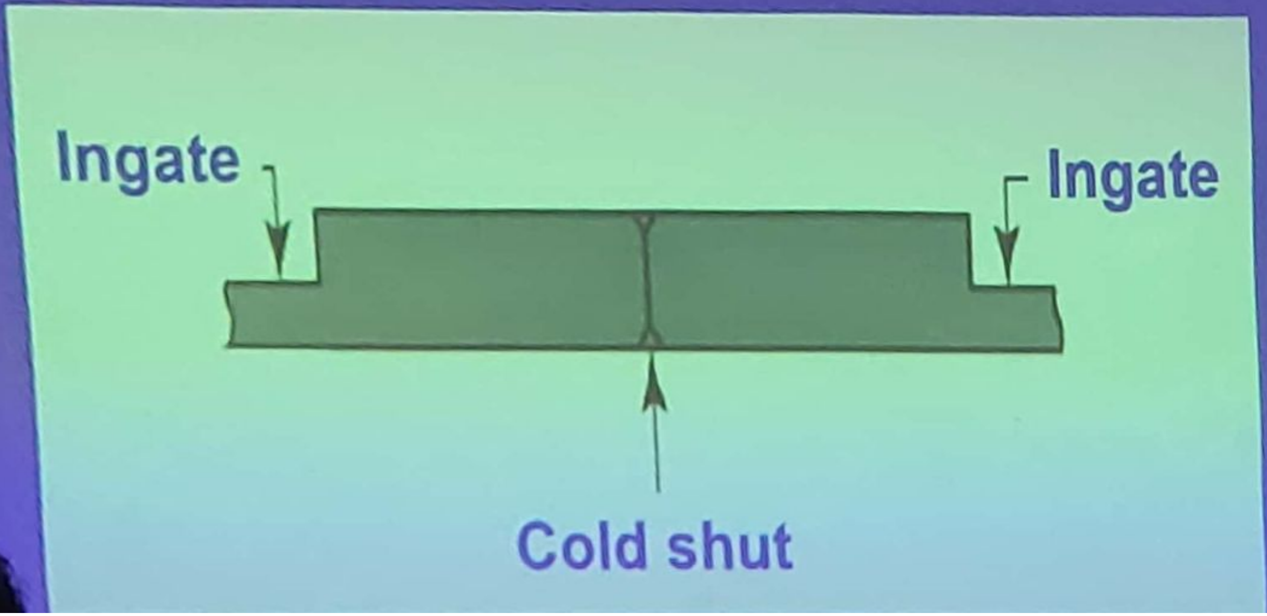


Cold shut

REMEDIAL MEASURES:

Use more number of ingates.

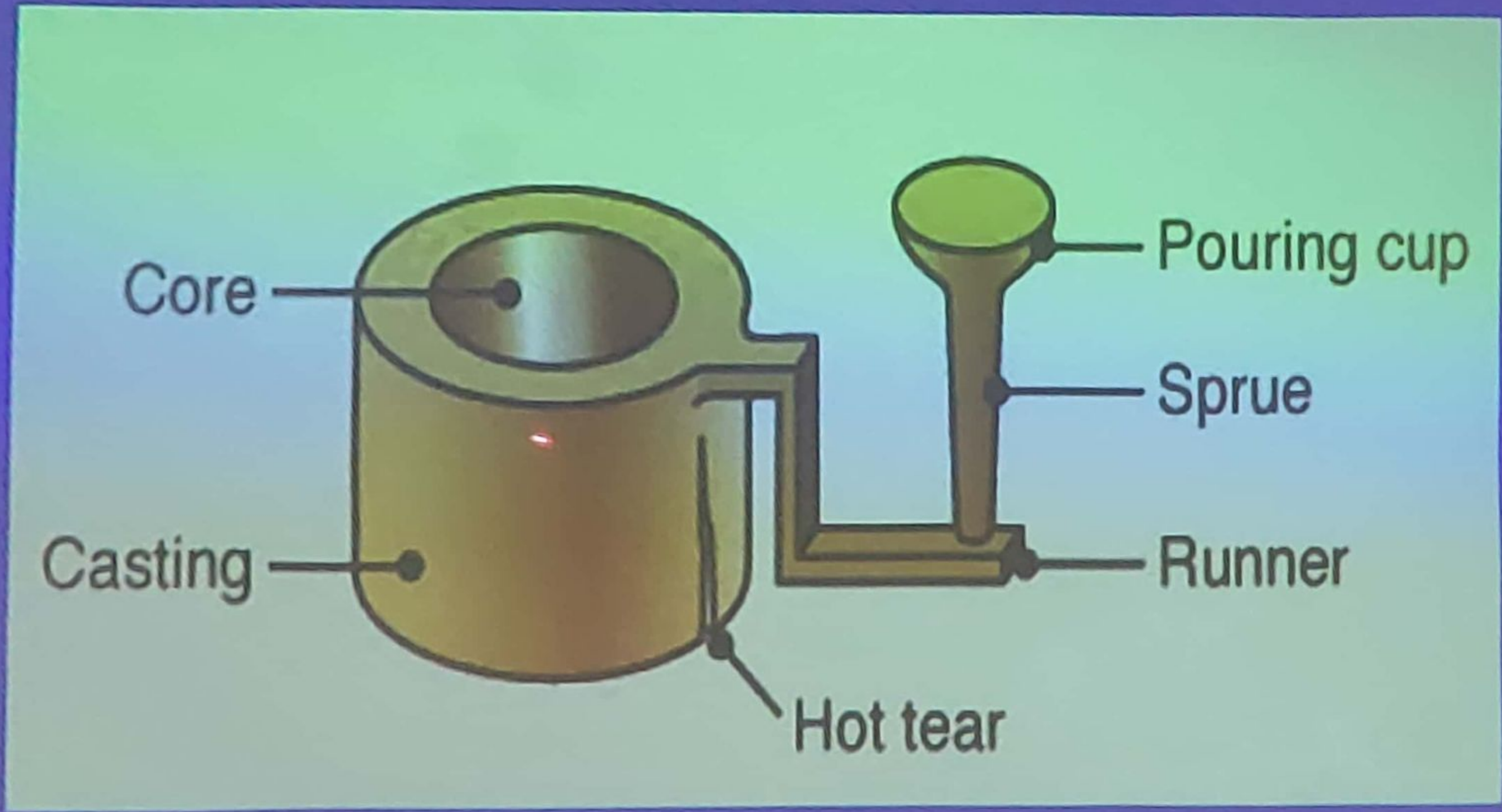
Increase the pouring temperature.



Defects due to metallurgical factors

1. Hot tears

Typical appearance of **Hot Tear**

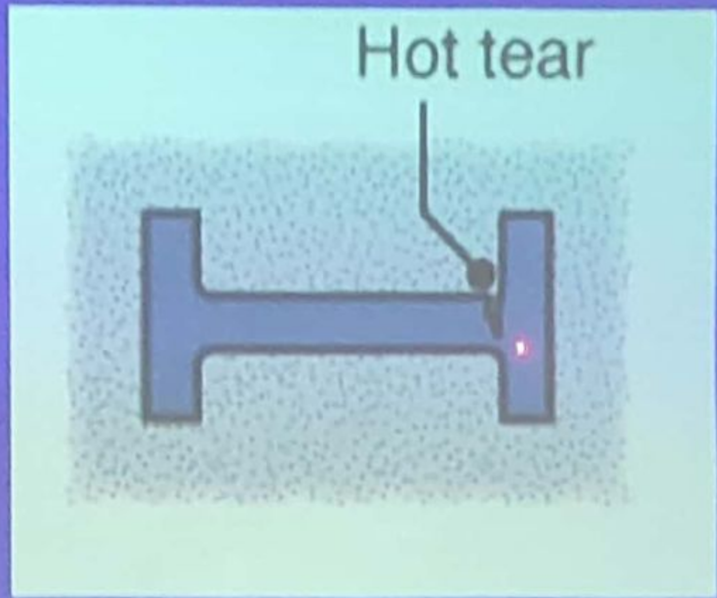


Hot tearing is the macroscopic separation due to differential contraction of the casting during solidification.

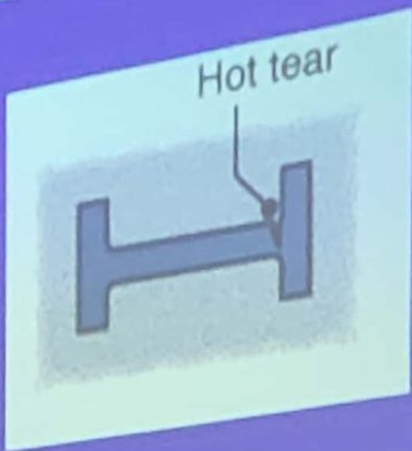
Hot Tears

CAUSES FOR HOT TEARS

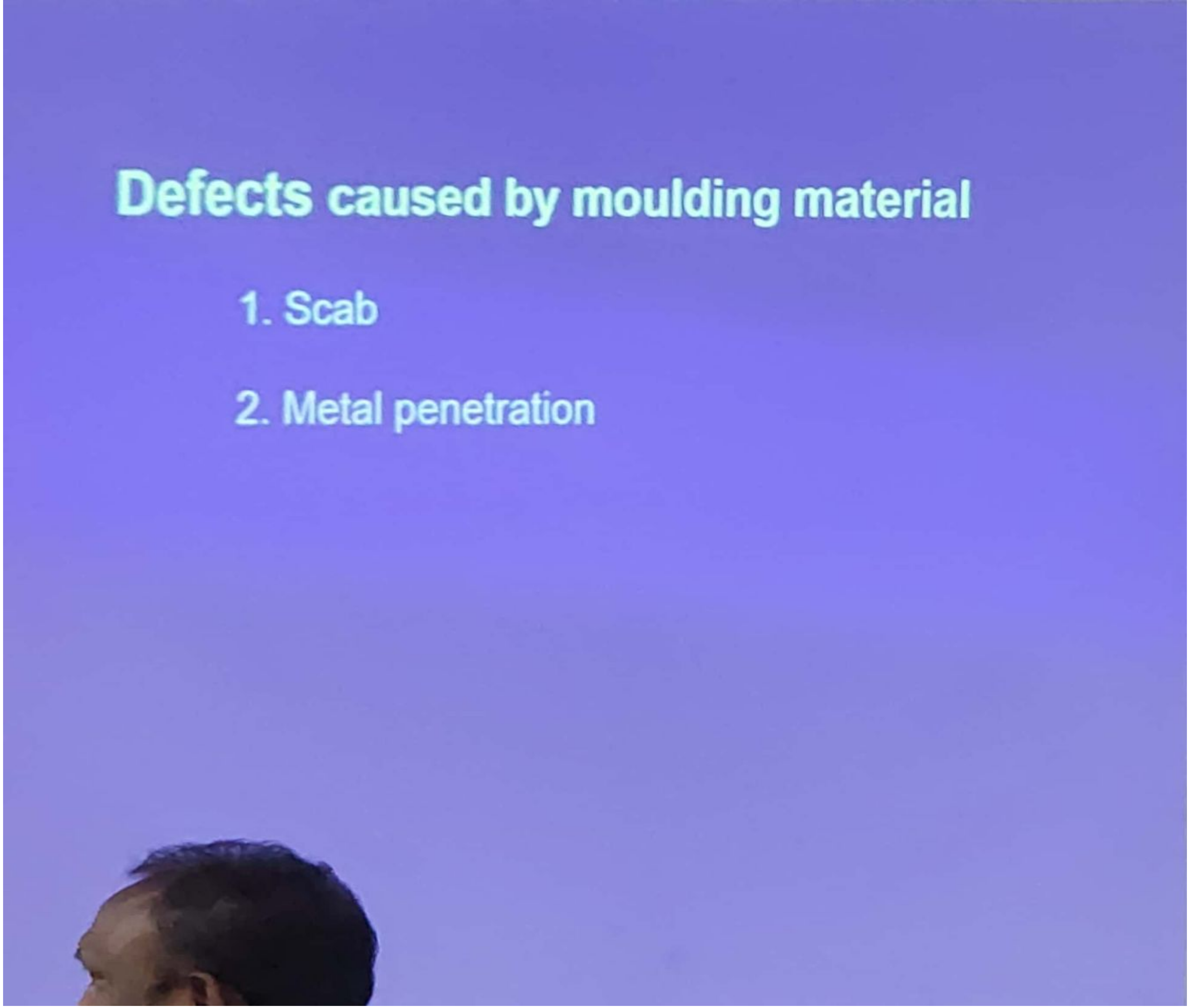
The casting could not undergo shrinkage freely during solidification, due to casting design or presence of cores.



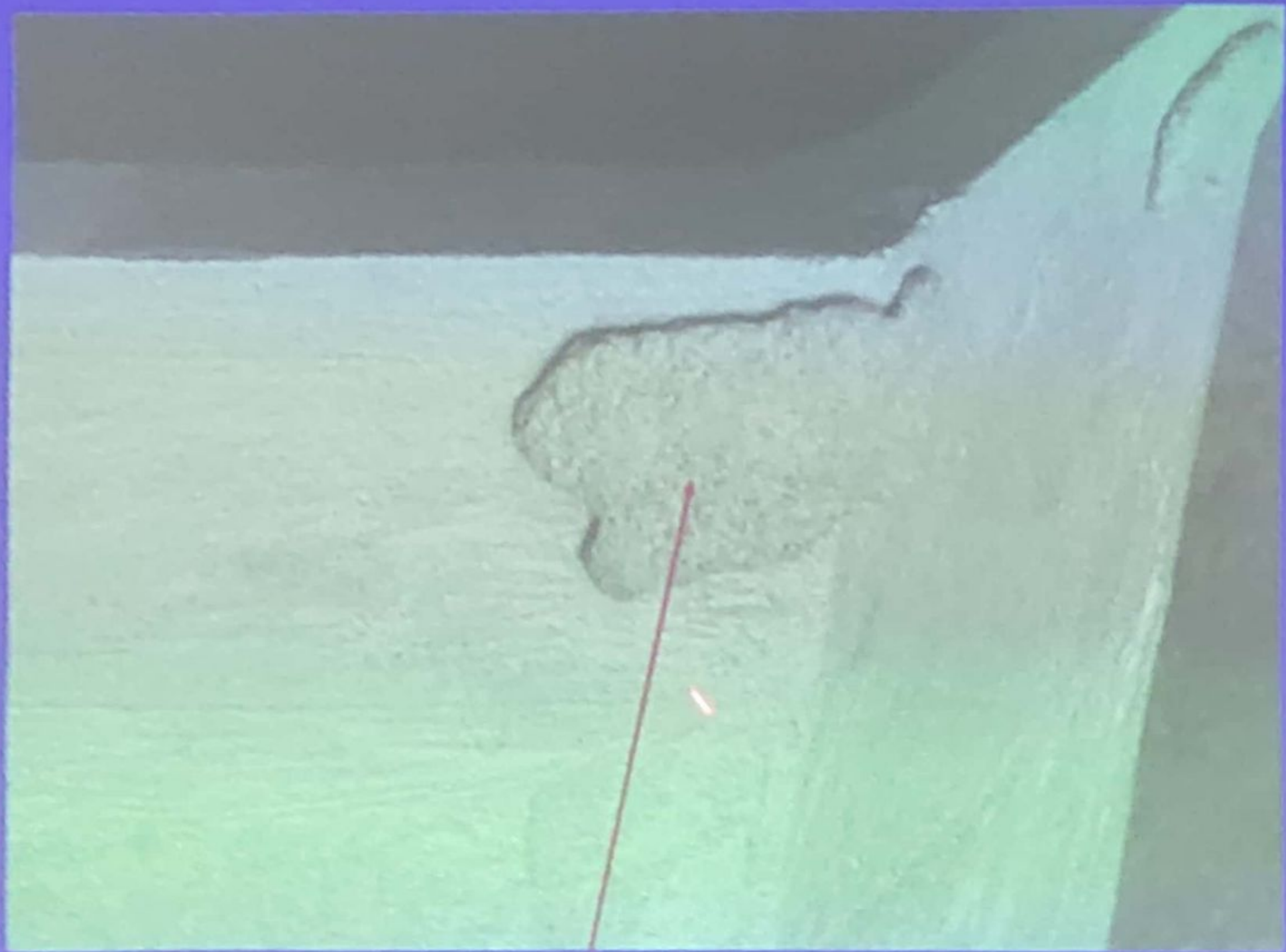
REMEDIAL MEASURES FOR HOT TEARS



1. Use exothermic pads.
2. Control the composition – minimize Sulphur content in the liquid metal.
3. Use grain refiners (Eg. Al-8B, Al-3B, Al-3Ti-0.15C, Al-5Ti-1B, etc.)


Defects caused by moulding material
1. Scab
2. Metal penetration

Typical appearance of **Scab**



Liquid metal flows beneath the mould surface and mixes with moulding sand.

Scab

CAUSES:

1. Low moisture content in the moulding sand (below 3 %).

2. Insufficient clay in the moulding sand.

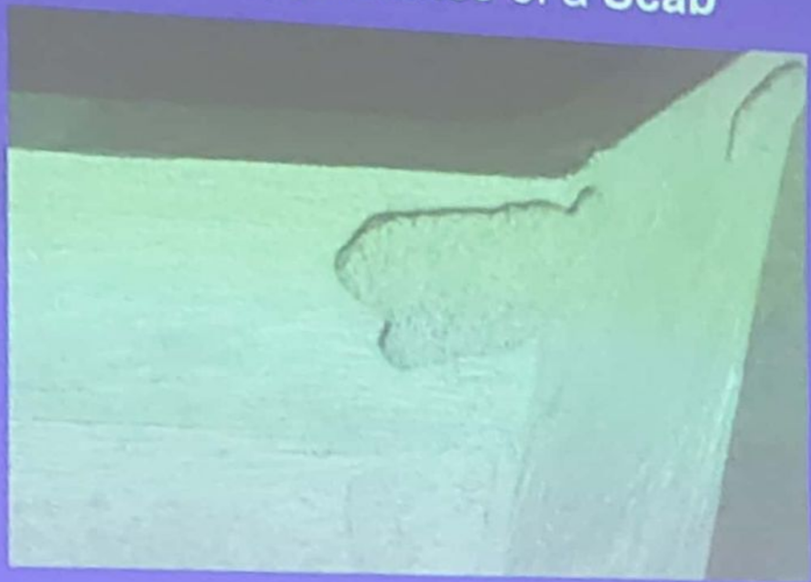
Typical appearance of a **Scab**

Scab

REMEDIAL MEASURES:

Proper moisture and clay contents are to be taken.

Typical appearance of a **Scab**



Typical appearance of **Metal Penetration**

Metal goes inside the mould.

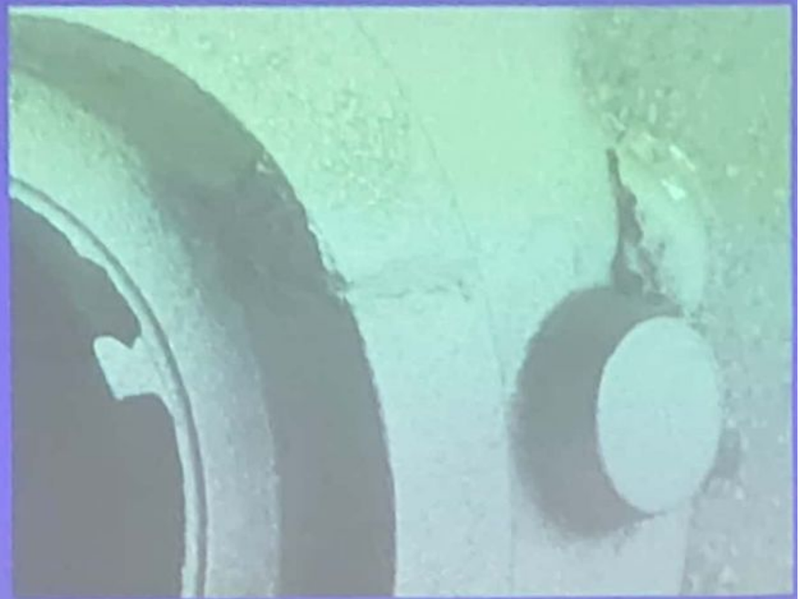
Metal Penetration

CAUSES:

1. Larger sand grains.

2. Insufficient compaction of sand.

Typical appearance of
Metal Penetration



Metal Penetration

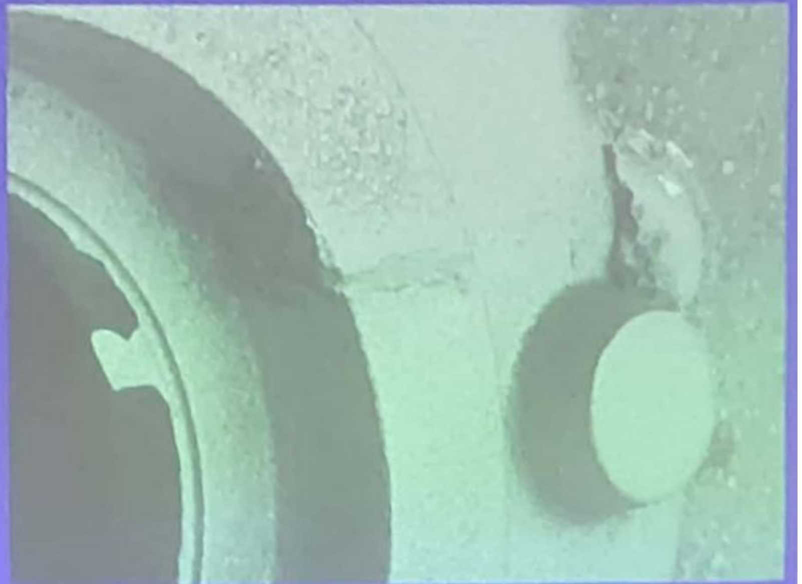
REMEDIAL MEASURES:

1. Use fine sand grains.

2. Reduce casting temperature.

3. Apply sufficient compaction of mould.

Typical appearance of
Metal Penetration



~~SHRINKAGE~~

"Defect due to Shrinkage:

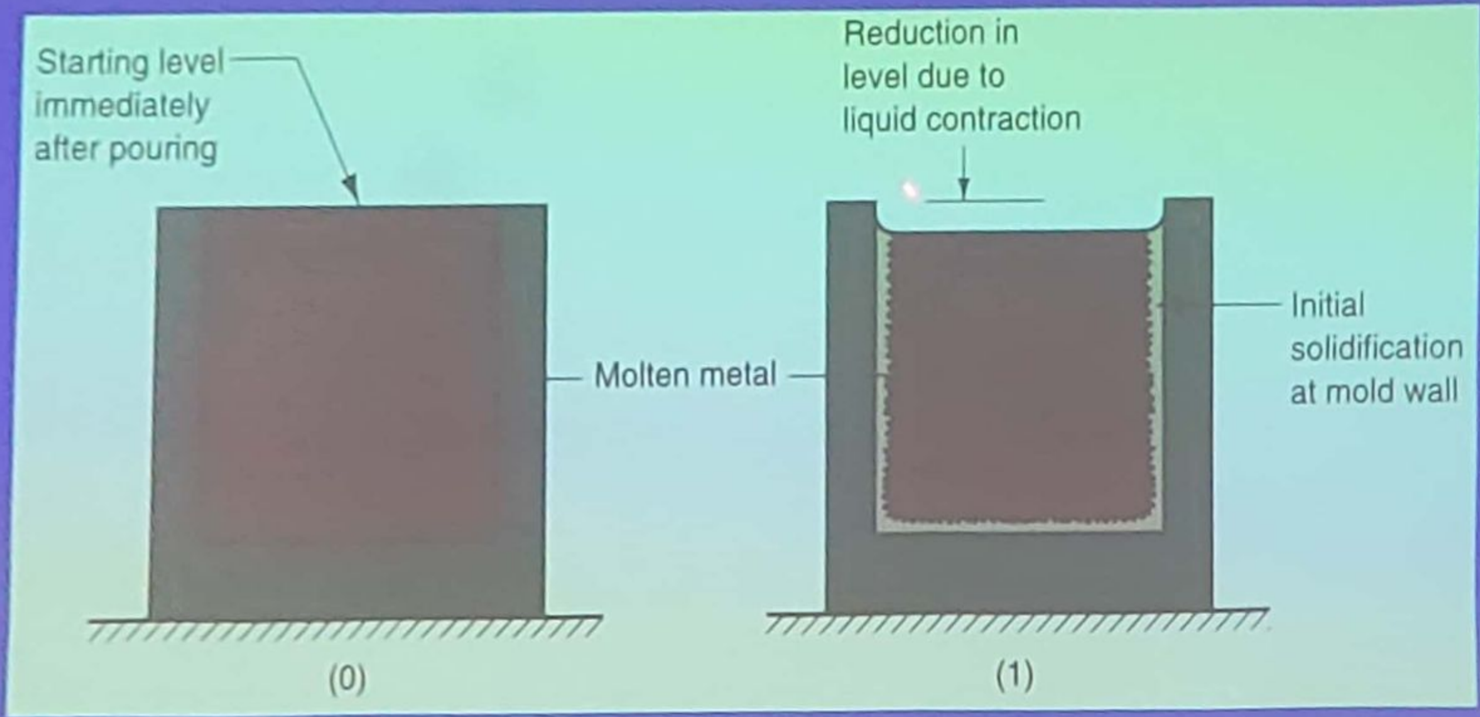
- Shrinkage Cavity.

Solidification Shrinkage

- Solidification causes a reduction in volume in almost all the metals.

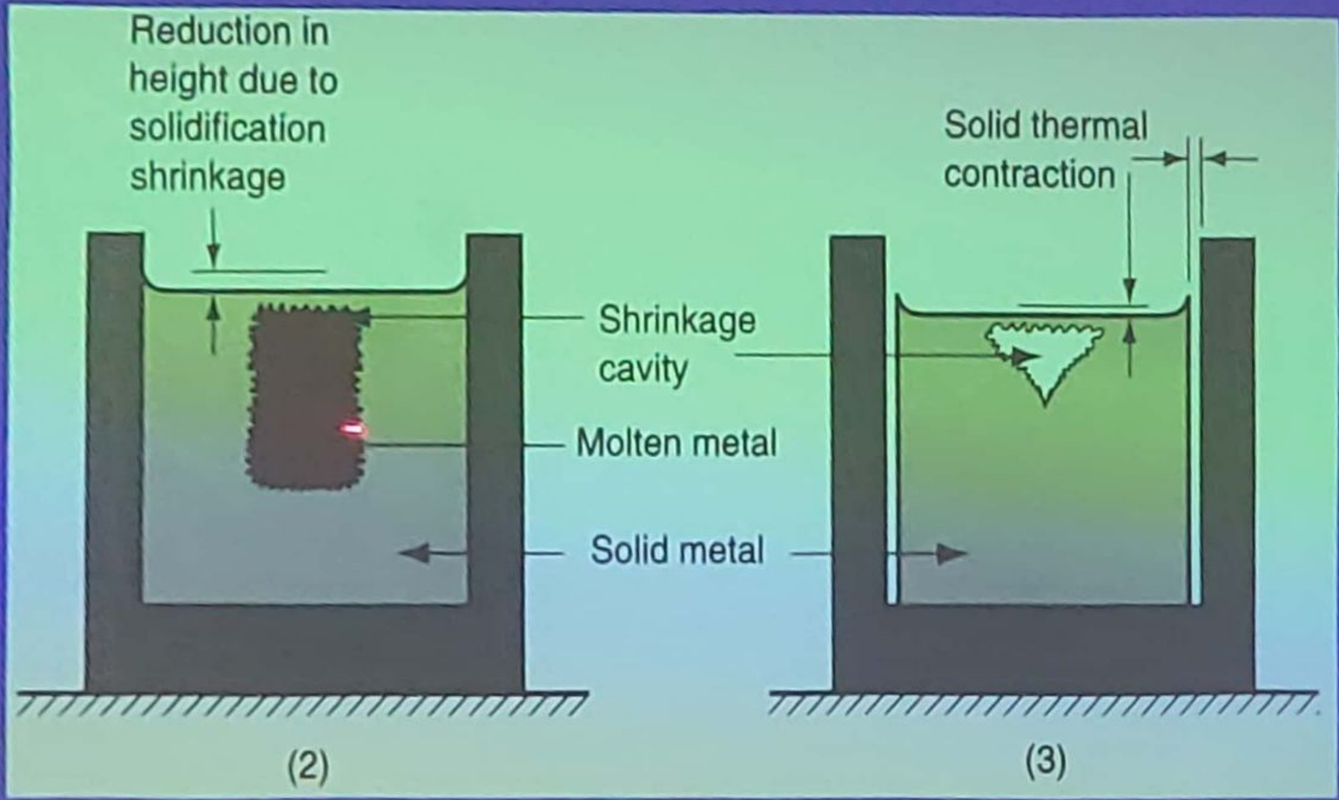
- Exception: **Cast Iron** with high Carbon content
  - Graphitization during final stage of freezing causes expansion, which counteracts the volumetric shrinkage.

Shrinkage cavity



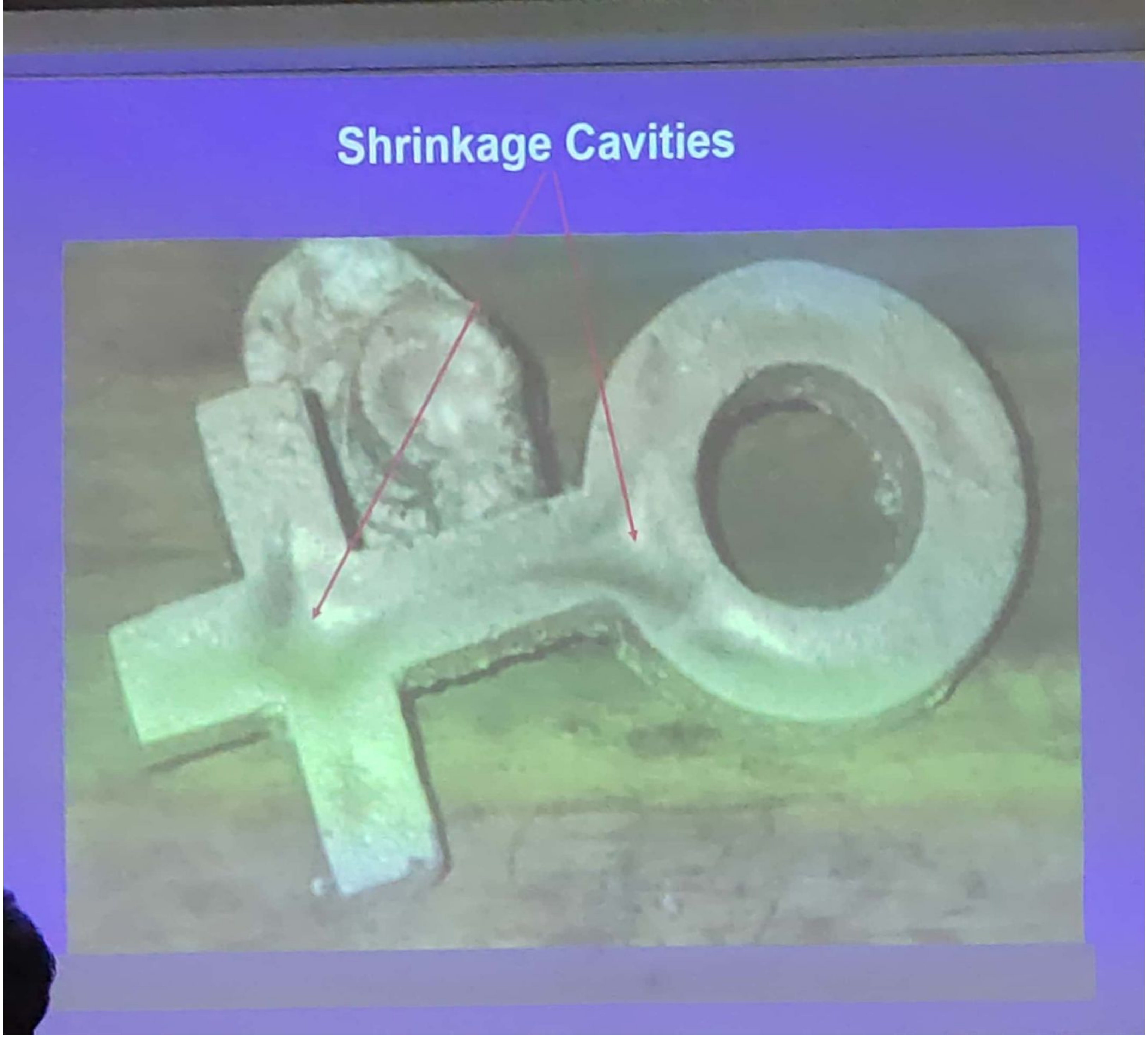
(0) Starting level of molten metal immediately after pouring.

(1) Reduction in level caused by liquid contraction during cooling.



(2) Reduction in height and formation of shrinkage cavity caused by solidification shrinkage.

(3) Further reduction in height and diameter due to thermal contraction during cooling of the solid metal.


Shrinkage Cavities

Types of Production

- Job shop Production- Production volume is very low. E.g. Machine tool, special tools etc.
- Batch Production- Manufacturing of medium sized lots of same items. The lots may be produced only once or at regular intervals. E.g. Electrical motors.
- Mass Production- Continuous specialized manufacturing of identical components. Very high production rate. E.g.-Ball bearing, spark plug.

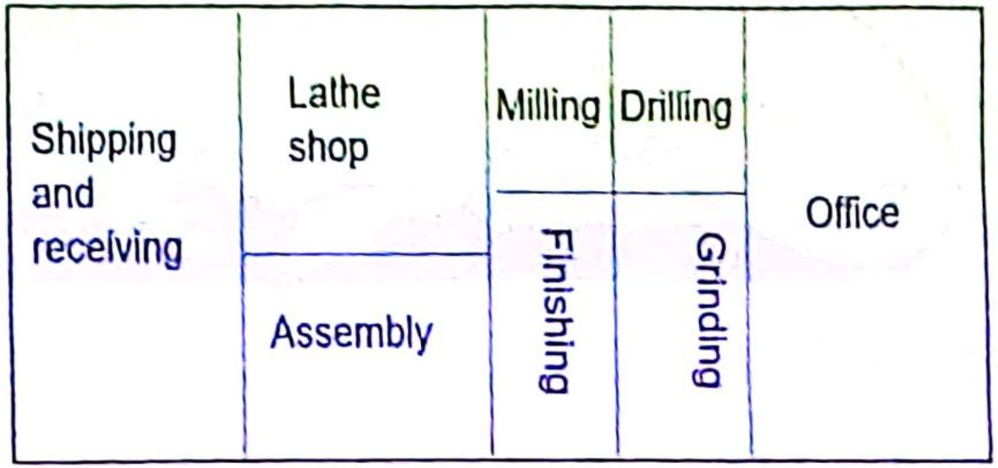
Plant Layout

1. Fixed position layout
2. Process layout
3. Product layout

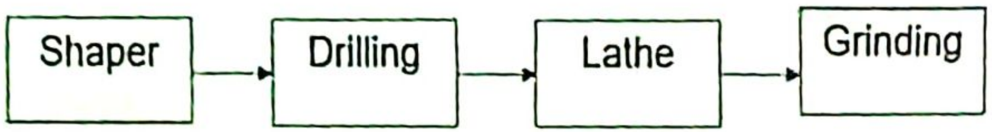
➢ **1. Fixed position layout-** Work station are arranged as per the size and shape of the product. High equipment handling cost.

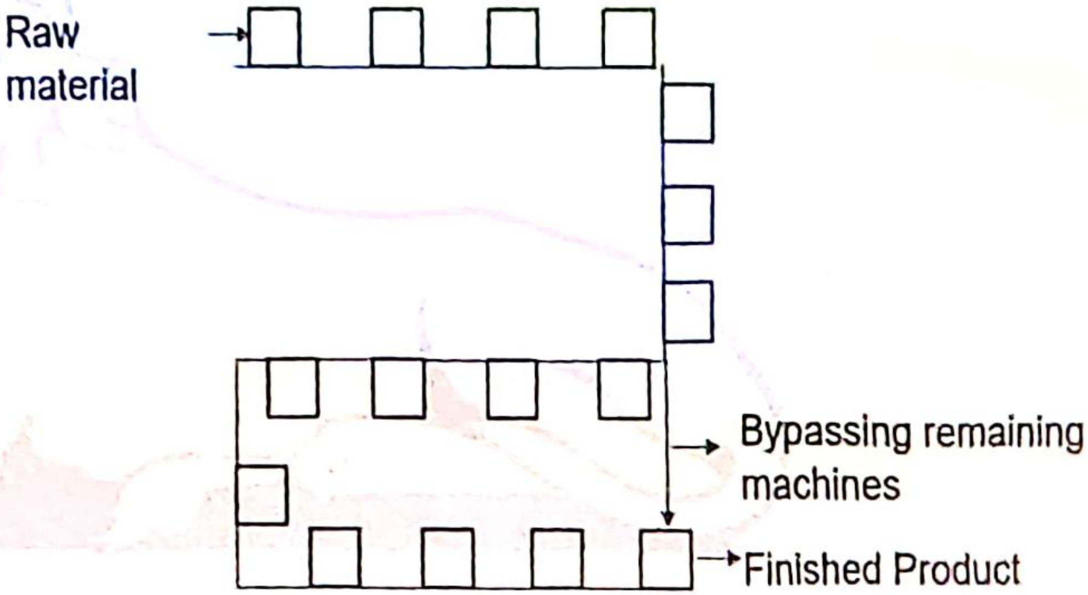
- E.g.- Aero plane and ship building.

➢ **2. Process layout-** It is also known as function layout. Keeping similar machines at one location. In other words, all lathes are placed in one place, all milling machines placed in other place. Better product quality became supervisor and workers attend one type of operation.



- **3. Product flow layout-** Work stations are arranged as per the sequence of requirement.
- It is also known as line layout. Various operations on raw material are performed in a sequence and machines are placed along product flow line.





Types of Production Systems

- Stand alone machines
- Transfer lines
- Flexible Manufacturing System

Types of Production System

❑ **Stand alone machines-** Individual machines without any network.

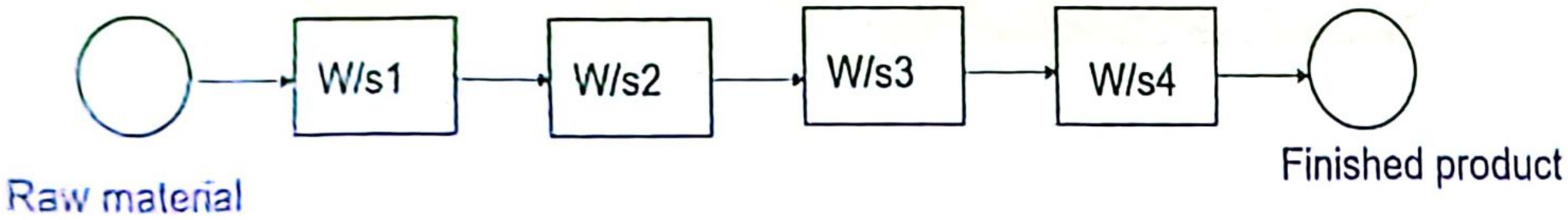
✓ Advantage- High flexibility

✓ Disadvantage- Low production

❑ **Transfer lines-** Consists of several machines or workstations which are linked together by work handling devices that transfer parts between them.

✓ Advantage- High productivity

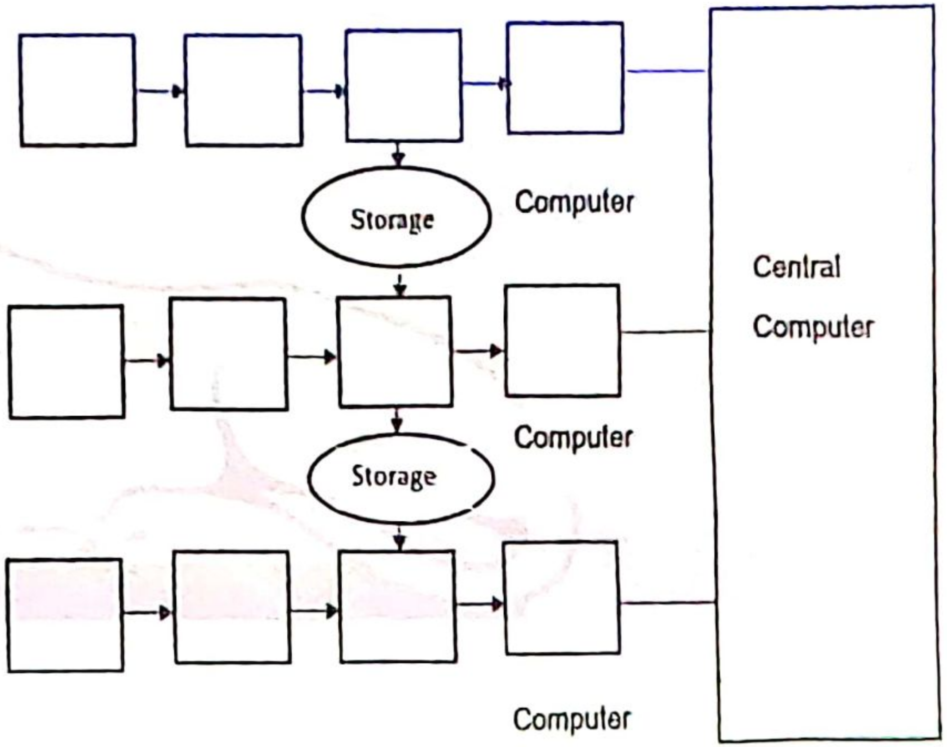
✓ Disadvantages- Low flexibility, Expensive



❑Flexible Manufacturing System (FMS)- It consists of a group of processing stations (predominantly CNC machine) interconnected by means of automated material handling system and storage system and controlled by an integrated computer system.

➢ Components

1. Processing station
2. Material handling and storage system
3. Computer control system



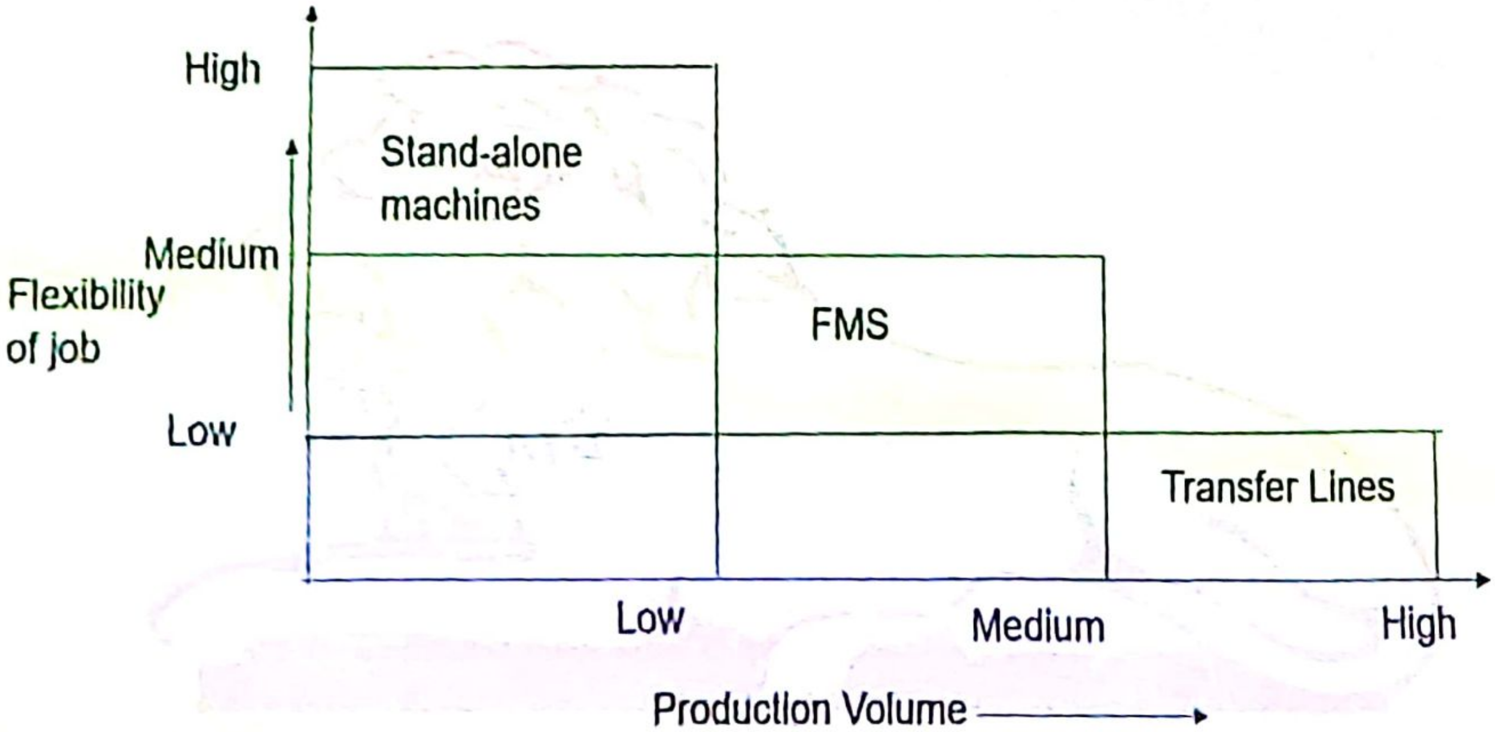
❑ Flexibilities

Job flexibility

Route flexibility

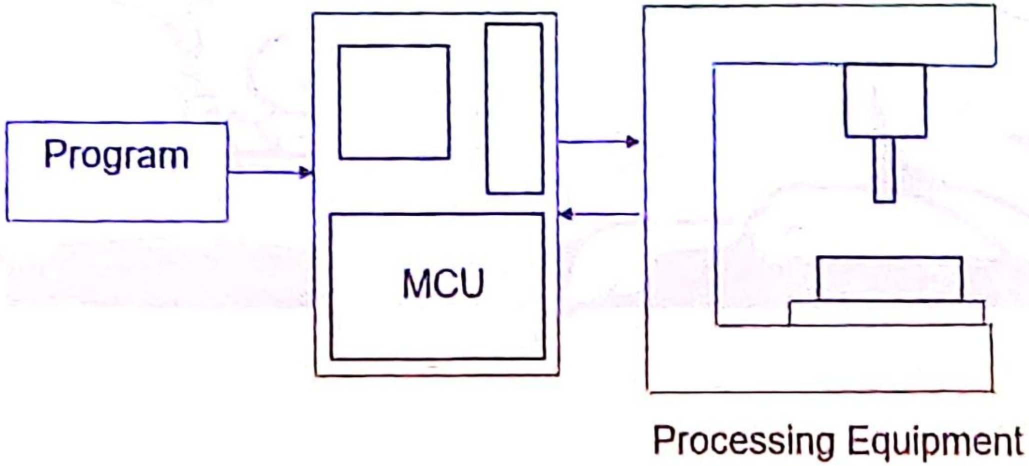
Material handling flexibility

Comparison of stand alone machine, transfer lines and FMS



Numerical Control

- Numerical control is a form of programmable automation in which processing equipment is controlled by means of numbers, letters, and other symbols.
- History- Originated in 1952, U.S.A.
- Initially punched cards were used. Later punched tapes were used. Later magnetic tapes were used.
- Main components- (1) Program of instructions, (2) Machine Control Unit (MCU), (3) Processing equipments.



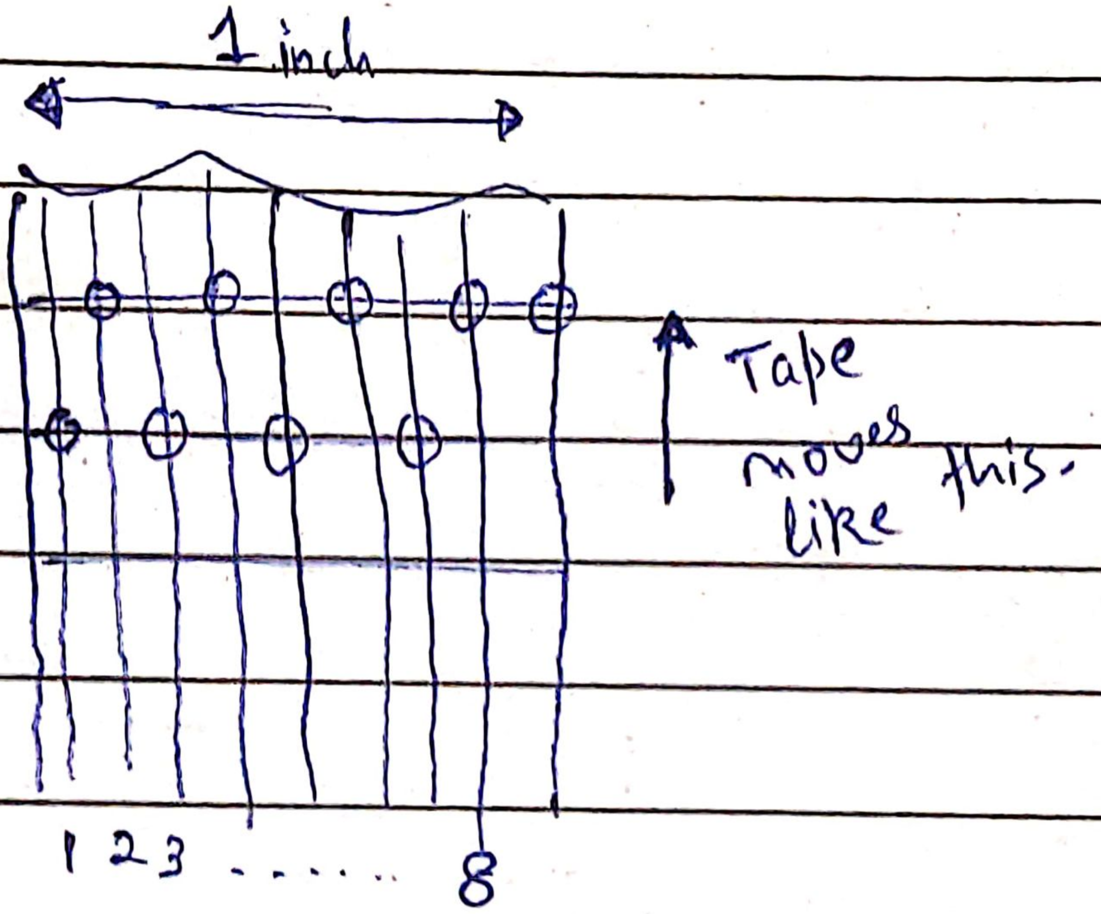
Tape readers

- A tape reader is an electrical-mechanical device for reading the punched tape containing the program of instructions.
- The punched tape format consists of eight parallel tracks of holes along its length. The presence or absence of a hole in a certain position represents bit information, and the entire collection of holes constitutes the NC program.

Types of tape readers

- Photoelectric tape reader
- Electrical tape reader
- Pneumatic tape reader

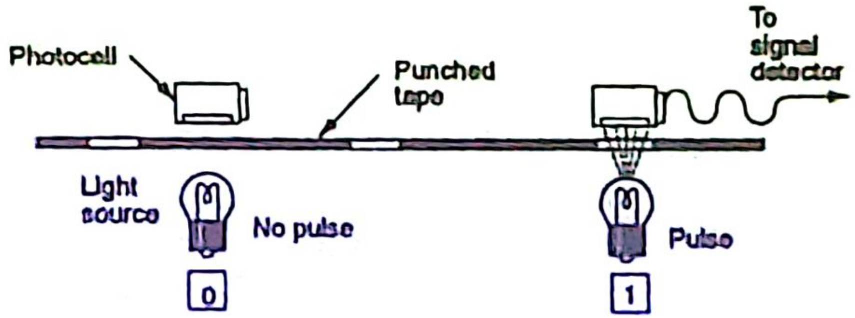
2L :-



Tape Reader (reading punched tape)

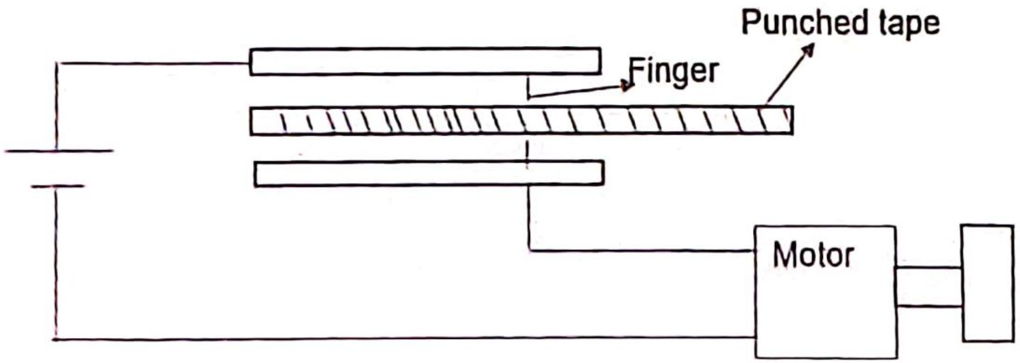
Photoelectric tape reader

If a beam of light falls on a photoelectric cell, the latter generates an electrical signal.

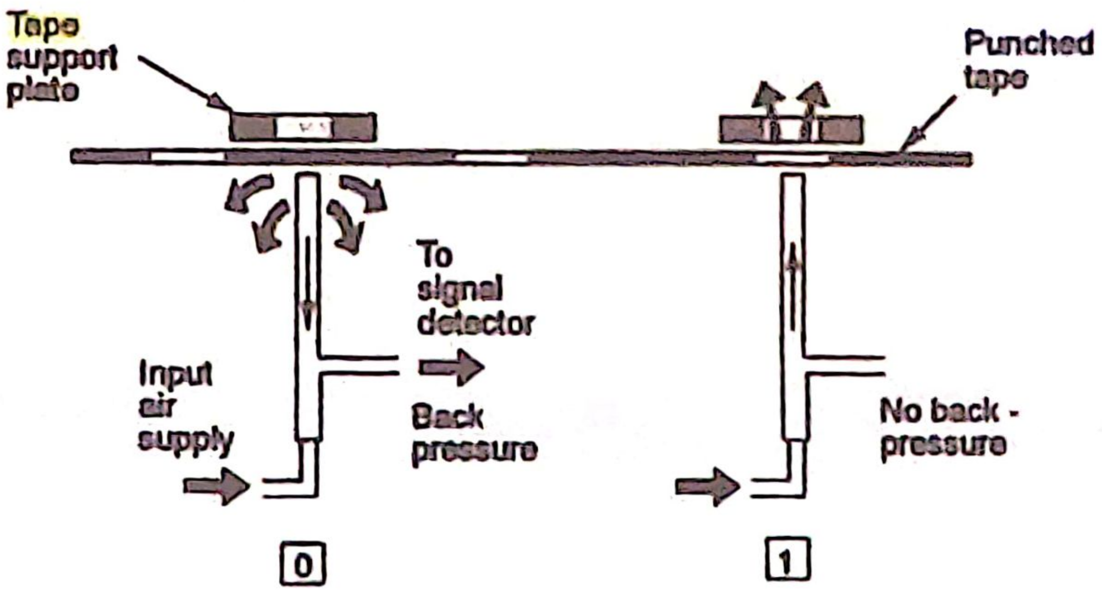


Electrical tape reader

Each finger completes an electrical contact on the opposite side of the tape when a hole is present. In this manner, bit information is read into the MCU.

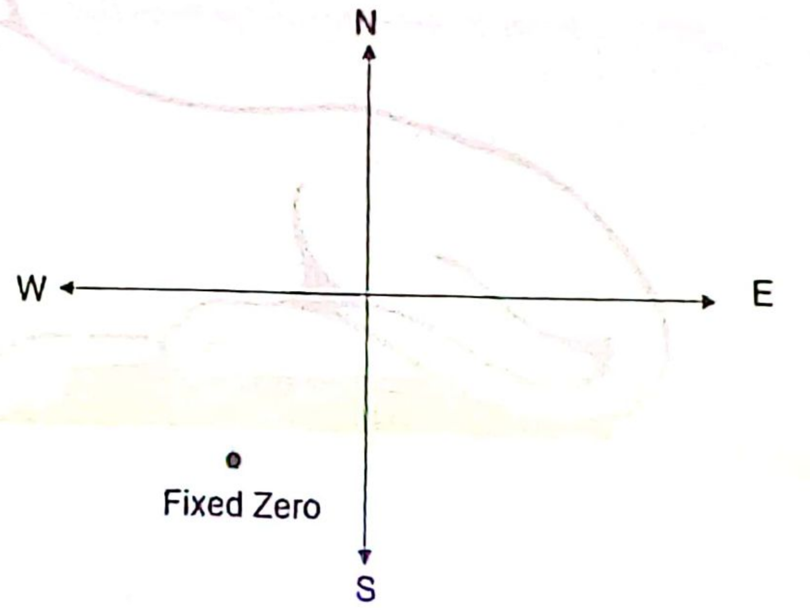


Pneumatic tape reader



Fixed zero vs. Floating zero

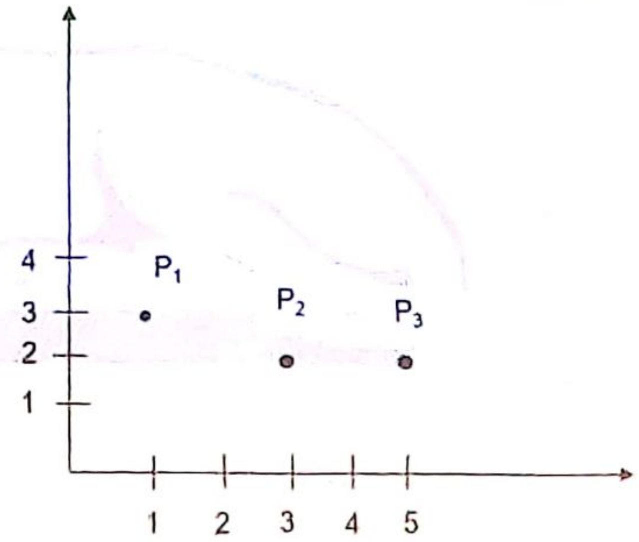
- In case of fixed zero, the origin is always located at the same position on the machine table. The south west position is the fixed zero.
- Floating zero can be set by the operator at any convenient position.



Absolute vs. Incremental positioning

- The tool location are always defined from same datum. The datum position in x-axis, y-axis, z-axis is defined by the programmer before setting the operation on machine.
- In incremental mode, tool locations are defined with respect to previous position.

Point	Absolute	Incremental
P_1	1, 3	1, 3
P_2	3, 2	2, -1
P_3	5, 2	2, 0



Types of NC

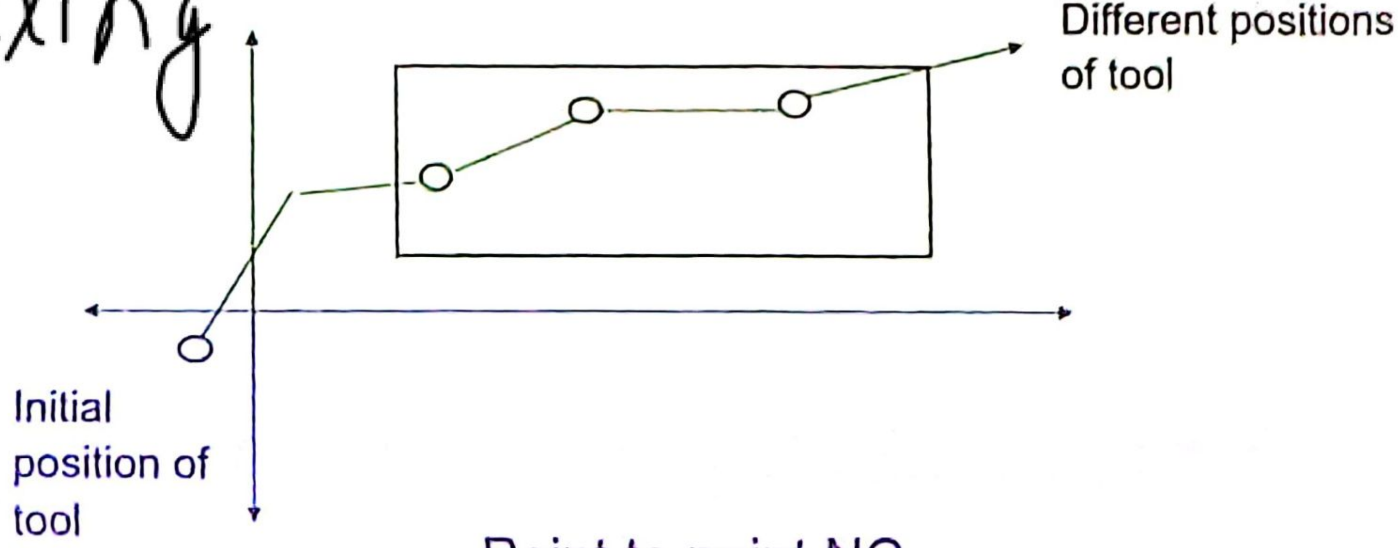
- Point to Point NC
- Straight Cut NC
- Contouring NC

Types of NC

Point to Point NC

It is also called positioning system. In PTP, the objective is to move the cutting tool to some predefined location. Path is not important.

eg: drilling

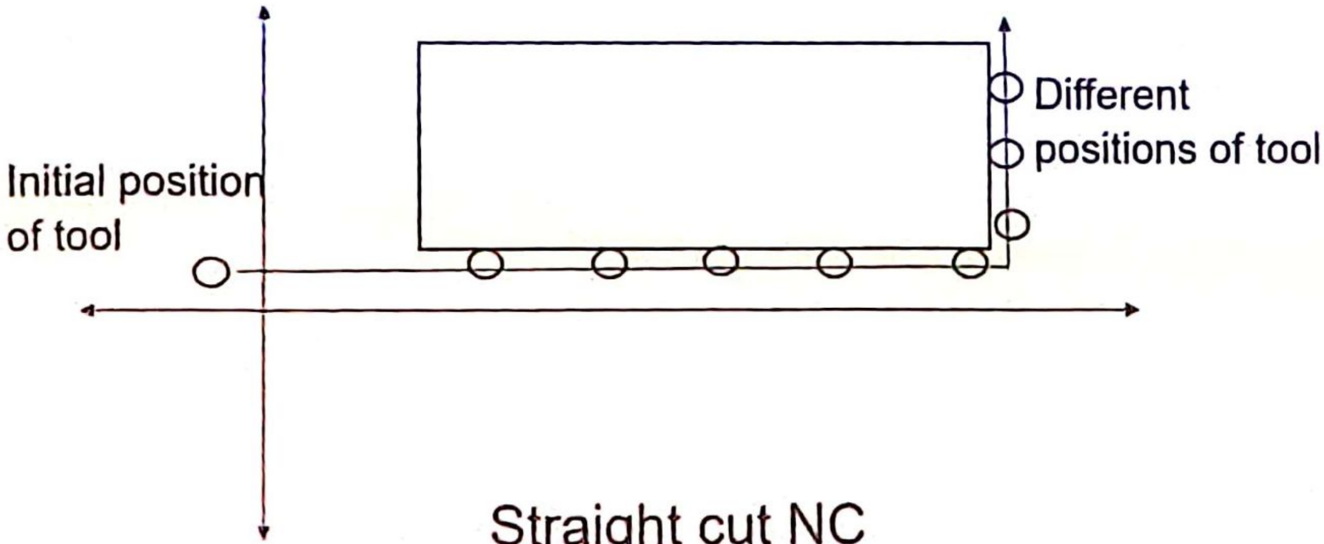


Point to point NC

Straight Cut NC

The tool moves parallel to one of the major axis at a controlled rate suitable for machining.

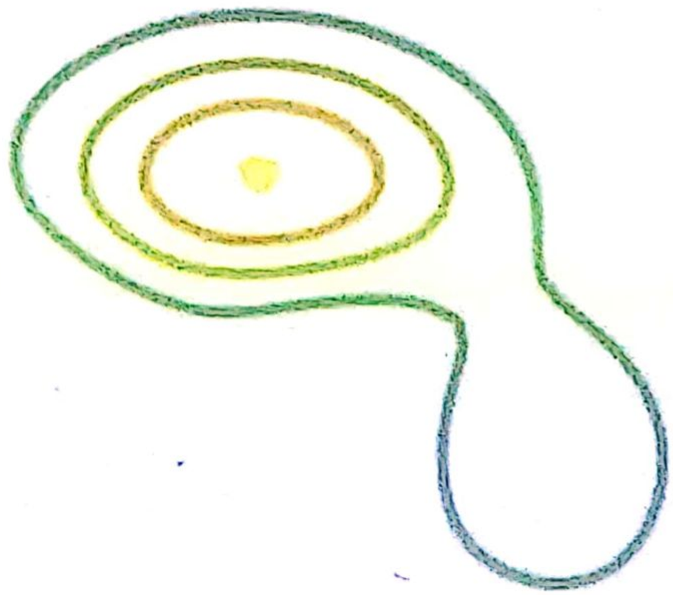
eg: milling



Straight cut NC

Contouring NC

The path of the cutter is continuously controlled to generate a desired geometry of the work- piece.

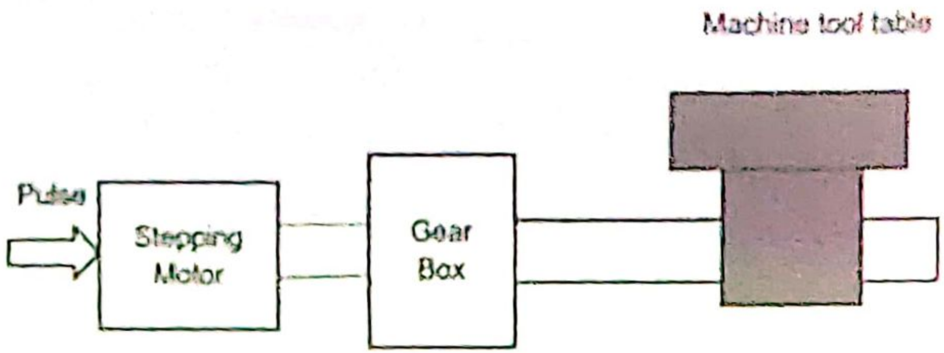


Contouring NC

Open loop and closed loop control in NC

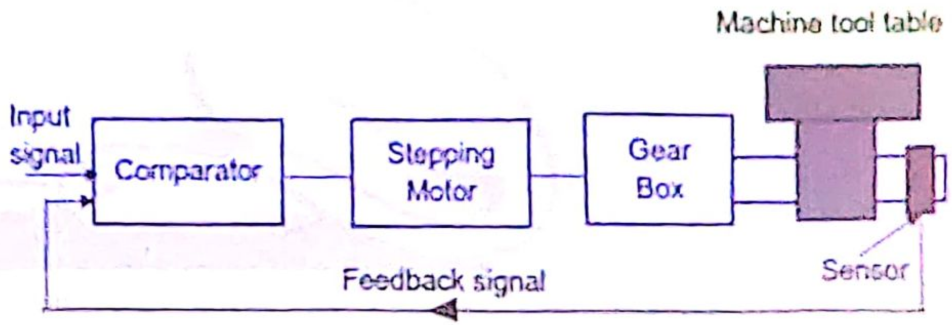
Open loop control

➢ The open loop control system does not use feedback signals to indicate the tool/ table movements. It offers less accuracy.



Closed loop control

➢ In closed loop control, the system uses feedback signals to indicate the tool/ table movements. It offers more accuracy.



Accuracy and Repeatability

➢Accuracy is a measure of the control systems ability to position the machine table/ tool at a desired location.

➢Repeatability is the ability of control system to return to a given location that was previously programmed into the controller.

Machining Center

- It is a machine tool capable of performing several operations on a work part in one setup under program control.

- A NC machine center includes the following:

  (1) Automated tool change

  (2) Automated work part positioning

  (3) Part shuttle: one pallet keeps the job under tool & other pallet moves the job.

Different machining tools in NC

- Drill tools
- Milling (Vertical & Horizontal)
- Turning(Vertical & Horizontal)
- Boring(Vertical & Horizontal)
- Grinding (Surface & cylindrical)

Metal working processes using NC

- Sheet metal punching
- Sheet metal blanking

❑ Other applications

- ➢ Electric wire wrap machines- for electrical wiring
- ➢ Component insertion machine- to assemble PCB etc.
- ➢ Drafting machines – for input device of CAD/CAM.
- ➢ Coordinate measuring machines- for measuring dimensions of part.
- ➢ Flame cutting, plasma cutting, Laser cutting etc.
- ➢ Tube bending, riveting etc.

❑ Advantages of NC

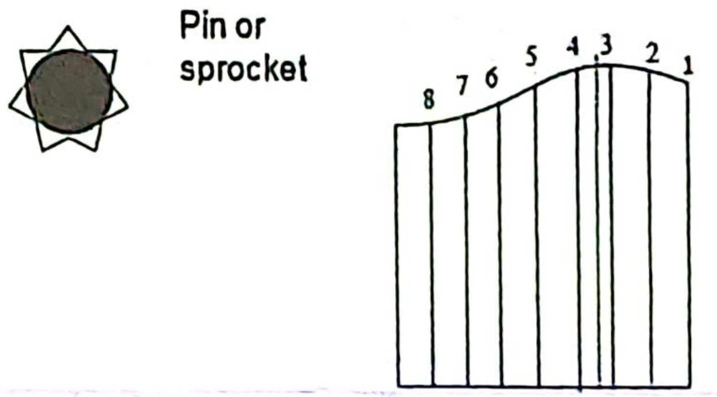
- ➢ Reduced non production time, Reduced lead time, Greater manufacturing flexibility, Improved accuracy, Reduced fixturing, Lesser accidents.

❑ Drawbacks of NC

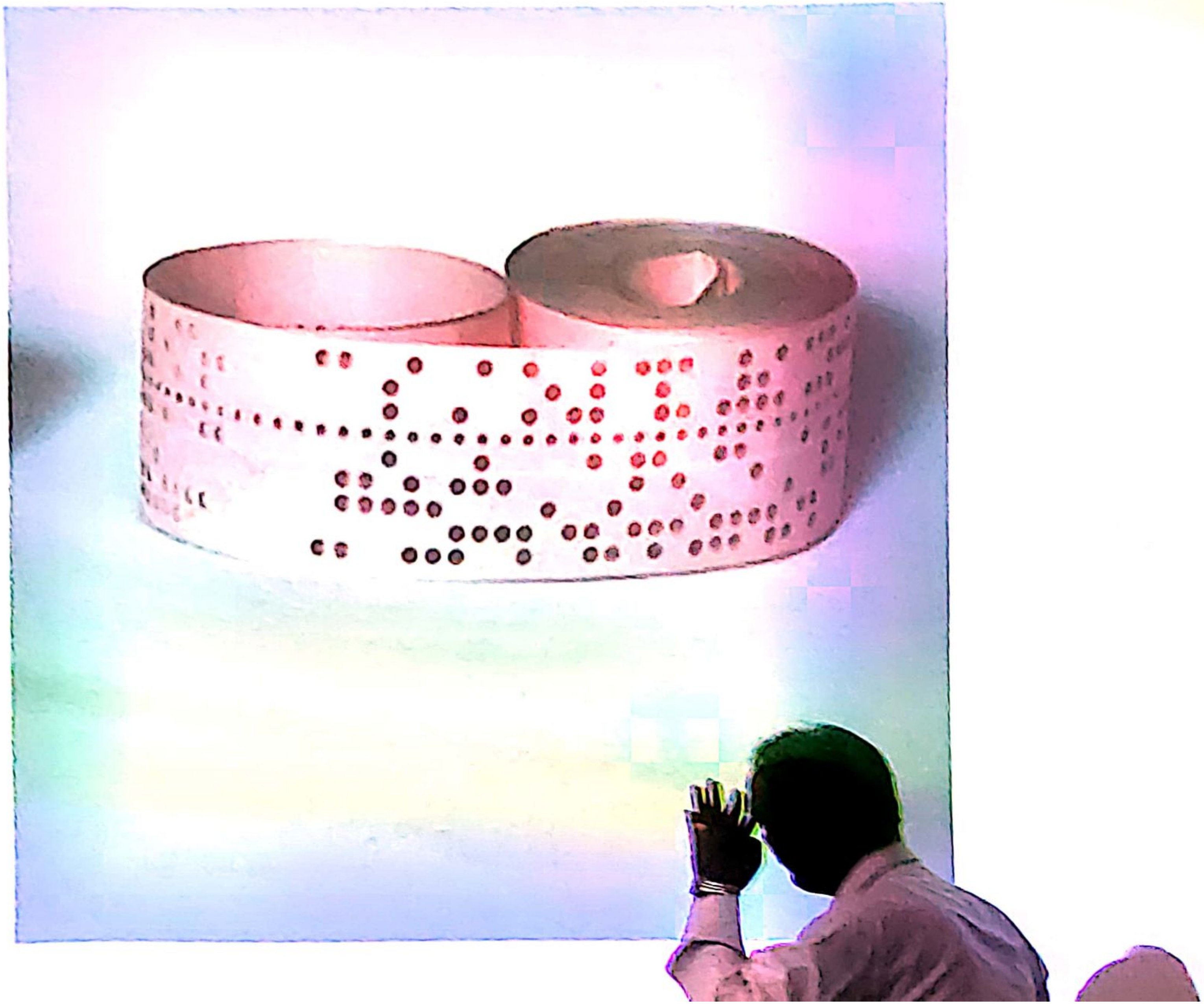
- ➢ High initial investment, Requires qualified personnel, increases unemployment.

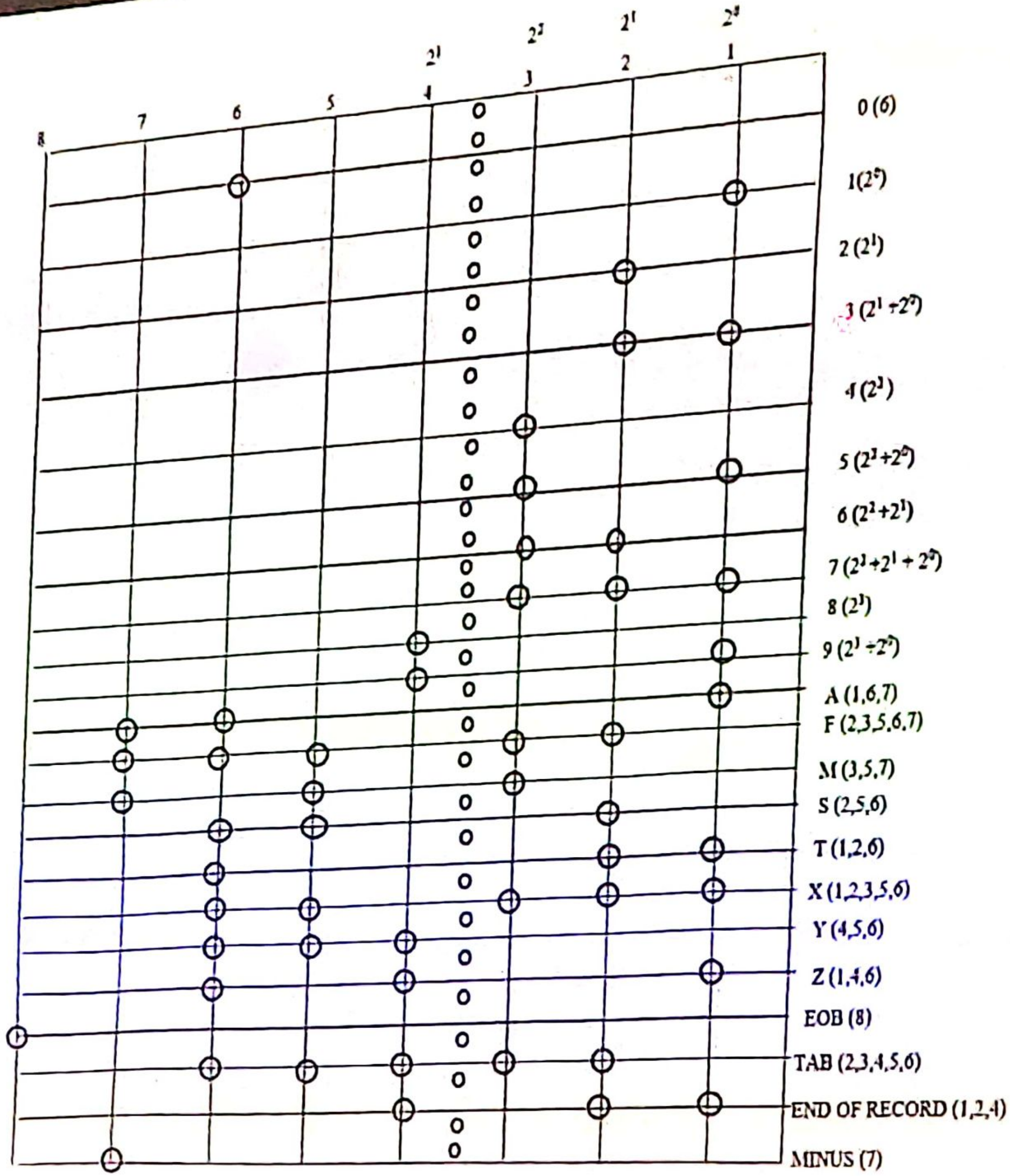
Paper tape

- It is a one inch width thick paper tape. There will be 8 tracks on the tape. Between 3rd and 4th track, there will be sprocket track.



- First four tracks are meant for indicating the numbers.
- Fifth track is meant for odd parity [EIA (Electronics Industries Alliance)system]
- Other system- ASCII (American Standard Code for Information Interchange)
- 6th & 7th tracks in conjunction with tracks 1, 2, 3, 4 are used to indicate alphabets.
- 8th track is meant for EOB (End of Block).
- 6th track is for indicating Zero.





2³ 2² 2¹ 2⁰
8 7 6 5 4 3 2 1
0 (6)
1 (2⁰)
2 (2¹)
3 (2¹ + 2⁰)
4 (2²)
5 (2² + 2⁰)
6 (2² + 2¹)
7 (2² + 2¹ + 2⁰)
8 (2³)
9 (2³ + 2⁰)
A (1,6,7)
F (2,3,5,6,7)
M (3,5,7)
S (2,5,6)
T (1,2,6)
X (1,2,3,5,6)
Y (4,5,6)
Z (1,4,6)
EOB (8)
TAB (2,3,4,5,6)
END OF RECORD (1,2,4)
MINUS (7)

- Remember: (X, Y, Z, F, S, T)

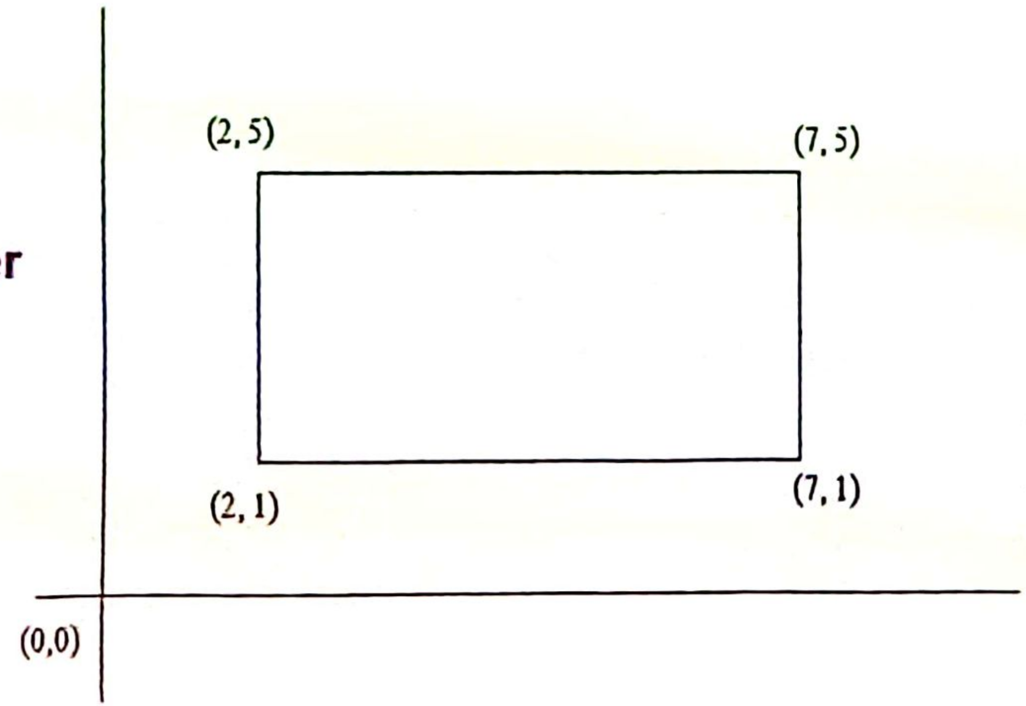
(saare ही हो जाए, ugh)

EOB → End of set of instructions.

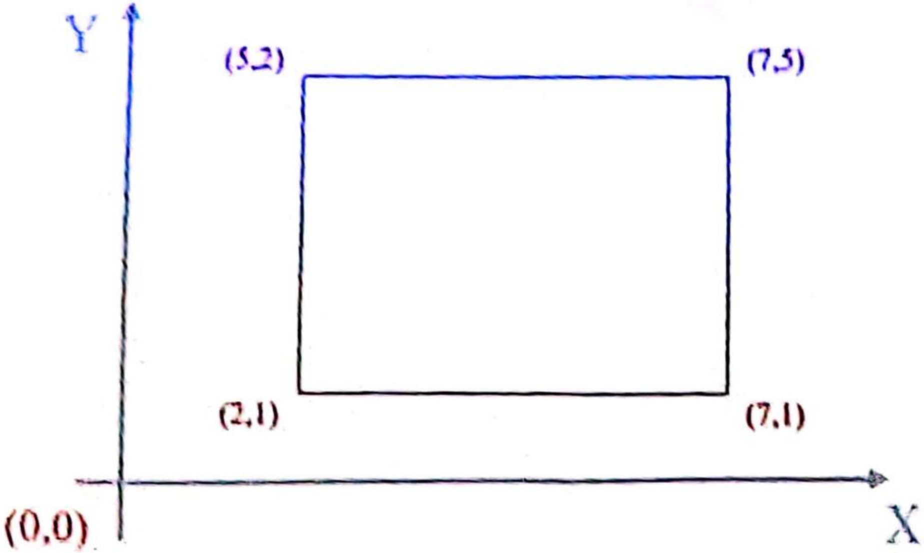
TAB → End of instruction.

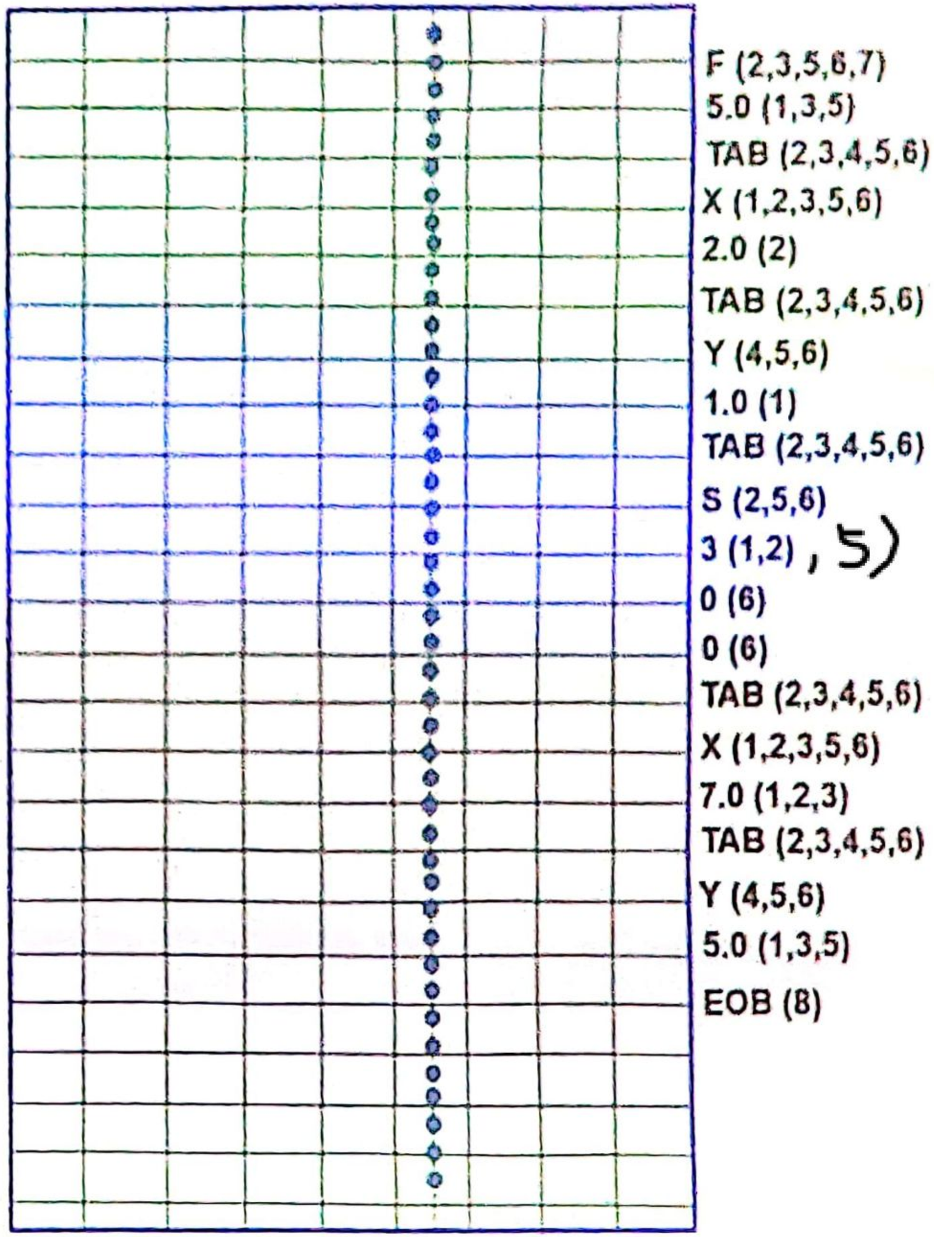
Problem 1: Write a punch tape program to execute end milling for the given job at a spindle speed of 300 rpm. Feed is 5mm/min. Assume that the tape is already punched for absolute positioning & fixed zero.

CAD/CAM by M. Groover



Solution-





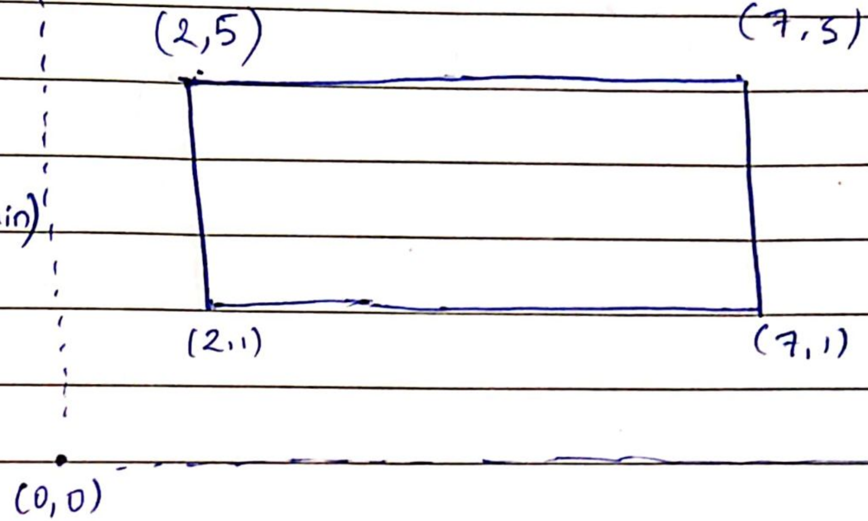
CamScanner

* Reasoning :

(i) F - feed kitna dena (mm/min)

(ii) S - spindle speed kitna dena

(iii) 300 लिखना तो use separate lines for 3, 0, 0 .

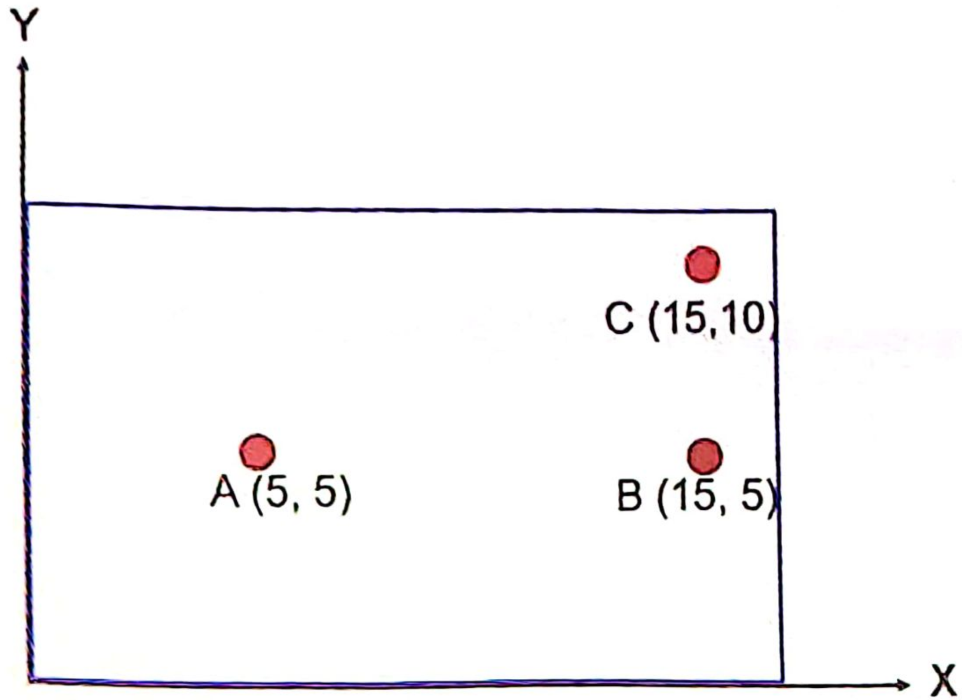


(iv) Why is 5 = (1, 3, 5) ?? ⟹ { agar Total no. of holes = even ⟹ put hole on "5" to make it odd . }

(v) S is written after (2,1) ; cuz motor rotation (machining) तभी start करना ||

F "would" have been written after (2,1) too; but पहले likhne से np.

Problem 2: Write a punch tape program to drill the set of holes shown in the given job at a spindle speed of 800 rpm. Feed is 10 mm/min. Assume that the tape is already punched for absolute positioning & fixed zero. Thickness of the job is 5 mm.



Problems with punched tapes

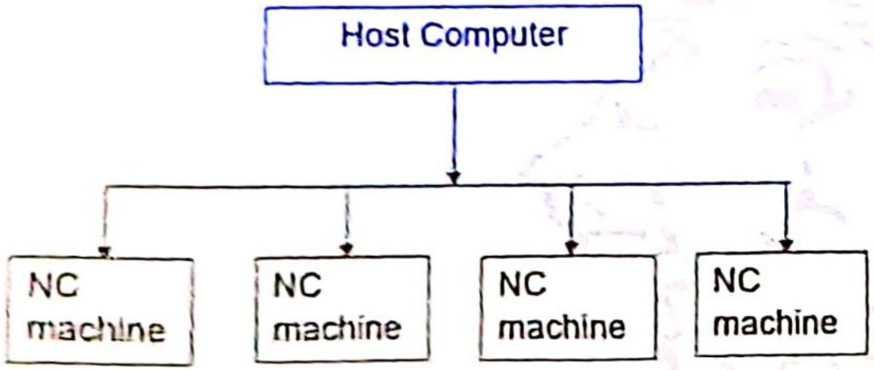
- Programming mistakes
- Non optimal speed and feeds
- Life of punched tapes (fragile etc.)
- Controller is without computer
- Management information: It is not equipped with management information such as piece count, tool change requirements etc.

❑ Further developments in NC technology

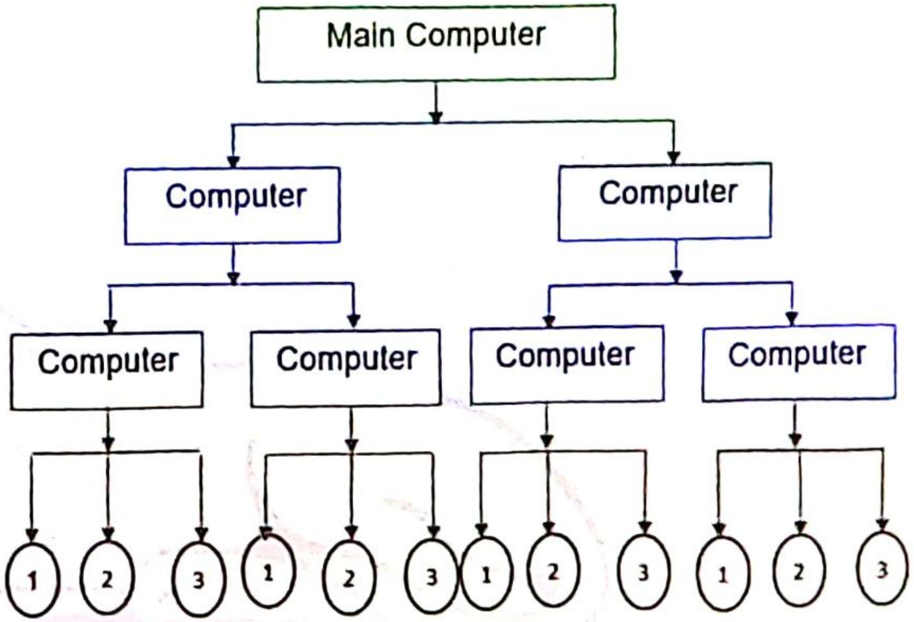
- Vacuum tubes (1952)
- Electromechanical relays (1955)
- Discrete semiconductors (1960)
- Integral circuits (1965)
- Direct Numerical Control (1968)
- Computer Numerical Control (1970)

Direct Numerical Control & Distributed Numerical Control

Direct Numerical Control



Distributed Numerical Control



1- NC machine tools

2- Robots

3- Inspection

Computer Numerical Control

- The machine tool/ work station is directly equipped with a computer.

CNC words

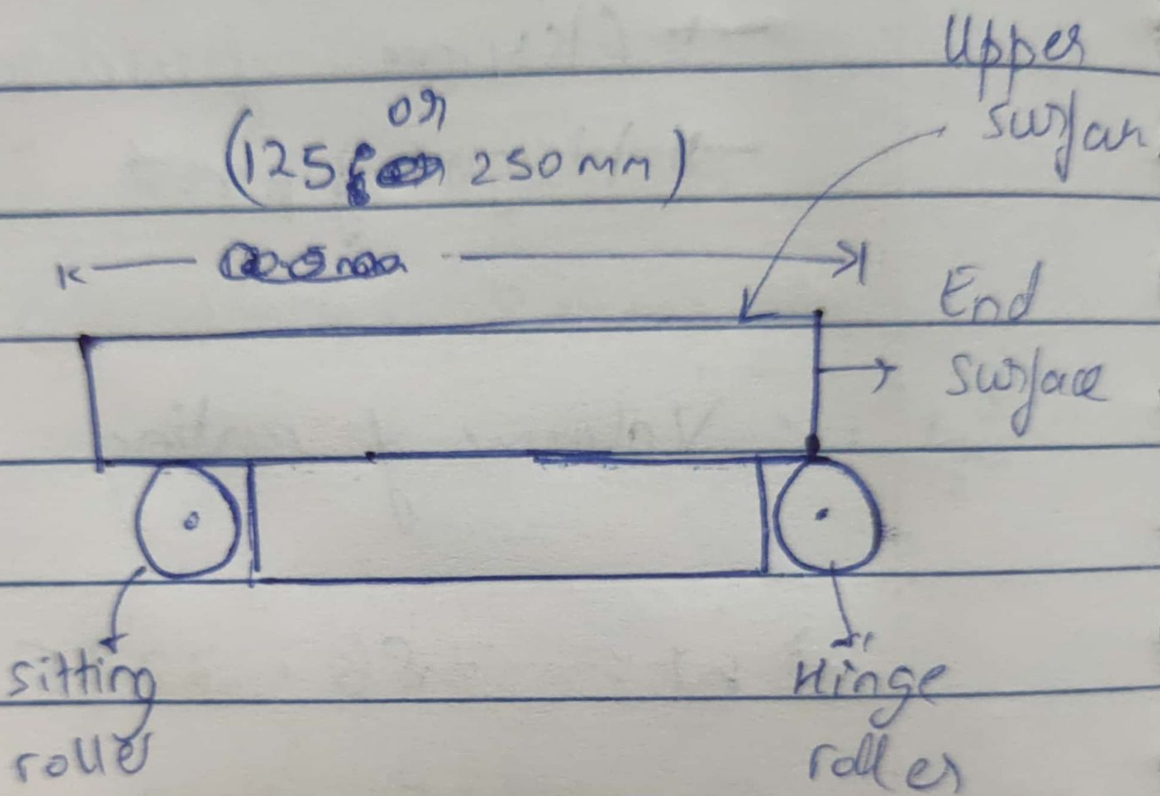
- (1) Sequence Number – (N words) – used to identify the block. E.g.- N10………, N11………., N12…………
- (2) Preparatory words (G words)- used to prepare the controller for instructions that are to be followed. E.g.- G00, G01, G02
- (3)Coordinates words (X,Y,Z words)- used to move the controller in the different directions. E.g.- X70.0 Y50.0
- (4) Feed Rate(F word)- It specifies the feed in a machining operation. E.g.- F2.0
- (5) Tool selection (T words)- used to specify the required tool. E.g. T01, T03.
- (6) Miscellaneous function (M words)- used to specify miscellaneous functions. E.g. M03- spindle rotation (CW), M04 – spindle rotation (ACW)

Angular measurement

1. Spirit level
2. Vernier bevel protactor
3. Sine bar
4. Angle gauges
5. Dividing head
6. Clinometer
7. Auto Collimeter

...urization, less time to melt.

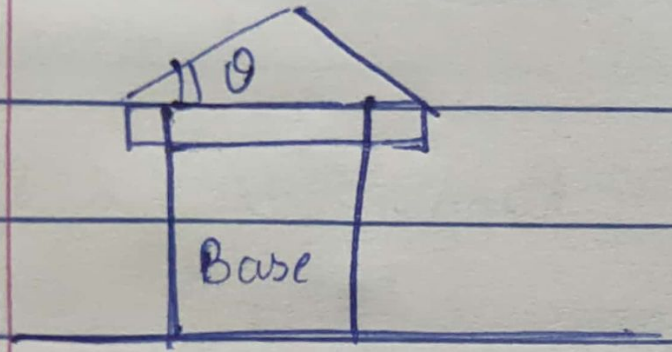
A · A



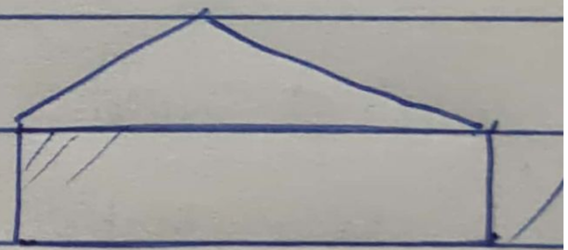
SINE BAR

Qs: How to measure $\angle^r$ by sine bar :-

sitting roller



(need to find "θ" of workpiece, ~~aka~~
aka :

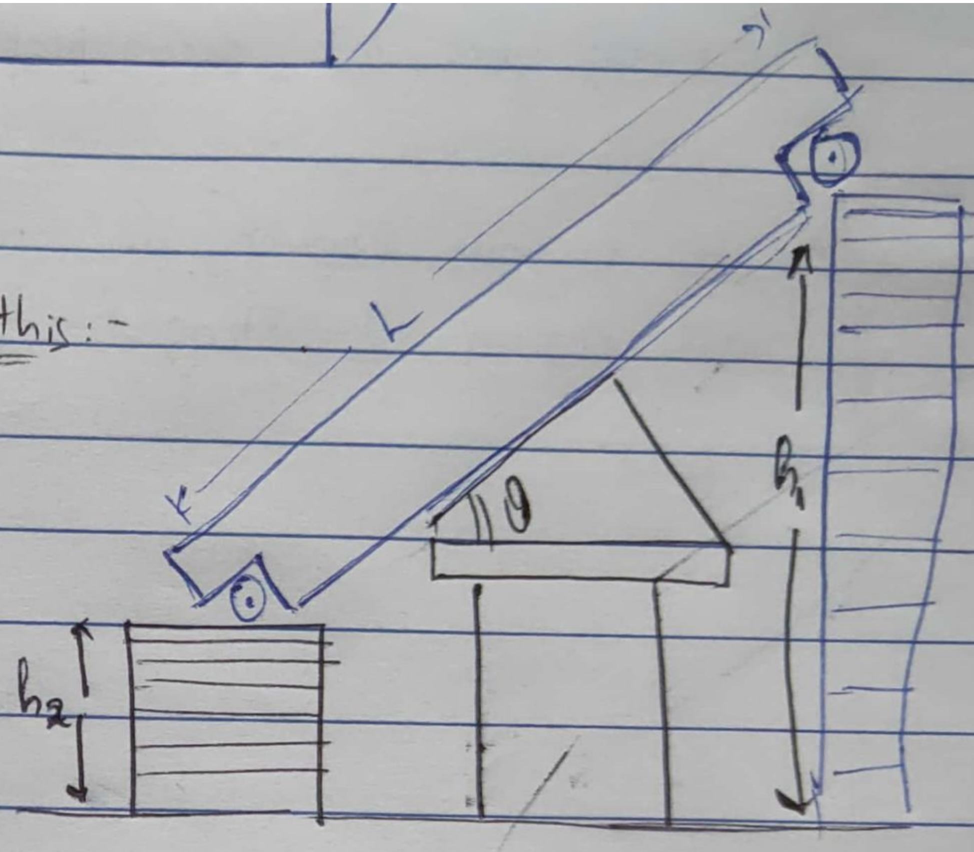


* Then, bring in slip-gauges & do this :-

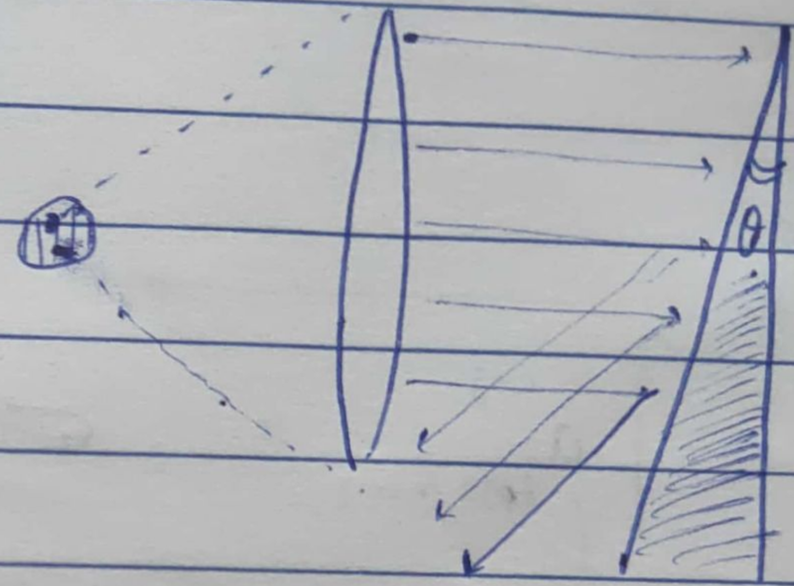
now, ~~$\theta = (\tan^{-1}$~~

$$\boxed{\sin\theta = \frac{h_1 - h_2}{L}}$$

(125 or 250 mm.)



* Auto Collimeter :-



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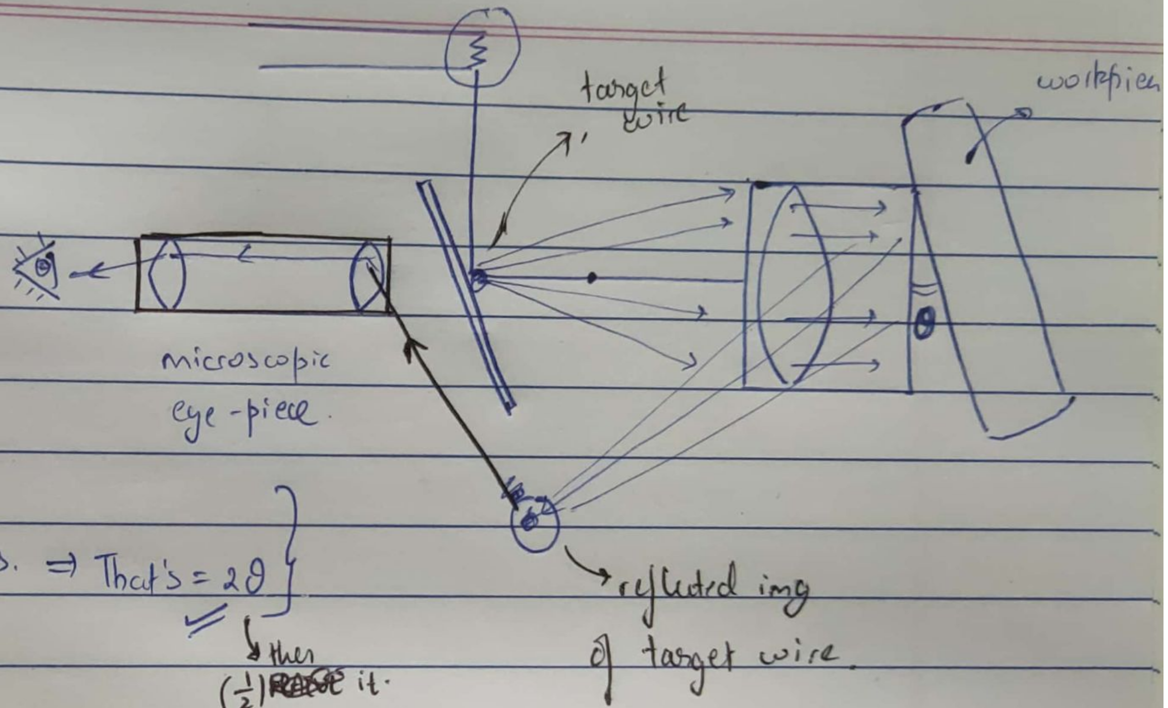
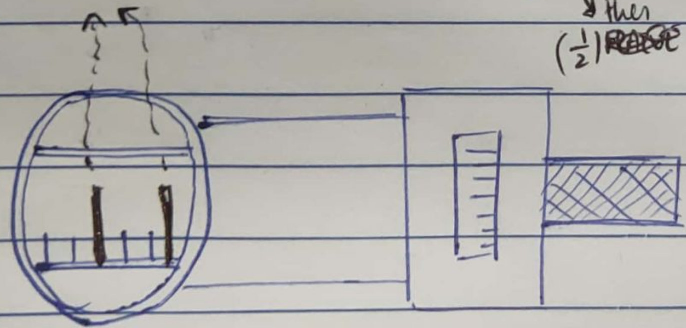
(b): APPARATUS:



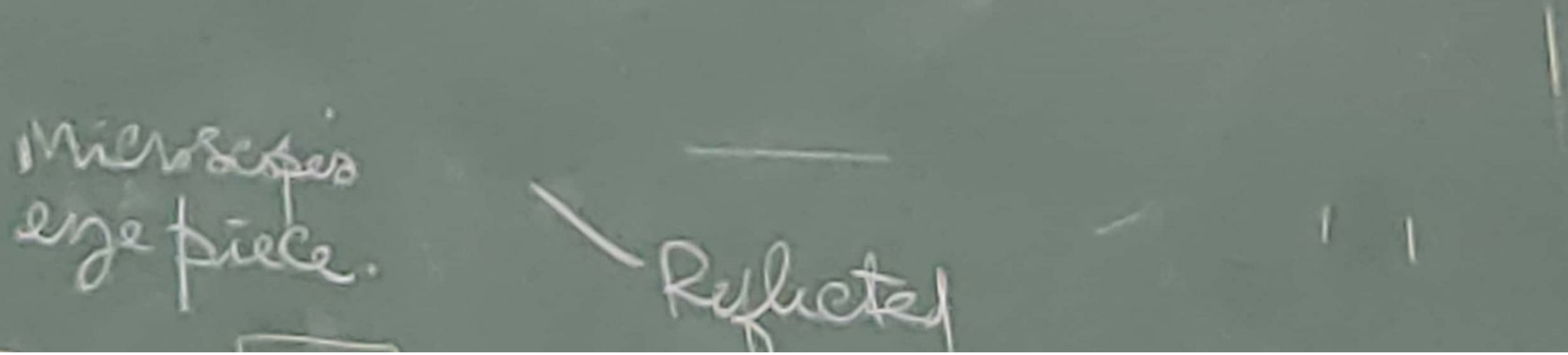
Find "dist"/angle b/w both target & reflected lines. ⇒ That's = 2θ

then ($\frac{1}{2}$) ~~RAISE~~ it.

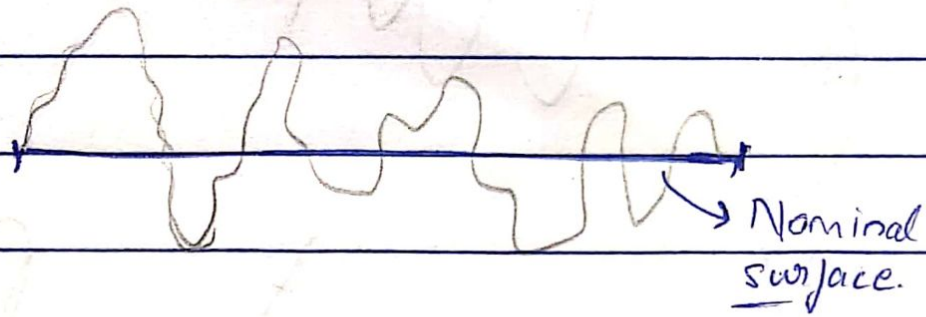


Applications

1. Machine tool allignment
2. Detecting angular deviations.
3. Angular measurement



* **Measurement of Surface Roughness :-**



surface.

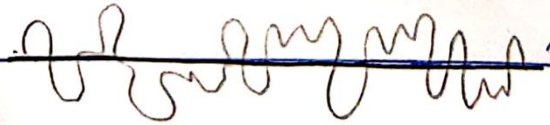
→ ★ Elements of Surface Roughness:

(1.) **Actual surface:** Refers to surface which is actually obtained after manufacturing.

(2.) **Nominal surface:** Theoretical, geometrically perfect surface, which doesn't exist in practice.

(3.) **Roughness:** Relatively finely spaced irregularities which might be produced by the action of cutting tool.

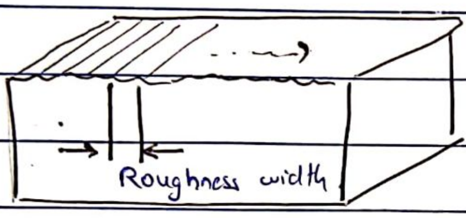
(4.) **Roughness-height:-** Arithmetic average deviation expressed in microns normal to the imaginary centerline.


→ Imaginary line ; (roughness height = avg height of peaks.)

(5) **Roughness width** :- It is distance between successive peaks parallel to the normal surface.

(6) **Waviness** : Surface irregularities with larger spacing, caused due to warping, vibration, etc.

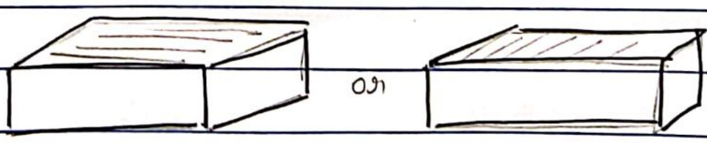
⇒ waviness ✓.



(7) **Flaw** : Surface irregularities or imperfections at random intervals. They might be serations, cracks, pits etc.

(8) **Roughness width Cutoff** : Sampling length while measuring surface roughness. It is expressed in cm or inch.

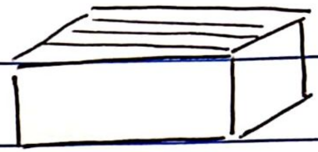
(9) **Lay** :- The direction of predominant surface produced by the tool marks.



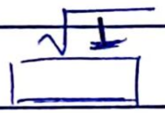
Lay depends how you moved tool.

* Symbols to indicate Lay:-

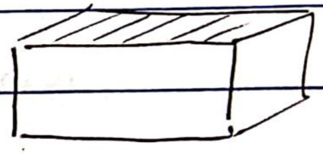
|| → Lay ||^{le} to reference edge.



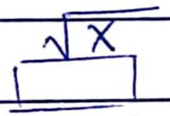
(on shaper)



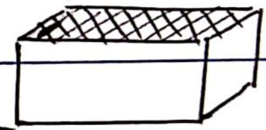
⊥ → Lay ⊥^{r} to " ".



(on shapes)

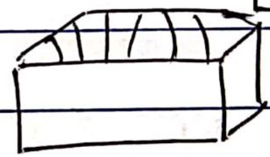


X → Lay angular to reference edge.



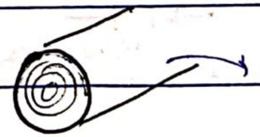
(~~on shap~~ (Knurling, lathe)

M → Lay in multi-directions.



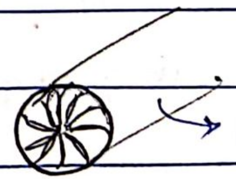
(milling machine)

C → Lay approximately circular.



(Facing, lathe)

R → Lay approximately radial to center of the surface.

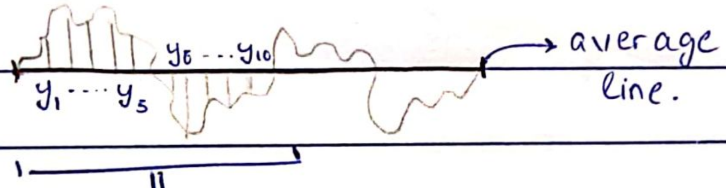


(also on milling machine)

#11

* Methods to Evaluate Surface Roughness :-

① Root Mean Square value :- (rms value)



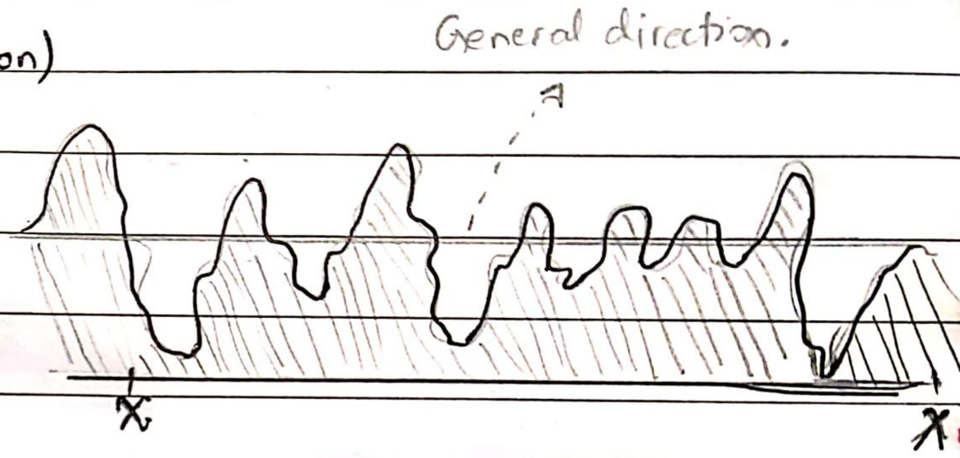
⇓

Divide each into 5 ordinates each. ⟹ $rms\text{-}value = \sqrt{\dfrac{y_1^2 + y_2^2 + \cdots y_{10}^2}{10}}$ ($\simeq$ microns)

can take upto n-heights too. Better only.

→ Drawback :→ No differentiation in peaks or valleys ; you don't know valleys ~~taller~~ deeper or peaks taller.

(2) Centre-Line Average: (CLA) method
(or arithmetic mean deviation)



1.) → Denoted as R_a.

2.) → Draw line X-X parallel to general direction of the profile, touching the deepest ~~value~~ valley.

3.) Find area under the curve using a planimeter.

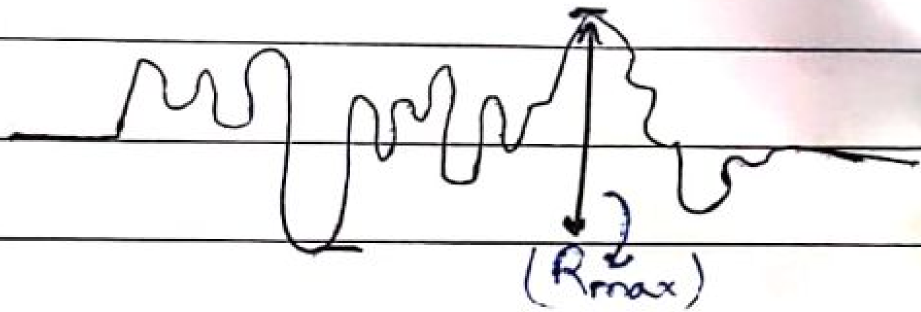
4.)

$$\boxed{R_a = \frac{\text{Area under curve}}{L}}$$

→ sort of कि "अगर" h height ke rectangle से represent karna hota है .....

(3) Max peak-to-Value height method :-

→ Denoted as R_{max}



→ Limitations:

(i) R_{max} value doesn't give complete characteristic of roughness profile.

(ii) Roughness width not taken into consideration.

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→ Is important / useful when you need to machine for "superfinishing" operations. [eg: $\leq 1 \mu m$ roughness needed etc.].

CamScanner

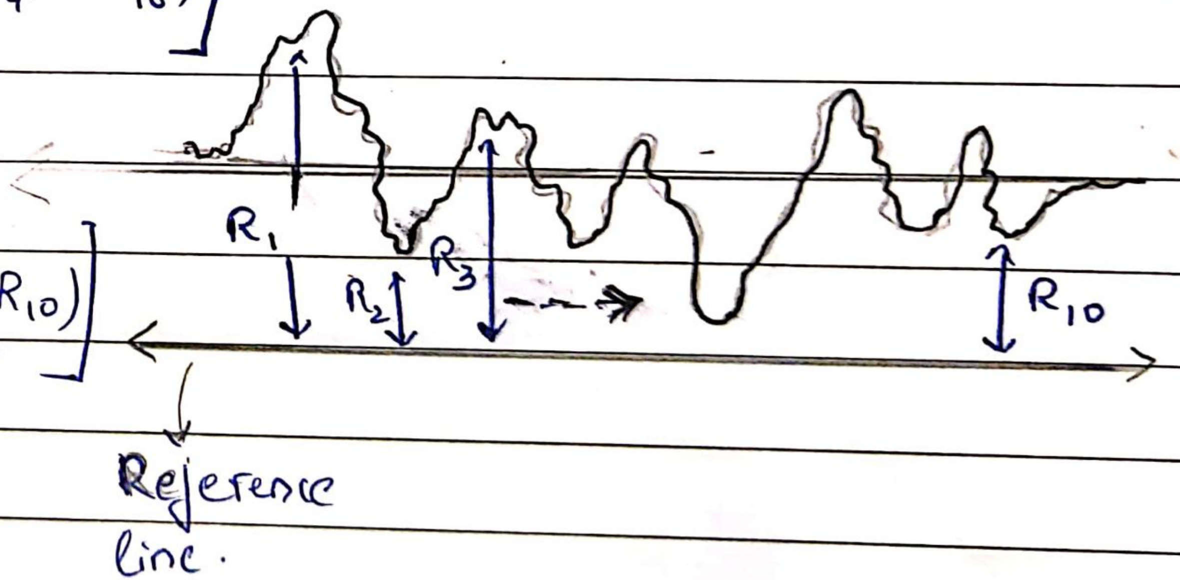
(4.) **Average of 5 heights & 5 valleys :-** (denoted as R_z)

→ Average difference b/w 5 peaks & 5 valleys, measured from a line $\parallel^{le}$ to the general direction of profile.

→ $$R_z = \frac{1}{5}\Big[(R_1 + R_3 + \dots R_9) - (R_2 + R_4 + \dots R_{10})\Big]$$

(or)

$$R_z = \frac{1}{5}\left[\frac{(R_1 - R_2) + (R_3 - R_4) + \dots (R_9 - R_{10})}{R_5}\right]$$



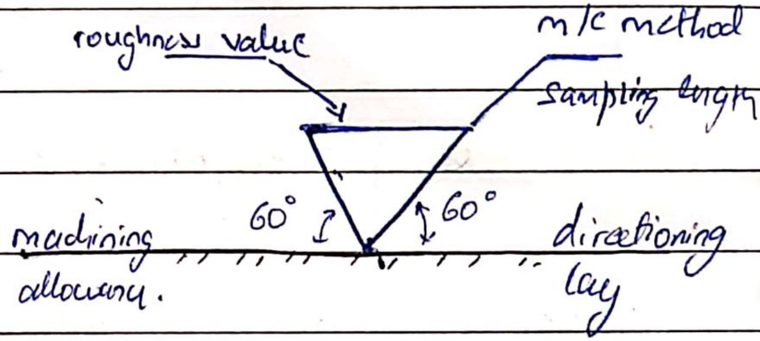
★ SAMPLING (as per Indian Standards)

(1.)

Type of machining	Sampling length L (mm)
(1.) Shaping & milling	0.8, 2.5, 8, 10
(2) Planning	8, 10, 25
(3) Turning	0.8, 2.5
(4) Grinding	0.25, 0.8, 2.5
(5) Super finishing	0.25, 0.8

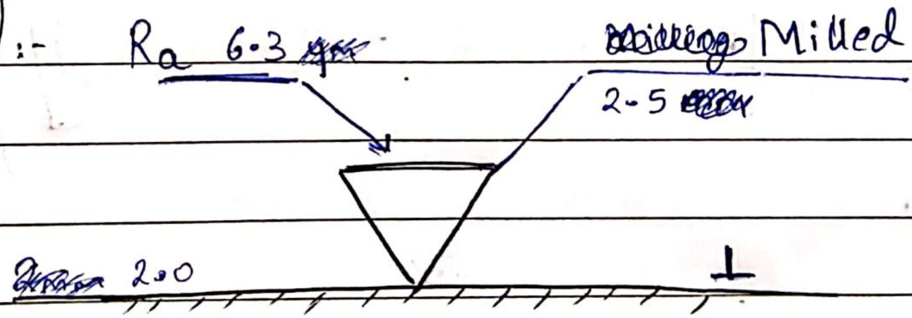
★ Representation of Surface Roughness:

E.g - Machining method – milling
Sampling length – 2.5 mm.
Directioning lay – $\perp^r$ to surface
machining allowance – 2mm
Roughness, R_a = 6.3 μm.



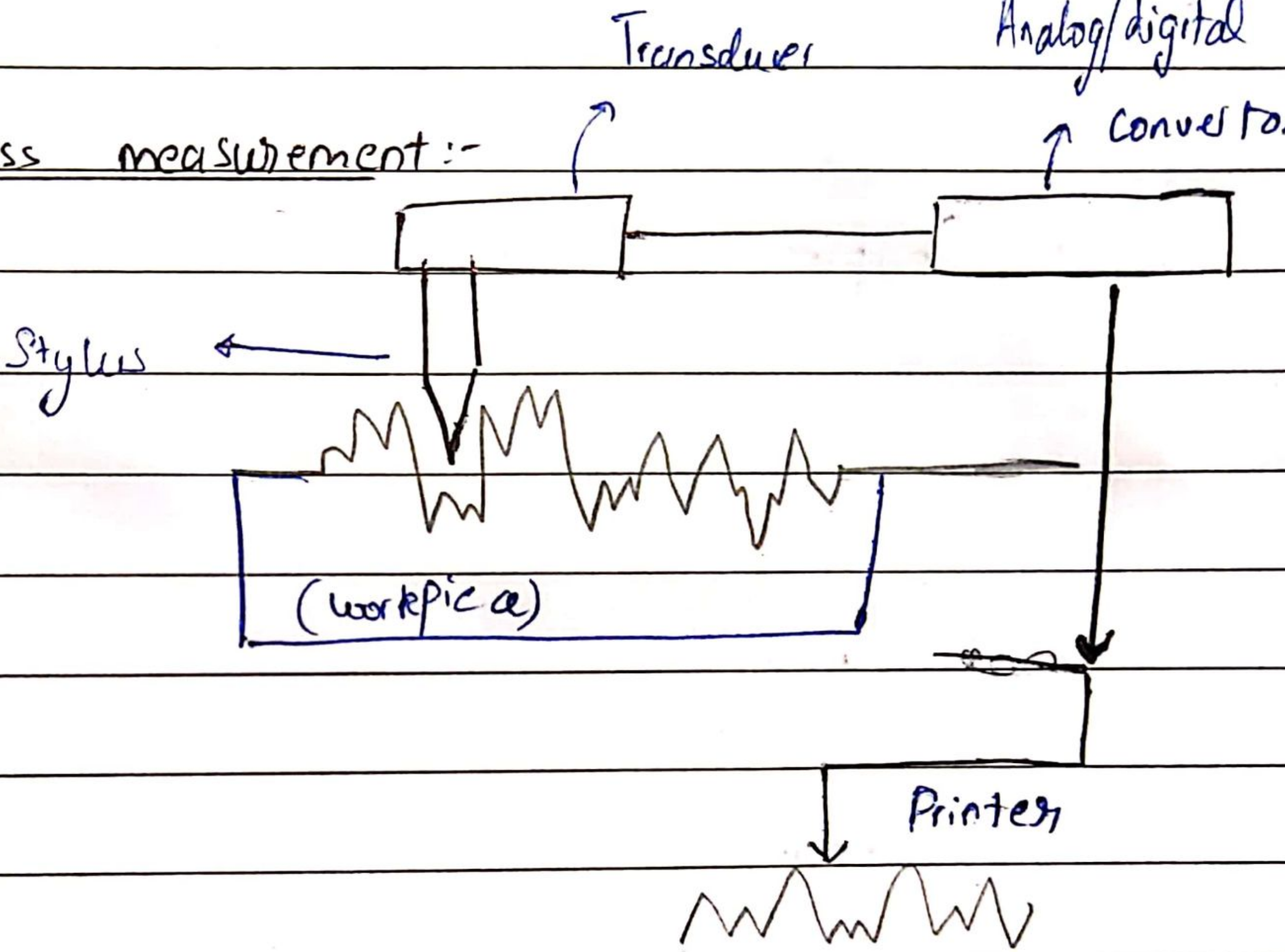
⇓

Solution :-



(yes, units intepreted by default,)
via IST standards.

★ <u>Principle of surface roughness measurement:-</u>



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Date

UNIT: "METROLOGY:"

* SURFACE MEASUREMENT. (TOPIC; continuation)

(= R_a)

Qs: Calculate CLA of surface with following data:

sampling data = 0.8 mm

vertical magnification = 15,000

Horizontal magnification = 100

Areas above the datum line are: 160, 90, 180, 50 mm^2

Areas below datum line: 95, 65, 170, 150 mm^2.

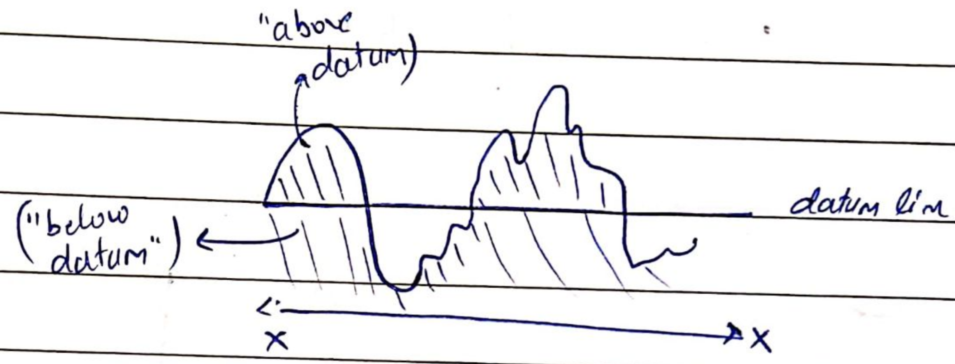
Sol^n:

"above datum)

... above the datum line are : 160, 90, 180, 50 mm^2

Areas below datum line : 95, 65, 170, 150 mm^2.

Solⁿ :



now,

$$\text{actual area} = \frac{\overline{\alpha}\,(160 + 95 + 90 + 65 + \ldots)}{15000 \times 100}$$

$$= 0.00064\ mm^2$$

and sampling length (real world) = 0.8 mm.

$$\Rightarrow \boxed{R_a = 0.008\ mm} = 8\mu m.$$

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Qs: Calculate arithmetic average, rms value, R_{max} value of surface ~~width~~ with of following data:-

Ordinate	deviation (μm)
1	0.15
2	0.25
3	0.35
4	−0.25
5	−0.3
6	−0.15
7	0.1
8	0.3
9	0.35
10	0.10

8	0.3
9	0.35
10	0.10

Sol^n: Arithmatic avg ⇒ well, "arithmetic average" & "average difference" is same only; cuz "इसमें" −0.5 &+0.5 को =0 तो you can't do.

⇓

abs. value ही लेंगे so yep.

so arithmetic avg $= \dfrac{0.15 + 0.25 + 0.35 + 0.25 + 0.3 + \cdots}{10}$

avg value = 0.23

rms − value = 0.248

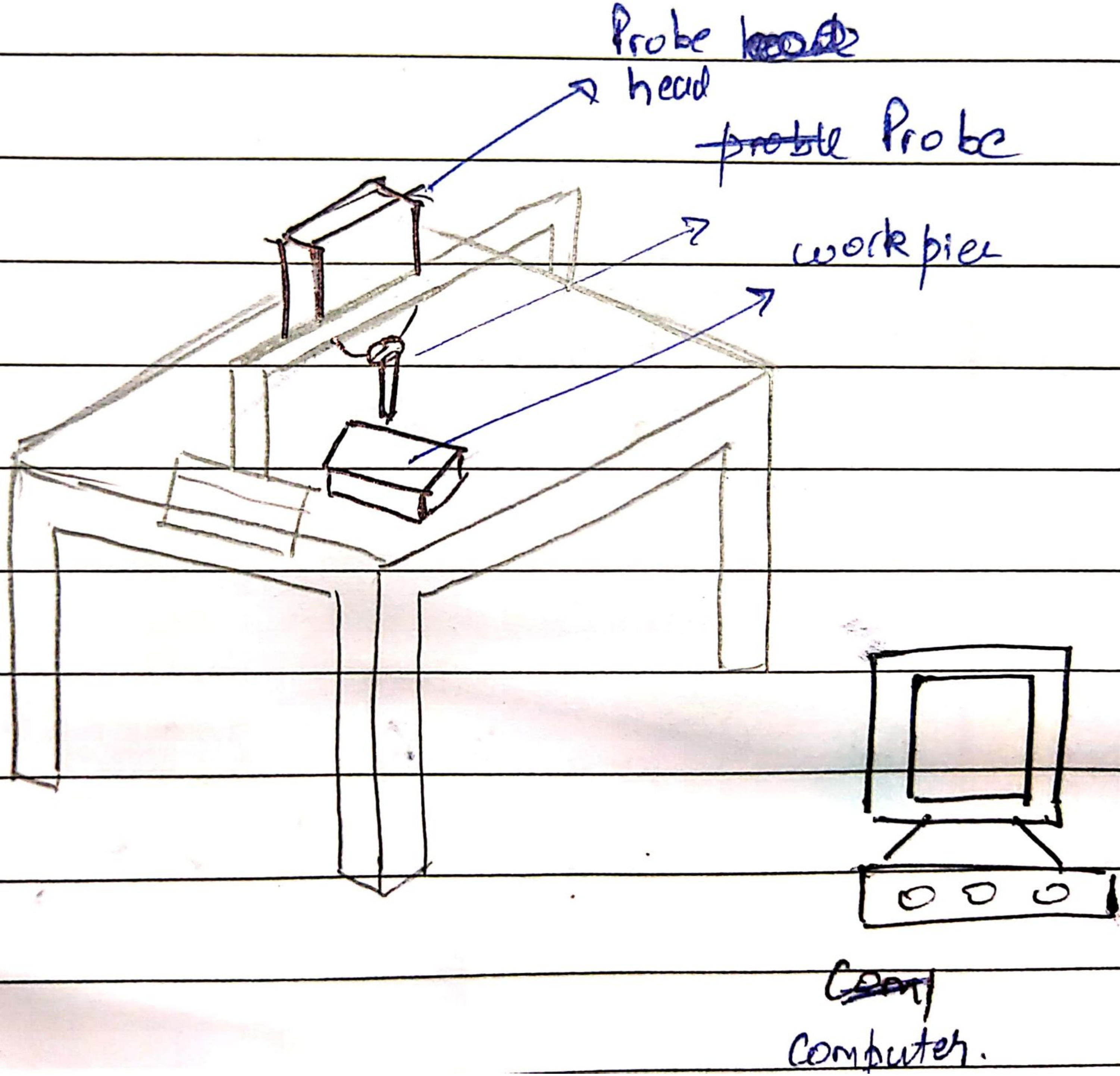
$R_{max} = 0.65$

★ Topic : Coordinate Measuring Machine :- (CMM)

It is a machine used for measuring dimensions using sensors.

Need for CMM :

(i) Traditional measuring instruments require more time.
(ii) Require space & proper care.
(iii) Human error caused by traditional methods.
(iv) Traditional methods not suitable for automated production.


Probe head
~~proble~~ Probe
workpiec
~~Com~~ computer.

Features of CMM:

→ Includes surface plate.

→ Includes height gauge/slip gauges.

→ Dial gauge

→ Angle measurements.

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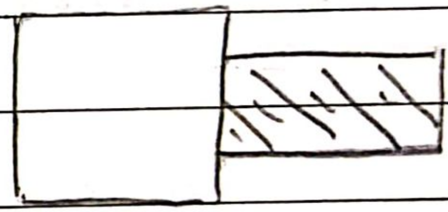
* TOPIC: MEASUREMENT of SCREW THREADS :-

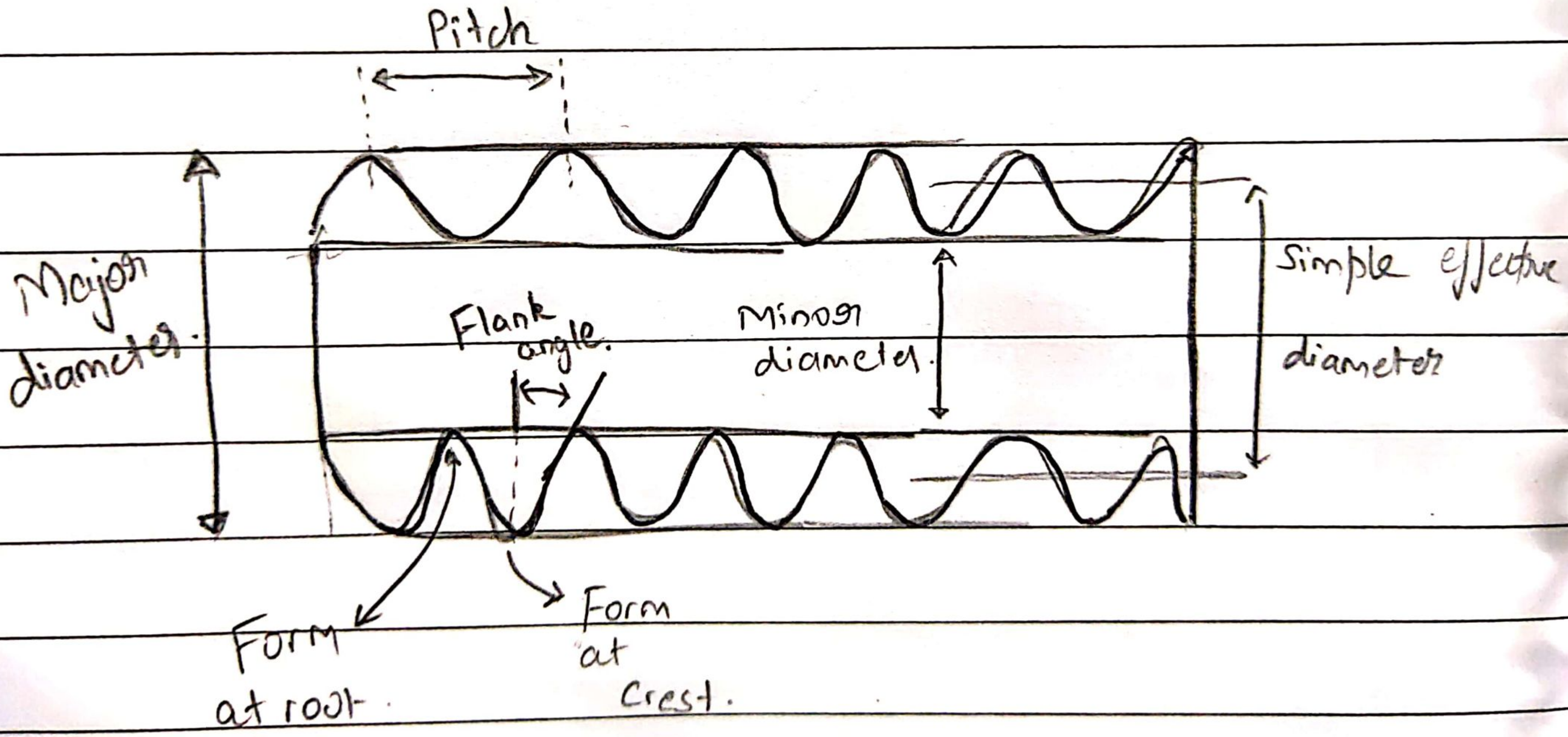
* Elements of Screw Threads :



1.) Major diameter
2.) Simple, effective diameter
3.) Minor diameter.
4.) Pitch
5.) Flank angle
6.) Form at the root.
7.) Form at the crest.

root.

crest.



Pitch
Major diameter.
Flank angle.
Minor diameter.
Simple effective diameter
Form at root.
Form at crest.

(1.) Major diameter:-

Defined as diameter of imaginary cylinder just embracing crest of external thread or root of internal thread.

(2.) Simple effective diameter:- (aka Pitch diameter)

Diameter of an imaginary cylinder intersecting flank surface into two equal halves.

(3) Minor diameter:-

........~~is~~ just touching Root of external ~~cyl~~ thread or Crest of internal thread.

(basically; ~~choo~~ chhota diameter; in comparision to major one.)

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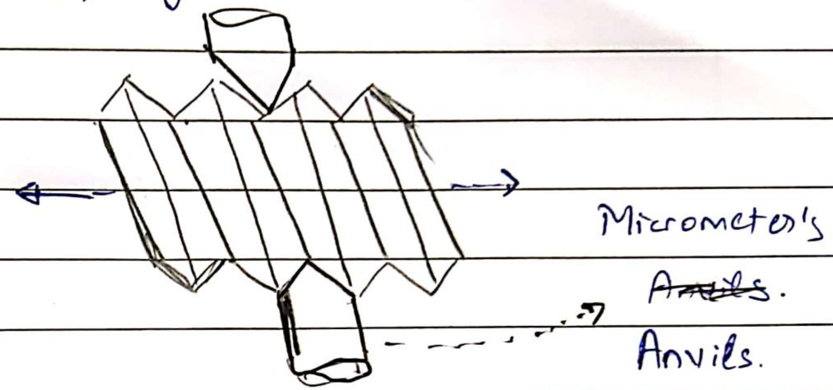
↦ Way to measure minor diameter. $\Longrightarrow$ by Bench micrometer.

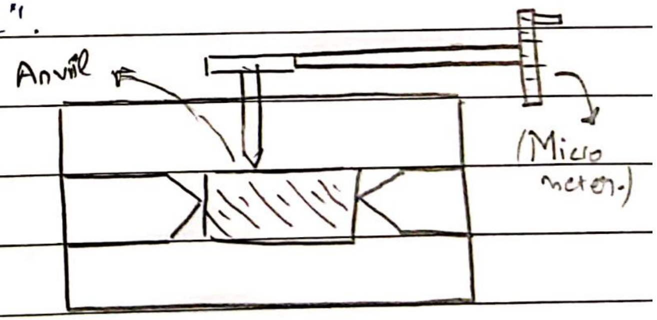


(4) Pitch:

Dist. b/w 2 adjacent threads; measured $\parallel^{l}$ to axis.

↦ Measured by "pitch-measuring machine".

rotate ~~ano~~ s.t. anvil goes through one thread; then measure on micrometer.

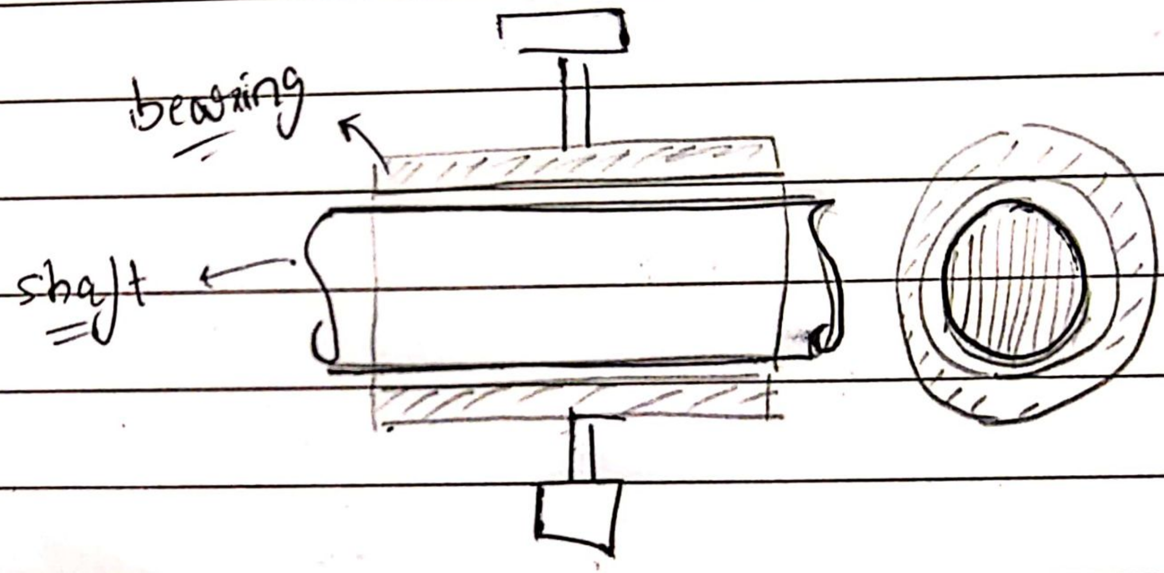


(5.) Flank angle - self explanatory

(6.) & (7.): Radii of circles of those profiles at crest/root.

for moving parts e.g

TOPIC: LIMITS, FITS & TOLERANCES. :– shaft, bearing.



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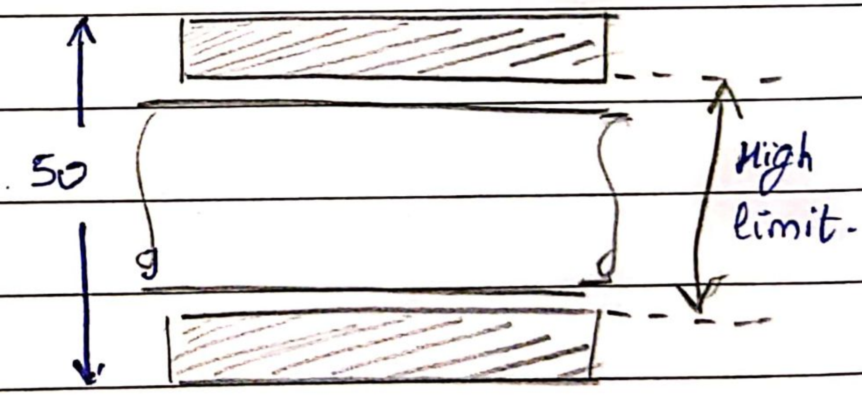
Outer dia. of bearing = 50.0 mm.

Required diameter of hole = 25.0 mm.



→ **High limit**: maximum size permitted for the part/feature

→ **Low limit**: Minimum size permitted for the part/feature.

Here; high limit $\simeq$ 25.02 mm

low limit $\simeq$ 24.98 mm, that we can give.

2.) **Tolerance :**

Difference between high & low limits.

(a) Unilateral Tolerance : — ~~250 ctoo.~~ $25^{+0.02}_{-0.00}$ ~~(e.g. good for our example~~

(b) Bilateral Tolerance :- ~~$25^{+0.02}$~~ $25^{+0.02}_{-0.02}$

(3) **Allowance :** Intentional difference b/w high limit (of inner part) & low limit (of outer part)

E.g. if Cut is $25^{+0.02}_{-0.02}$

and shaft is $24.9^{+0.02}_{-0.02}$

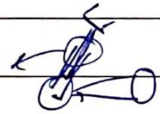
$\Rightarrow$ Allowance $= 24.98 - 24.92 = \boxed{0.06}$

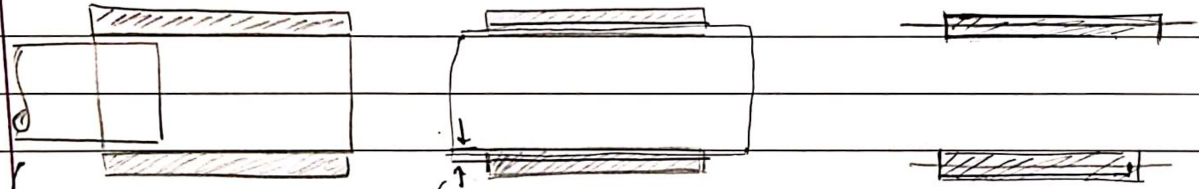
(Tolerance is on single part. Allowance is on a pair. Even with max dia of one & min dia of other; there is some INTENTIONAL gap.)

That's allowance.

(4.) **Fit** :- Relationship existing b/w two mating parts ; wrt amount of interference.

Types of fits:

Clearance fit.	Transition fit.	Interference fit.
eg: (freely rotat? i.e ~~ball~~ bearings)	eg: Keying fit in machine tools.	eg:- Bicycle 



Tolerance.

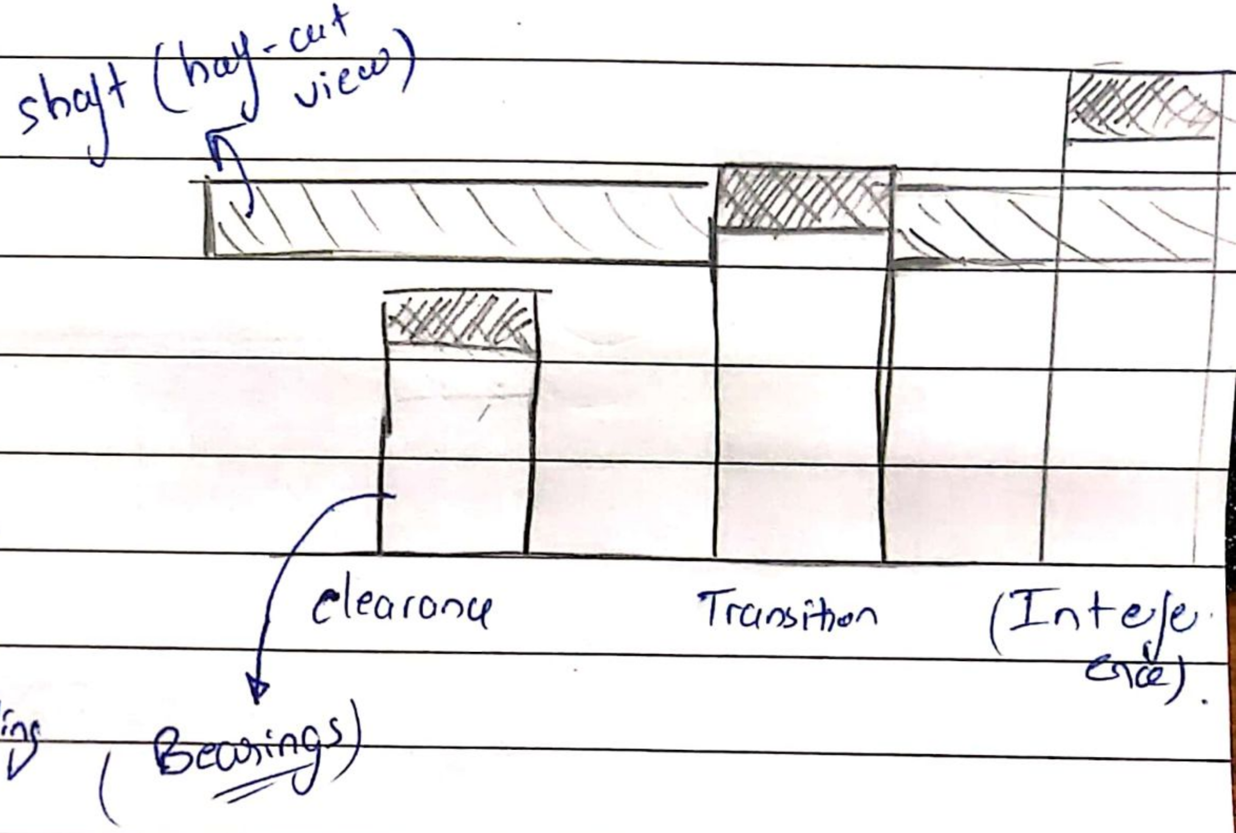
Clearance fit: {max diameter of inner part < min diameter of outer part}

Transition fit: low limit of outer < (Max dia. of inner) < High limit of outer

(high limit & max dia is same)

Interference fit: (Minimum diameter of inner part) > (High limit of outer part.)

Different Types of Fits



Hole Basis System:

~~something like "hole is fixed first".~~

Hole (bearing) fixed first. Then shaft is machined to fit according to need.

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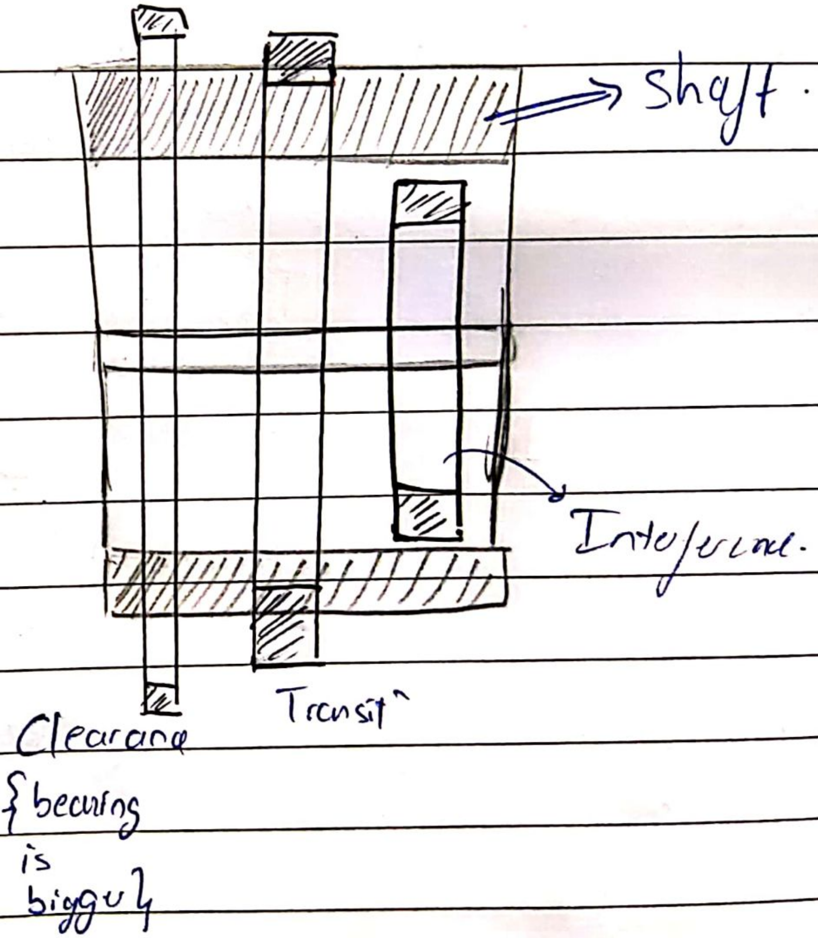
(2.) Shaft basis system:

No physical difference. But here you fix the shaft's diameter & then make bearing (hole) dia. big or small.



Question: Find values of allowance, hole tolerance, shaft tolerance of following dimension of moving parts according to

{bearing is bigger}

Question: Find values of allowance, hole tolerance, shaft tolerance of following dimension of moving parts according to hole basis system.

Hole dia. = 37.5 mm. to 37.52 mm

shaft dia: 37.47 to 37.45 mm

Sol^n: ~~Hole tolerance~~ • Firstly; its clearly a clearance fit.

Anyways,

Tolerance = 0.02 mm. (for both)

Allowance = 0.03 mm

Allowance = 0.03 mm

Questⁿ: A 75 mm dia. shaft rotates in a bearing. Tolerance for ~~the~~ both shaft & bearing is 0.075 mm, and required allowance is ~~determined~~ 0.10 mm. Determine dimensions of the shaft & bearing bore with basis of hole standard.

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~~Sol^n~~ Ans: Well; its hole-standard so 75MM is hole diameter.

Tolerance is 0.075 MM

so hole is ~~$75 \pm \frac{0.075}{2}$~~

{yes, idhar कोई $^{+}_{0}$ की bakchodi nahi.}

★NOTE: Hole-basis ⇒ Low limit is 75 MM of HOLE.
Shaft-basis ⇒ High limit is 75 MM, voh bhi of SHAFT.

Hence, hole is $75^{+0.075}_{0}$

and

allowance is 0.10 MM ⇒ ~~shafter~~ shaft is ~~74.9~~

High limit of shaft = 74.9 MM

Low limit of shaft is = 74.825 MM.

Case-II if ~~75m~~ it were shaft-basis as standard:

Then shaft ⇒ H.L of shaft = 75 MM

LL of shaft = 74.925 MM.

and allowance

= 0.1 MM ⇒ LL of hole = 75.1 MM

HL of hole = 75.175 MM.