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GATE 2024
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CASTING
LEC-07
Mechanical Engineering


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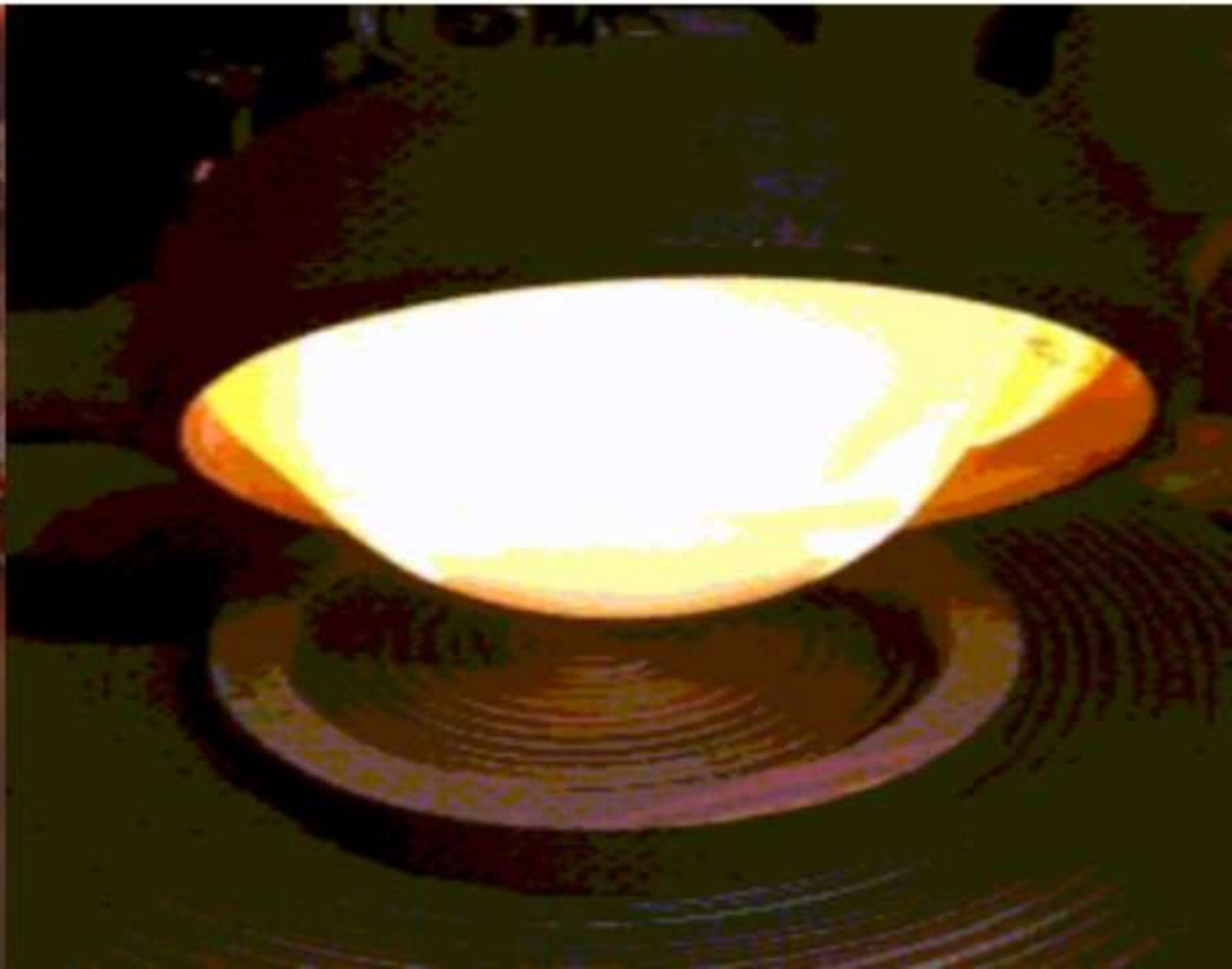
GATE 2024
GATE
प्रचण्ड Batch
MECHANICAL ENGINEERING
MON/ TUE/ WED- 9PM
THEORY OF MACHINE (TOM)
THUR/ FRI/ SAT- 6PM
PRODUCTION ENGINEERING

CASTING



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Introduction of Casting

Broad Steps in Sand Casting

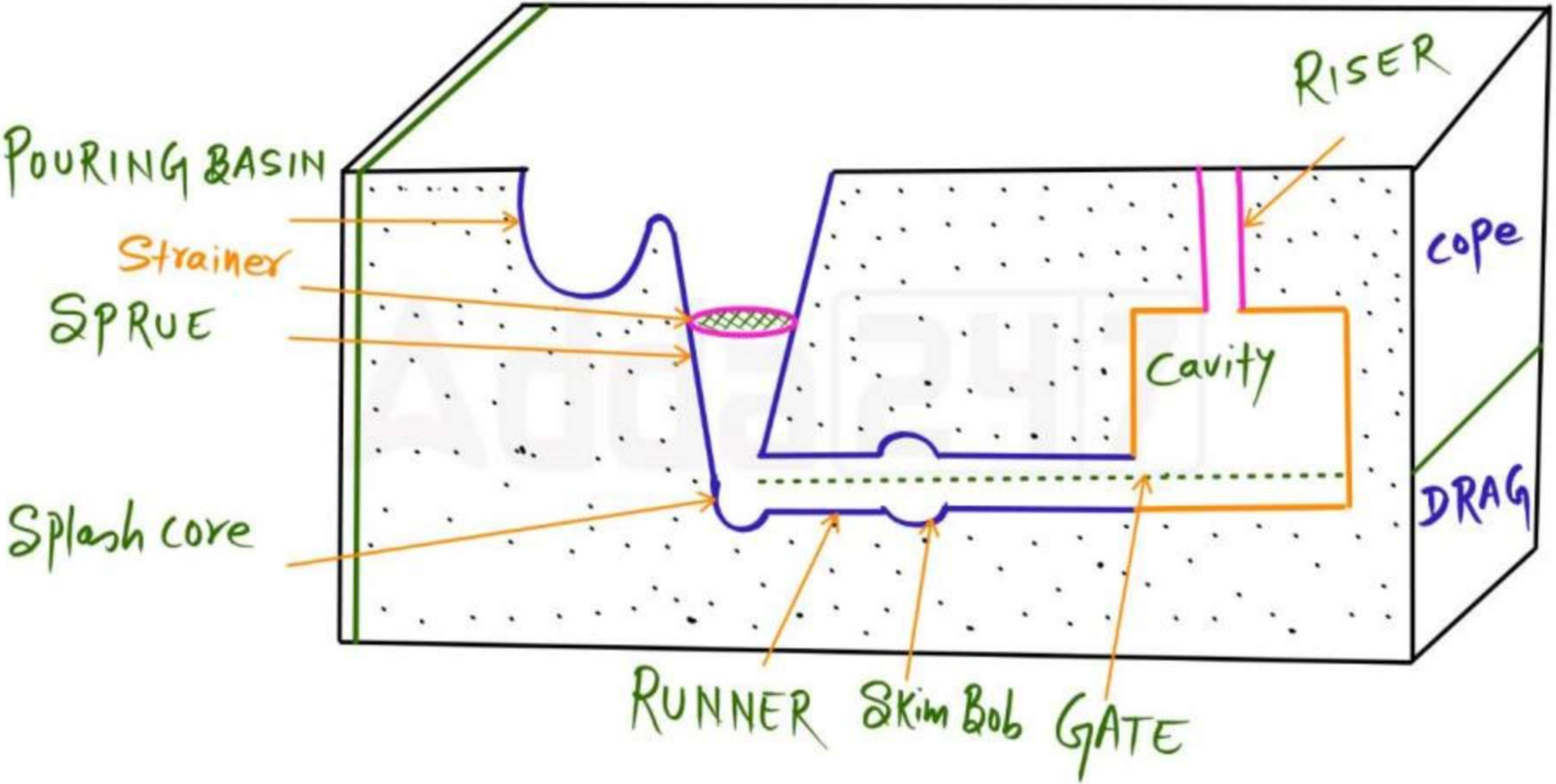
Cooling Curve for Sand Casting

Types of allowances

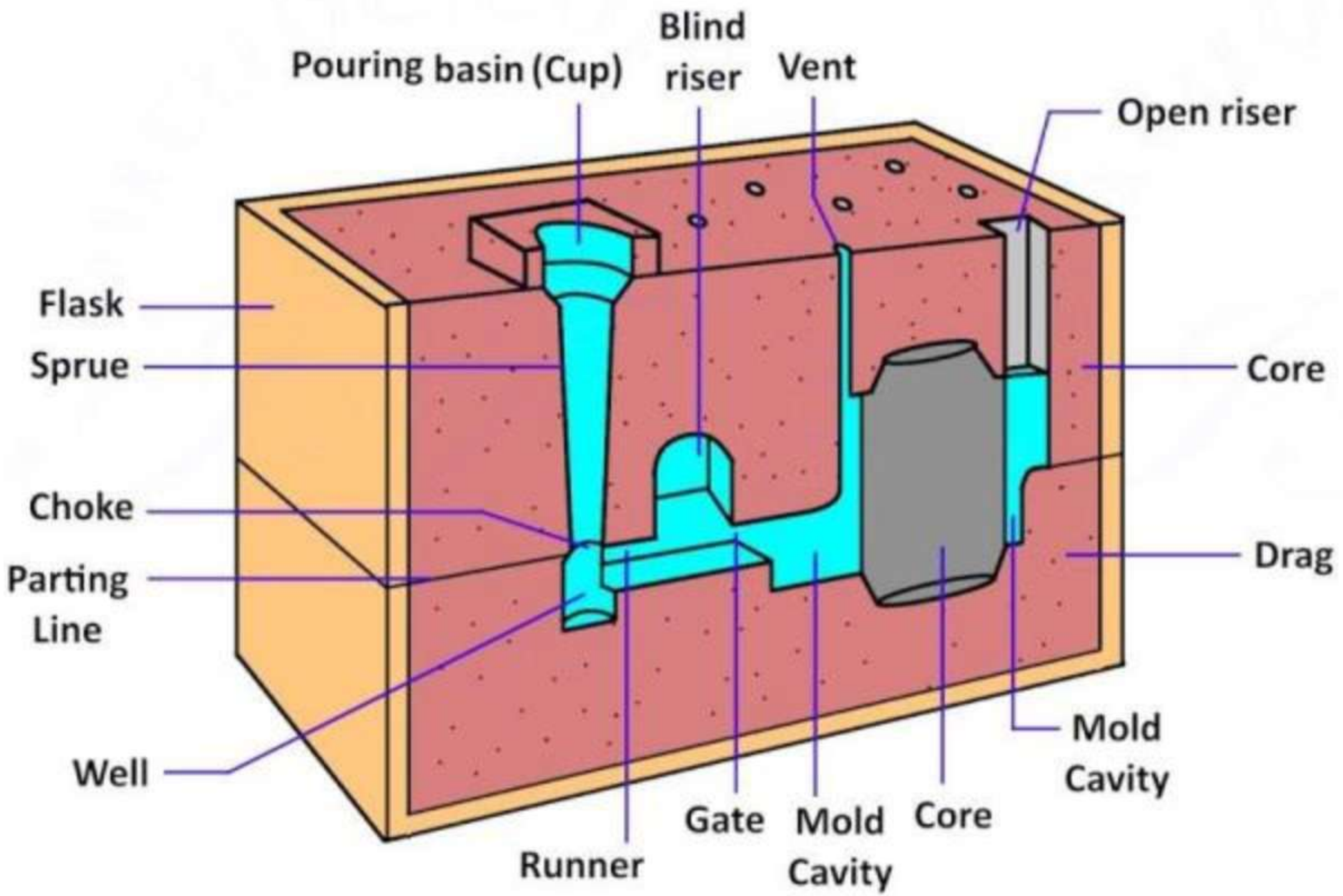
Types of pattern

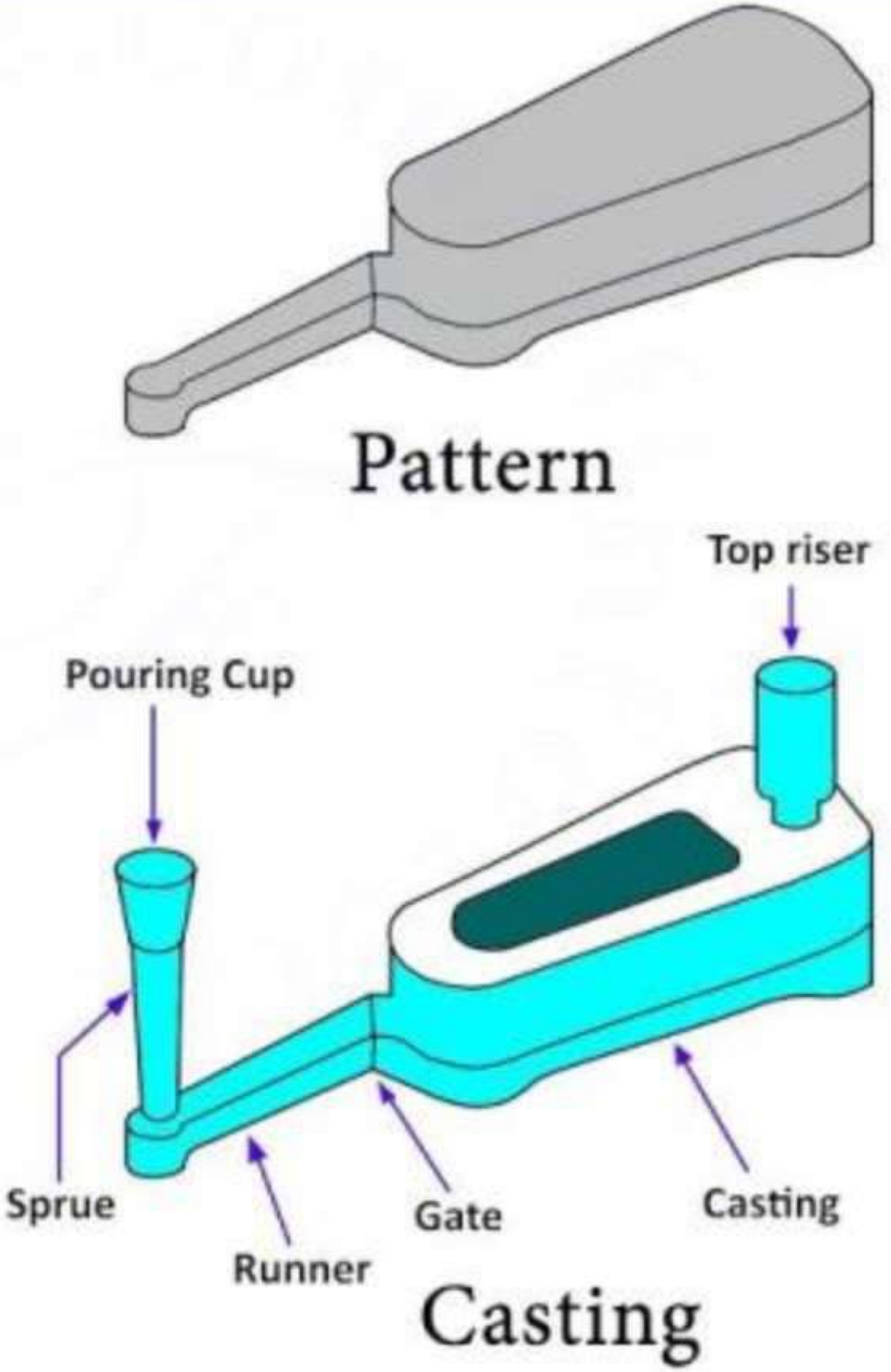
Moulding sand and its properties

Elements of Gating Design


POURING BASIN
Strainer
SPRUE
Splash core
RISER
cope
Cavity
DRAG
RUNNER
Skim Bob
GATE

Gating System (Metal Casting Process)

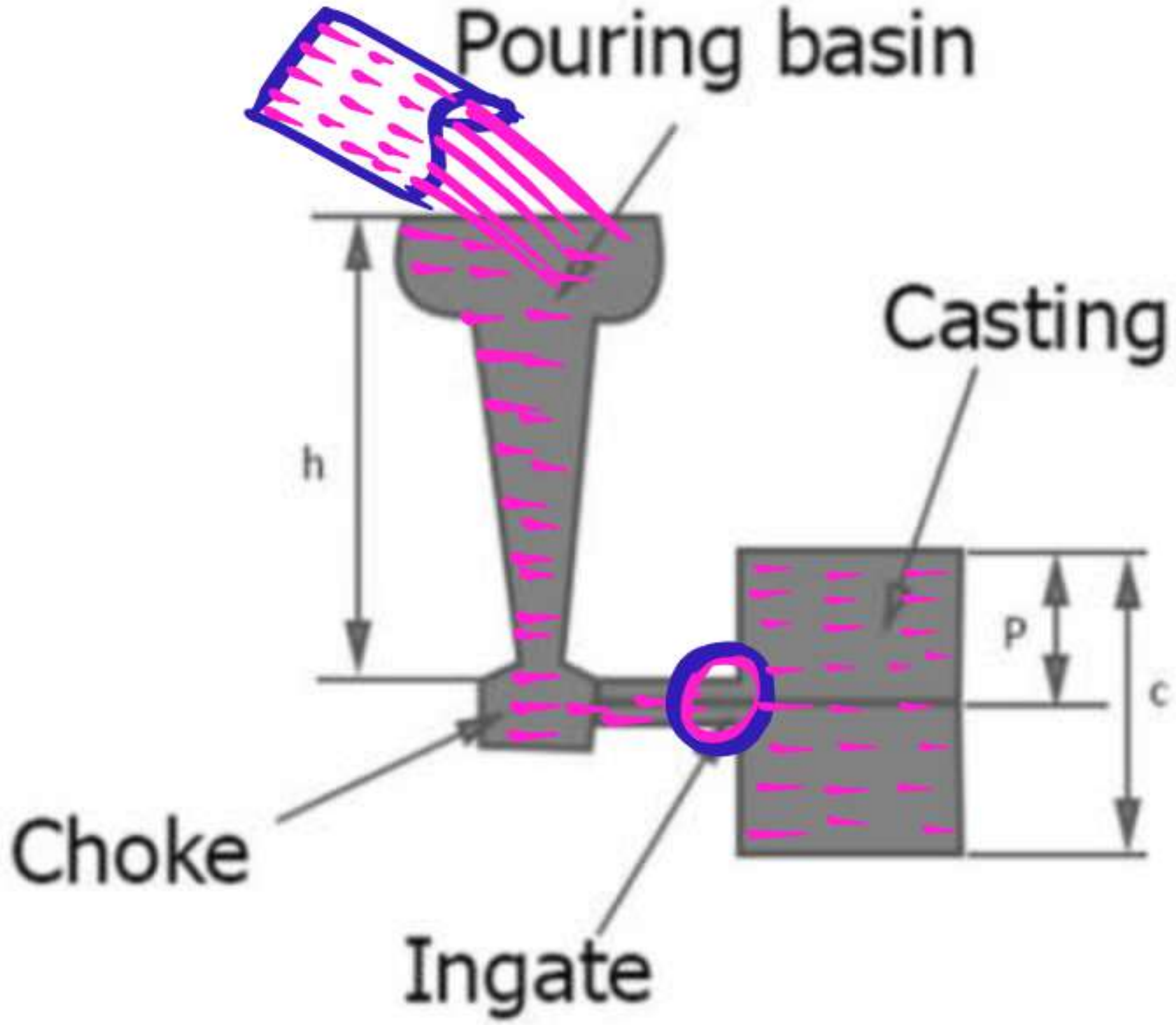




Gate

(In GATE)

It is the actual entry point through which liquid metal can be enter into the cavity.



Types

1 Top gate

2 Bottom gate

3 Parting line gate

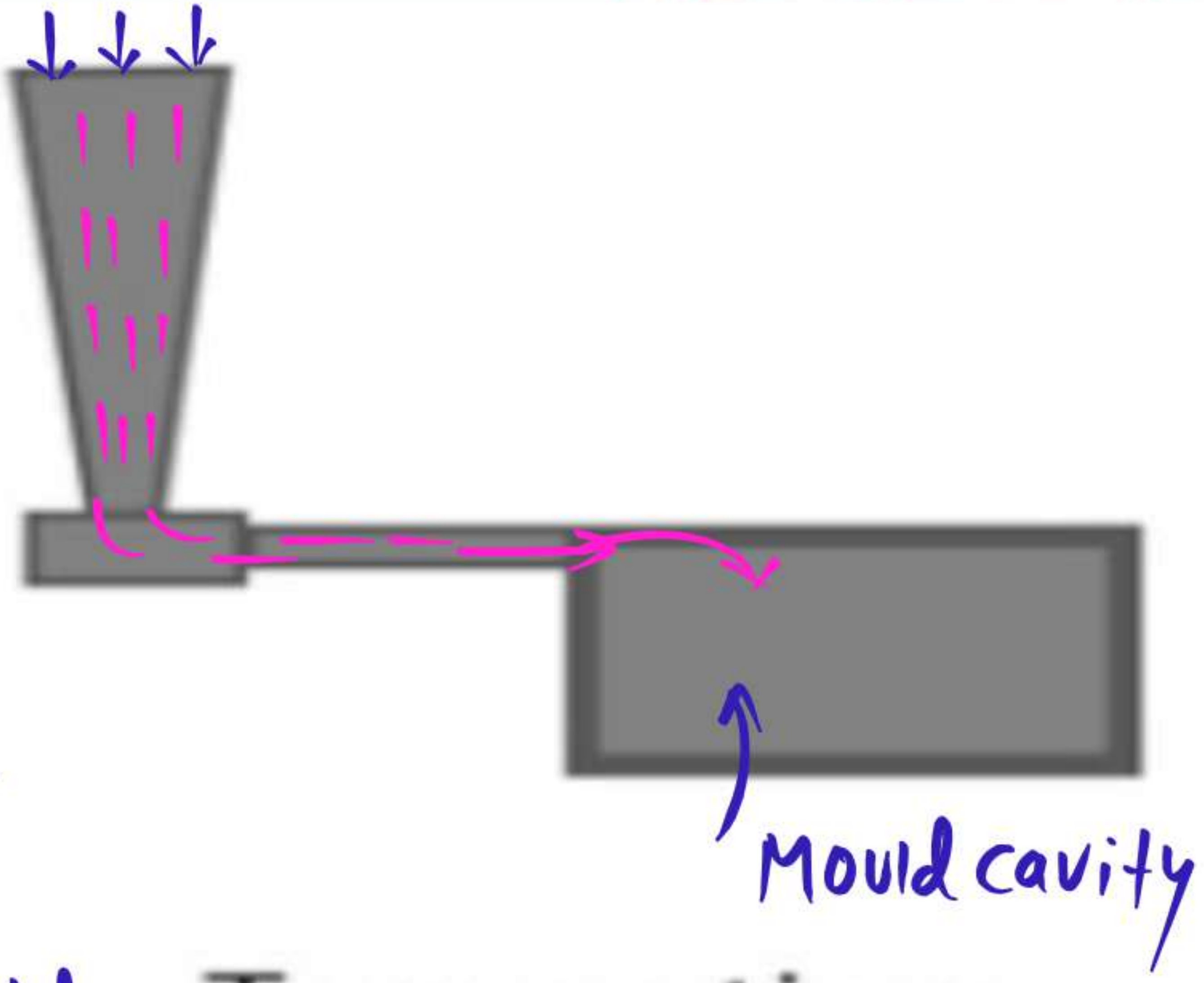
4 Step gate

① → Top Gate

② → Bottom Gate

Top Gate

* Molten Liquid Metal enter into the cavity from bottom of Sprue at Atmospheric pressure.
* Velocity of Molten Liquid Metal in the cavity will be Very High.
* There is a possibility of Turbulence, Mould Errosion and Splacing of Molten Liquid Metal.



Top gating

* It can be used casting of ferrous Materials

* It can not be used for casting of Soft Material like Non-ferrous Material, Al, Mg etc.

* Temperature Gradient $= \left(\frac{\Delta t}{h}\right) \rightarrow$ favourable temp Gradient

$\Downarrow$

Directional Solidification Achieved

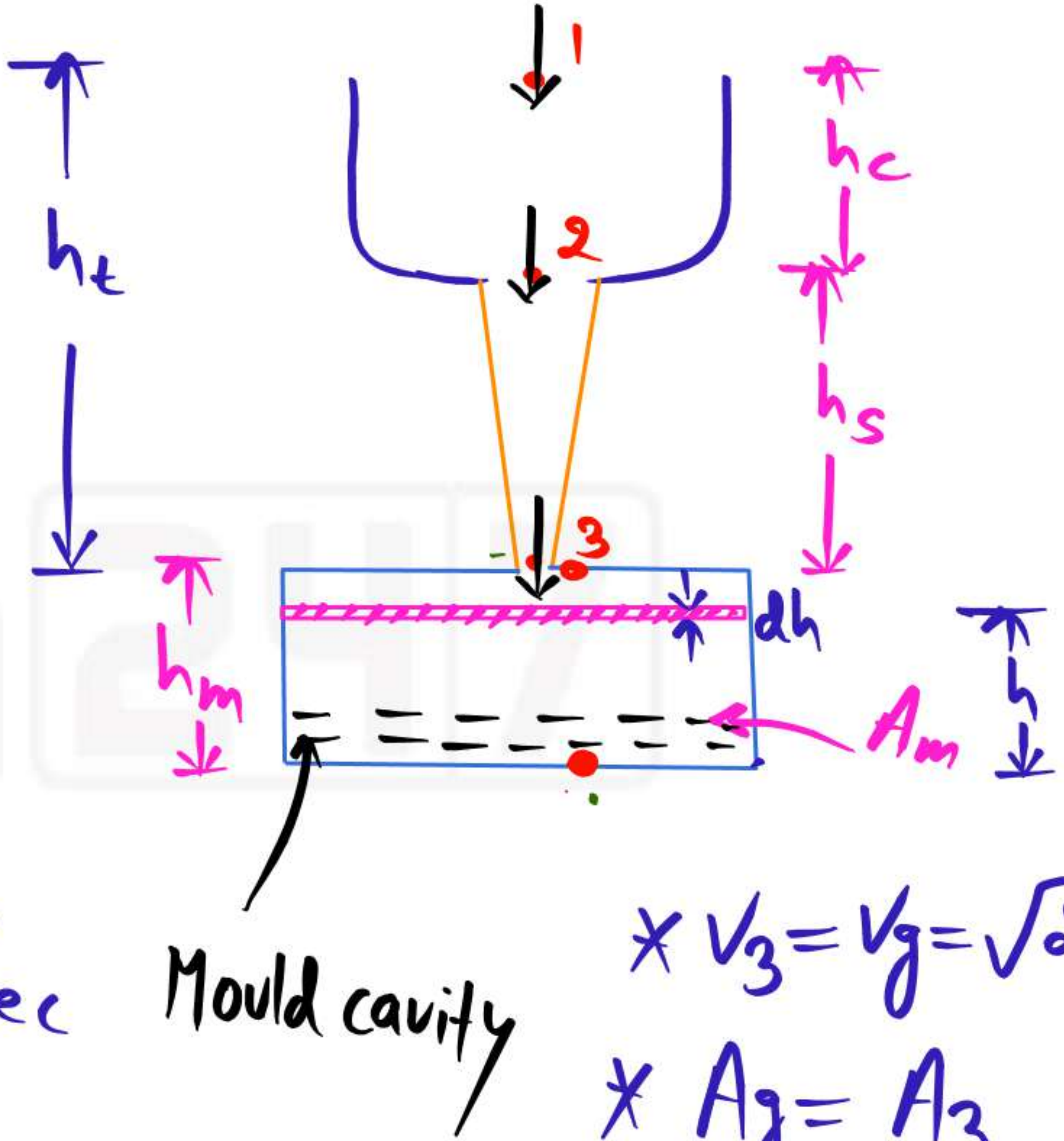
$\Downarrow$

Uniform Solidification

(7) capacity of Mould $(V_m) = h_m \times A_m$

(8) Time Required to fill the Mould cavity by Top Gate (t_{f_T})

3 → Top Gate



$$* \ \text{Time} = \frac{\text{Volume} \rightarrow mm^3}{\text{Discharge} \rightarrow mm^3/sec}$$

Time ↓ sec

$* \ V_3 = V_g = \sqrt{2gh_t}$

$* \ A_g = A_3$

$$* \; t_{f_T} = \frac{V_m}{Q_3} = \frac{A_m \cdot h_m}{A_g \times V_g} = \frac{A_m \cdot h_m}{A_g \times \sqrt{2g \cdot h_t}}$$

$$* \; \boxed{t_{f_T} = \frac{V_m}{A_g \times \sqrt{2gh_t}} = \frac{A_m \times h_m}{A_g \times \sqrt{2 \cdot g \cdot h_t}}}$$

2nd Method :→

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

$$* \int_{t=0}^{t=t_f} dt = \frac{A_m \cdot}{A_g \cdot V_g} \int_{h=0}^{h=h_m} dh$$

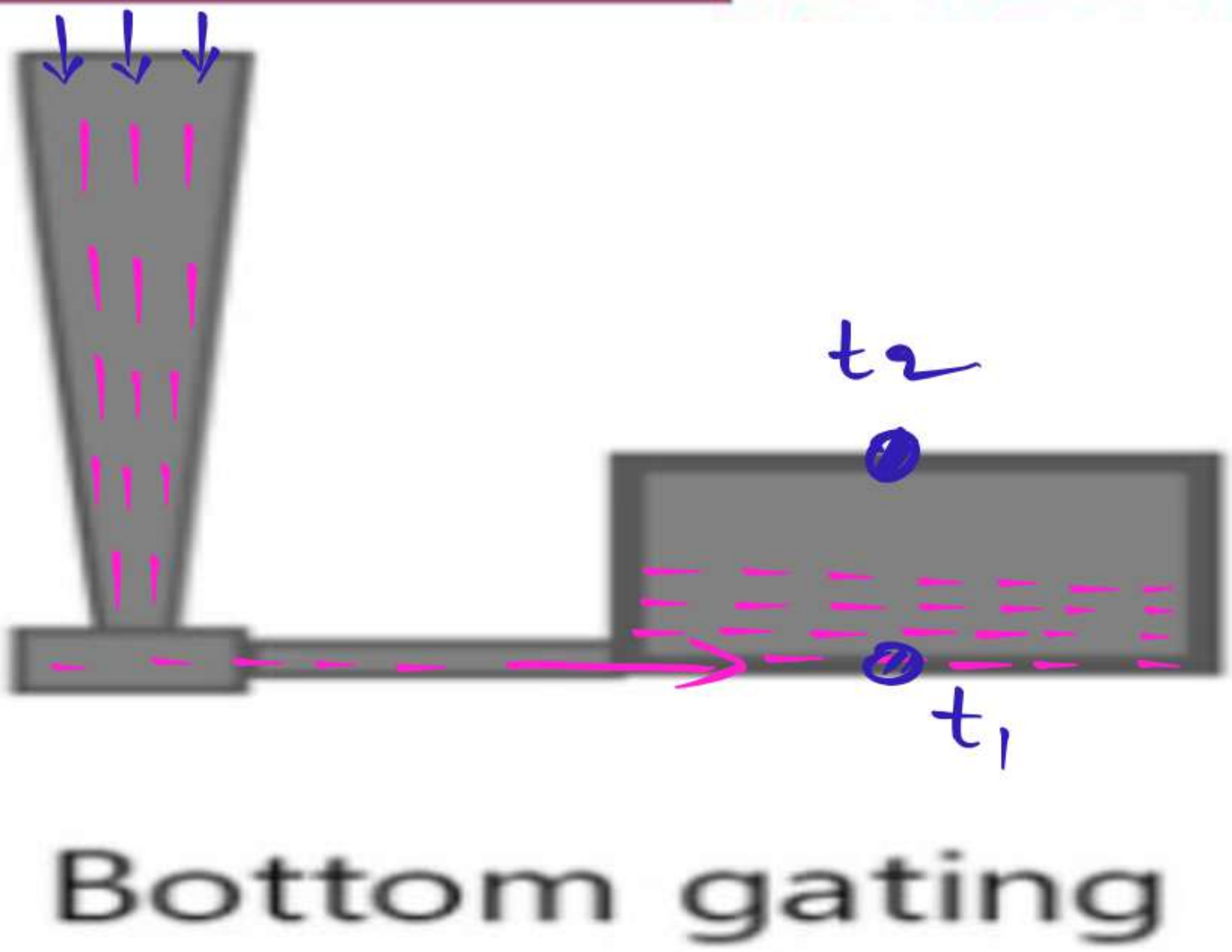
$$* \; t_f = \frac{A_m}{A_g \cdot V_g} \times h_m$$

$$* \; t_f = \frac{A_m \cdot h_m}{A_g \cdot V_g}$$

$$* \; \boxed{t_{f_T} = \frac{A_m \cdot h_m}{A_g \times \sqrt{2gh_t}} = \frac{V_m}{A_g \times \sqrt{2gh_t}}}$$

Bottom Gate

* Liquid Metal Enter into the cavity from Bottom to top vertically upward in Direction.
* Velocity of Molten liquid Metal in the cavity is low → Negliagble
* There is No Possibility of Turbulence, Mould Erossion And Splacing of Molten liquid Metal



$t_1 >> t_2$

* By this Gating System Soft Material will be casted. e.g → Al, Mg

* It can be used for casting of Non-ferrous Material

* Temperature Gradient ⇒ $\left(\frac{\Delta t}{h}\right)\uparrow$ ⇒ Un-favourable temp Gradient

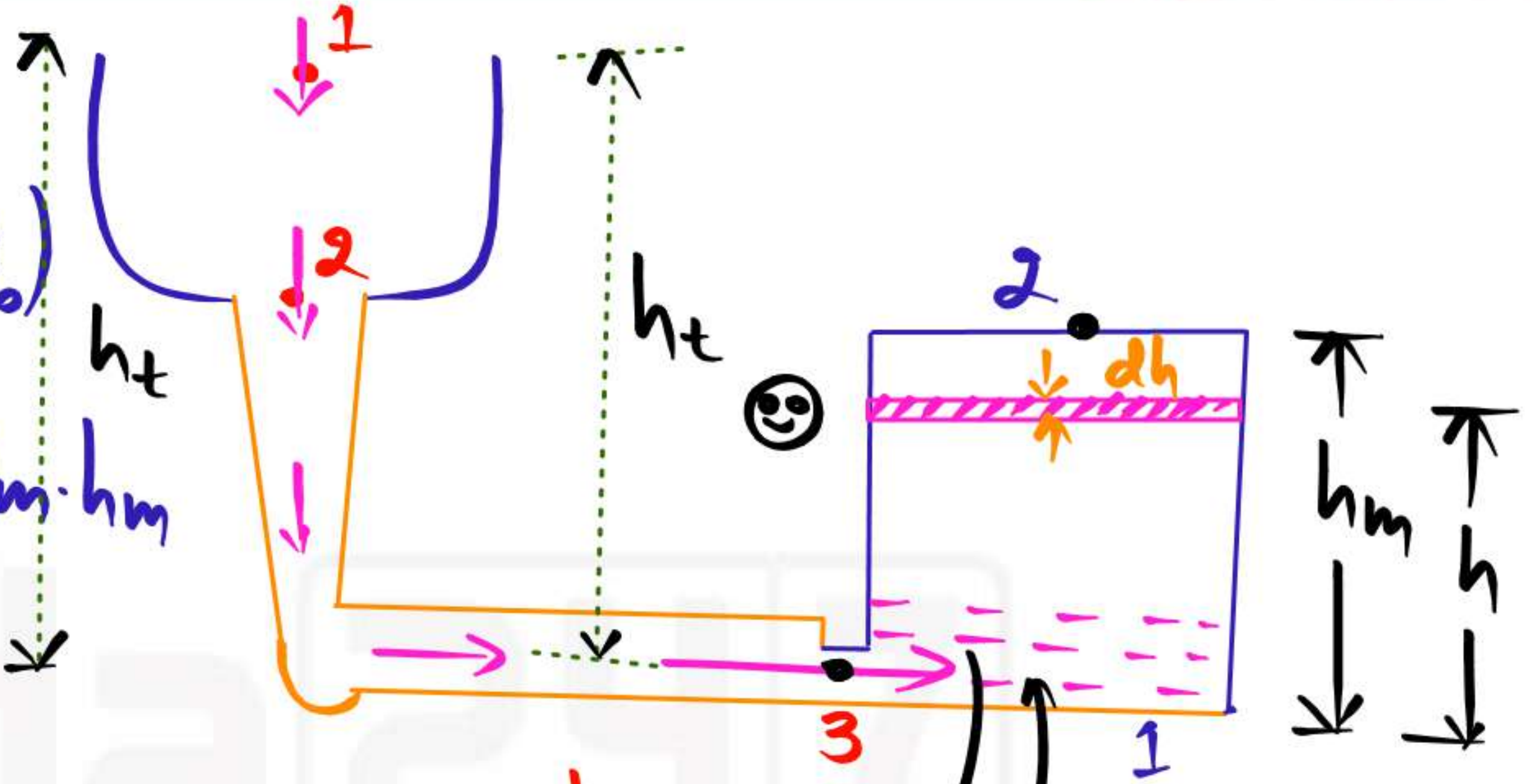
⇓

Non-uniform Solidification

⇓

Not Acheving Directional Solidification ☹

Time Required to Fill the Mould cavity by Bottom Gate (t_{fb})



* capacity of Mould cavity $(V_m) = A_m \cdot h_m$

3 → Bottom Gate

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

* $dt = \frac{A_m \cdot dh}{A_g \cdot V_g}$

* ~~$V_3 = V_g = \sqrt{2gh_t}$~~

* $V_3 = V_g = \sqrt{2g(h_t - h)}$

Mould cavity

A_m

* $V_1 = \sqrt{2gh_t}$
* $V_2 = \sqrt{2g(h_t - h_m)}$

$$* \quad dt = \frac{A_m \cdot dh}{A_g \times V_g}$$

$$* \int_{t=0}^{t=t_f} dt = \int_{h=0}^{h=h_m} \frac{A_m \times dh}{A_g \times \sqrt{2g(h_t - h)}}$$

$$* \int_{t=0}^{t=t_f} dt = \frac{A_m}{A_g \times \sqrt{2g}} \times \int_0^{h_m} \frac{dh}{\sqrt{(h_t - h)}}$$

$$* \quad t_f = \frac{A_m}{A_g \times \sqrt{2g}} \times \int_0^{h_m} (h_t - h)^{-1/2} \, dh$$

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

$$* \quad t_f = \frac{-2A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t - h} \right]_0^{h_m}$$

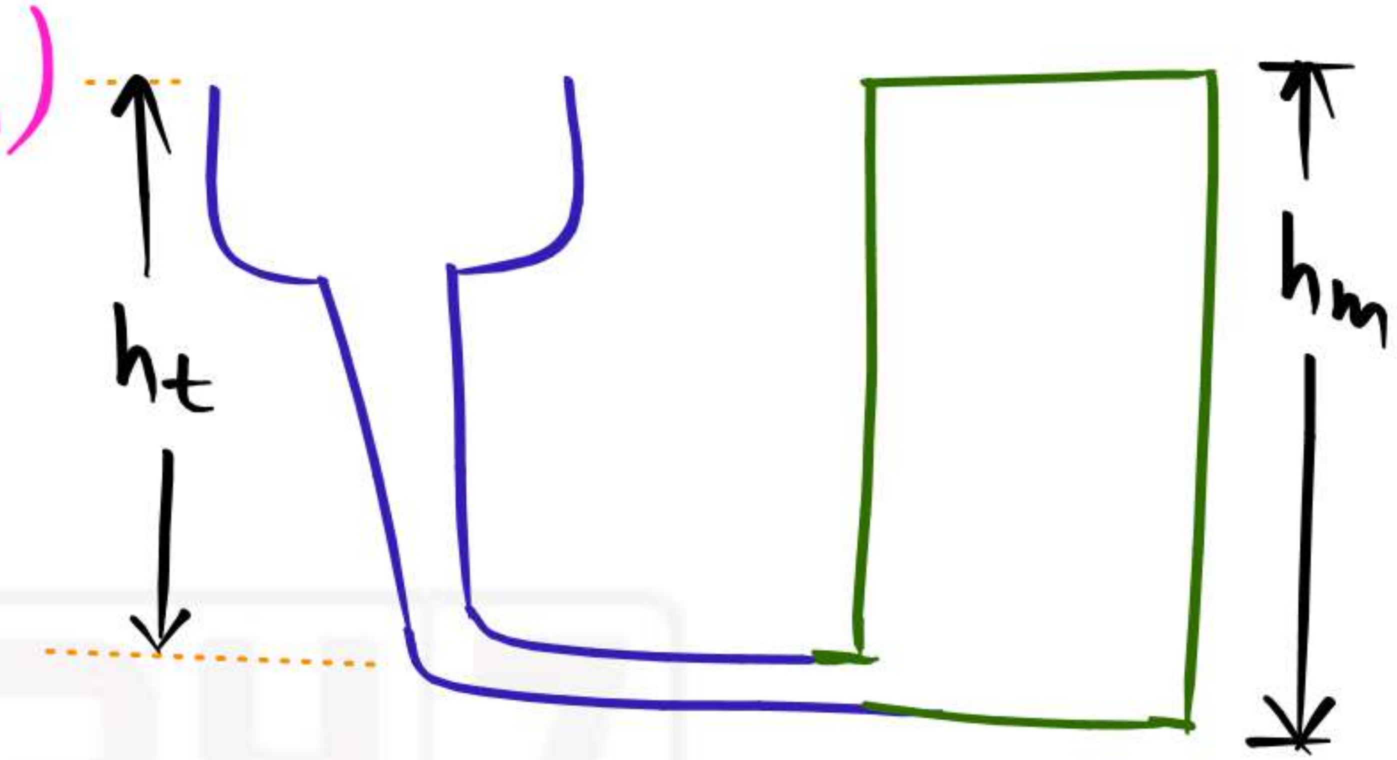
$$* \quad t_f = \frac{-2A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t - h_m} - \sqrt{h_t} \right]$$

$$* \quad t_{f_b} = \frac{2A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t} - \sqrt{h_t - h_m} \right]$$

* $$t_{f_T} = \frac{V_m}{A_g \times v_g} = \frac{A_m \times h_m}{A_g \times \sqrt{2 \cdot g \cdot h_t}}$$

* $$t_{f_b} = \frac{2 A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t} - \sqrt{h_t - h_m} \right]$$

Relation between Top and Bottom Gate when $(h_t = h_m)$



* $t_{fb} = \frac{2A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t} - \sqrt{h_t - h_m}\right]$

If $(h_t = h_m)$

* $t_{fb} = \frac{2A_m}{A_g \times \sqrt{2g}} \times \sqrt{h_t}$

* $t_{fb} = \frac{2A_m}{A_g \times \sqrt{2g}} \times \sqrt{h_t} \times \frac{\sqrt{h_t}}{\sqrt{h_t}}$

* $t_{fb} = \frac{2A_m \cdot h_t}{A_g \times \sqrt{2gh_t}} = \frac{2A_m \cdot h_m}{A_g \times \sqrt{2gh_t}} = \frac{2 \times V_m}{A_g \times V_g}$ → t_{fT}

* $$t_{fb} = 2 \times t_{fT}$$

If ($h_t = h_m$)

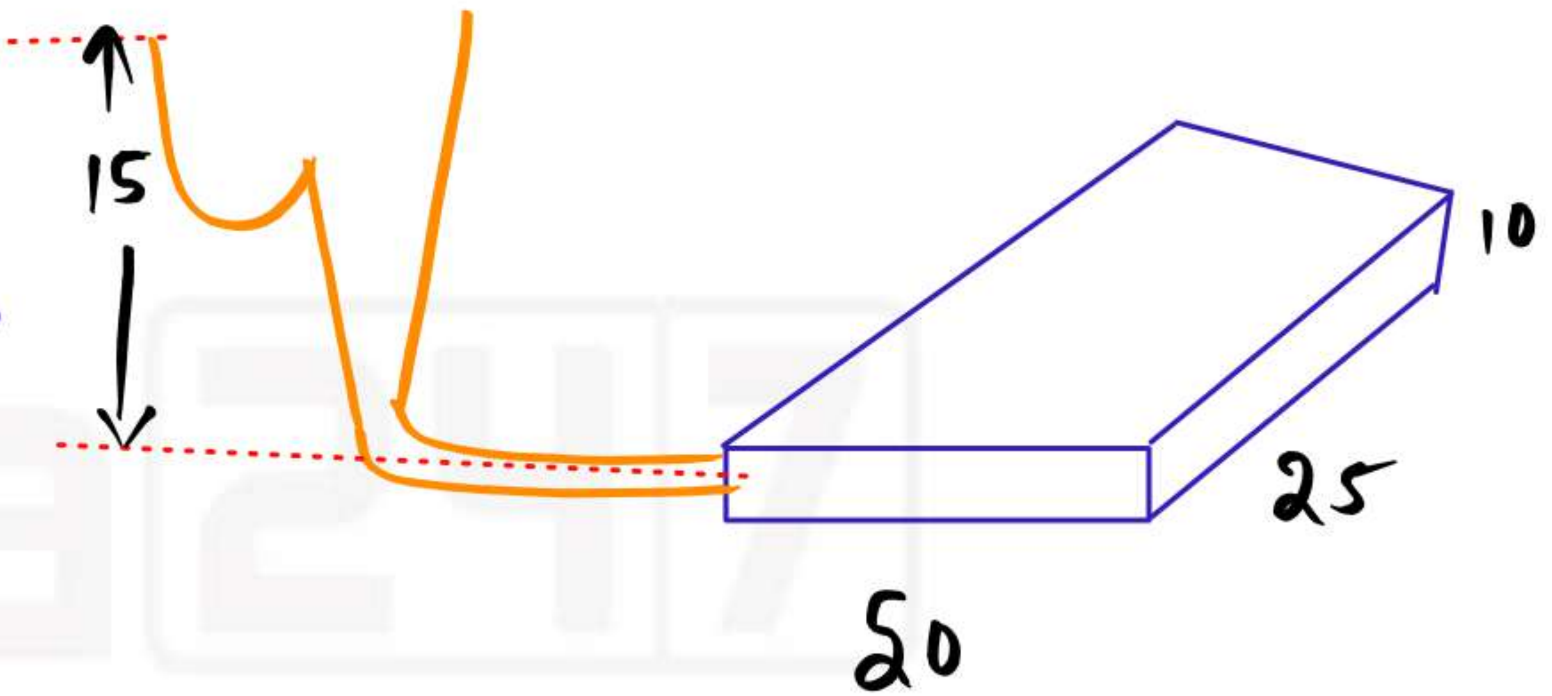
Q

In a gating design dimensions of the cavity is 50cm,25cm and 10cm.it will be filled by providing gate on the top of the cavity with the pouring height of 15cm.Area of the gate is 5cm2.Determine time taken to fill the cavity.

1. By using top gate
2. By using bottom gate

Given Data: → $V_m = 50 \times 25 \times 10 \, cm^3$

* $A_g = 5 \, cm^2$
* $h_t = 15 \, cm$



Solution :→

$* \; g = 9.81 \, m/s^2 \Rightarrow 981 \, cm/s^2$

① By Top Gate

$$* \; t_{fT} = \frac{V_m}{A_g \times V_g} = \frac{V_m}{A_g \times \sqrt{2 \cdot g \cdot h_t}}$$

$$* \; t_{fT} = \frac{20 \times 25 \times 10}{5 \times \sqrt{2 \times 981 \times 15}} \quad \begin{matrix} \rightarrow cm^3 \\ \rightarrow cm^3/sec \end{matrix}$$

$$* \; \boxed{t_{fT} = 14.57 \; sec}$$

(2) By using Bottom Gate

* $t_{fb} = \frac{2 \cdot A_m}{A_g \times \sqrt{2g}} \left[\sqrt{h_t} - \sqrt{h_t - h_m} \right]$

* $t_{fb} = \frac{2 \times 50 \times 25}{5 \times \sqrt{2 \times 981}} \left[\sqrt{15} - \sqrt{15 - 10} \right]$

* $t_{fb} = 18.47$ Sec

Q

In a gating design the mould dimensions are 50cm,25cm and 15cm the height of liquid metal above the gate is 15cm area of the gate is 5cm2.Determine time required to fill the mould cavity by using Bottom gate.

Given Data :→

* $V_m = 50 \times 25 \times 15 \text{ cm}^3$
* $h_t = 15 \text{ cm}$
* $A_g = 5 \text{ cm}^2$
* $t_{fb} = ?$

* $h_m = 15 \text{ cm}$
* $h_t = 15 \text{ cm}$

$\Rightarrow h_t = h_m$

* $t_{fb} = 2 \times t_{fT}$

* $t_{fb} = 2 \times 21.85$

* $t_{fb} = 43.72 \text{ sec}$

* $t_{fT} = \frac{V_m}{A_g \times V_g} = \frac{V_m}{A_g \times \sqrt{2gh_t}}$

* $t_{fT} = \frac{50 \times 25 \times 15}{5 \times \sqrt{2 \times 981 \times 15}} \text{ cm}^3$

* $t_{fT} = 21.85 \text{ sec}$

Parting line gate

Parting line gating

Calculate the cross-sectional area of the gate such that liquid metal can be filled into the cavity in 10 seconds

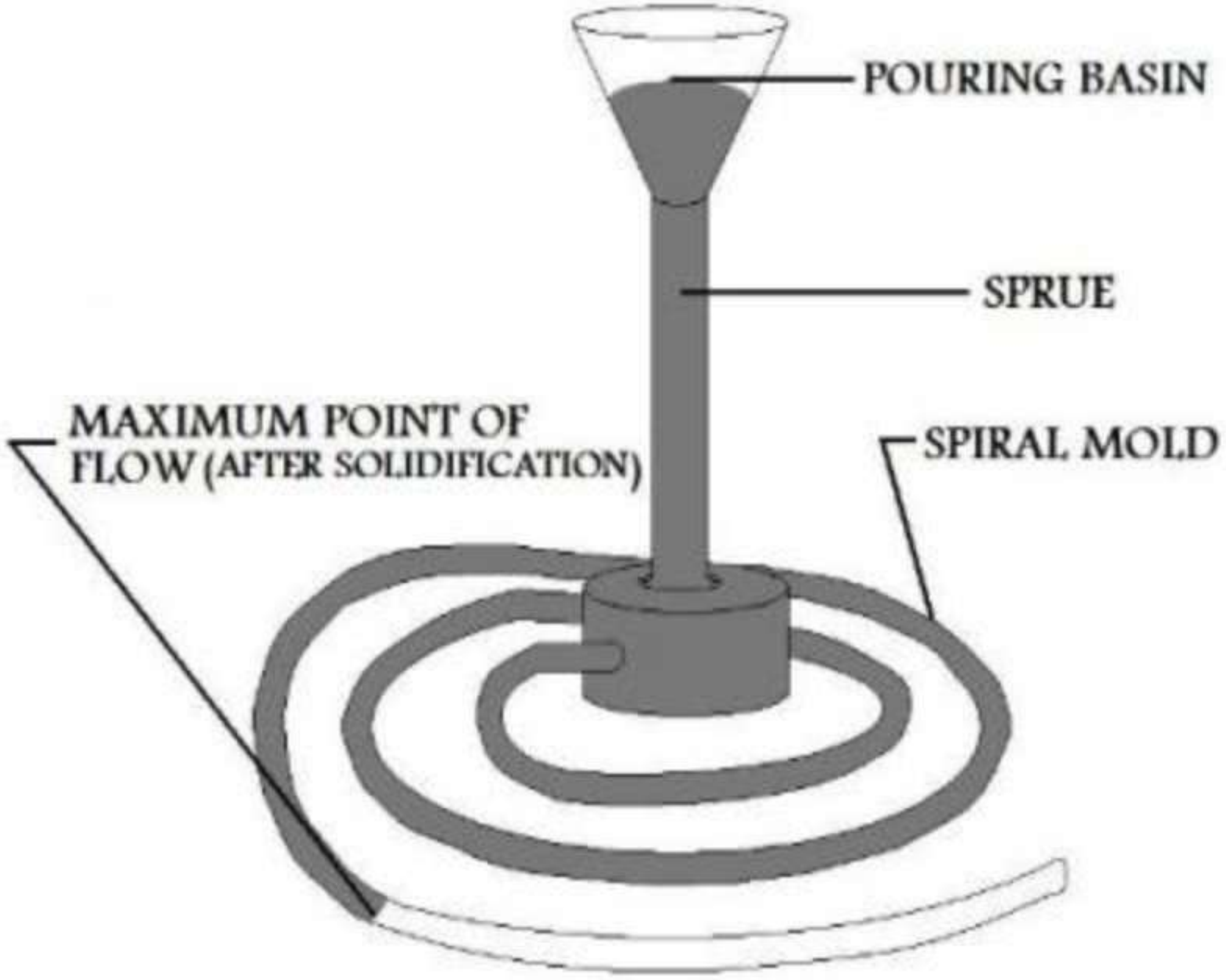
Fluidity

Ability of the liquid metal to fill into the cavity is known as fluidity.

It is the property of the liquid metal.

It can be determine by conducting spiral test.

Distance covered by liquid metal before solidification in a standard spiral will gives the value of fluidity.



Property	Fluidity
1.Pouring temperature	
2.Viscosity	
3.Density	
4.Percentage of water in sand	
5.Surface finish of cavity	

Choke Area

It is a minimum c/s area in all the gating elements .

It will control the flow of the liquid metal which is enter into the cavity.

It is the parameters to be calculated in all the gating elements.

Gating Ratio

Unpressurised Gating system

Pressurised Gating system