Chapter 2: Foundry Technology (Casting)

Repeated Questions:

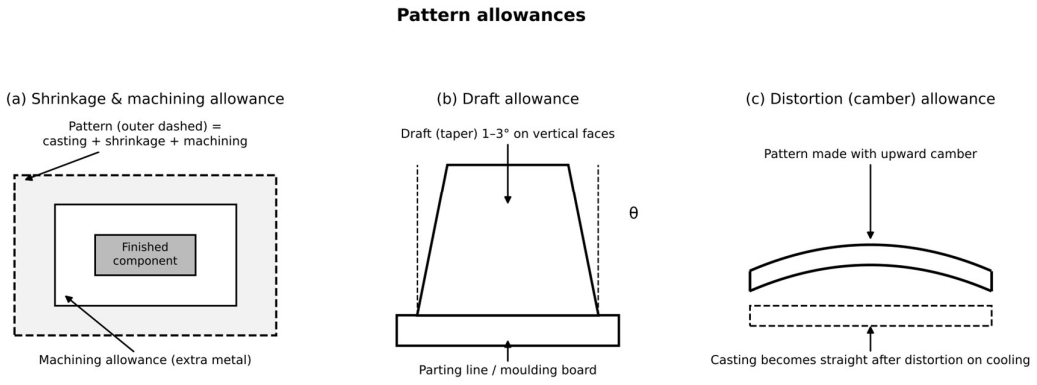
1. Pattern Allowances:

- **Q.** Explain various types of pattern allowances with a neat sketch. **(SUMMER 2022, 4 Marks; WINTER 2022, 7 Marks; WINTER 2024, 7 Marks; SUMMER 2025, 3 Marks)**

Answer:

- Pattern allowances are extra dimensions provided on a pattern to compensate for changes during casting and machining.
- **Shrinkage Allowance:** Molten metal contracts during solidification and cooling; pattern is made larger by shrinkage allowance.
  - **Formula:** Shrinkage allowance = $\alpha L \Delta T$ (approx.)
  - **Typical:** Cast iron 10–12 mm/m; Steel 20–25 mm/m; Aluminium 15–20 mm/m.
- **Draft Allowance:** Vertical surfaces of pattern are tapered so it can be withdrawn from sand without damaging mould.
  - Usually 1–3° for wooden patterns; less for metal patterns.
- **Machining Allowance:** Extra material provided on casting surfaces that will be machined later.
  - Depends on metal, size, and surface finish required.
- **Shake/Rapping Allowance:** Slight negative allowance (pattern made slightly smaller) because rapping the pattern before withdrawal enlarges the mould cavity.
- **Distortion/Camber Allowance:** For U-shaped, V-shaped, or long flat castings that distort on cooling; pattern is given opposite camber.
- **Mould Wall Movement Allowance:** In large moulds, sand walls may move due to molten metal pressure; pattern is made slightly larger to compensate.

Diagram Description: A rectangular pattern block showing enlarged dimensions for shrinkage/machining; tapered vertical sides for draft; a U-shaped pattern with upward camber for distortion allowance.



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2. Gating System:

- **Q.** What is a gating system? Why is a down sprue tapered? What are its functions? **(SUMMER 2022, 3 & 7 Marks; WINTER 2023, 7 Marks; WINTER 2024, 4 Marks)**

Answer:

- **Definition:** A gating system is the network of channels through which molten metal flows from the pouring ladle into the mould cavity. It includes pouring basin, sprue, runner, gates, and risers.

Functions of Gating System:

- Fill the mould cavity completely and uniformly.

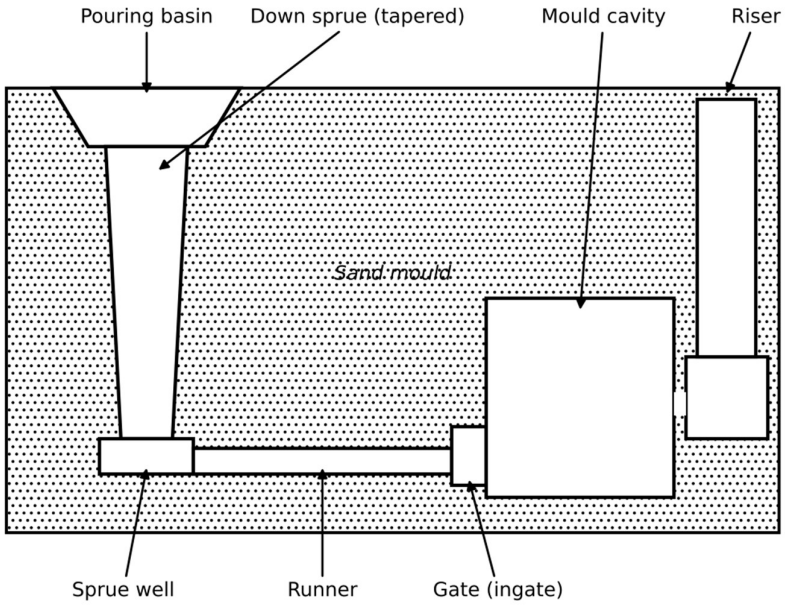
- Regulate metal flow velocity and avoid turbulence.
- Trap slag, sand, and impurities before entering cavity.
- Provide proper temperature gradient for directional solidification.
- Minimize erosion of mould walls and cores.
- Supply liquid metal to compensate shrinkage through risers.

Why Down Sprue is Tapered:

- As molten metal falls down the sprue, its velocity increases due to gravity.
- By continuity equation A1 V1 = A2 V2, if velocity increases, area must decrease.
- A tapered sprue (narrower at bottom) keeps the metal stream full and prevents air aspiration, turbulence, and oxidation.
- It maintains pressure and reduces mould erosion.

Diagram Description: A pouring basin at top connected to a downward tapered sprue; sprue leads to horizontal runner, which branches into gates entering the mould cavity; a riser is shown at the top of the cavity.

Gating system (section through mould)



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3. Casting Defects:

- **Q.** Explain the casting defects in detail with a diagram. **(WINTER 2022, 7 Marks; SUMMER 2025, 7 Marks; SUMMER 2025, 7 Marks)**

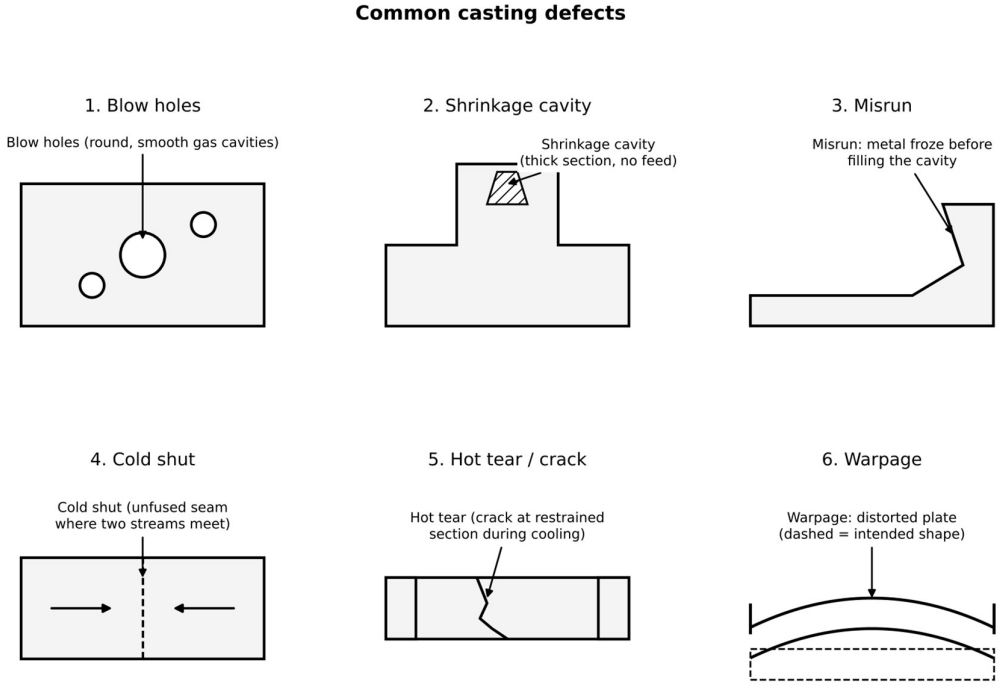
Answer:

Common Casting Defects:

- **Blow Holes / Gas Porosity:** Smooth, round cavities inside or on surface due to entrapped gases.
  - **Causes:** High moisture in sand, poor venting, low permeability.
  - **Remedies:** Control moisture, improve venting, use dry sand.

- **Shrinkage Cavity:** Irregular internal or surface cavity due to liquid/solidification shrinkage not fed by riser.
    - **Remedies:** Proper riser design, directional solidification, chills.
- **Misrun:** Metal solidifies before filling the entire mould cavity, leaving incomplete casting.
    - **Causes:** Low pouring temperature, too-thin sections, slow pouring.
    - **Remedies:** Increase pouring temperature, improve gating, increase section thickness.
- **Cold Shut:** Two streams of metal meet but do not fuse, forming a line/weak seam.
    - **Causes:** Low temperature, poor gating, oxidized metal.
    - **Remedies:** Raise temperature, redesign gating.
- **Hot Tears / Cracks:** Cracks formed during cooling due to restrained contraction.
    - **Remedies:** Improve mould collapsibility, uniform cooling, proper fillets.
- **Warpage:** Distortion of casting due to uneven cooling and residual stresses.
    - **Remedies:** Uniform cooling, proper design, stress-relief annealing.
- **Sand Inclusion / Scab / Drop:** Loose sand or mould pieces enter cavity or surface breaks.
    - **Remedies:** Better sand strength, proper ramming, clean mould.

Diagram Description: A cast block showing a round internal blow hole, a shrinkage cavity near a thick section, an incomplete misrun edge, a cold-shut seam line, and a warped flat plate.



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4. Investment Casting:

- **Q.** Explain the Investment casting process. **(WINTER 2022, 7 Marks; SUMMER 2025, 7 Marks; WINTER 2025, 7 Marks)**

Answer:

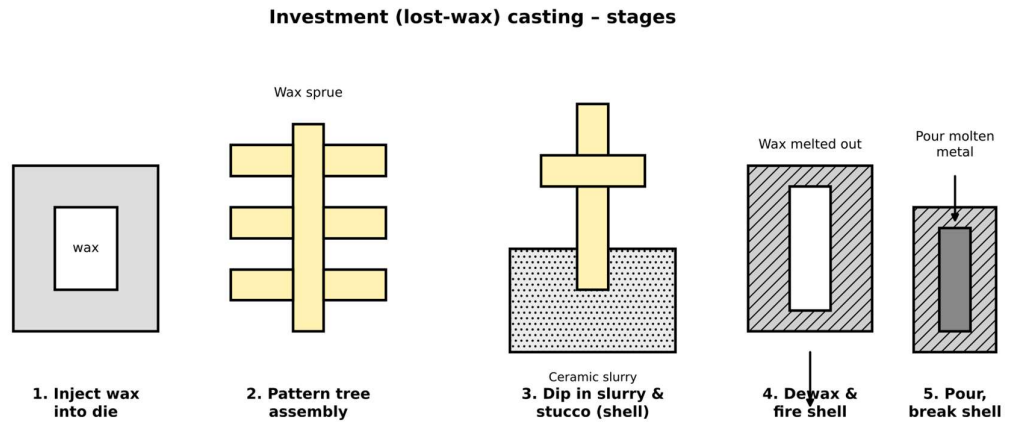
- **Definition:** Investment casting (lost-wax process) produces high-accuracy castings using an expendable wax pattern coated with refractory shell.

Steps:

- **Wax Pattern:** Inject molten wax into a metal die to form pattern.

- **Pattern Tree Assembly:** Multiple wax patterns attached to a central wax sprue.
- **Shell Making:** Dip tree into ceramic slurry, then stucco with refractory sand; repeat several times to build shell.
- **Dewaxing:** Heat shell in autoclave/oven to melt out wax.
- **Firing:** Sinter shell at high temperature for strength.
- **Pouring:** Pour molten metal into preheated shell.
- **Knockout & Cleaning:** Break shell, cut off gates, finish casting.
- **Advantages:** Excellent surface finish, close tolerances, complex shapes, less machining.
- **Limitations:** High cost, slow process, pattern size limitation.
- **Applications:** Turbine blades, jewelry, dental/medical implants, small precision parts.

Diagram Description: Wax patterns attached to central sprue forming a tree; tree dipped in ceramic slurry to form shell; shell after dewaxing filled with molten metal.



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5. Moulding Sand:

- **Q.** Explain properties of moulding sand. / Enlist the properties of moulding sand. Explain any four. **(WINTER 2024, 7 Marks; SUMMER 2025, 4 Marks)**

Answer:

Properties of Moulding Sand:

- **Green Strength:** Strength of moist sand in green condition to retain mould shape during handling.
- **Dry Strength:** Strength after mould surface dries due to heat from molten metal.
- **Permeability:** Ability to allow gases and steam to escape through sand voids.
  - Low permeability causes blow holes.
- **Refractoriness:** Ability to withstand high temperature without fusing or softening.
- **Plasticity:** Ability to deform and take pattern shape under ramming.
- **Adhesiveness:** Ability of sand to stick to mould box and other sand grains.
- **Cohesiveness:** Ability of sand grains to stick together.
- **Collapsibility:** Ability to collapse after casting solidification, allowing free contraction.
- **Flowability:** Ability to flow around pattern under ramming.
- **Durability:** Ability to retain properties after repeated use.

Explanation of Four:

- **Permeability:** Controlled by grain size, shape, moisture, and ramming; essential to vent gases.
- **Refractoriness:** Depends on silica content; prevents sand fusion at pouring temperature.

- **Green Strength:** Provides mould rigidity before pouring; depends on clay and moisture.
- **Collapsibility:** Prevents hot tears by yielding during casting contraction.

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6. Cores:

- **Q.** What is core? Why and when are cores used? Sketch different types of cores. **(SUMMER 2023, 4 Marks; WINTER 2024, 4 Marks; SUMMER 2025, 4 Marks)**

Answer:

- **Definition:** A core is a shaped sand mass placed in the mould cavity to form internal cavities, holes, or passages in the casting.

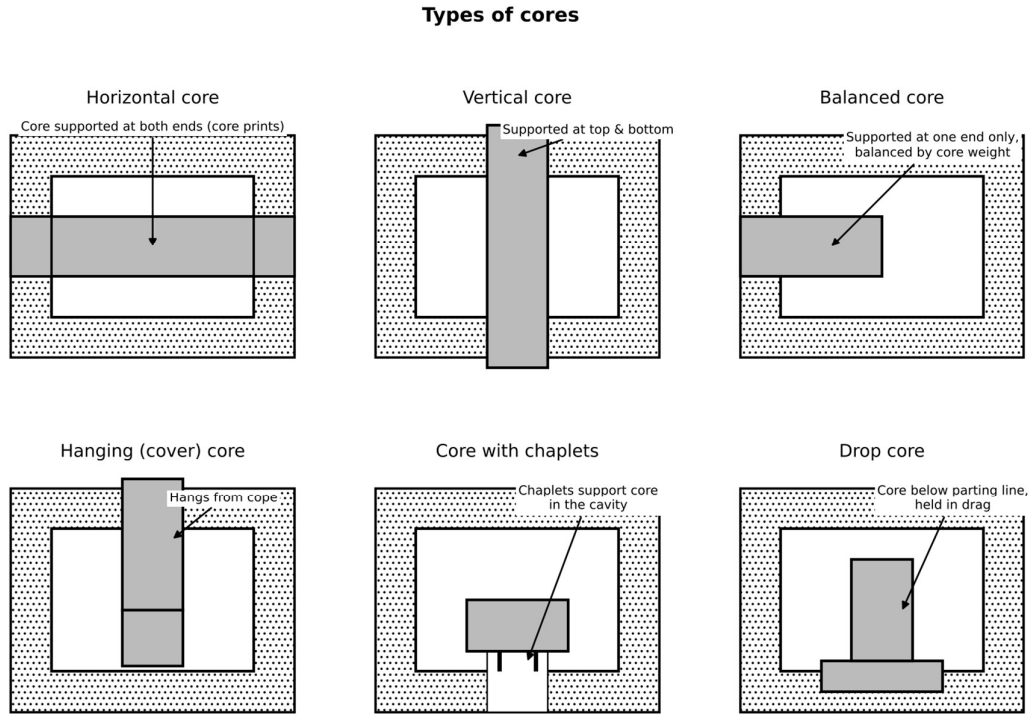
Why/When Cores are Used:

- To produce internal hollow cavities and passages that cannot be made by pattern.
- When the internal shape cannot be withdrawn by the pattern.
- For complex internal features like water jackets, oil galleries, and pipe bores.

Types of Cores:

- **Horizontal Core:** Placed horizontally in drag; supported at both ends.
- **Vertical Core:** Placed vertically; supported at bottom and top.
- **Balanced Core:** Supported at one end only and balanced to prevent floating.
- **Hanging/Cover Core:** Supported only at one end; hangs from cope.
- **Drop Core:** Placed below parting line; supported by chaplets.
- **Chaplet-Supported Core:** Uses metal chaplets to support core.

Diagram Description: Mould cross-section showing horizontal core forming a pipe bore; vertical core forming a vertical hole; hanging core supported from cope; chaplets supporting a drop core.



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7. Cupola Furnace:

- **Q.** Explain Cupola furnace with a neat sketch. **(SUMMER 2022, 3 Marks; SUMMER 2026, 7 Marks)**

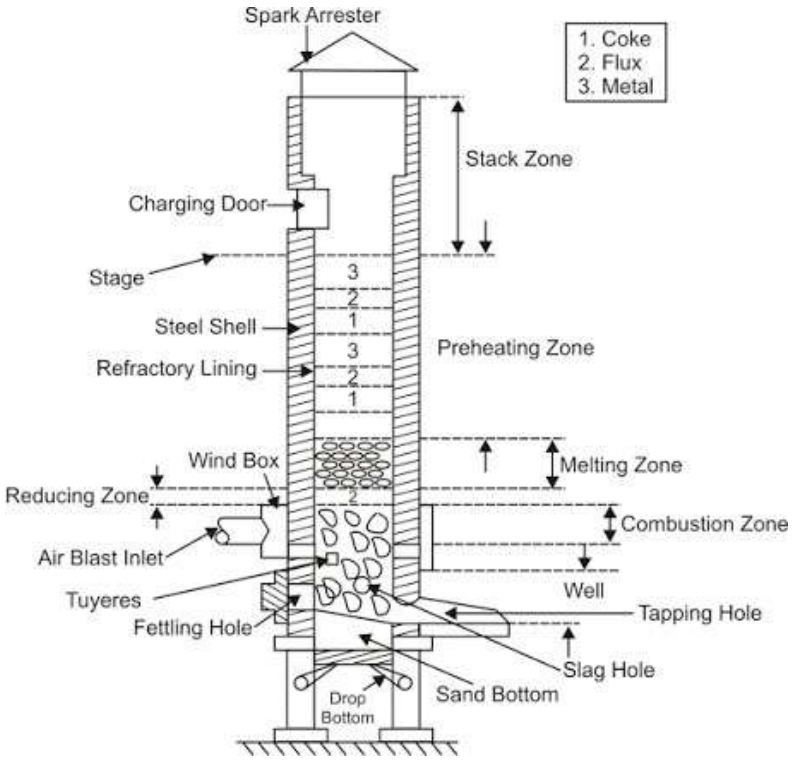
Answer:

- **Definition:** Cupola is a vertical shaft furnace used for melting cast iron in foundries.

Main Parts/Zones:

- **Charging Door:** For charging coke, limestone, and metal.
- **Preheating Zone:** Top zone where charge is preheated by rising gases.
- **Melting Zone:** Coke combustion and metal melting occur.
- **Reducing Zone:** CO_2 reduced to CO; protective atmosphere.
- **Combustion/Oxidizing Zone:** Near tuyeres; coke burns with air.
- **Well:** Molten iron collects at bottom.
- **Slag Hole:** Removes slag.
- **Tap Hole:** Taps molten iron.
- **Tuyeres:** Air nozzles for blast.
- **Blower:** Supplies air.
- **Operation:** Coke bed ignited; alternate layers of metal, coke, and limestone charged; air blast through tuyeres; metal melts and collects in well; slag floats; molten iron tapped periodically.

Diagram Description: Vertical cylindrical furnace with charging door at top, tuyeres near bottom, tap hole and slag hole at lower side, and molten iron collecting in well.



Other Important Questions:

1. Shell Moulding and Investment Casting:

- **Q.** Compare precision investment casting and shell moulding. **(SUMMER 2023, 7 Marks)**

Answer:

Comparison Table:

Feature	Investment Casting	Shell Moulding
Pattern	Expendable wax pattern	Reusable heated metal pattern
Mould	Ceramic shell around wax	Resin-bonded sand shell
Accuracy/Finish	Very high; complex shapes	Good; moderate complexity
Cost/Production	High cost, low-to-medium rate	Moderate cost, higher production rate

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- **Q.** Describe the Shell mould casting process. **(SUMMER 2022, 7 Marks)**

Answer:

Shell Mould Casting Process:

- **Pattern:** Heated metal pattern (200–300°C) placed on a plate.
- **Resin Sand:** Fine sand mixed with thermosetting resin (phenolic) is dumped over heated pattern.
- **Shell Formation:** Resin cures and forms a thin hard shell on pattern.
- **Curing:** Shell and pattern heated in oven to complete curing.
- **Stripping:** Shell halves removed from pattern.
- **Assembly:** Two shell halves clamped/glued; cores placed if needed.
- **Pouring:** Metal poured into shell; shell breaks after solidification.

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2. Chvorinov's Rule and Freezing Ratio (Numerical):

- **Q.** State the Chvorinov's rule. Discuss it briefly. **(WINTER 2023, 3 Marks)**

Answer:

- **Chvorinov's Rule:** Solidification time of a casting is proportional to the square of its volume-to-surface-area ratio:
  - $t = B (V/A)^n$
  - where t = solidification time, B = mould constant, V = volume, A = surface area, $n \approx 2$.

Brief Discussion:

- The ratio M = V/A is called the modulus.
- Larger modulus → slower freezing.
- A riser must freeze after the casting: M(riser) > M(casting).
- Freezing ratio FR = M(riser) / M(casting) (or inverse convention = (A/V)(casting) / (A/V)(riser)).

- **Q.** Numerical: A slab of size 300 × 300 × 50 mm is to be cast... Calculate the freezing ratio. **(WINTER 2023, 7 Marks)**

Answer:

- **Given:** Slab size 300 × 300 × 50 mm.
- **To Find:** Freezing ratio.
- **Formula:** V = l b h; A = 2(lb + bh + hl); M = V/A.

Solution:

- V = 300 × 300 × 50 = 4.5 × 10^6 mm^3
- A = 2(300 × 300 + 300 × 50 + 300 × 50) = 2(90000 + 15000 + 15000) = 240000 mm^2
- M(casting) = 4.5 × 10^6 / 240000 = 18.75 mm
- (A/V)(casting) = 240000 / (4.5 × 10^6) = 0.05333 mm^{-1}
- **Final Answer:** Casting modulus = 18.75 mm. Freezing ratio cannot be computed exactly without riser dimensions; use FR = M(riser)/18.75 or FR = 0.05333/(A/V)(riser).

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3. Riser Design:

- **Q.** Discuss about Riser design of casting. **(WINTER 2022, 3 Marks)**

Answer:

Riser Design:

- **Function:** Supplies liquid metal to compensate shrinkage during solidification.
- **Requirement:** Riser must solidify after the casting; M(riser) > M(casting) using Chvorinov's rule.
- **Placement:** At hot spots/thick sections; use top or side risers; use exothermic sleeves and chills to promote directional solidification.
- **Size:** Designed using modulus method or freezing ratio; avoid remote risers that freeze early.

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4. Casting Defects (Short Notes):

- **Q.** Explain Blow holes, Misrun and warpage in terms of casting. **(WINTER 2024, 3 Marks)**

Answer:

- **Blow Holes:** Smooth round gas cavities on/in casting due to entrapped gases from moist sand, poor venting, or low permeability; remedy by controlling moisture and improving venting.
- **Misrun:** Incomplete casting because metal solidifies before filling thin sections; caused by low pouring temperature or slow pouring; remedy by increasing temperature and improving gating.
- **Warpage:** Distortion of casting due to uneven cooling and residual stresses; remedy by uniform cooling, proper design, and stress-relief annealing.

- **Q.** Explain Blow holes, Shrinkage and warpage in terms of casting. **(WINTER 2025, 3 Marks OR)**

Answer:

- **Blow Holes:** Smooth round gas cavities on/in casting due to entrapped gases from moist sand, poor venting, or low permeability; remedy by controlling moisture and improving venting.
- **Shrinkage Cavity:** Irregular cavity from insufficient feeding of solidification shrinkage; remedy by proper riser design and directional solidification.
- **Warpage:** Distortion of casting due to uneven cooling and residual stresses; remedy by uniform cooling, proper design, and stress-relief annealing.

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5. Sand Casting and Moulding Sand:

- **Q.** What is casting? List out step by step procedure of sand casting. **(WINTER 2025, 3 Marks)**

Answer:

- **Definition:** Casting is a manufacturing process in which molten metal is poured into a mould cavity and allowed to solidify to obtain desired shape.

Sand Casting Steps:

- Pattern making and moulding box preparation.
- Place pattern in drag, ram sand, and form parting line.

- Place cope, pattern upper half, sprue pin; ram sand.
- Remove pattern, cut gates/runner, repair mould.
- Place core if required; close mould.
- Melt metal and pour into mould.
- Allow cooling and solidification.
- Shakeout, remove casting, clean gates/risers, inspect.

- **Q.** State the functions of (1) facing sand (2) backing sand (3) system sand and (4) core sand. **(SUMMER 2026, 4 Marks)**

Answer:

Functions of Sands:

- **Facing Sand:** Directly contacts pattern/mould cavity; high strength and refractoriness; gives good surface finish.
- **Backing Sand:** Supports facing sand; reused sand; provides bulk and strength.
- **System Sand:** Used throughout mould after pattern removal; general moulding sand with adequate strength/permeability.
- **Core Sand:** High-strength sand for cores; withstands metal pressure and heat; often mixed with core oil/resin.

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6. Gating System – Types of Gates:

- **Q.** What is gating system? What are its functions? Explain any two types of gates with its advantages. **(SUMMER 2026, 7 Marks OR)**

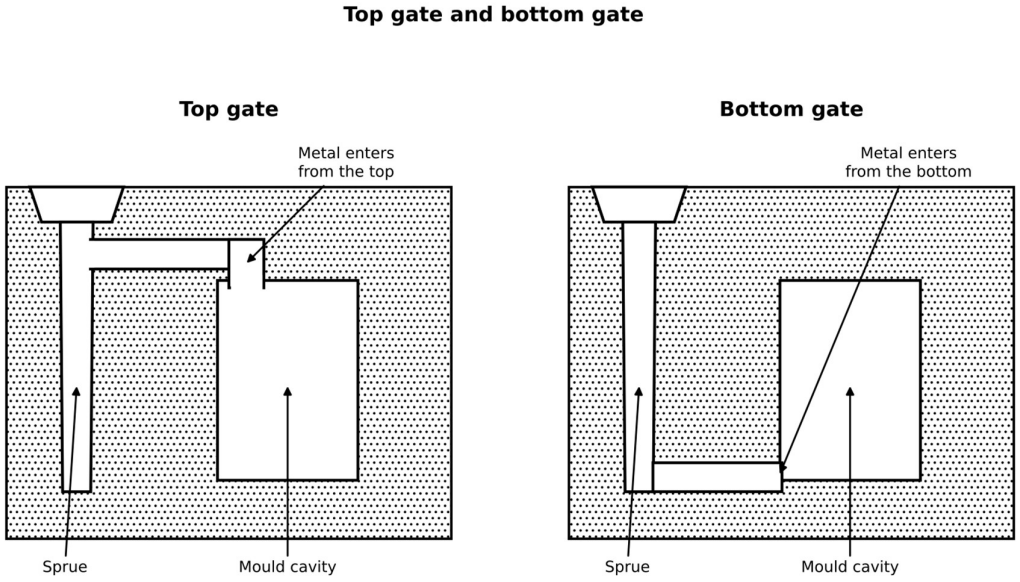
Answer:

- **Gating System:** Channels for molten metal flow from ladle to mould cavity: pouring basin, sprue, runner, gates, riser.
- **Functions:** Fill cavity uniformly, control flow, trap impurities, avoid turbulence, provide directional solidification, feed shrinkage.

Types of Gates:

- **Top Gate:** Gate at top of mould cavity; metal enters from top.
  - **Advantages:** Simple, fast filling, good for tall castings, promotes directional solidification downward.
  - **Disadvantages:** Turbulence, mould erosion, oxidation.
- **Bottom Gate:** Gate at bottom; metal enters from bottom.
  - **Advantages:** Smooth flow, less turbulence, reduces mould erosion and oxidation.
  - **Disadvantages:** Slow filling, unfavorable temperature gradient, may cause cold shuts in thin top sections.
- (Other types: parting-line gate, step gate, siphon gate.)

Diagram Description: Mould cross-section showing top gate entering cavity from top; bottom gate entering cavity from bottom through runner.



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7. Special Casting Processes:

- **Q.** Explain centrifugal casting process with neat diagram. **(SUMMER 2026, 7 Marks OR)**

Answer:

- **Definition:** Centrifugal casting uses centrifugal force from a rotating mould to distribute molten metal and form cylindrical parts.

Types:

- **True Centrifugal Casting:** Mould rotates about its own axis; metal forms hollow cylinder (pipes, bearings).
- **Semi-Centrifugal Casting:** Mould rotates; metal poured into central sprue; used for wheels, pulleys.
- **Centrifuging:** Small moulds arranged around central sprue; used for small parts.

Working:

- Rotating mould set at high speed.
- Molten metal poured into rotating mould.
- Centrifugal force throws metal outward against mould wall.
- Metal solidifies as hollow cylinder.
- Mould stopped; casting removed and machined.
- **Advantages:** No core needed for hollow cylinders, dense structure, good surface, high production.
- **Applications:** Pipes, cylinder liners, bearings, wheels, pulleys.

Diagram Description: A cylindrical mould rotating about horizontal axis; molten metal poured through a ladle into rotating mould; metal distributed as hollow cylinder on inner wall.

Centrifugal casting (horizontal axis)

