Chapter 4: Forming and Shaping Processes

Repeated Questions:

1. Hot Working and Cold Working:

- **Q.** Explain hot working and cold working processes. Compare them. **(SUMMER 2022, 7 Marks; SUMMER 2023, 7 Marks; WINTER 2024, 7 Marks; WINTER 2025, 3 Marks)**

Answer:

- **Hot Working:** Deformation of metal above its recrystallization temperature.
- **Cold Working:** Deformation of metal below its recrystallization temperature.

Comparison Table:

Feature	Hot Working	Cold Working
Temperature	Above recrystallization temp	Below recrystallization temp
Force Required	Low (metal is soft)	High (strain hardening occurs)
Surface Finish	Poor (oxide scale)	Excellent
Strength & Hardness	Unchanged (recrystallization)	Increased (strain hardening)
Dimensional Accuracy	Low	High
Grain Structure	Refined, uniform	Elongated, distorted

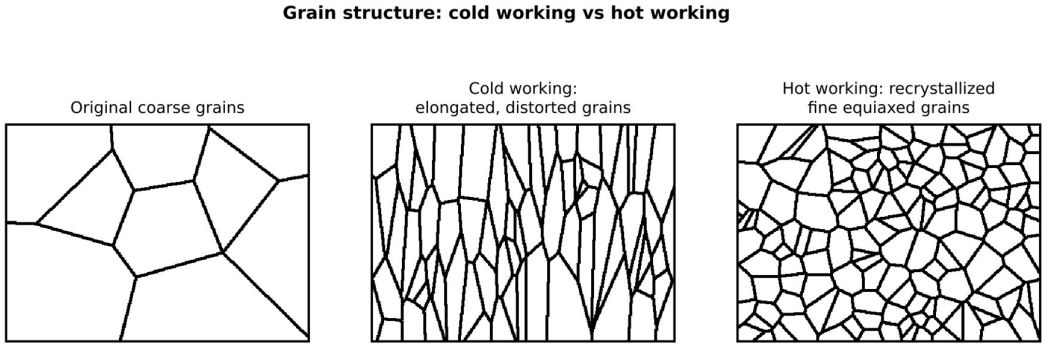
Explanation – Hot Working:

- Metal is heated above recrystallization temperature (e.g., steel ~900–1200°C).
- Deformation occurs with dynamic recrystallization; no strain hardening.
- Large deformations possible with less force.
- Oxide scale forms; surface finish is poor.
- Used for ingot breakdown, rolling, forging of large parts.

Explanation – Cold Working:

- Deformation at room temperature or slightly elevated (below recrystallization).
- Strain hardening increases strength and hardness; ductility decreases.
- Excellent surface finish and close tolerances.
- Requires higher forces and intermediate annealing.
- Used for wire drawing, cold rolling, sheet metal forming.

Diagram Description: Hot working shows large grains recrystallizing into new equiaxed grains; cold working shows elongated grains with increased dislocation density.



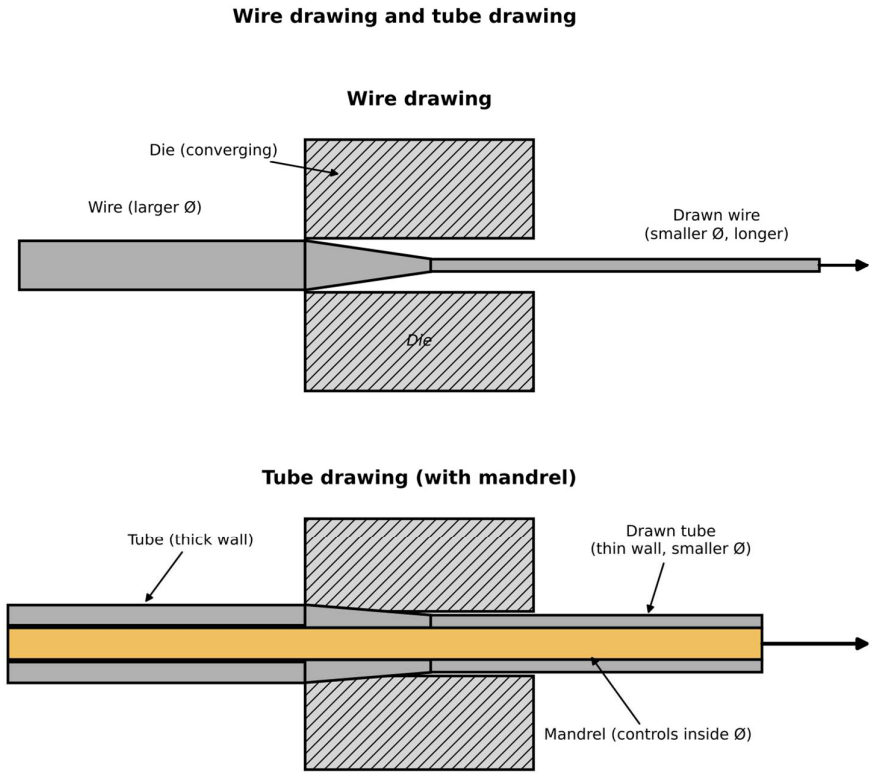
2. Wire Drawing and Tube Drawing:

- **Q.** Distinguish between wire drawing and tube drawing with neat sketches. **(SUMMER 2022, 4 Marks; SUMMER 2025, 4 Marks; WINTER 2025, 7 Marks)**

Answer:

Feature	Wire Drawing	Tube Drawing
Product	Solid wire/rod	Hollow tube/pipe
Die	Conical die reducing diameter	Die with mandrel (for ID control)
Cross-Section	Solid circular	Annular (hollow)
Process	Pulled through die	Pulled over mandrel or through die
Purpose	Reduce diameter, increase length	Reduce wall thickness/diameter, control ID & OD

Diagram Description: Wire drawing: solid wire pulled through conical die, diameter reduces. Tube drawing: hollow tube pulled through die with internal mandrel, wall thickness reduces.



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3. Extrusion:

- **Q.** Classify extrusion processes and explain forward and backward extrusion process. **(WINTER 2022, 7 Marks; SUMMER 2025, 7 Marks; SUMMER 2026, 4 Marks OR)**

Answer:

Classification of Extrusion:

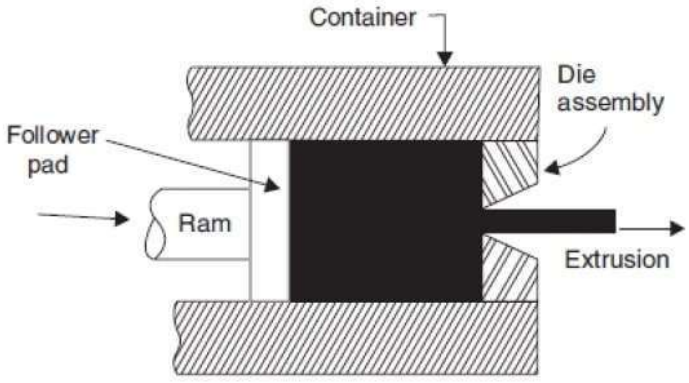
- **Based on Direction:** Forward (direct) extrusion, Backward (indirect) extrusion.
- **Based on Temperature:** Hot extrusion, Cold extrusion.
- **Based on Equipment:** Horizontal extrusion, Vertical extrusion.

- **Special:** Impact extrusion, Hydrostatic extrusion.

Forward (Direct) Extrusion:

- Billet is pushed through a die by a ram; metal flows in the same direction as ram motion.
- Billet moves relative to container; high friction between billet and container wall.
- Requires higher force; used for tubes, rods, shapes.

Diagram Description: Container with billet; ram pushes from left; die at right; extruded product emerges from die in same direction.



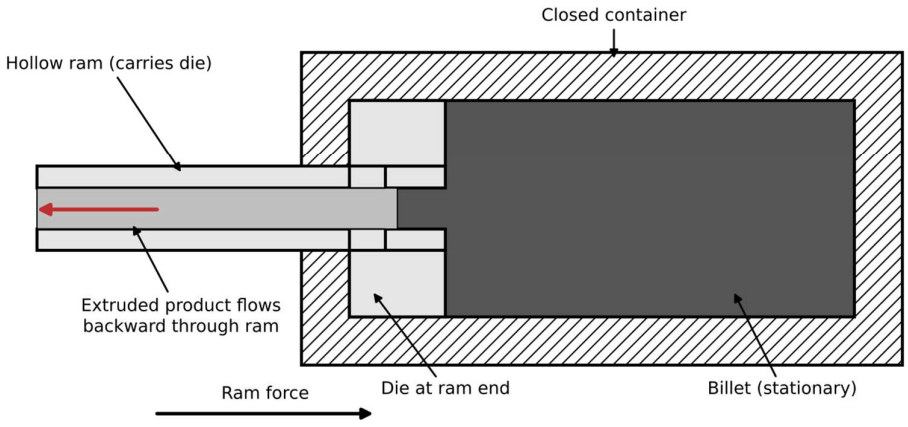
Forward or direct extrusion

Backward (Indirect) Extrusion:

- Die is mounted on the ram; ram pushes into billet; metal flows opposite to ram motion through die.
- No relative motion between billet and container (except at die); lower friction.
- Requires lower force; used for hollow shapes and small parts.

Diagram Description: Hollow ram carries die; ram pushes into billet in container; metal flows backward through die in ram; extruded product exits opposite to ram motion.

Backward (indirect) extrusion



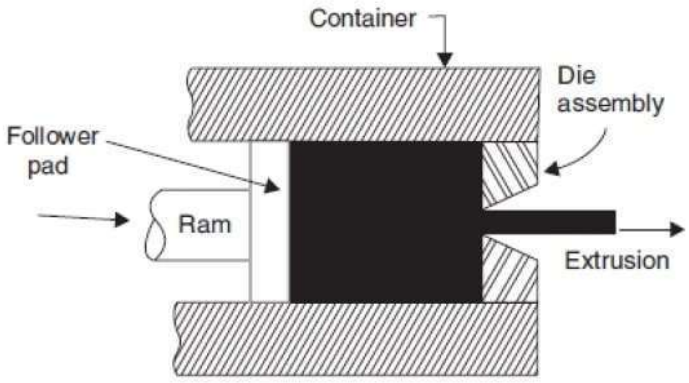
- **Q.** Explain with sketches the difference between direct and indirect extrusion. **(SUMMER 2023, 7 Marks; SUMMER 2026, 4 Marks)**

Answer:

Forward (Direct) Extrusion:

- Billet is pushed through a die by a ram; metal flows in the same direction as ram motion.
- Billet moves relative to container; high friction between billet and container wall.
- Requires higher force; used for tubes, rods, shapes.

Diagram Description: Container with billet; ram pushes from left; die at right; extruded product emerges from die in same direction.



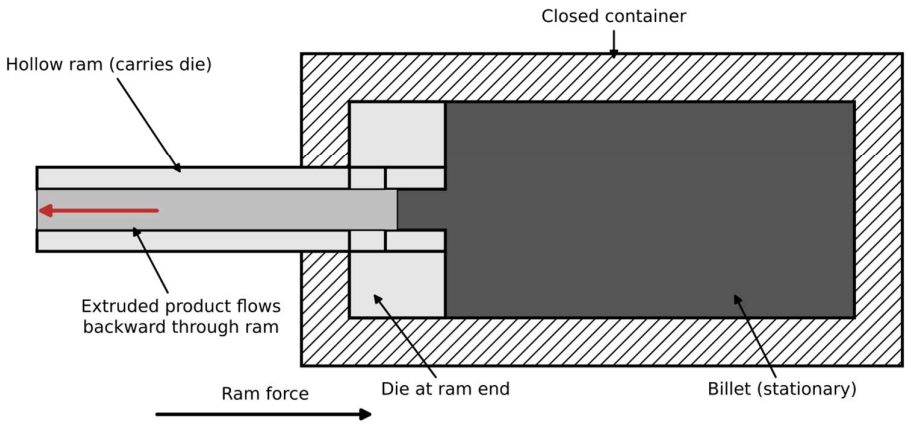
Forward or direct extrusion

Backward (Indirect) Extrusion:

- Die is mounted on the ram; ram pushes into billet; metal flows opposite to ram motion through die.
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- Requires lower force; used for hollow shapes and small parts.

Diagram Description: Hollow ram carries die; ram pushes into billet in container; metal flows backward through die in ram; extruded product exits opposite to ram motion.

Backward (indirect) extrusion



Comparison Table:

Feature	Forward Extrusion	Backward Extrusion
Metal Flow	Same direction as ram	Opposite to ram
Friction	High (billet-container)	Low
Force Required	High	Low
Product Support	Simple	Needs support at exit

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4. Sheet Metal Operations:

- **Q.** Define: Deep drawing, Coining and Embossing. **(WINTER 2022, 3 Marks; SUMMER 2025, 3 Marks)**

Answer:

- **Deep Drawing:** Sheet metal blank is drawn into a die cavity by a punch to form a cup-shaped or hollow part; depth > diameter.
- **Coining:** Precision closed-die forging/pressing to form fine details and sharp corners on both surfaces; used for coins, jewelry.
- **Embossing:** Forming raised or recessed designs on sheet metal surface by pressing between matched dies; used for decorative panels, nameplates.

- **Q.** Differentiate between punching and blanking operations. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

Answer:

- **Punching (Piercing):** A hole is punched in a sheet; the punched-out slug is scrap; the sheet with hole is the product.
- **Blanking:** A shaped piece is cut from sheet; the cut-out piece is the product; the remaining sheet is scrap.

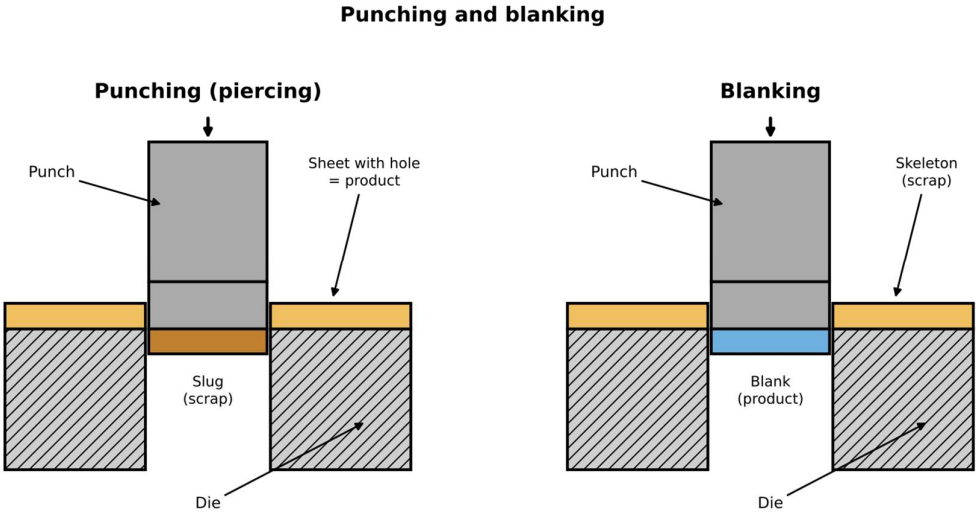
Comparison Table:

Feature	Punching	Blanking
Product	Sheet with hole	Cut-out blank
Scrap	Slug (punched piece)	Remaining sheet
Tool	Punch and die	Punch and die
Purpose	Create holes/openings	Produce shaped blanks
Application	Rivet holes, bolt holes	Washers, discs, brackets

Explanation:

- Both use shearing action between punch and die.
- Clearance depends on sheet thickness and material.
- **Punching:** punch diameter = hole size; die opening larger by clearance.
- **Blanking:** die opening = blank size; punch smaller by clearance.
- Both are high-speed, economical for mass production.

Diagram Description: Punching: sheet over die; punch descends to punch hole; slug falls through die. Blanking: sheet over die; punch descends; blank falls through die; remaining sheet is scrap.



- **Q.** Explain shearing, piercing, and blanking operations. **(SUMMER 2025, 3 Marks; SUMMER 2025, 3 Marks)**

Answer:

- **Shearing:** Cutting sheet metal along a straight line between two blades (punch and die) without forming chips; used for cutting sheets to size.
- **Piercing (Punching):** Making a hole in sheet by punching; slug is waste; sheet with hole is product.
- **Blanking:** Cutting a shaped piece from sheet; cut-out piece is product; remaining sheet is scrap.

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5. Ingot, Bloom and Billet:

- **Q.** Define: Ingot, Bloom, Billet. **(SUMMER 2022, 3 Marks; WINTER 2024, 3 Marks)**

Answer:

- **Ingot:** Large cast metal block, usually rectangular or square, produced by pouring molten metal into a mould; starting material for rolling/forging.
- **Bloom:** Semi-finished rolled product with square/rectangular cross-section, area > 230 cm^2; further rolled into sections or billets.
- **Billet:** Semi-finished rolled product with smaller cross-section (area 40–230 cm^2), usually square; rolled into bars, rods, tubes.

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6. Strain Hardening:

- **Q.** Explain the effects of strain hardening / Explain in brief Strain Hardening. **(SUMMER 2022, 3 Marks; WINTER 2023, 3 Marks)**

Answer:

Strain Hardening (Work Hardening):

- Plastic deformation increases dislocation density, which impedes further dislocation motion.
- **Effects:** Increased yield strength and hardness; decreased ductility and toughness; increased residual stresses; improved surface finish (in cold working).
- **Recovery:** Annealing can restore ductility by recrystallization.

- **Application:** Cold rolling, wire drawing benefit from strength increase; intermediate annealing may be required.

Other Important Questions:

1. Rolling:

- **Q.** Write difference between Hot rolling and Cold rolling. Explain the terms: Bloom, Billet, Slab, Plate, and sheet. **(SUMMER 2025, 7 Marks)**

Answer:

Hot Rolling vs Cold Rolling:

Feature	Hot Rolling	Cold Rolling
Temperature	Above recrystallization temp	Room temperature
Force	Low	High
Surface Finish	Poor (oxide scale)	Excellent
Thickness Reduction	Large	Small per pass
Strength	Unchanged	Increased (strain hardening)
Applications	Ingot breakdown, structural shapes	Precision sheets, foils

Definitions:

- **Bloom:** Square/rectangular cross-section, area > 230 cm^2; used for structural sections.
- **Billet:** Smaller square cross-section, area 40–230 cm^2; used for bars, rods, tubes.
- **Slab:** Rectangular cross-section with width much greater than thickness; rolled into plates/sheets.
- **Plate:** Rolled flat product with thickness > 6 mm.
- **Sheet:** Rolled flat product with thickness < 6 mm (thin sheet < 0.5 mm is foil).

- **Q.** Define Forward slip, Backward slip, and Neutral point in Rolling. **(SUMMER 2022, 3 Marks)**

Answer:

- **Forward Slip:** At exit, roll surface speed is less than strip speed; strip moves faster than roll.
- **Backward Slip:** At entry, strip speed is less than roll surface speed; roll moves faster than strip.
- **Neutral Point:** Point along arc of contact where strip speed equals roll surface speed; no slip; point of maximum pressure.

- **Q.** Derive the equation for the length of the deformation zone during rolling. **(SUMMER 2024, 4 Marks)**

Answer:

Derivation:

- Let R = roll radius, h0 = initial thickness, hf = final thickness, $\Delta h = h0 - hf$.
- Projected length of arc of contact $L = \sqrt{(R^2 - (R - \Delta h/2)^2)}$.
- **Expand:** $L^2 = R^2 - (R^2 - R\Delta h + \Delta h^2/4) = R\Delta h - \Delta h^2/4$.
- **For small Δh, neglect $\Delta h^2/4$:** $L \approx \sqrt{(R\Delta h)}$.
- **Final Result:** $L = \sqrt{(R (h0 - hf))}$.

- **Q.** Discuss about various types of rolling mill arrangements. **(WINTER 2025, 4 Marks)**

Answer:

Types of Rolling Mills:

- **Two-High Mill:** Two rolls; reversing or non-reversing; used for blooms, slabs.
- **Three-High Mill:** Three rolls; workpiece passes back and forth between top-middle and middle-bottom; no reversing.
- **Four-High Mill:** Four rolls; small work rolls + large backup rolls; used for thin sheets, reduces deflection.
- **Cluster Mill (Sendzimir):** Multiple backup rolls supporting small work rolls; for very thin foils.
- **Tandem Mill:** Series of stands; continuous rolling; high production.

- **Q.** Explain the principle and operation of rolling process. **(SUMMER 2026, 7 Marks OR)**

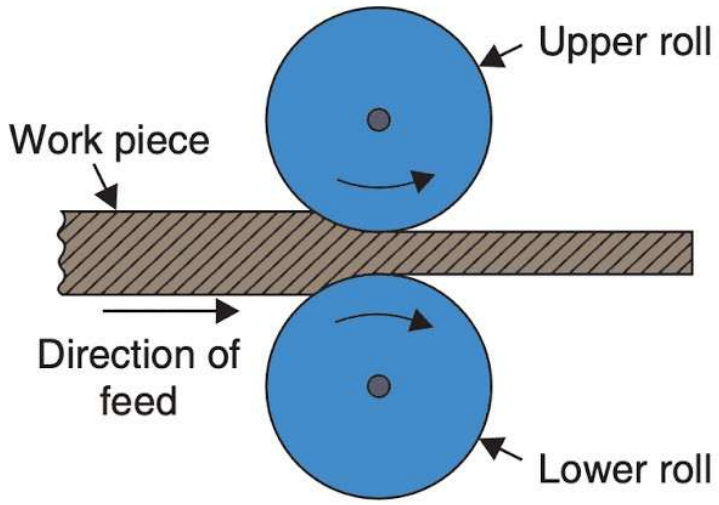
Answer:

- **Principle:** Rolling is a forming process in which metal is passed between rotating rolls to reduce thickness and change cross-section. Friction between rolls and workpiece draws metal into gap; compressive stress causes plastic deformation.

Operation Steps:

- Workpiece (ingot/bloom/billet/slab) is heated (hot rolling) or at room temperature (cold rolling).
- Workpiece is fed between rotating rolls.
- Rolls exert compressive force; thickness reduces; length increases (volume constancy).
- Multiple passes may be required to achieve final thickness.
- Cold rolling improves surface finish and strength; annealing may be needed.
- **Key Parameters:** Roll radius, roll gap, friction, speed, temperature.

Diagram Description: Two rotating rolls with a workpiece between them; initial thickness h0, final thickness hf; arc of contact with neutral point; forward and backward slip zones.



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2. Forging:

- **Q.** Enlist Forging operations. Discuss any two with a neat sketch. **(WINTER 2024, 7 Marks)**

Answer:

Forging Operations:

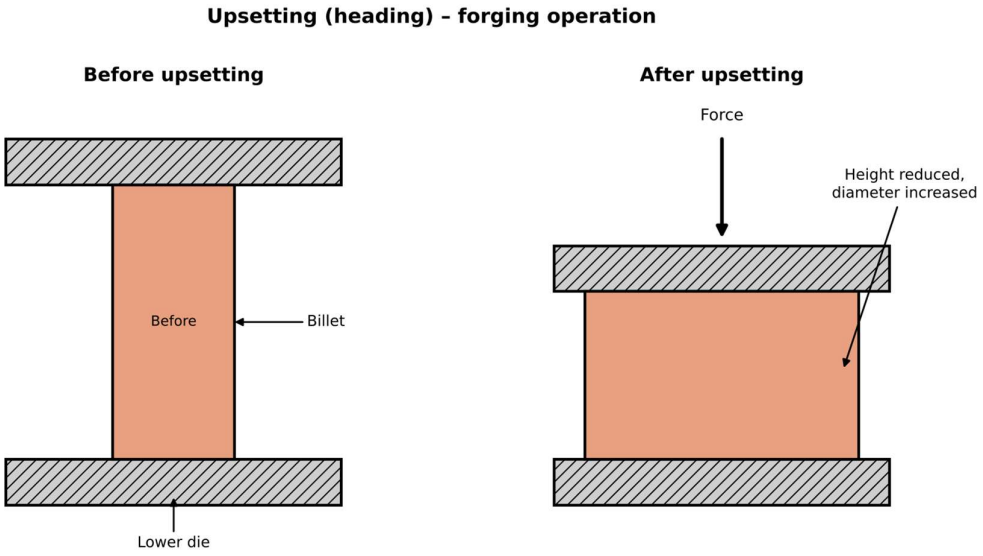
- Upsetting (Heading)
- Drawing down
- Punching
- Fullering
- Swaging
- Bending
- Coining
- Extruding
- Roll forging

Two Operations Explained:

1. Upsetting (Heading):

- Compressive force applied along longitudinal axis to reduce height and increase cross-section.
- Used for bolt heads, rivet heads, gear blanks.

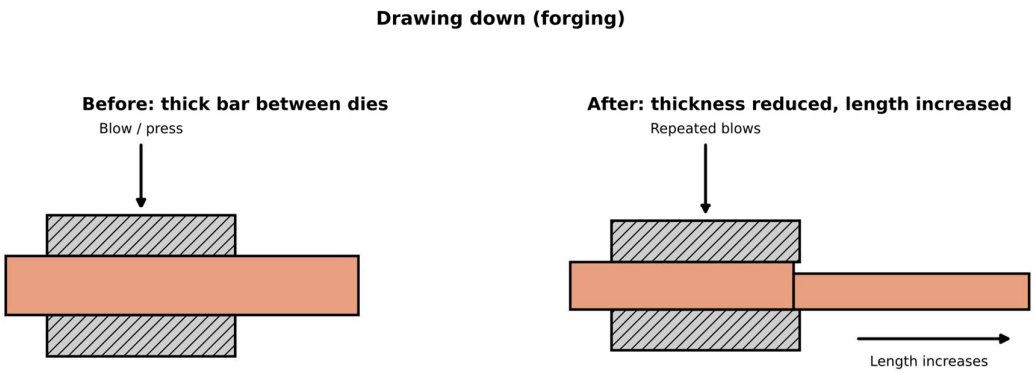
Diagram Description: Cylindrical billet between flat dies; upper die moves down; height reduces, diameter increases.



2. Drawing Down:

- Cross-section reduced and length increased by hammering/stretching between dies.
- Used for bars, rods, wire.

Diagram Description: Billet between dies; repeated blows reduce thickness and increase length.



- **Q.** Explain the types of forging defects and write name of four products which are manufactured using the forging process. **(WINTER 2025, 7 Marks OR)**

Answer:

Forging Defects:

- **Laps/Folds:** Overlapping metal folds due to improper die design or flash; causes weakness.
- **Cracks:** Surface/internal cracks due to low temperature, excessive strain, or poor material.
- **Scale Pits:** Oxide scale embedded in surface; poor surface finish.
- **Underfilling:** Die cavity not completely filled; due to insufficient metal or poor design.
- **Cold Shuts:** Two metal streams meet but do not fuse; low temperature or poor die design.
- **Residual Stresses:** Uneven cooling/deformation; may cause warpage.
- **Products:** Crankshafts, connecting rods, gears, bolts, rivets, hand tools, railway wheels.

- **Q.** Explain briefly the following forging operations with neat sketches: (a) Coining operations: (b) Heading operation; (c) Punching operation (d) Blanking. **(WINTER 2025, 7 Marks OR)**

Answer:

(a) Coining:

- Precision closed-die pressing/forging to form fine surface details on both faces.
- High pressure; used for coins, medals, jewelry.

(b) Heading:

- Upsetting operation to form heads on bolts, rivets, screws.
- Bar stock gripped; end upset to form head.

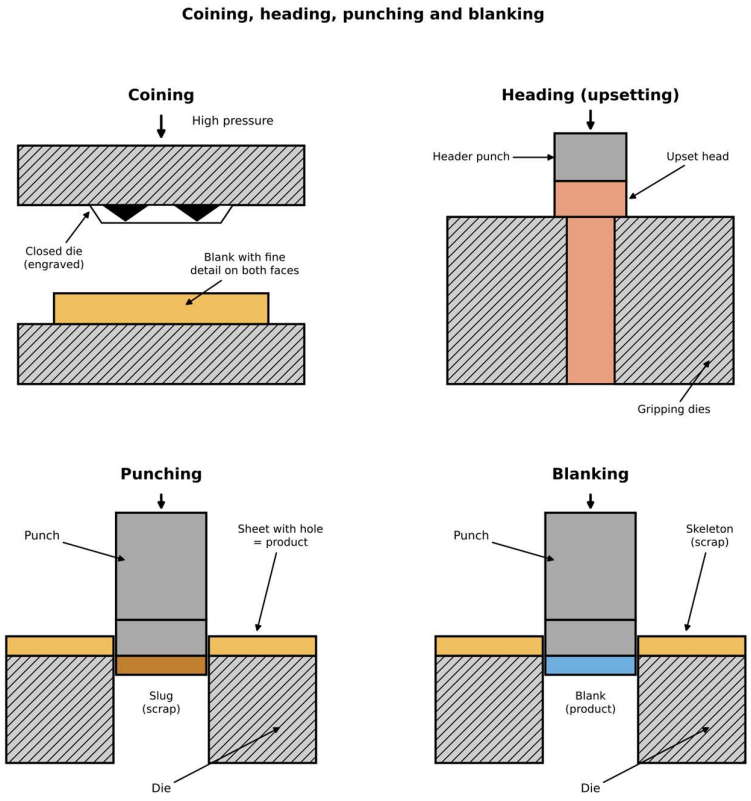
(c) Punching:

- Shearing operation to make a hole in sheet; slug is scrap.
- Punch forces through sheet into die.

(d) Blanking:

- Shearing operation to cut a shaped blank from sheet; blank is product.
- Punch and die cut the outline; blank falls through die.

Diagram Description: Coining: closed die with detailed cavity; Heading: bar end upset between dies; Punching: punch makes hole in sheet; Blanking: punch cuts blank shape from sheet.



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3. Sheet Metal Operations (Detailed):

- **Q.** Explain blanking, piercing, coining and embossing in brief with required diagrams. **(SUMMER 2026, 7 Marks)**

Answer:

- **Blanking:** Cutting a shaped piece (blank) from sheet; blank is product; remaining sheet is scrap. Punch and die used; clearance depends on thickness.
- **Piercing (Punching):** Making a hole in sheet; slug is scrap; sheet with hole is product.
- **Coining:** Closed-die pressing to form fine details on both surfaces; high pressure; used for coins, jewelry.
- **Embossing:** Forming raised/recessed designs on sheet surface between matched dies; decorative; used for nameplates, panels.

Diagram Description: Blanking: punch cuts blank from sheet; Piercing: punch makes hole, slug falls; Coining: closed die with detailed cavity; Embossing: matched dies with raised/recessed pattern.

