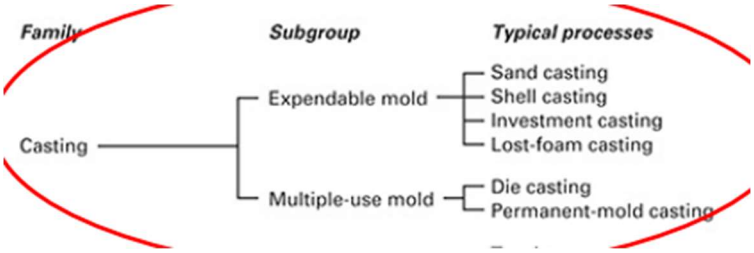
Casting



Process:

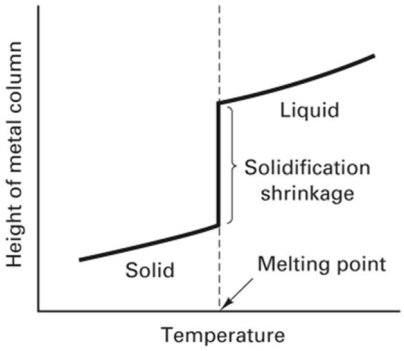
1. Material is melted.
2. Heated to temp.
3. Treated to modify its chemical makeup.
4. Molten metal is poured into mold.
5. Solidification.

Advantages:

- Complex shapes
- Parts can have hollow sections.
- Very large parts & large-scale production.
- Intricate shapes.
- Different mold materials can be used – sand, metal, ceramics.

Steps of Casting:

1. *Mound cavity* is produced, taking shrinkage into account.
2. *Melted.*
3. *Poured* at a right rate to ensure erosion and defects are minimized.
4. *Solidification* – controlled cooling to determine properties. Should be designed so that shrinkage is controlled.
   Defects can occur:

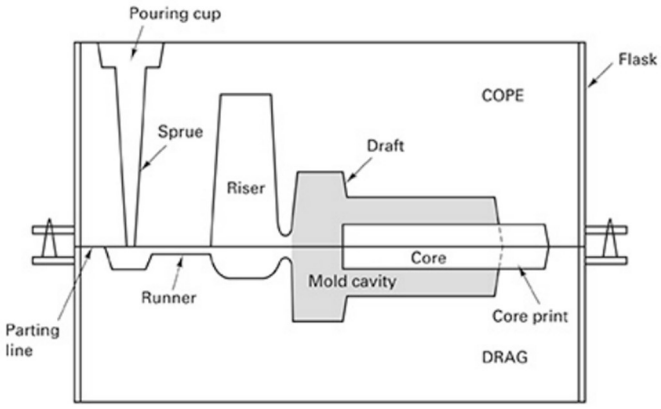


- **Gas Porosity**: gas is rejected from the liquid and trapped when solidifies.
  We can prevent the gas from dissolving: melting in vacuum, low-solubility gases and minimizing turbulence.
  Degas before the metal is poured.
  Gas flush – pass inert/reactive gasses through the liquid metal
- Solidification Shrinkage: most metals will undergo noticeable contraction when cooled.
  Amount it shrinks depends on thermal coefficient of contraction.
  Cavities and voids can be avoided by having directional solidification.
  Hot Tears occur when there is significant tensile stress on the surface when casting.

5. *Mold removal* – casting removed. Carely not to damage parts.
6. *Clean, finish and inspect.*

Pattern	approximate duplicate of the part to be cast
Molding Material	material that is packed around the pattern to provide the mould cavity
Flask	rigid frame that holds the moulding aggregate
Cope	top half of the pattern
Drag	bottom half of the pattern
Core	sand or metal shape that is inserted into the mould to create internal features
Mould Cavity	combination of the mould material and cores

Riser	additional void in the mould that provides additional metal to compensate for shrinkage
Gating System	network of channels that delivers the molten metal to the mould
Pouring Cup	portion of the gating system that controls the delivery of the metal
Sprue	vertical portion of the gating system
Runners	horizontal channels
Parting Line	separates the cope and drag
Draft	angle or taper on a pattern that allows for easy removal of the casting from the mould
Casting	describes both the process and the product when molten metal is poured and solidified



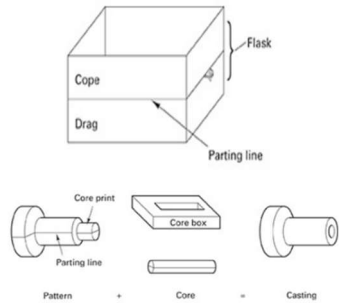


Figure 11-2 Cross section of a typical two-part sand mould, indicating various mould components and terminology.

Risers – Are reservoirs of liquid meta that feed extra metal to the mold, compensates shrinkage.

- Conserve metal.
- Located to that directional solidification occurs toward the riser.
- Feeds to the thickest regions.
- Must be separated from cast when complete – should be as small as possible.
- **Blind Riser:** contained entirely within the mold cavity. (will not see it)
- **Open Riser:** common in sand casting.

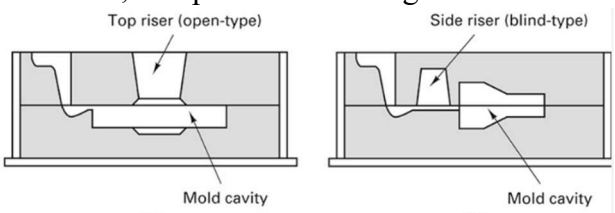


Figure 11-13 Schematic of a sand casting mould, showing a) an open-type top riser and b) a blind-type side riser. The side riser is a live riser, receiving the last hot metal to enter the mould. The top riser is a dead riser, receiving metal that has flowed through the mould cavity.

Patterns:

1. Expendable Mold – requires pattern.
2. Permanent Mold

Made from wood, metal, foam, plastic.
Patterns are changed to allow for:

- Shirkage allowance, so pattern is slightly larger than final product.
- Phase changes, martensite formation
- Surface finishing/machining.

Removal of Pattern:

- Parting lines are most preferred.
- Damaged can be done at corners/parting surfaces if tapes/draft angles are not used properly.

Factors influencing draft:

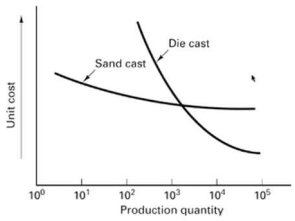
- Size/shape of pattern.
- Depth of mold cavity.
- Method used to remove pattern.
- Pattern material.

- Mold material.
- Molding procedure.

Cleaning & Finishing.

- Removing cores/gates/risers, fins/flash/rough spots, cleaning surface and repairing defects.
- Can be expensive so you should try minimize operations.

- Sand cores can be removed by mechanical shaking/chemical dissolving
- Flash can be removed by being tumbled in barrels.
- Manual finishing.
- Porosity at surfaces may be filled with resin.
- Pores can be filled with lower melting point metals.
- Heat treatment to improve properties.



Process Selection: each process has their advantages & disadvantages.

- Size, complexity, precision, surface finish, quantity, rate of production.
- Cost – dies, equipment, metals.

TABLE 13-6 Comparison of Casting Processes

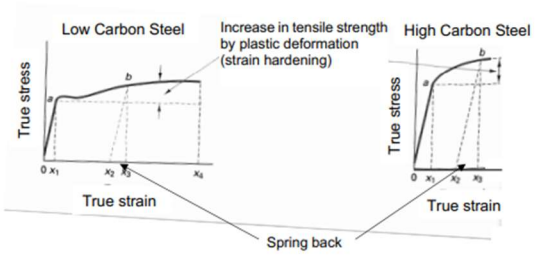
Property or Characteristic	Green-Sand Casting	Chemically Bonded Sand (Shell, Sodium Silicate, Air-Set)	Ceramic Mold and Investment Casting	Permanent-Mold Casting	Die Casting
Relative cost for small quantity	Lowest	Medium high	Medium	High	Highest
Relative cost for large quantity	Low	Medium high	Highest	Low	Lowest
Thinnest section (inches)	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{32}$
Dimensional precision (+/− in inches)	0.01–0.03	0.005–0.015	0.01–0.02	0.01–0.05	0.001–0.015
Relative surface finish	Fair to good	Good	Very good	Good	Best
Ease of casting complex shape	Fair to good	Good	Best	Fair	Good
Ease of changing design while in production	Best	Fair	Fair	Poor	Poorest
Castable metals	Unlimited	Unlimited	Unlimited	Low-melting-point metals	Low-melting-point metals

Summary:

- Casting involves pouring of molten metal into a shaped cavity called a ‘die’ or ‘mold’
- Control of mound shape, liquid flow and solidification controls properties
- Good for making complex 3D shapes.

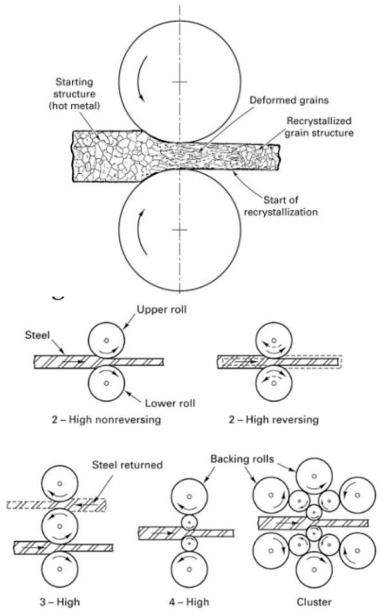
Metal Working

Unlike casting the metal will remain in solid form throughout the whole process. This gives you the ability to deform and metal work specific material propeties into metals.



Bulk Forming	Sheet Forming
Where the thicknesses or cross sections are reduced. - Rolling - Forging - Extrusion - Wire rod/tube drawing - Cold forming, forging and impact extrusion. - Piercing - Squeezing.	Involves the deformation of materials where thickness and cross section remain fairly constant.

Rolling: reduce thickness or changes the cross section through compressive forces.



- Used to convert material into a finished wrought product.
- Thick stock can be rolled into blooms, billets/slabs.

Process:

- Metal is squeezed between 2 rolls that rotate in opposite directions.
- The friction pushes it forward.
- Metal elongates due to decreased CSA

Roll Configurations:
Smaller diameter – uses less length and therefore less force is required to produce a change.
However, this causes reduced stiffness and therefore the sheet will be prone to bending.
We place rolls on the top and bottom to prevent this. (backing rolls).

Tandem (Continuous) Rolling Mills: slabs are heated and fed through an integrated series of rolling mills. Thickness changes can make it hard though.

Forging: Plastic deformation through localized compressive forces – applied through dies.

- Oldest form
- Parts range in size.
- Methods – Drawing, Upset, Squeezing.

Open-Die Hammer Forging: blacksmithing. Essentially dropping a hammer on a metal.

Impression-Die Hammer Forging: pressing a shape (die) around a metal to control the shape.

- **Flash** – extra metal can be squeezed out of the die.
  This helps to remove accuracy in metal pour. Excess can be removed and reused.