Metal Casting - 2

Outline

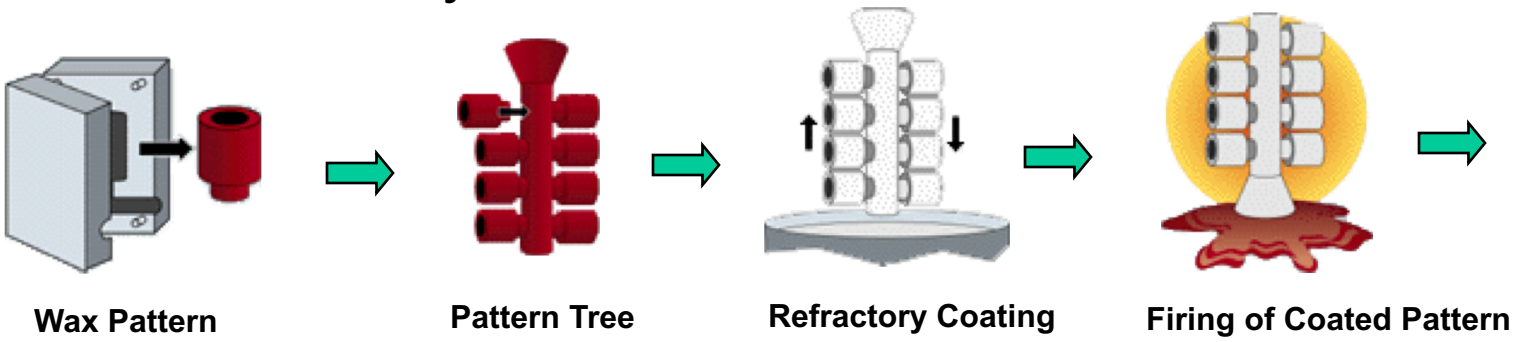
- Expendable mold casting
  - Sand casting
  - Investment casting
- Permanent mold casting
  - Permanent mold process
  - Die casting
  - Centrifugal casting

Sand Casting: Process Capability

- ***Process***: molten metal poured into sand mold
- ***Advantages***: almost no limit on shape, weight, complexity or type of metal
- ***Limitations***: poorer tolerances and surface finish (compared to other casting processes), post-processing necessary, relatively slow cycle time
- ***Common Metals***: cast iron, steel, alloys of Al, Cu, Mg and Ni
- ***Size Limits***: 30 g to 3000 kg
- ***Thickness Limits***: 0.25 cm and above
- ***Typical Tolerances***: $\pm$ 0.8 mm for first 15 cm, $\pm$ 0.003 cm for each additional cm
- ***Surface Finish***: 2.5 – 25 μm R_q

Investment Casting "Lost Wax Process"

- Basic process: mold made from a refractory (ceramic) slurry coated on a wax pattern; mold is heated to remove wax; molten metal is then poured into mold cavity



Investment Casting: Process Capability

- ***Process***: molten metal poured into mold made from refractory slurry using a wax pattern
- ***Advantages***: excellent surface finish, high dimensional accuracy, high intricacy, most metals
- ***Limitations***: costly patterns and molds, high labor costs, limited size range
- ***Common Metals***: any castable metal; Al, Cu, steel, precious metals
- ***Size Limits***: 3 g to 5 kg
- ***Thickness Limits***: 0.06 cm – 7.5 cm
- ***Typical Tolerances***: $\pm$0.01 cm for first 2.5 cm; $\pm$0.002 cm for each additional cm
- ***Surface Finish***: 1.3 – 4 μm R_q

Permanent Mold Casting Process

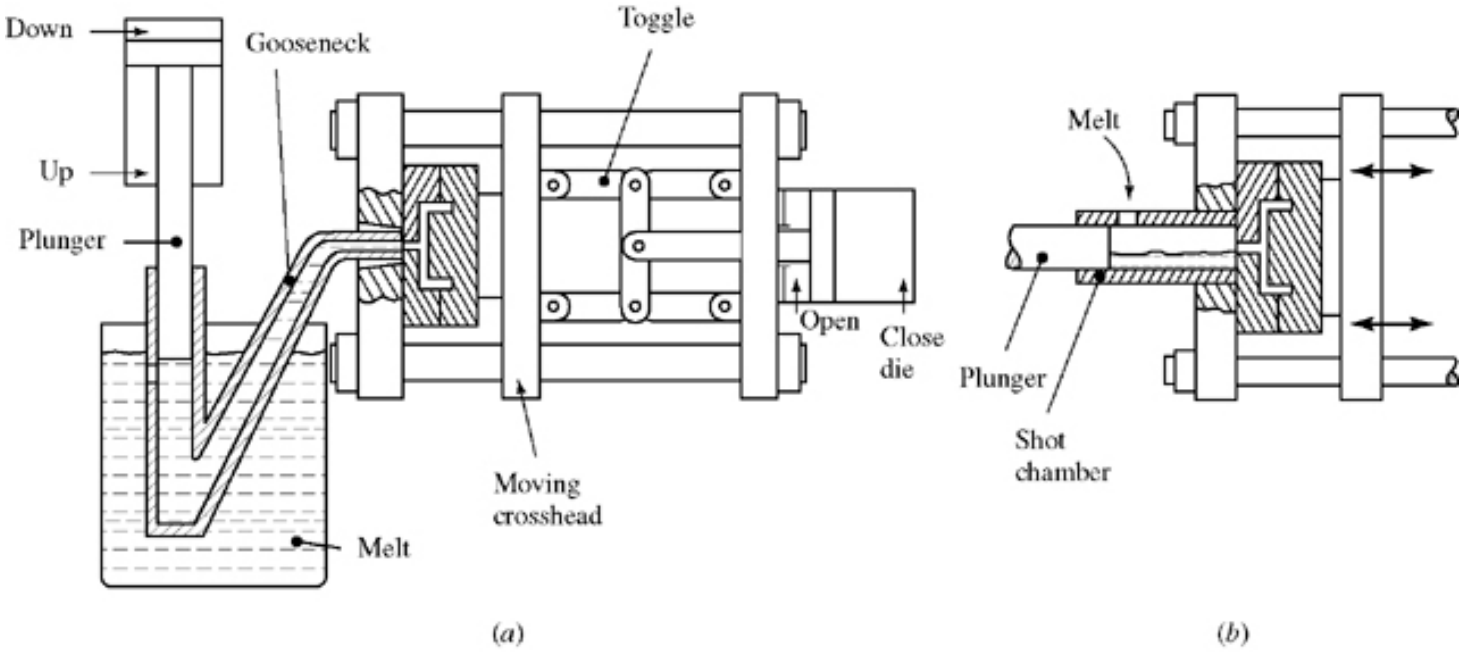
- ***Process***: molten metal poured into pre-heated machined metal mold made of cast iron, steel, bronze, or graphite. Also called gravity die casting.
- ***Process Variations*****:** slush casting, low pressure permanent mold casting
- ***Examples of Parts Cast*****:** lamp bases, candlesticks, and certain structural parts

Permanent Mold Casting: Process Capability

- ***Process***: molten metal poured into machined metal molds
- ***Advantages***: good surface finish and dimensional accuracy, fine grain structure, reusable mold
- ***Limitations***: high initial mold cost, limited shape, size and complexity; < 60% yield
- ***Common Metals***: alloys of Al, Mg, Cu, Zn, Sn, Pb; cast irons and steel in graphite molds
- ***Size Limits***: 100 g to 75 kg
- ***Thickness Limits***: ~3 mm – 50 mm
- ***Typical Tolerances***: $\pm$ 0.4 mm for first 2.5 cm; $\pm$ 0.02 mm for each additional cm
- ***Surface Finish***: 2.5 – 7.5 μm R_q

Die Casting Process

- ***Process***: metal is injected into clamped metal dies under high pressures and allowed to solidify
- ***Process Types***: hot chamber and cold chamber
- ***Example Parts***: Al cylinder heads, transmission case



Hot Chamber Process

Cold Chamber Process

Die Cast Parts

Die Cast Zinc Faucet

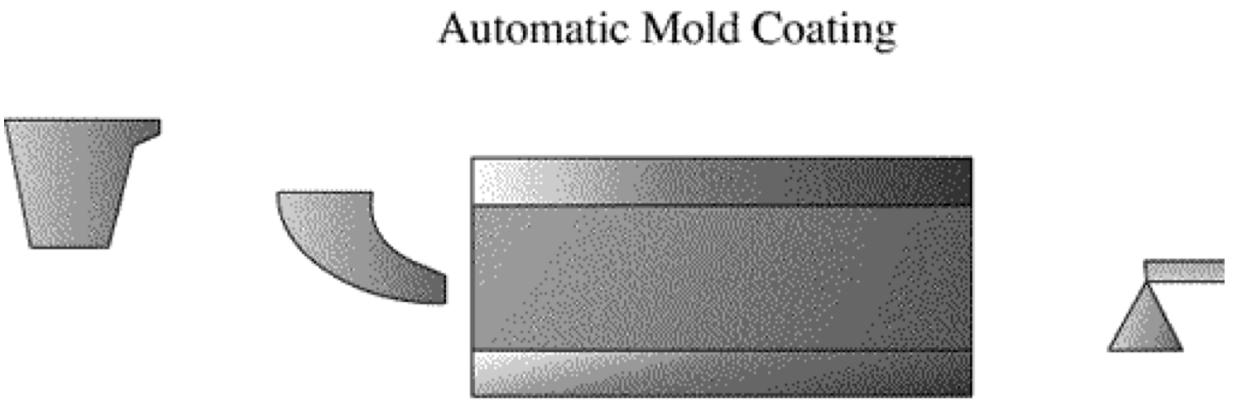
Die Cast Structural Part

Die Casting: Process Capability

- ***Process***: molten metal injected into machined metal dies under pressures of 10~175 MPa
- ***Advantages***: excellent surface finish and dimensional accuracy; high production rates
- ***Limitations***: high initial die cost, limited to high-fluidity non-ferrous metals, limited part size
- ***Common Metals***: alloys of Al, Mg, Zn, Pb, Cu
- ***Size Limits***: 30 g to 7 kg
- ***Thickness Limits***: ~0.75 mm – 13 mm
- ***Typical Tolerances***: $\pm$ 0.1 mm for first 2.5 cm; $\pm$ 0.02 mm for each additional cm
- ***Surface Finish***: 1 – 2.5 μm R_q

Centrifugal Casting Process

- ***Process***: molten metal poured into rotating sand, metal or graphite mold
- ***Example Parts***: pipes, light poles, pressure vessels, cylinder liners



Source: http://www.ccmcotulsa.com/animation.html

Centrifugally Cast Parts

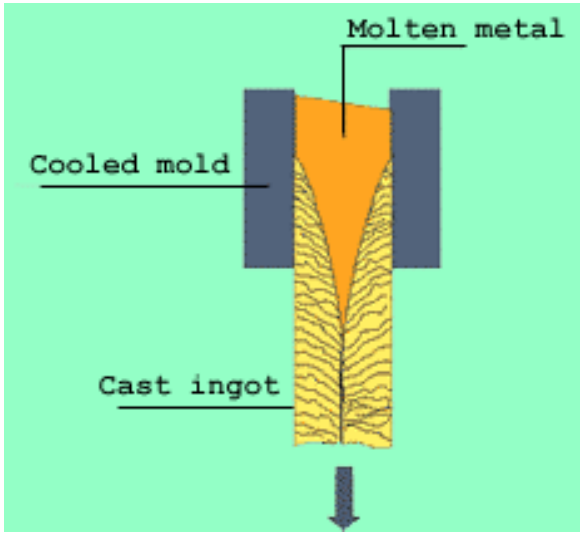
Cast Iron Rolls

Centrifugal Cast Pipes

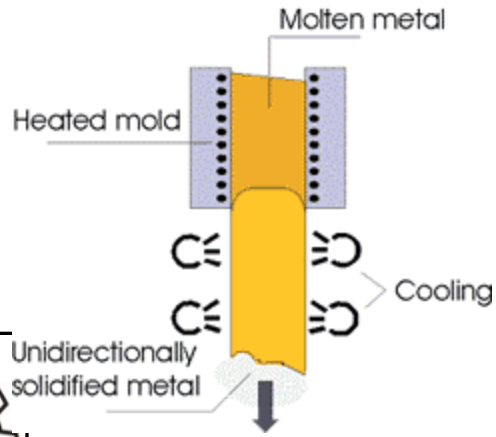
Centrifugal Casting: Process Capability

- ***Process***: molten metal poured into rotating sand, metal or graphite mold
- ***Advantages***: wide range of cylindrical parts; good dimensional accuracy
- ***Limitations***: limited shapes; high equipment cost
- ***Common Metals***: iron, steel, Al, Cu, Ni
- ***Size Limits***: 3 m to 15 m in length
- ***Thickness Limits***: wall thickness 2.5~125 mm
- ***Typical Tolerances***: OD to within $\pm$ 2.5 mm and ID to within $\pm$ 4 mm
- ***Surface Finish***: 2.5-12.5 μm R_q

Continuous Casting

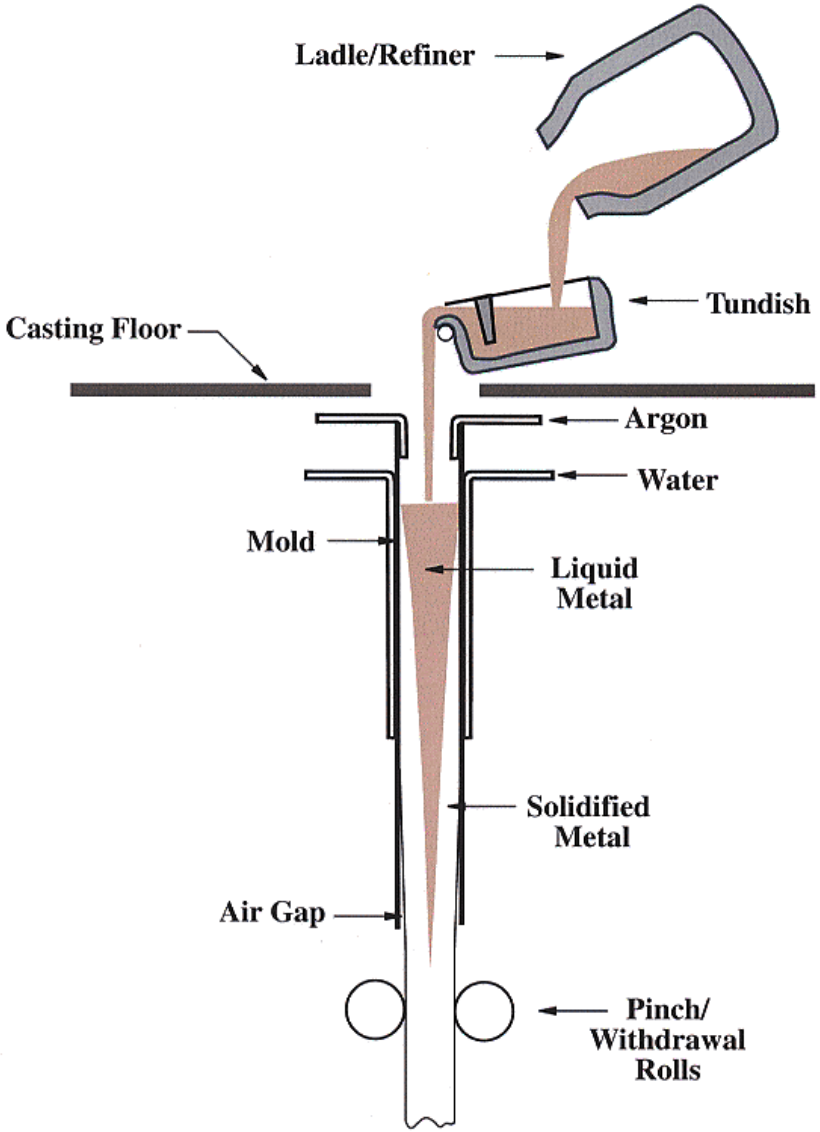


OCC Process

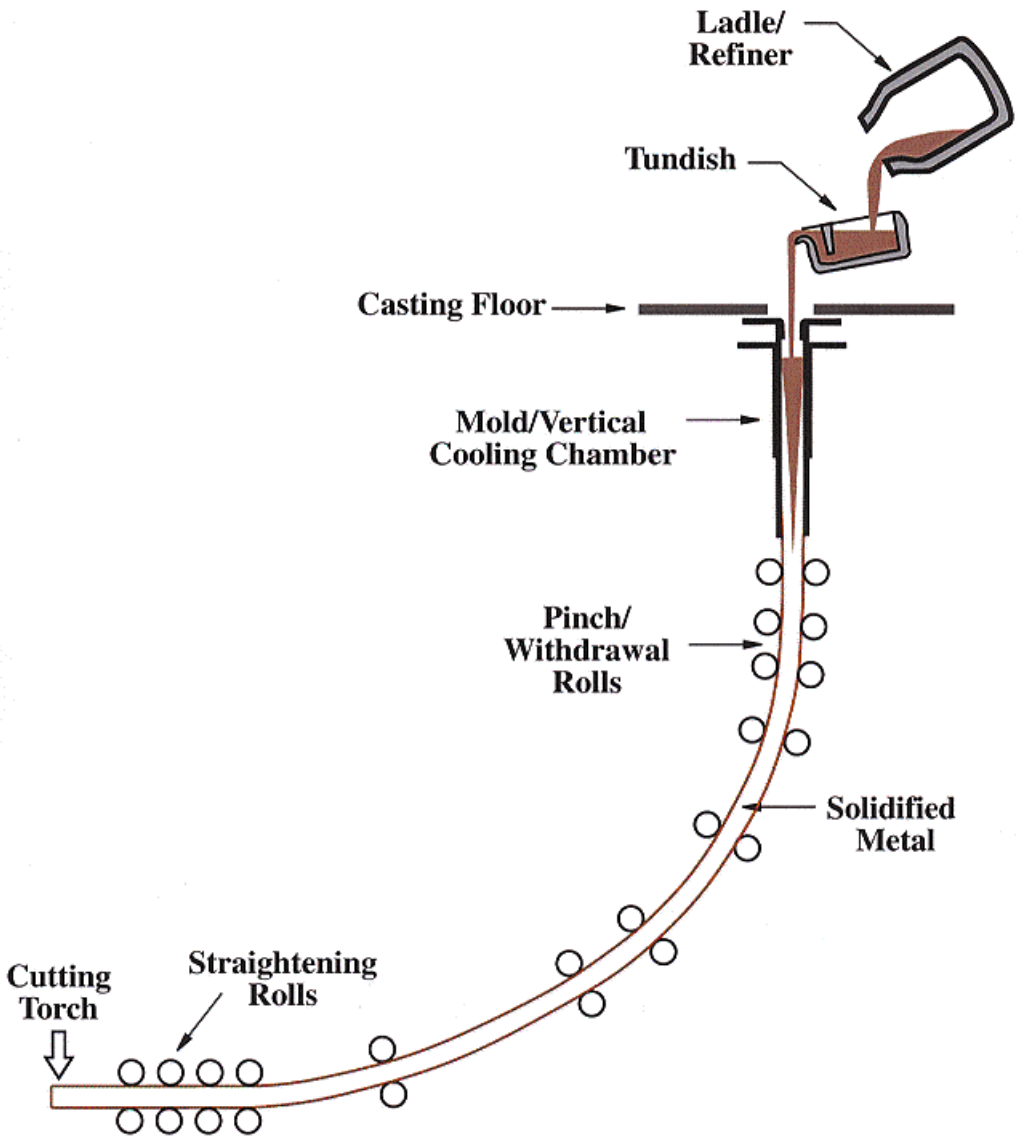


http://www.youtube.com/watch?v=wAcnOpOHeCU

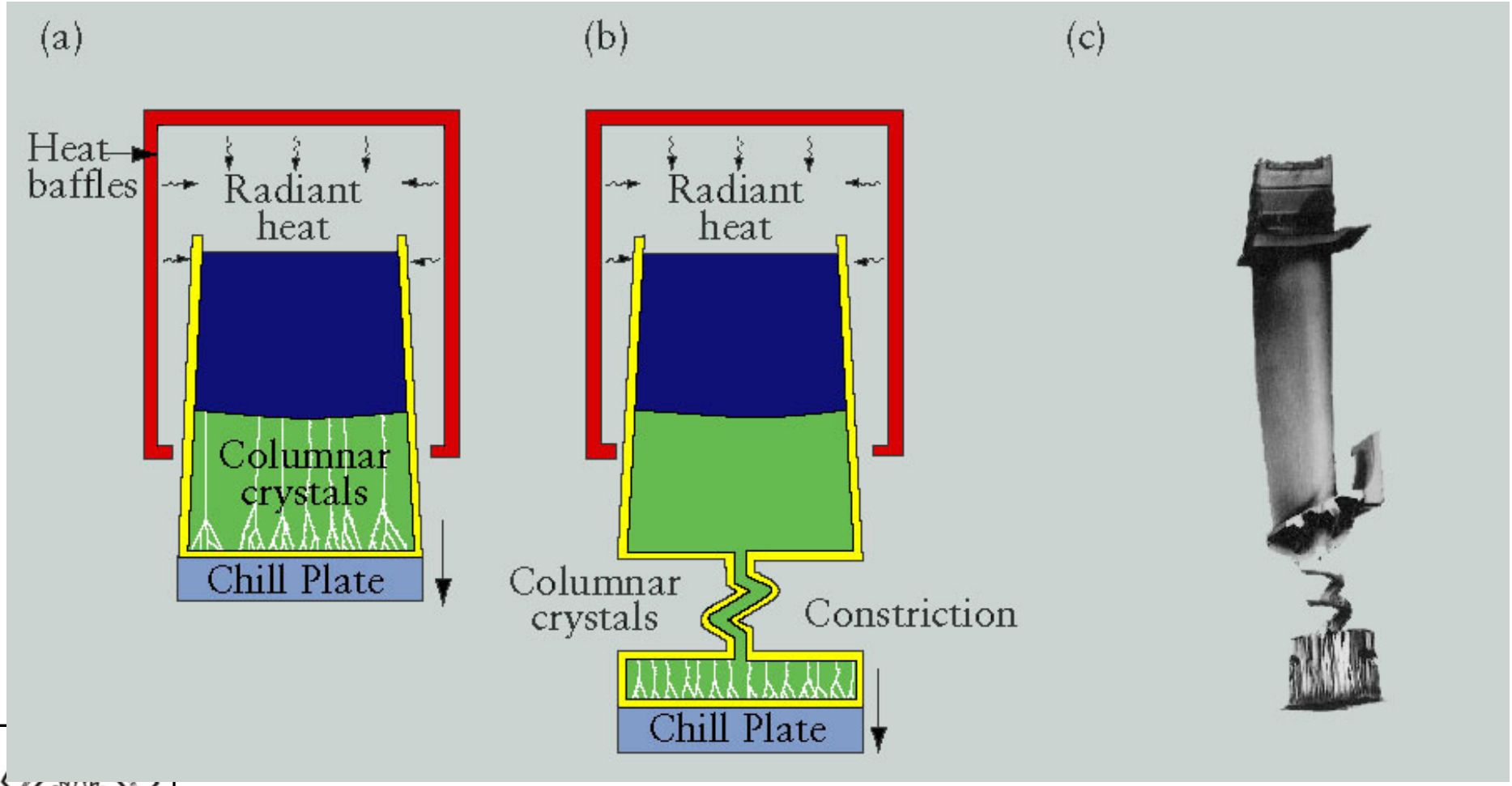
CONTINUOUS CASTING I



CONTINUOUS CASTING II



Directional Solidification



Casting Summary

- Basic steps in casting
  - Melting, pouring, solidification
  - Simplified analyses
  - Defects and remedies
- Casting process capability
  - Expendable mold processes
    - Sand casting
    - Investment casting
  - Permanent mold processes
    - Permanent mold casting
    - Die casting
    - Centrifugal casting
  - Continuous Casting
  - Directional Solidification