Casting Methods
Overview

- **Lost mould**
  - Permanent pattern
    - Sand casting
      - Manual shaping
      - Mechanical shaping
    - Shell moulding
    - Ceramic moulding
  - Lost pattern
    - Investment casting (lost-wax casting)
    - Lost foam casting
    - Vacuum casting

- **Permanent mould**
  - Without pattern
    - Die casting
    - Gravity die casting
    - Centrifugal casting
    - Injection moulding
    - Continuous casting
    - Strip casting
Casting

- Fluid metal poured into a mold and solidified by cooling

Casting four crankshafts (Gravity casting)

Casting six cover plates (Gravity casting)

http://www.magmasoft.de/ms/products_de_processes/
Sand casting
lost mould, permanent pattern

- Cope
- Drag
- Core
- Gating system
  - Riser
  - Sprue
Sand casting

Riser

• Reservoir of molten metal
  – Prevent cavities due to shrinkage
  – Liquid is less dense than solid

• Controlling of the solidification direction
  – Preferably pointed to the riser

• Leakage of the gas while casting
  – Open-riser

Sand casting
Pattern

• Solid pattern
  – geometrically simple parts
  – low quantities

• Split pattern
  – geometrically complex parts
  – moderate quantities

http://www.custompartnet.com/wu/SandCasting
Sand casting
Pattern

- Match-plate pattern
  - larger quantities
  - often in automated process

- Cope and drag Pattern
  - when a match-plate pattern would be too heavy
  - larger quantities
  - often in automated process

http://www.custompartnet.com/wu/SandCasting
Sand casting
Cope pattern
Sand casting
Mold making

- Silica sand $\text{SiO}_2$
- Binder
- Water
Sand casting
Insert cores
Sand casting
Assembly

Sand casting
Casting

http://www.custompartnet.com/wu/SandCasting
Sand casting
Mechanical shaping
Sand casting

- **Advantages**
  - Very large parts
  - Complex shapes
  - Many material options
  - Low tooling and equipment cost
  - Recyclable scrap
  - Short lead time possible

- **Disadvantages**
  - Some porosity possible
  - Moderate surface finish and tolerance
  - Secondary machining often required
  - Low production rate
  - High labor cost
  - Often cores needed
Shell moulding
lost mould, permanent pattern

- Heated pattern
- Resin in mixture cures
- Thin-walled shell

http://www.custompartnet.com/wu/shell-mold-casting
Shell moulding

- **Advantages**
  - Complex shapes and fine details
  - Very good surface finish
  - Little scrap generated

- **Disadvantages**
  - High equipment cost
  - High tooling costs
  - Environment aspects

http://www.custompartnet.com/wu/shell-mold-casting
Ceramic moulding
lost mould, permanent pattern

- Permanent pattern
- Ceramic slurry
  - Binder
  - Refractory powder
- Can fill the rest with sand
- Mould forming at low temperatures
- Shaw-method
  - burn
- Unicast-method
  - evaporate
Ceramic moulding

• Advantages
  – For high temperature castings
  – Very good surface finish
  – Very accurate
  – No casting skin

• Disadvantages
  – Mold must be baked
  – Expensive

http://en.wikipedia.org/wiki/Ceramic_molding
http://www.unicastdev.com/process.htm
Investment casting
lost mould, lost pattern
Investment casting

• Assembling casted wax pattern to a pattern tree

• Building the ceramic shell
  – Ceramic slurry
  – Sand and fireclay
  – Drying

http://www.buerstlein-guss.de/verfahren/
Investment casting

- Melting out of the wax
  - Hollow ceramic shell

- Firing the hollow ceramic shell
  - Over 1000 °C

http://www.buerstlein-guss.de/verfahren/
Investment casting

- Casting direct in the hot shells
- Break of the ceramic shell
  - by vibration
  - chemical

http://www.buerstlein-guss.de/verfahren/
Investment casting

- Automatic gearbox housing
  - EN AC-AlSiMg0.6
  - Quick-Cast (Stereolithography SL)

http://www.kug.bdguss.de/fileadmin/content/Publikationen-Normen-Richtlinien/buecher/Feinguss.pdf
Investment casting

- One-piece compressor stator
  - 108 separate airfoils
  - Courtesy Howmet Corp
Investment casting

• Advantages
  – Complex shapes and fine details
  – Many material options,
  – High strength parts
  – Very good surface finish and accuracy
  – Little need for secondary machining
  – CAD-Models direct usable

• Disadvantages
  – Time-consuming process
  – High labor cost
  – High tooling cost
  – Long lead time possible

http://www.custompartnet.com/wu/investment-casting
Lost foam casting
lost mould, lost pattern

- Polystyrene (foam) Pattern
  - Sprayed refractory compound
- No cavity
- Molten metal vaporizes foam
  - Metal fill the resulting mold cavity
Lost foam casting

http://www.magmasoft.de/ms/products_de_processes/
Lost foam casting

http://de.wikipedia.org/wiki/Vollformgießen
Lost foam casting

• Advantages
  – Complex shapes without cores
  – Dimensionally accurate
  – Excellent surface finish
  – No draft required
  – No parting line (no flash)
  – Natural directional solidification

• Disadvantages
  – High pattern costs
  – Low strength of the pattern
    • Easily damaged or distorted

http://en.wikipedia.org/wiki/Lost-foam_casting
Die casting (hot chamber)
permanent mould, no pattern

- Alloy with low melting point
  - Zn-, Sn-, Pb-alloys
- Molten metal in a open pot
- Injection by plunger through a gooseneck
- 70 – 350 bar
- Fine grain due to the pressure
  - High strength
- 200-400 shots per hour
Die casting (hot chamber)
permanent mould, no pattern
Die casting (cold chamber)
permanent mould, no pattern

- Alloys with higher melting point
  - Al-, Cu-, Mg-alloys
- Ladled from the pot into shot camber
- Injection by plunger
- 140 – 1400 bar
- Fine grain due to the pressure
  - High strength
- 200-400 shots per hour
Die casting

• Advantages
  – Large parts
  – Complex shapes
  – High strength parts
  – Very good surface finish and accuracy
  – High production rate
  – Low labor cost
  – Scrap can be recycled

• Disadvantages
  – Trimming is required
  – High tooling cost
  – High equipment cost
  – Limited die life
  – Long lead time
Gravity die casting
permanent mould, no pattern

- Similar to sand casting and die casting
- Pre-heated permanent mould
  - 150-260 °C
- Ceramic coating for part removal and mould lifetime
- Pouring like sand casting

http://www.custompartnet.com/wu/permanent-mold-casting
Gravity die casting

• Advantages
  – Complex shapes
  – Good mechanical properties
  – Many material options
  – Low porosity
  – Low labor cost
  – Scrap can be recycled

• Disadvantages
  – High tooling cost
  – Long lead time possible

http://www.custompartnet.com/wu/permanent-mold-casting
Centrifugal casting
permanent mould, no pattern

- Refractory ceramic coating
- No runner or gating system
- 300-3000 RPM
  - Fine grain at the outer surface
  - Less dense impurities at the inner surface
Centrifugal casting

- **Advantages**
  - Very large parts
  - Good mechanical properties
  - Good surface finish and accuracy
  - Low equipment cost
  - Low labor cost
  - Little scrap generated

- **Disadvantages**
  - Limited to cylindrical parts
  - Secondary machining is often required for inner diameter
  - Long lead time possible

Continuous casting/Strip casting
permanent mould, no pattern
Continuous casting