IME 601 - FUNDAMENTALS OF MFG. ENG.

CASTING PROCESSES — BASIC CLASS NOTES

Class Preparation and Reading Review
This should be completed prior to class

Key Concepts to Be Discussed in Class:

Questions About Subject Matter for Class Session:

Outline

- General Casting Principles
- Specific Processes
  - Green Sand Casting
  - Lost Foam Casting
  - Investment Casting
  - Permanent Mold Casting
  - Die Casting
- Acknowledgment
  - W.R. Riffe (For Use of Casting Images)

Casting in General

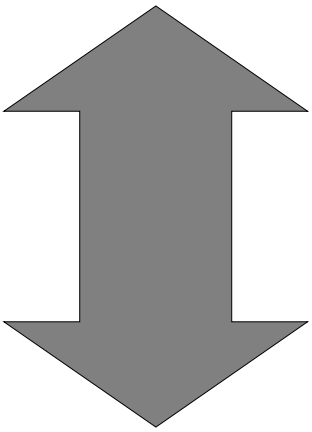
- Basic Definition
  - Pour Liquid Material (Metal) Into a Cavity of Prescribed Geometry and Let it Solidify

- Need to Consider
  - Melting of Metal (Energy, Purity)
  - Freezing of Metal (Heat Transfer, Thermal Ranges)
  - Shrinkage and Porosity
  - First Step in Many Manufacturing Processes

- Wide Variety of Shapes can be Produced

Concept Question

- What Has to Happen (Start to Finish) to Form Something Through Casting?



Assume You Want to Make A Simple Part Through Casting?

- What Technical Considerations are Important?

- We are Going to Discuss Several Forms of Casting in Class Today Make a List of The Questions Which Need to Be Asked as You Learn About Each Process
  - Casting in General
  - Non-Technical Considerations

Melting

- First Step in Casting
- Requires Energy
- Example for 10kg of Aluminum
  - Heat Up Solid to T_M

Properties of Aluminum
$T_M = 660^oC$
$\Delta H_F = 9.5x10^8\ J/m^3$
$C_{PS} = 3.0x10^6\ J/m^3K$
$C_{PL} = 2.6x10^6\ J/m^3K$

$$\Delta H = VC_{PS}(T_M - T_0)$$

$$\left(3.7\times10^{-3}m^3\right)\left(3.0\times10^6\frac{J}{m^3C}\right)(660C-25C)$$

$$7.0\times10^6\,J$$

  - Melt the Solid

$$\Delta H = V\Delta H_F$$

$$\left(3.7\times10^{-3}m^3\right)\left(9.5\times10^8\frac{J}{m^3}\right)$$

$$3.5\times10^6\,J$$

  - Heat Liquid Above T_M

$$\Delta H = VC_{PS}(T_M - T_0)$$

$$\left(3.7\times10^{-3}m^3\right)\left(2.6\times10^6\frac{J}{m^3C}\right)(100C)$$

$$0.96\times10^6\,J$$

Solidification

- Requires the Following
  - Heat Transfer to Mold
  - Time
- Early Solidification
  - Can Cause Defects

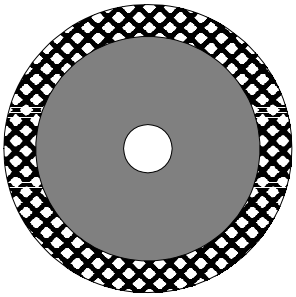
$$t_s = C\left(\frac{V}{A}\right)^2$$

A Sphere Will take 22% Longer to Solidify than A Cube

Shrinkage

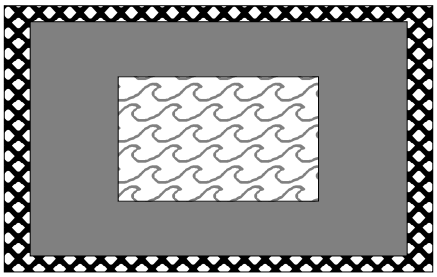
- Solid Metals are More Dense Than Liquid Metals
  - Solid Aluminum $\rho = 2.7$ g/cc
  - Liquid Aluminum $\rho = 2.4$ g/cc

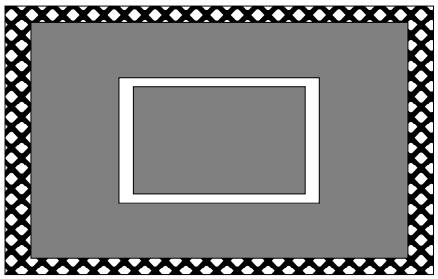
Metal	Shrinkage
Al	6.6%
Copper	4.9%
Brass	4.5%
Steel	3.0%
Mg	4.2%

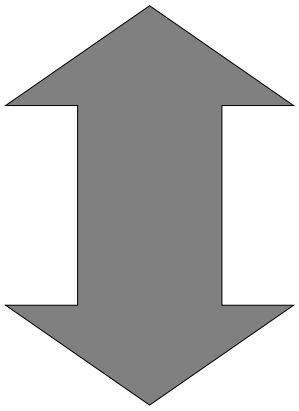


Solidification of Alloys

- Most Alloys Solidify Over A Range of Temperatures
  - Can Cause Compositional Variation
  - Can Cause Hot Tearing





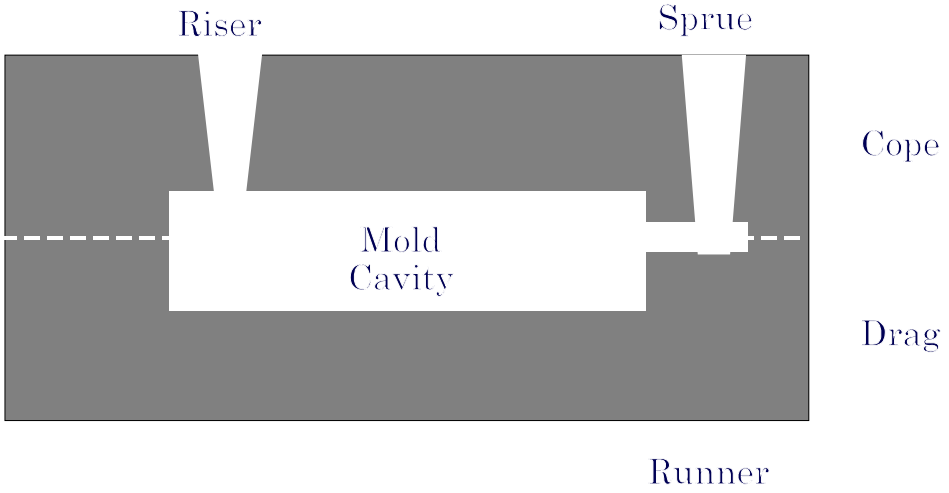


Team Problem

- In Order to Make The Part Shown (Assume Melting Is Accounted For)
  - How Can We Design a Mold?
  - Take Into Account Heat Transfer, Solidification, Shrinkage (etc.)

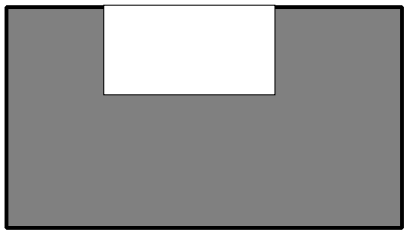
Green Sand Casting

- Use Green Sand As a Mold
  - Heat Transfer Through Green Sand
- Place Pattern In Sand
  - Requires PreMade Pattern
  - Well Packed Sand to Hold Cavity
- Requires Two Halves
  - The Mold Cavity Will Be in the Center
- Assembled Casting Mold



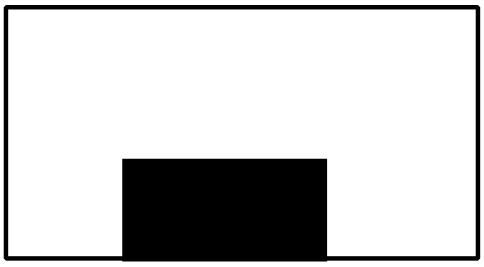
Procedure for Making Mold (1/3)

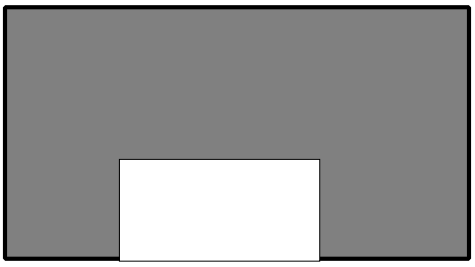
- Make Drag First
  - Place Pattern in Drag
  - Add Gates and Runners



Procedure for Making Mold (2/3)

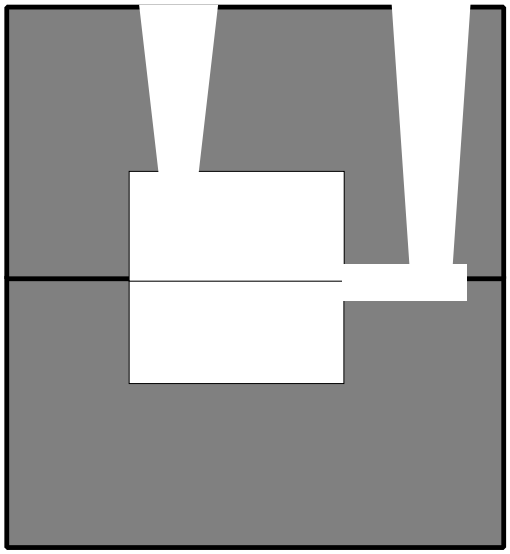
- Make the Cope Second
  - Place Pattern in Cope
  - Add Sprue and Risers





Procedure for Making Mold (3/3)

- Assemble Drag and Cope
- Pour Metal
- Variations
  - Insert Sprue and Runner on Complete Assembly



Advantages of Green Sand Casting

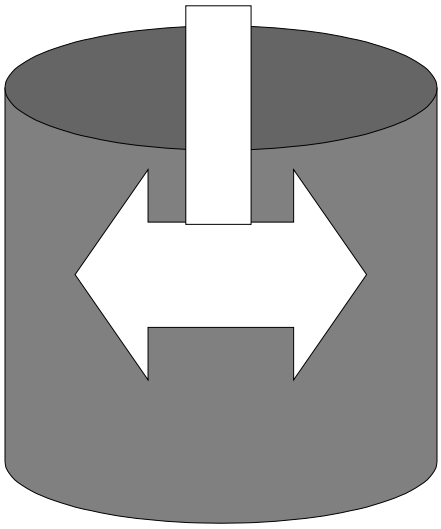
- Inexpensive
  - Mold Material Cheap and Recylable
  - Make One and Only One Pattern
- Versatile
  - Can Make Variety of Shapes
  - Can Make Automate
  - Can Make a Variety of Materials

Concerns With Green Sand Casting

- Mold Cavity Surrounded by Sand
  - Precision Problems
  - Transfer Problems
- Need to Make 2 Parts
  - Cope
  - Drag
- Time to Cool
  - Time in Production
  - Still Parts

Lost Foam Casting

- Full Mold or Evaporative Casting
  - Make Pattern out of Polystyrene
  - Place In Sand
  - Add Sprue
- Add Hot Metal
  - Mold Pattern Evaporates

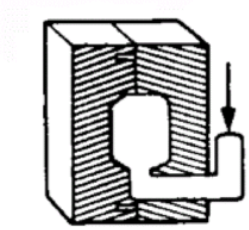


Lost Foam vs Green Sand Casting

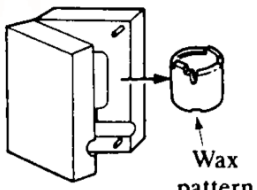
Similarities	Differences

Investment Casting

- Lost Wax Casting
  - Use Wax to Make Pattern
  - Form Ceramic Mold
  - Pour In Metal



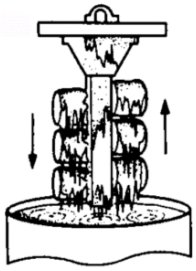
Injection wax or plastic pattern



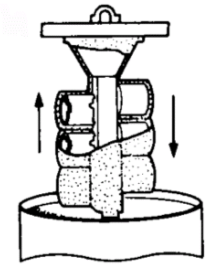
Ejecting pattern

Investment Casting

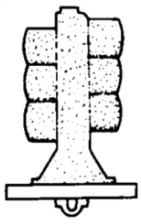
- Making of Mold
  - Get a Pre- Ceramic Coating



Slurry coating



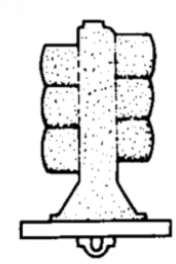
Stucco coating



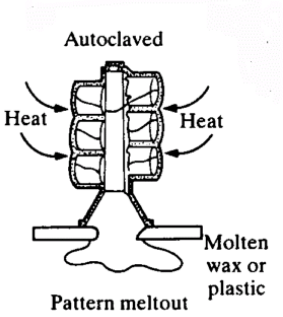
Completed mold

Investment Casting

- Final Formation of Mold
  - Heat and Cure Ceramic
  - Melt Wax
- Mold Cavity Remains



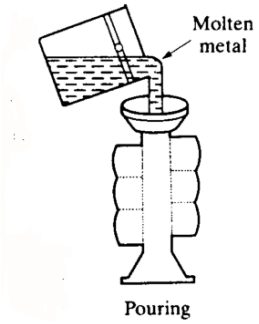
Completed mold



Pattern meltout

Investment Casting

- Pour Metal Into Mold
  - Final Step of Process



Pouring

Casting

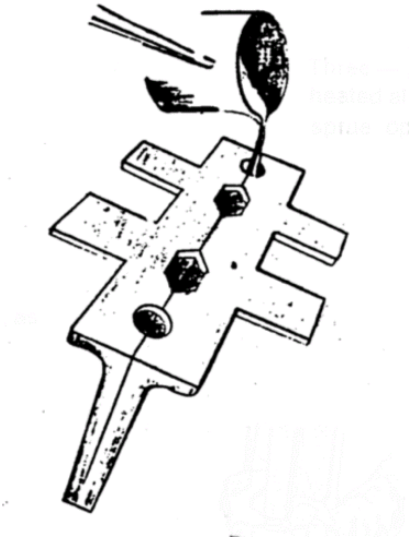
Pattern

Investment vs Green Sand Casting

Similarities	Differences

Permanent Mold Casting

- Make a Mold From High T_M Metal
  - Include Gate Runner System

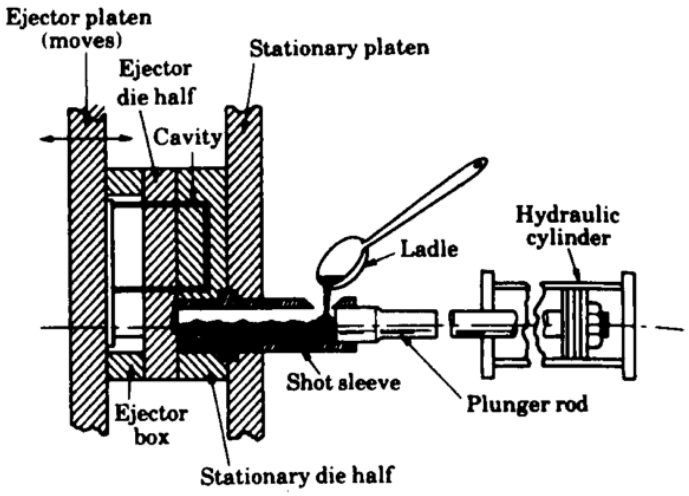


Permanent Mold vs Green Sand Casting

Similarities	Differences

Die Casting

- Permanent Mold Casting Under Pressure
  - Cold Chamber Illustrated



Die vs Green Sand Casting

Similarities	Differences

Summary

- Casting is Conceptually One of the Easiest Processes to Visualize and Implement
- Casting Processes Comparison
  - Similarities
  - Differences
- Acknowledgment
  - W.R. Riffe (For Use of Casting Images)

After Class Review

Summarize Key Concepts and List Further Questions

Key Concepts	Questions