The H-J Family of Companies

Basics of Forgings and Castings

Rev 01

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Basics of Forgings and Castings Overview

- The H-J Family of Companies has extensive experience with forgings and castings in many ferrous and non-ferrous alloys such as copper, aluminum, stainless steel, etc.
- This presentation is intended to help educate customers about some of the basics types of forging and casting processes, as well as some of the advantages and disadvantages of each.
- Contact H-J for questions regarding:
  - New product development
  - Cost reduction projects
  - Quality and problem solving
  - Material and application evaluation

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Overview of Forgings

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Basics of Forgings and Castings
Forging process

- Basic steps include:
  - Cutting of the material
  - Pre-heat the forging dies
  - Heating of the material
  - Forging operation
  - Cooling of the forged part

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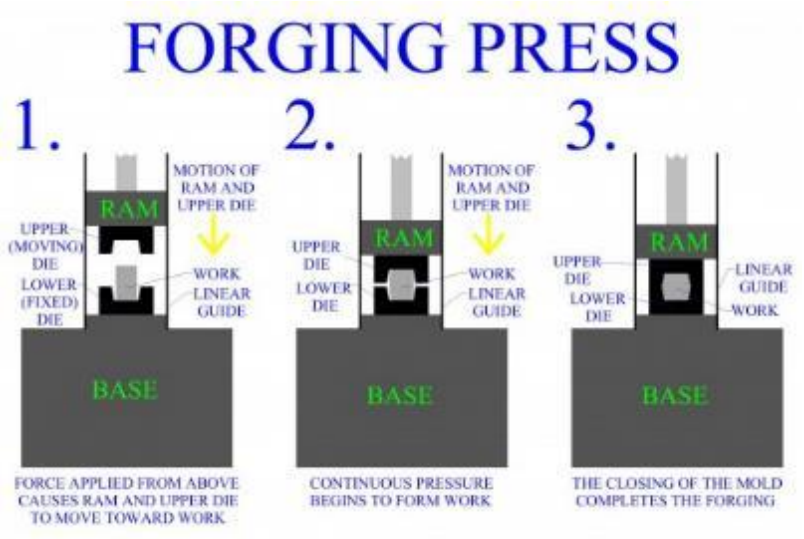
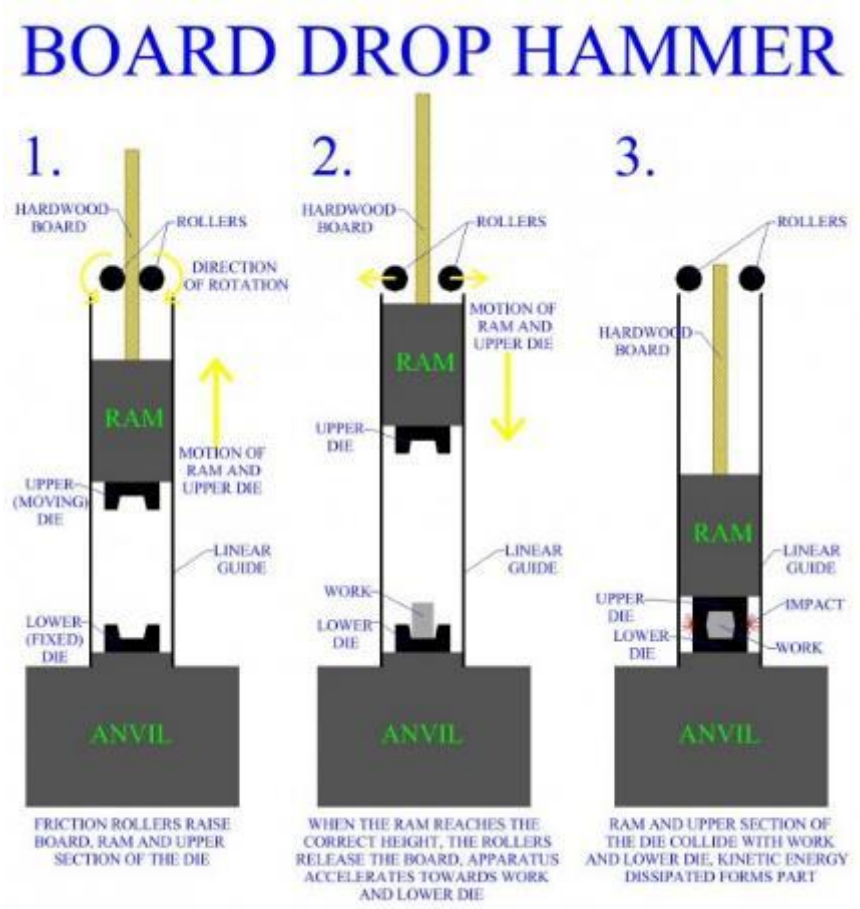
Basics of Forgings and Castings
Forging process

- Impression Die forming
  - Hammer
  - Press
  - Horizontal





Basics of Forgings and Castings
Forging process

- Cold forging process
- Open Die forging process
- Rolled Ring forging process

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Basics of Forgings and Castings
Forging process

What are typical forging temperatures?

- Ferrous metals
  - Carbon and Alloy Steel: 2,250˚F (1,232˚C)
- Non-ferrous metals
  - Brass: 1,500˚F (816˚C)
  - Copper: 1,650˚F (899˚C)
  - Aluminum: 1,000˚F (538˚C)

2000°F	Bright yellow	1093°C
1900°F	Dark yellow	1038°C
1800°F	Orange yellow	982°C
1700°F	Orange	927°C
1600°F	Orange red	871°C
1500°F	Bright red	816°C
1400°F	Red	760°C
1300°F	Medium red	704°C
1200°F	Dull red	649°C
1100°F	Slight red	593°C
1000°F	Very slight red, mostly grey	538°C
0800°F	Dark grey	427°C
0575°F	Blue	302°C
0540°F	Dark Purple	282°C
0520°F	Purple	271°C
0500°F	Brown/Purple	260°C
0480°F	Brown	249°C
0465°F	Dark Straw	241°C
0445°F	Light Straw	229°C
0390°F	Faint Straw	199°C

Basics of Forgings and Castings
Design considerations for Forgings

- Parting line location
- Recommended draft angles
  - Aluminum: 0-2 deg
  - Copper alloys (Brass): 0-3 deg
  - Steel: 5-7 deg
- Size of the part
- Part configuration
- Radii and Fillets
  - No sharp corners
  - Minimum fillet radius:
    - 0.130 – 0.250” (3.30 – 6.35 mm)
- Machine allowance
  - Typically 0.060” (1.52 mm)

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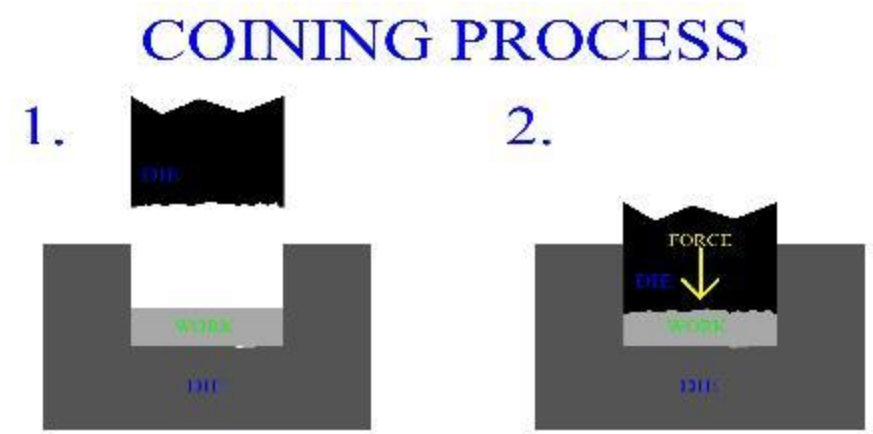
Basics of Forgings and Castings
Secondary operations for Forgings

- Heat treating
- Coining
- Cleaning
- Packaging



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Overview of Castings

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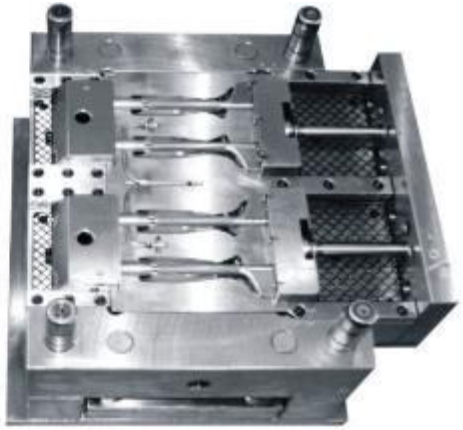
Basics of Forgings and Castings
Casting processes

- Sand casting
- Permanent mold casting
- Die casting
- Investment (lost-wax) casting



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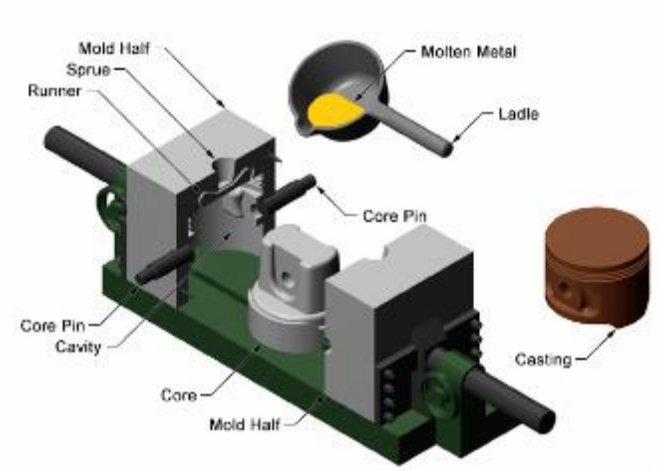
Basics of Forgings and Castings
Sand casting

- Sand castings offer very competitive tooling costs (upfront investment)
- Capabilities:
  - Hold max tolerances of +/- 0.032” (+/- 0.81mm)
  - Thinnest section castable is 0.100” (2.54mm)
  - Surface finish is fair to good
  - May be part size restrictions
  - Good for all metal alloys
- Types:
  - Green sand:
    - less expensive, good for lower volumes
  - Sodium silicate:
    - higher quality, more repeatable for larger volumes

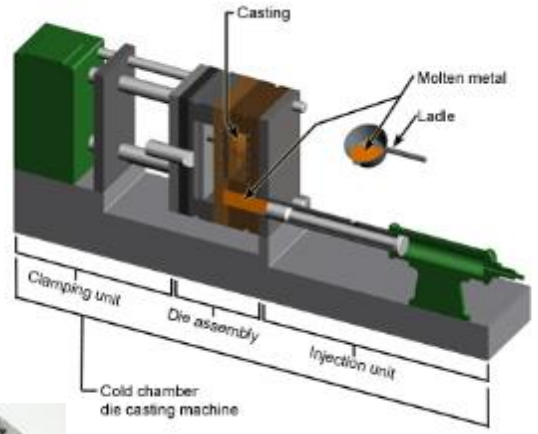
Basics of Forgings and Castings
Permanent mold casting

- Permanent mold tooling costs are slightly higher than sand cast, but still competitive
- Capabilities:
  - Hold max tolerances of +/- 0.020” (+/- 0.51mm)
  - Thinnest section castable is 0.125” (3.17mm)
  - Surface finish is good
  - Very good for large part designs
  - Best for aluminum and copper base alloys
  - Low volume part cost is competitive



Basics of Forgings and Castings
Die casting

- Tooling costs are more expensive due to complexity
- Capabilities:
  - Hold max tolerances of +/- 0.005” (+/- 0.127mm)
  - Thinnest section castable is 0.030” (0.76mm)
  - Surface finish is the best
  - Good for aluminum base alloys
  - Competitiveness:
    - Most competitive method in very high volumes
    - Least competitive method in low volumes



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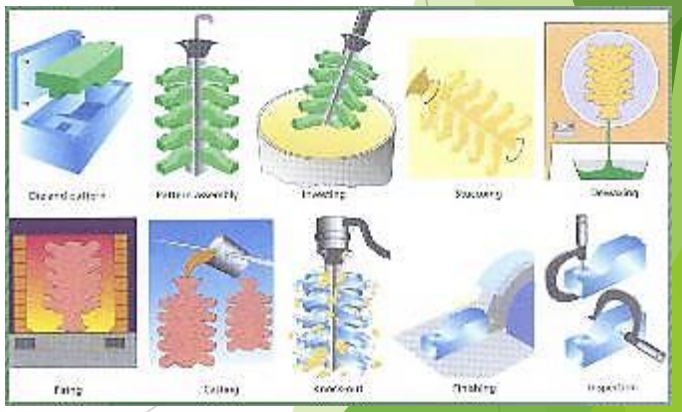
Basics of Forgings and Castings
Investment casting

- Tooling costs are between permanent mold and die casting
- Capabilities:
  - Hold max tolerances of +/- 0.015” (+/- 0.38mm)
  - Thinnest section castable is 0.063” (1.6mm)
  - Surface finish is good
  - Good for all ferrous and non-ferrous alloys
  - Competitiveness:
    - Least competitive method in very high volumes
    - Mid-competitive method in low volumes



Case studies

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Basics of Forgings and Castings
Case study: Copper forged fuse end

- Current process:
  - Copper sand casting, machined, silver-plated
- Issues:
  - Porosity and non-fill in critical areas
  - Not cost effective
- Resolution:
  - Copper forging, machined, silver-plated
- Conclusion:
  - Forging process supplying fully formed and solid part per print at a substantial cost reduction for the customer.

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Basics of Forgings and Castings
Case study: Two-piece universal clamp

- Current process:
  - Brass upset forging, tin-plated
- Issues:
  - Part not meeting specified torque requirements
- Resolution:
  - Brass flat forging, tin-plated
- Conclusion:
  - Discovered that torque was being applied parallel to the grain and causing failures; changed direction of forging grain and solved the issue.

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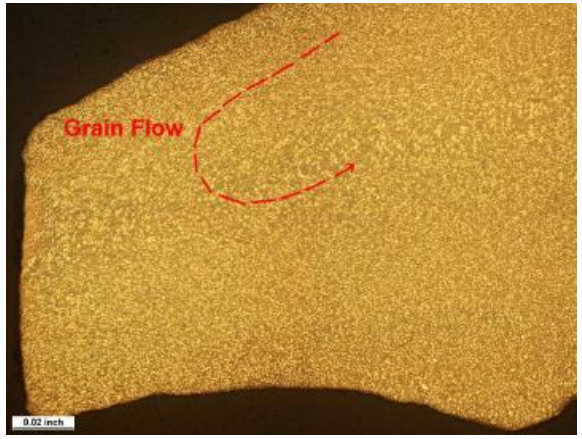
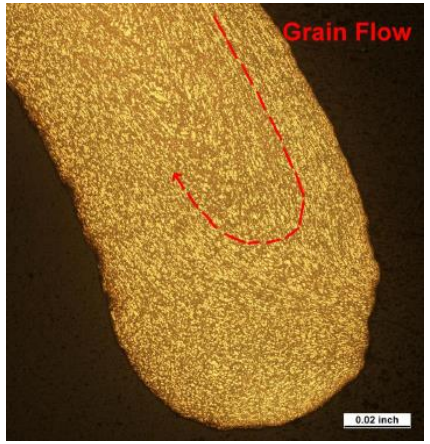
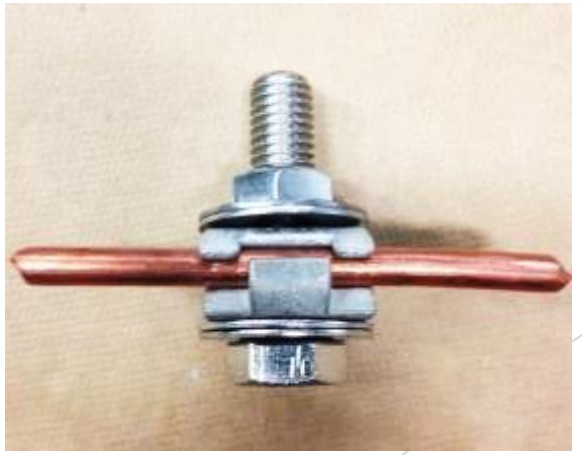
Basics of Forgings and Castings
Case study: Two-piece universal clamp







Basics of Forgings and Castings
Case studies: Convert two-piece designs to single-piece

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