Expendable-Mold Casting Process

Chapter 12

Veljko Samardzic

12.1 Introduction

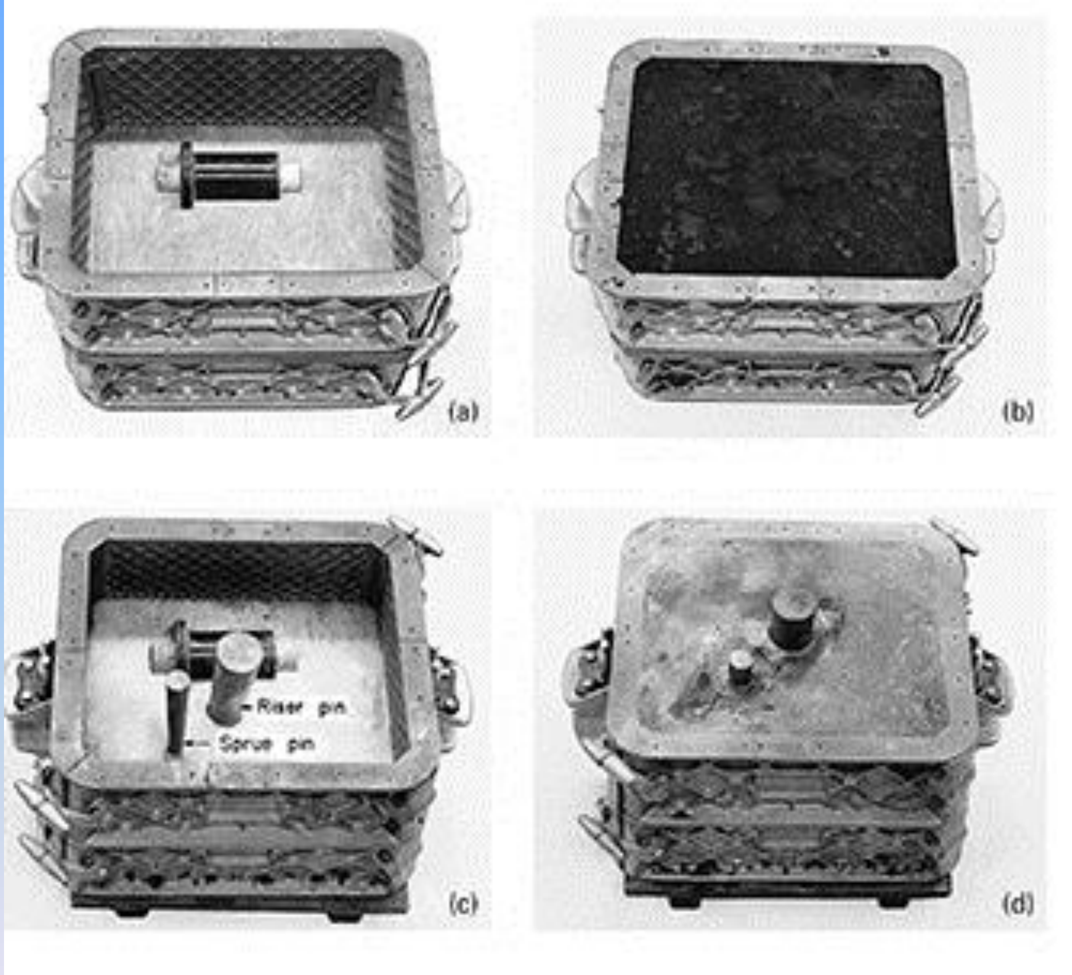
- Factors to consider for castings
  - Desired dimensional accuracy
  - Surface quality
  - Number of castings
  - Type of pattern and core box needed
  - Cost of required mold or die
  - Restrictions due to the selected material
- Three categories of molds
  - Single-use molds with multiple-use patterns
  - Single-use molds with single-use patterns
  - Multiple-use molds

12.2 Sand Casting

- Sand casting is the most common and versatile form of casting
  - Granular material is mixed with clay and water
  - Packed around a pattern
- Gravity flow is the most common method of inserting the liquid metal into the mold
- Metal is allowed to solidify and then the mold is removed

Sand Casting

Figure 12-1 Sequential steps in making a sand casting. a) A pattern board is placed between the bottom (drag) and top (cope) halves of a flask, with the bottom side up. b) Sand is then packed into the bottom or drag half of the mold. c) A bottom board is positioned on top of the packed sand, and the mold is turned over, showing the top (cope) half of pattern with sprue and riser pins in place. d) The upper or cope half of the mold is then packed with sand.



Sand Casting

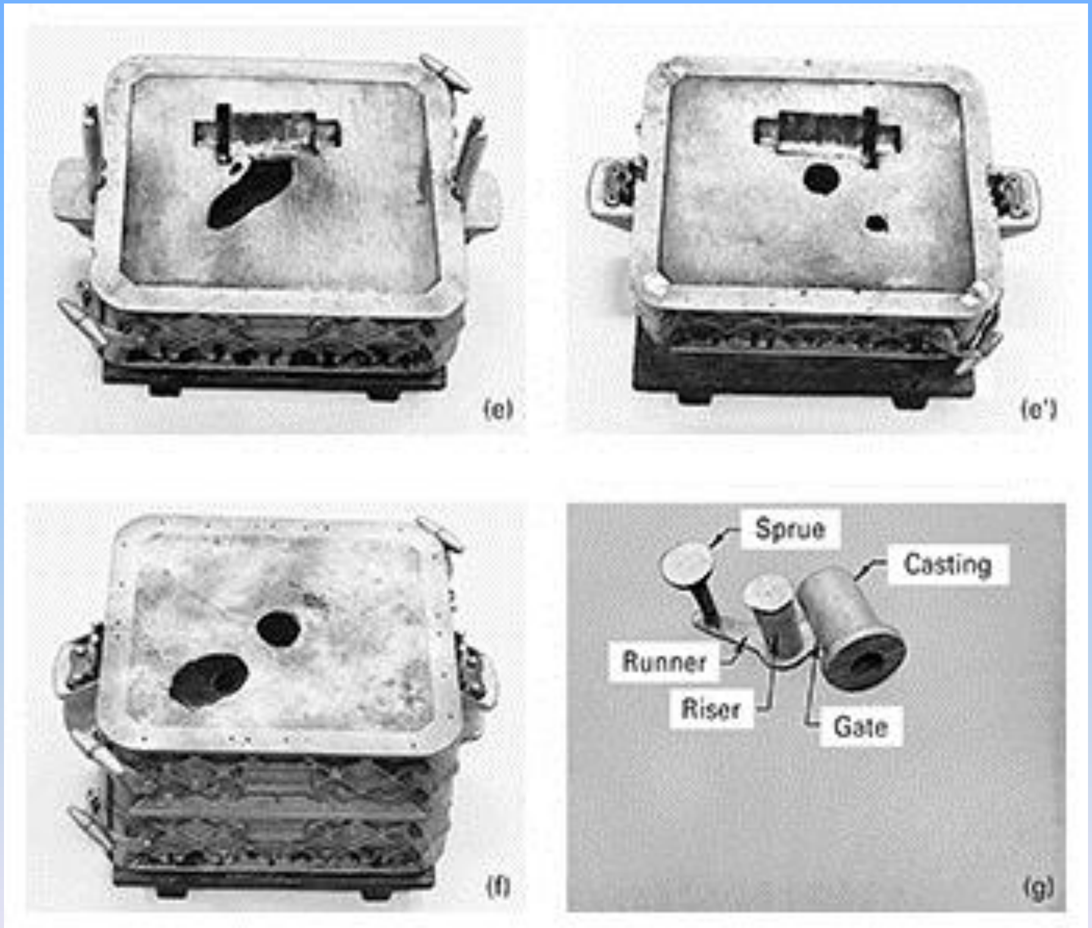


Figure 12-1 e) The mold is opened, the pattern board is drawn (removed), and the runner and gate are cut into the bottom parting surface of the sand. e') The parting surface of the upper or cope half of the mold is also shown with the pattern and pins removed. f) The mold is reassembled with the pattern board removed, and molten metal is poured through the sprue. g) The contents are shaken from the flask and the metal segment is separated from the sand, ready for further processing.

Patterns and Pattern Materials

- First step in casting is to design and construct the pattern
- Pattern selection is determined by the number of castings, size and shape of castings, desired dimensional precision, and molding process
- Pattern materials
  - Wood patterns are relatively cheap, but not dimensionally stable
  - Metal patterns are expensive, but more stable and durable
  - Hard plastics may also be used

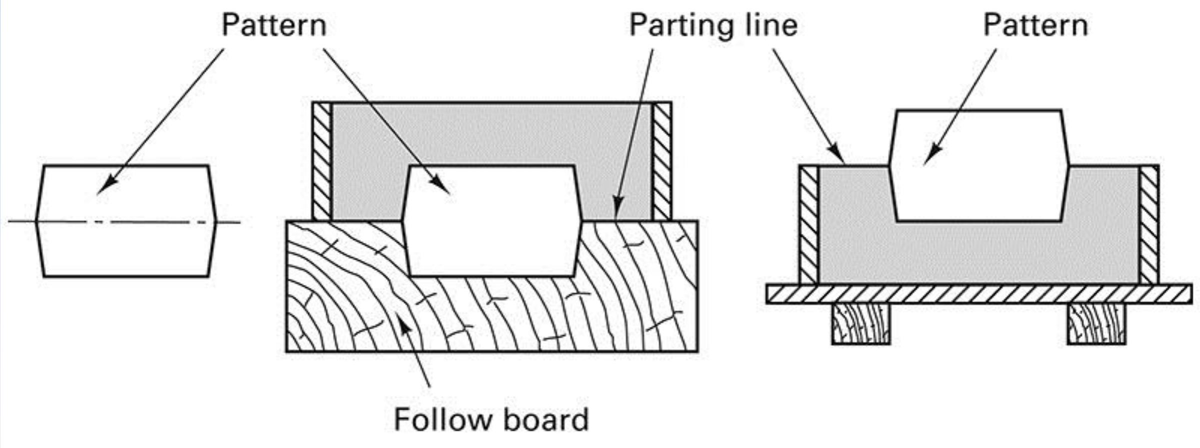
Types of Patterns

- The type of pattern is selected based on the number of castings and the complexity of the part
- One-piece or solid patterns are used when the shape is relatively simple and the number of castings is small
- Split patterns are used for moderate quantities
  - Pattern is divided into two segments

Types of Patterns

Figure 12-2 (Above) Single-piece pattern for a pinion gear.

Figure 12-3 (Below) Method of using a follow board to position a single-piece pattern and locate a parting surface. The final figure shows the flask of the previous operation (the drag segment) inverted in preparation for construction of the upper portion of the mold (cope segment).



Types of Patterns

- Match-plate patterns
  - Cope and drag segments of a split pattern are permanently fastened
  - Pins and guide holes ensure that the cope and drag will be properly aligned on reassembly
- Cope and drag patterns
  - Used for large quantities of castings
  - Multiple castings can occur at once
  - Two or more patterns on each cope and drag

Types of Patterns

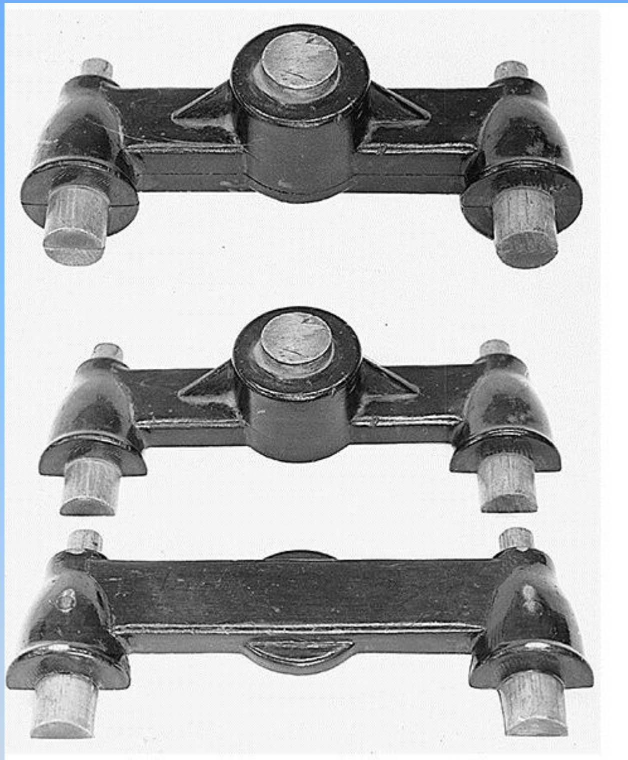


Figure 12-4 Split pattern, showing the two sections together and separated. The light-colored portions are core prints.

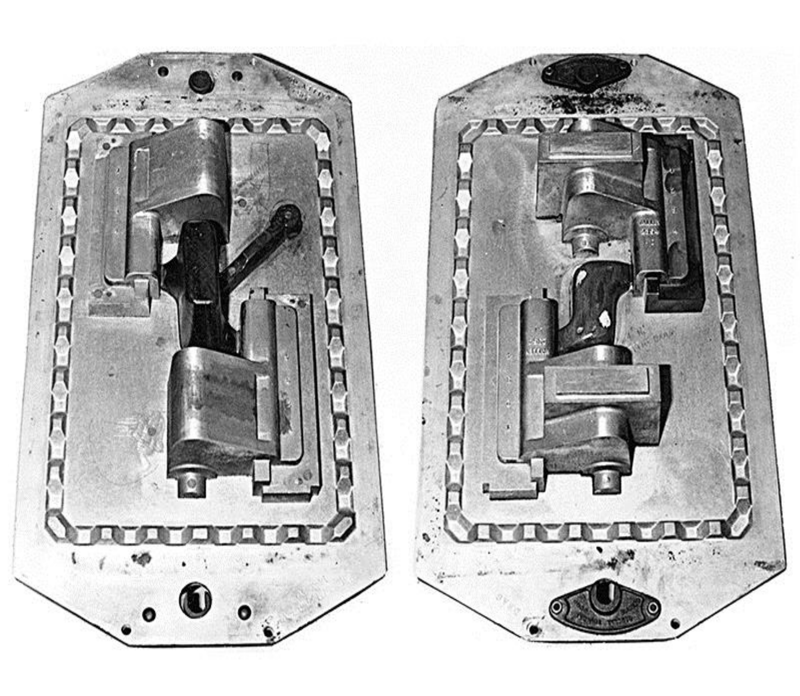


Figure 12-5 Match-plate pattern used to produce two identical parts in a single flask. (Left) Cope side; (right) drag side. (Note: The views are opposite sides of a single-pattern board.

Cope and Drag Patterns

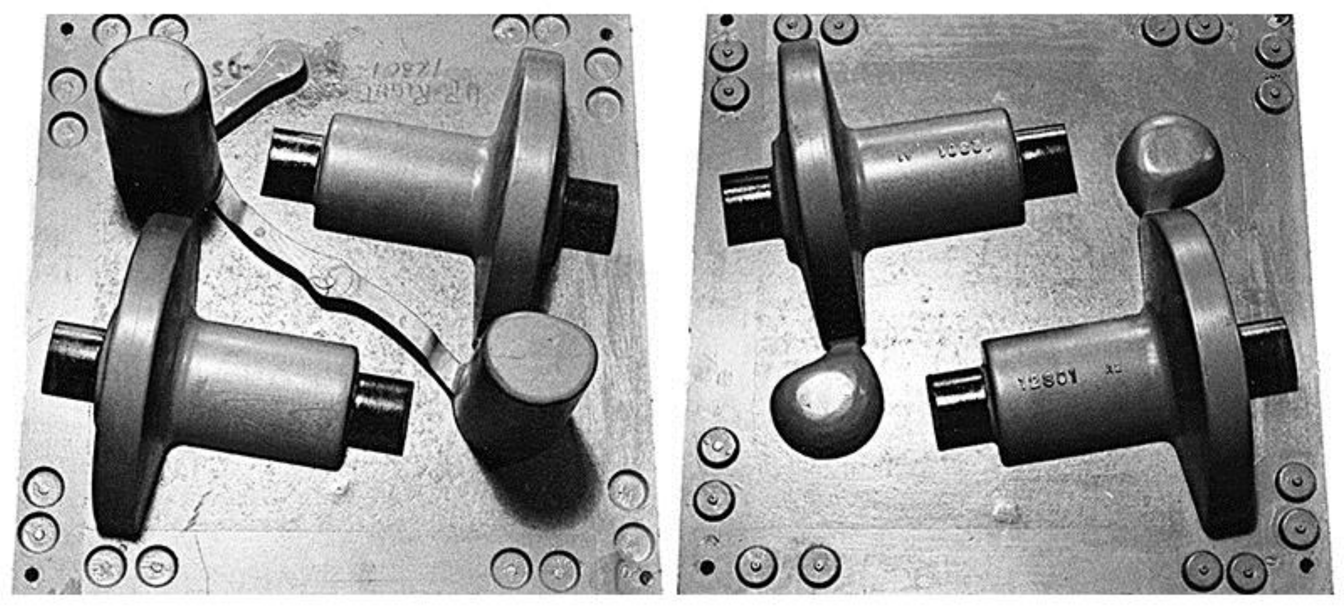


Figure 12-6 Cope-and-drag pattern for producing two heavy parts. (Left) Cope section; (right) drag section. (Note: These are two separate pattern boards.)

Sands and Sand Conditioning

- Four requirements of sand used in casting
  - Refractoriness-ability withstand high temperatures
  - Cohesiveness-ability to retain shape
  - Permeability-ability of a gases to escape through the sand
  - Collapsibility-ability to accommodate shrinkage and part removal
- Size of sand particles, amount of bonding agent, moisture content, and additives are selected to obtain sufficient requirements

Processing of Sand

- Green-sand mixture is 88% silica, 9% clay, and 3% water
- Each grain of sand needs to be coated uniformly with additive agents
- Muller kneads, rolls, and stirs the sand to coat it

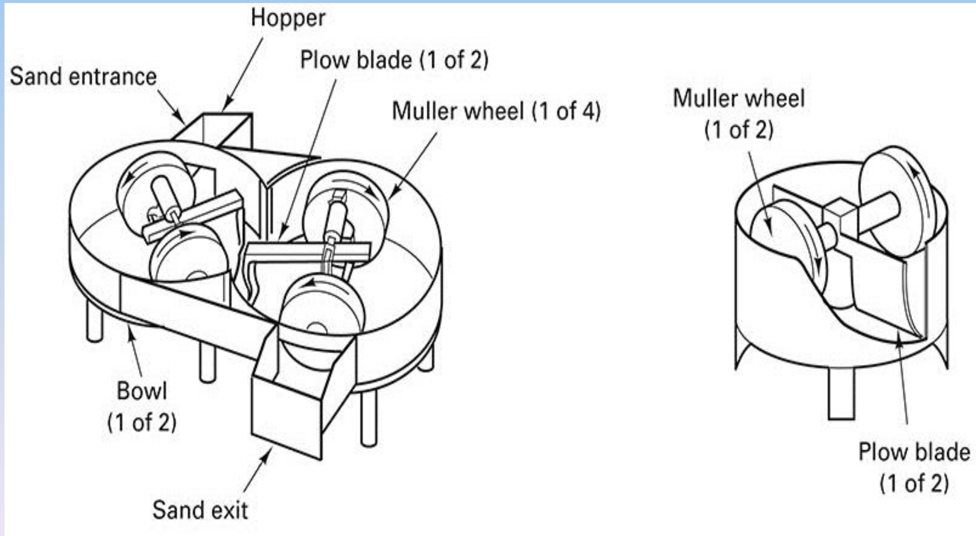


Figure 12-8 Schematic diagram of a continuous (left) and batch-type (right) sand muller. Plow blades move and loosen the sand, and the muller wheels compress and mix the components. (Courtesy of ASM International. Metals Park, OH.)

Sand Testing

- Blended molding sand is characterized by the following attributes
  - Moisture content, clay content, compactibility
- Properties of compacted sand
  - Mold hardness, permeability, strength
- Standard testing
  - Grain size
  - Moisture content
  - Clay content
  - Permeability
  - Compressive strength
  - Ability to withstand erosion
  - Hardness
  - Compactibility

Sand Testing Equipment

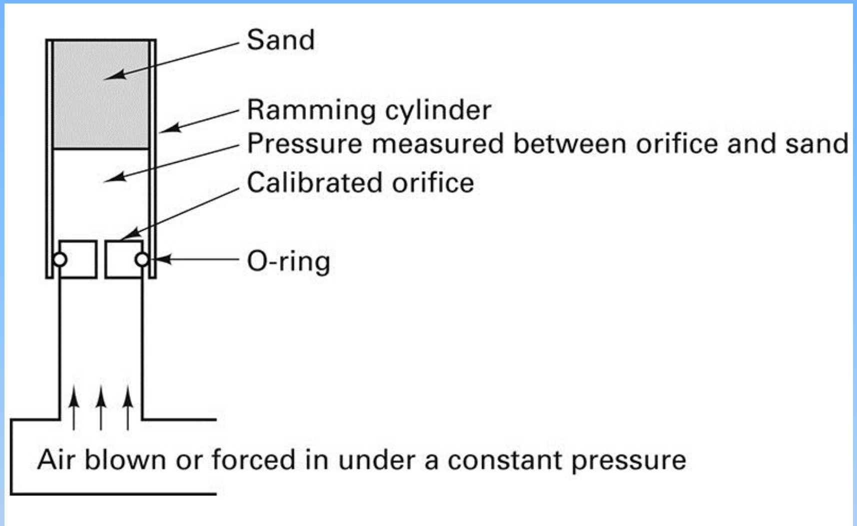
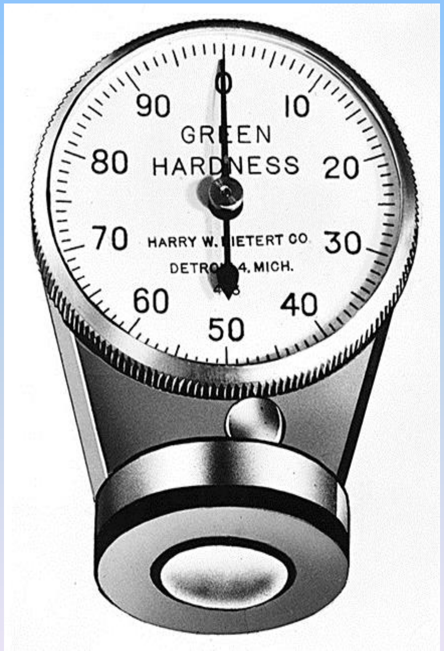


Figure 12-9 Schematic of a permeability tester in operation. A standard sample in a metal sleeve is sealed by an O-ring onto the top of the unit while air is passed through the sand. (Courtesy of Dietert Foundry Testing Equipment Inc, Detroit, MI)

Figure 12-10 Sand mold hardness tester. (Courtesy of Dietert Foundry Testing Equipment Inc., Detroit, MI)



Sand Properties and Sand-Related Defects

- Silica sand
  - Cheap and lightweight but undergoes a phase transformation and volumetric expansion when it is heated to 585°C
- Castings with large, flat surfaces are prone to sand expansion defects
- Trapped or dissolved gases can cause gas-related voids or blows

Sand Properties

- Penetration occurs when the sand grains become embedded in the surface of the casting
- Hot tears or crack occur in metals with large amounts of solidification shrinkage
  - Tensile stresses develop while the metal is still partially liquid and if these stresses do not go away, cracking can occur.

Sand Properties

TABLE 12-1 Desirable Properties of a Sand-Based Molding Material

1. Is inexpensive in bulk quantities
2. Retains properties through transportation and storage
3. Uniformly fills a flask or container
4. Can be compacted or set by simple methods.
5. Has sufficient elasticity to remain undamaged during pattern withdrawal
6. Can withstand high temperatures and maintains its dimensions until the metal has solidified
7. Is sufficiently permeable to allow the escape of gases
8. Is sufficiently dense to prevent metal penetration
9. Is sufficiently cohesive to prevent wash-out of mold material into the pour stream
10. Is chemically inert to the metal being cast
11. Can yield to solidification and thermal shrinkage, thereby preventing hot tears and cracks
12. Has good collapsibility to permit easy removal and separation of the casting
13. Can be recycled

The Making of Sand Molds

- Hand ramming is the method of packing sand to produce a sand mold
  - Used when few castings are to be made
  - Slow, labor intensive
  - Nonuniform compaction
- Molding machines
  - Reduce the labor and required skill
  - Castings with good dimensional accuracy and consistency

The Making of Sand Molds

- Molds begin with a pattern and a flask
- Mixed sand is packed in the flask
  - Sand slinger uses rotation to fling sand against the pattern
  - Jolting is a process in which sand is placed over the flask and pattern and they are all lifted and dropped to compact the sand
  - Squeezing machines use air and a diaphragm
- For match plate molding, a combination of jolting and squeezing is used

Methods of Compacting Sand

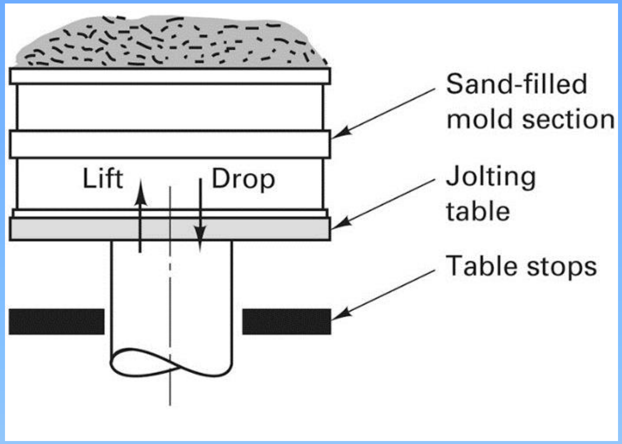


Figure 12-12 (Above) Jolting a mold section. (Note: The pattern is on the bottom, where the greatest packing is expected.)

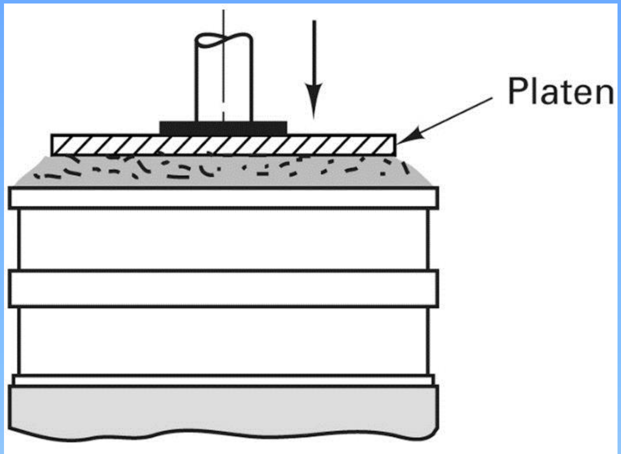


Figure 12-13 (Above) Squeezing a sand-filled mold section. While the pattern is on the bottom, the highest packing will be directly under the squeeze head.

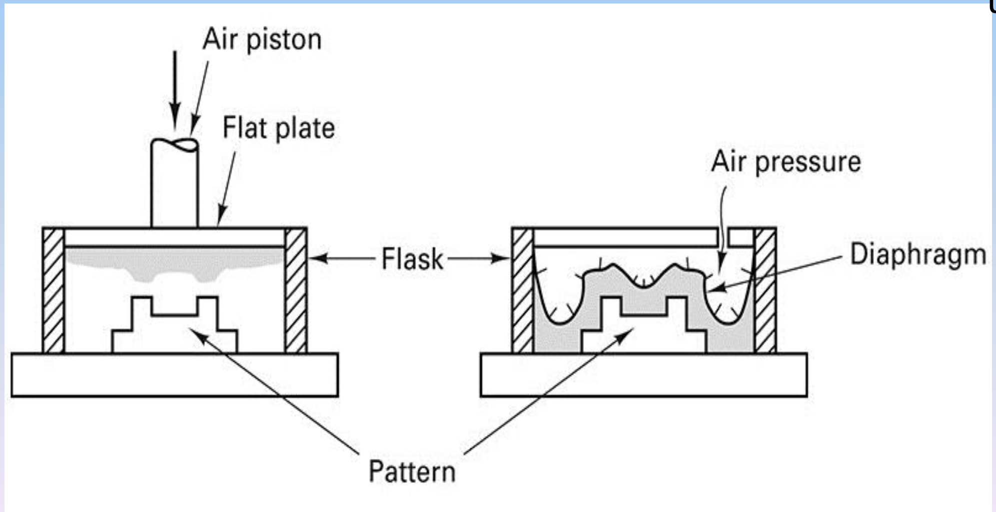


Figure 12-14 (Left) Schematic diagram showing relative sand densities obtained by flat-plate squeezing, where all areas get vertically compressed by the same amount of movement (left) and by flexible-diaphragm squeezing, where all areas flow to the same resisting pressure (right).

Alternative Molding Methods

- Stack molding
  - Molds containing a cope impression on the bottom and a drag impression on the top are stacked on top of one another vertically
  - Common vertical sprue
- Large molds
  - Large flasks can be placed directly on the foundry floor
  - Sand slingers may be used to pack the sand
  - Pneumatic rammers may be used

Green-Sand, Dry-Sand, and Skin-Dried Molds

- Green-sand casting
  - Process for both ferrous and nonferrous metals
  - Sand is blended with clay, water, and additives
  - Molds are filled by a gravity feed
  - Low tooling costs
  - Least expensive
- Design limitations
  - Rough surface finish
  - Poor dimensional accuracy
  - Low strength

Green-Sand Casting

TABLE 12-2 Green-Sand Casting

Process: Sand, bonded with clay and water, is packed around a wood or metal pattern. The pattern is removed, and molten metal is poured into the cavity. When the metal has solidified, the mold is broken and the casting is removed.

Advantages: Almost no limit on size, shape, weight, or complexity; low cost; almost any metal can be cast.

Limitations: Tolerances and surface finish are poorer than in other casting processes; some machining is often required; relatively slow production rate; a parting line and draft are needed to facilitate pattern removal; due to sprues, gates, and risers, typical yields range from 50% to 85%.

Common metals: Cast iron, steel, stainless steel, and casting alloys of aluminum, copper, magnesium, and nickel.

Size limits: 30 g to 3000 kg (1 oz to 6000 lb).

Thickness limits: As thin as 0.25 cm ($\frac{3}{32}$ in.), with no maximum.

Typical tolerances: 0.8 mm for first 15 cm ($\frac{1}{32}$ in. for first 6 in.), 0.003 cm for each additional cm; additional increment for dimensions across the parting line

Draft allowances: 1–3°.

Surface finish: 2.5–25 microns (100–1000 μin.) rms.

Dry-Sand

- Dry-sand molds are durable
  - Long storage life
  - Long time required for drying
- Skin-dried molds
  - Dries only the sand next to the mold cavity
  - Torches may be used to dry the sand
  - Used for large steel parts
  - Binders may be added to enhance the strength of the skin-dried layer

Cast Parts

Figure 12-17 A variety of sand cast aluminum parts. (Courtesy of Bodine Aluminum Inc., St. Louis, MO)

Sodium Silicate-CO_2 Molding

- Molds and cores can receive strength from the addition of 3-6% sodium silicate
- Remains soft and moldable until it is exposed to CO_2
- Hardened sands have poor collapsibility
  - Shakeout and core removal is difficult
- Heating makes the mold stronger

No-Bake, Air-Set, or Chemically Bonded Sands

- Organic and inorganic resin binders can be mixed with the sand before the molding operation
  - Curing reactions begin immediately
- Cost of no-bake molding is about 20-30% more than green-sand molding
- High dimensional precision and good surface finish

No-Bake Sands

- No-bake sand can be compacted by light vibrations
  - Wood, plastic, fiberglass, or Styrofoam can be used as patterns
- System selections are based on the metal being poured, cure time desired, complexity and thickness of the casting, and the possibility of sand reclamation
- Good hot strength
- High resistance to mold-related casting defects
- Mold decomposes after the metal has been poured providing good shakeout

Shell Molding

- Basic steps
  - Individual grains are sand are precoated with a thin layer of thermosetting resin
    - Heat from the pattern partially cures a layer of material
  - Pattern and sand mixture are inverted and only the layer of partially cured material remains
  - The pattern with the shell is placed in an oven and the curing process is completed
  - Hardened shell is stripped from the pattern
  - Shells are clamped or glued together with a thermoset adhesive
  - Shell molds are placed in a pouring jacked and surrounded by sand, gravel, etc. for extra support

Shell Molding

- Cost of a metal pattern is often high
  - Design must include the gate and the runner
  - Expensive binder is required
  - Amount of required material is less
  - High productivity, low labor costs, smooth surfaces, high level of precision

Dump-Box Shell Molding

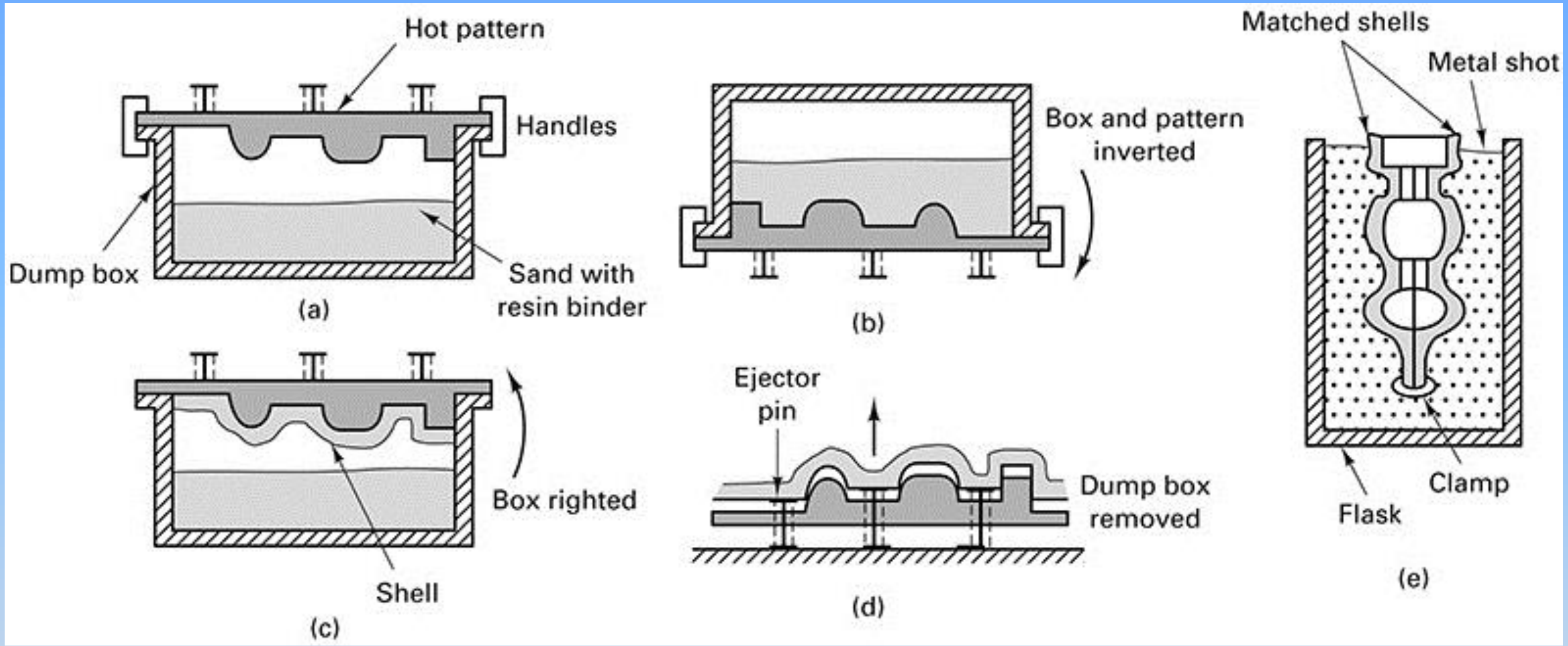


Figure 12-18 Schematic of the dump-box version of shell molding. a) A heated pattern is placed over a dump box containing granules of resin-coated sand. b) The box is inverted, and the heat forms a partially cured shell around the pattern. c) The box is righted, the top is removed, and the pattern and partially cured sand is placed in an oven to further cure the shell. d) The shell is stripped from the pattern. e) Matched shells are then joined and supported in a flask ready for pouring.

Shell-Mold Pattern

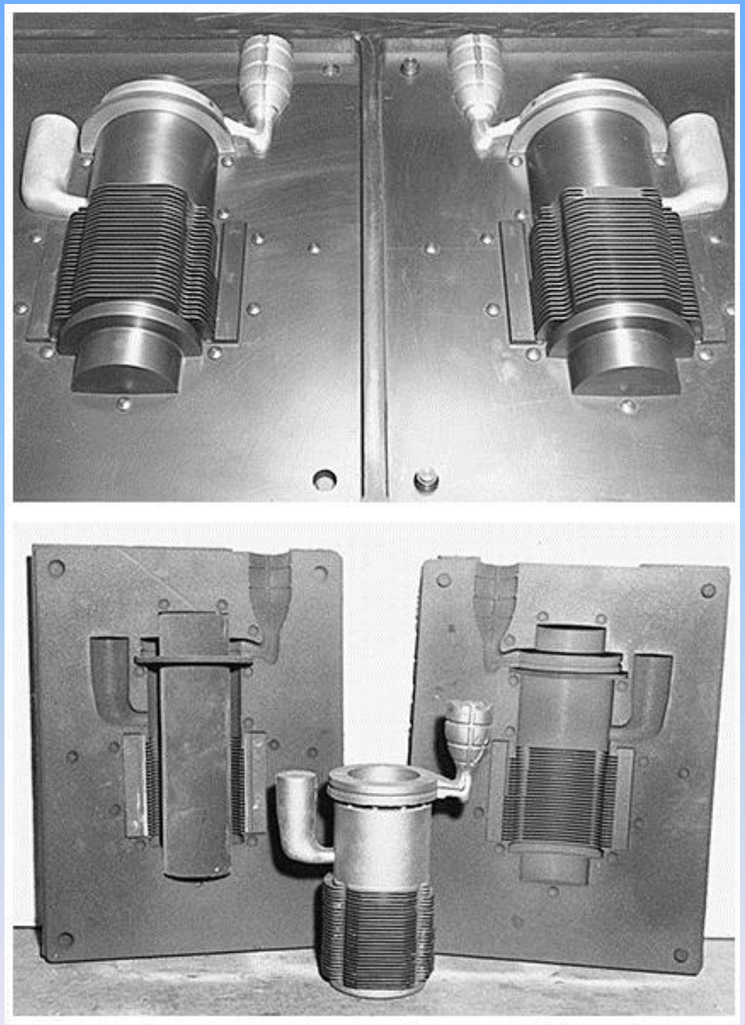


Figure 12-19 (Top) Two halves of a shell-mold pattern. (Bottom) The two shells before clamping, and the final shell-mold casting with attached pouring basin, runner, and riser. (Courtesy of Shalco Systems, Lansing, MI.)

Shell-Mold Casting

TABLE 12-3 Shell-Mold Casting

Process: Sand coated with a thermosetting plastic resin is dropped onto a heated metal pattern, which cures the resin. The shell segments are stripped from the pattern and assembled. When the poured metal solidifies, the shell is broken away from the finished casting.

Advantages: Faster production rate than sand molding, high dimensional accuracy with smooth surfaces.

Limitations: Requires expensive metal patterns. Plastic resin adds to cost; part size is limited.

Common metals: Cast irons and casting alloys of aluminum and copper.

Size limits: 30 g (1 oz) minimum; usually less than 10 kg (25 lb); mold area usually less than 0.3 m^2 (500 in^2).

Thickness limits: Minimums range from 0.15 to 0.6 cm ($\frac{1}{16}$ to $\frac{1}{4}$ in.), depending on material.

Typical tolerances: Approximately 0.005 cm/cm or in/in.

Draft allowance: $\frac{1}{4}$ or $\frac{1}{2}$ degree.

Surface finish: $\frac{1}{3}$–4.0 microns (50–150 μin.) rms.

Other Sand-Based Molding Methods

- V-process or vacuum molding
  - Vacuum serves as the sand binder
  - Applied within the pattern, drawing the sheet tight to its surface
  - Flask is filled with vibrated dry, unbonded sand
  - Compacts the sand and gives the sand its necessary strength and hardness
  - When the vacuum is released, the pattern is withdrawn

V-Process

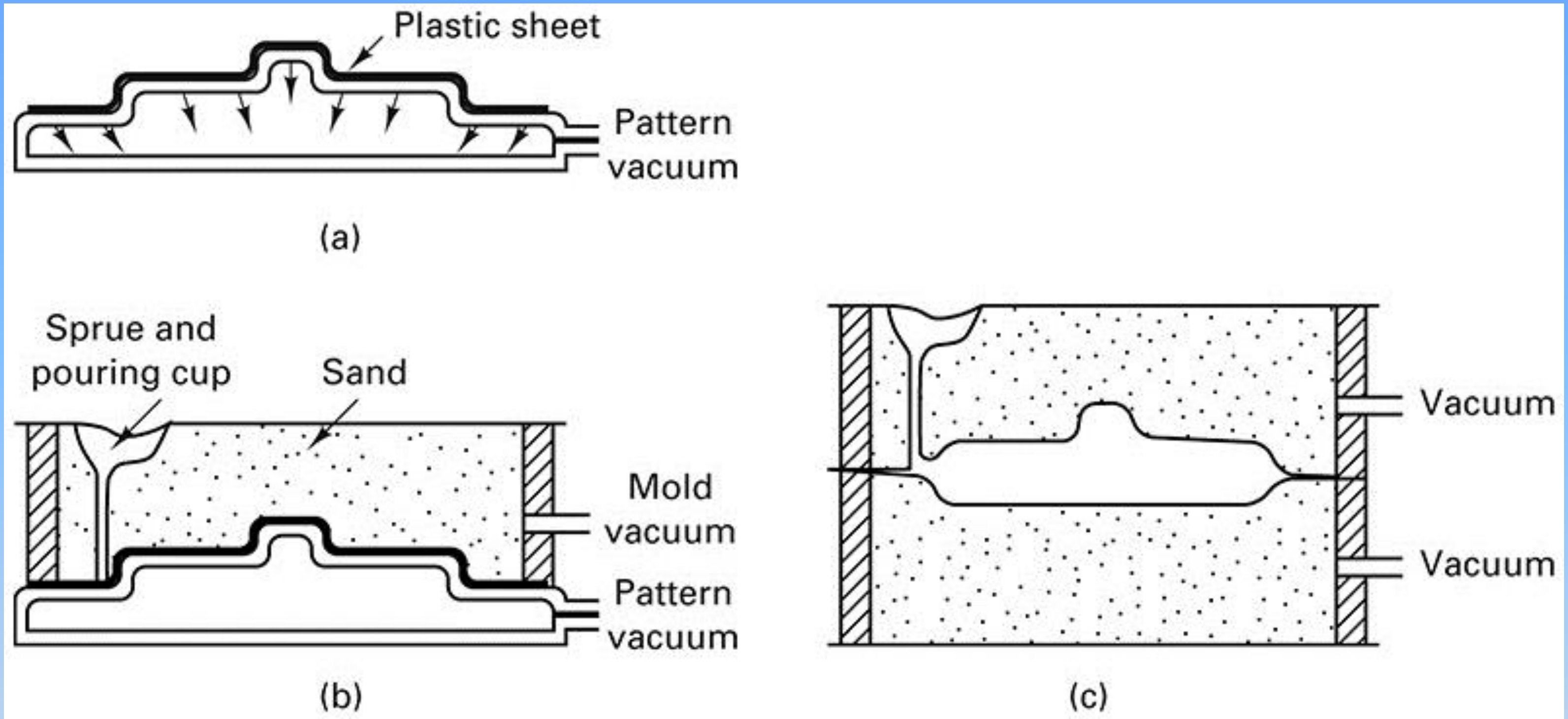


Figure 12-20 Schematic of the V-process or vacuum molding. A) A vacuum is pulled on a pattern, drawing a heated shrink-wrap plastic sheet tightly against it. b) A vacuum flask is placed over the pattern and filled with dry unbonded sand, a pouring basin and sprue are formed; the remaining sand is leveled; a second heated plastic sheet is placed on top; and a mold vacuum is drawn to compact the sand and hold the shape. c) With the mold vacuum being maintained, the pattern vacuum is then broken and the pattern is withdrawn. The cope and drag segments are assembled, and the molten metal is poured.

Advantages and Disadvantages of the V-Process

- Advantages
  - Absence of moisture-related defects
  - Binder cost is eliminated
  - Sand is completely reusable
  - Finer sands can be used
  - Better surface finish
  - No fumes generated during the pouring operation
  - Exceptional shakeout characteristics
- Disadvantages
  - Relatively slow process
  - Used primarily for production of prototypes
  - Low to medium volume parts
  - More than 10 but less than 50,000

Eff-set Process

- Wet sand with enough clay to prevent mold collapse
- Pattern is removed
  - Surface of the mold is sprayed with liquid nitrogen
- Ice that forms serves as a binder
- Molten metal is poured into the mold
- Low binder cost and excellent shakeout

12.3 Cores and Core Making

- Complex internal cavities can be produced with cores
- Cores can be used to improve casting design
- Cores may have relatively low strength
- If long cores are used, machining may need to be done afterwards
- Green sand cores are not an option for more complex shapes

Dry-Sand Cores

- Produced separate from the remainder of the mold
- Inserted into core prints that hold the cores in position
- Dump-core box
  - Sand is packed into the mold cavity
  - Sand is baked or hardened
- Single-piece cores
  - Two-halves of a core box are clamped together

Dry-Sand Cores

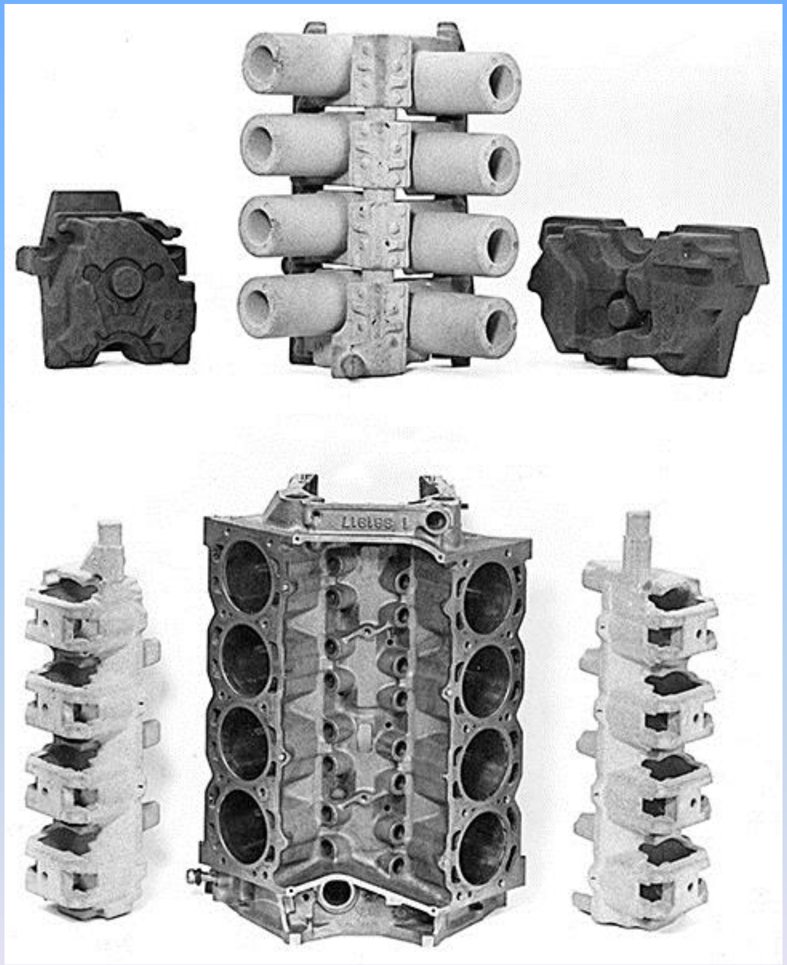


Figure 12-21 V-8 engine block (bottom center) and the five dry-sand cores that are used in the construction of its mold. (Courtesy of General Motors Corporation, Detroit, MI.)

Additional Core Methods

- Core-oil process
  - Sand is blended with oil to develop strength
  - Wet sand is blown or rammed into a simple core box
- Hot-box method
  - Sand is blended with a thermosetting binder
- Cold-box process
  - Binder coated sand is packed and then sealed
  - Gas or vaporized catalyst polymerizes the resin

Additional Core Methods

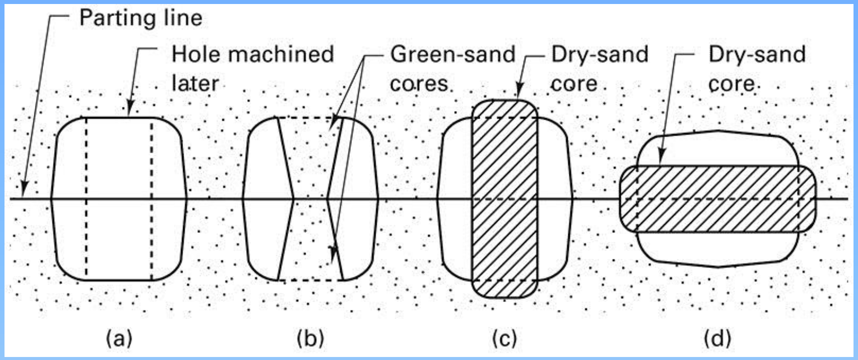


Figure 12-22 (Left) Four methods of making a hole in a cast pulley. Three involve the use of a core.

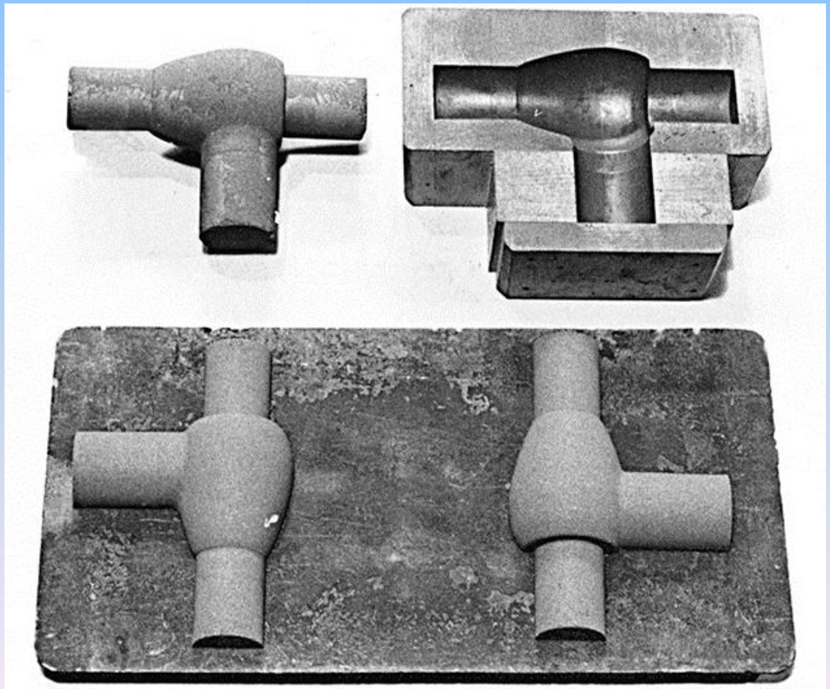


Figure 12-23 (Right) Upper Right; A dump-type core box; (bottom) core halves for baking; and (upper left) a completed core made by gluing two opposing halves together.

Additional Core Considerations

- Air-set or no-bake sands may be used
  - Eliminate gassing operations
  - Reactive organic resin and a curing catalyst
- Shell-molding
  - Core making alternative
  - Produces hollow cores with excellent strength
- Selecting the proper core method is based on the following considerations
  - Production quantity, production rate, required precision, required surface finish, metal being poured

Casting Core Characteristics

- Sufficient strength before hardening
- Sufficient hardness and strength after hardening
- Smooth surface
- Minimum generation of gases
- Adequate permeability
- Adequate refractoriness
- Collapsibility

Techniques to Enhance Core Properties

- Addition of internal wires or rods
- Vent holes
- Cores can be connected to the outer surfaces of the mold cavity
  - Core prints
- Chaplets- small metal supports that are placed between the cores and the mold cavity surfaces and become integral to the final casting

Chaplets

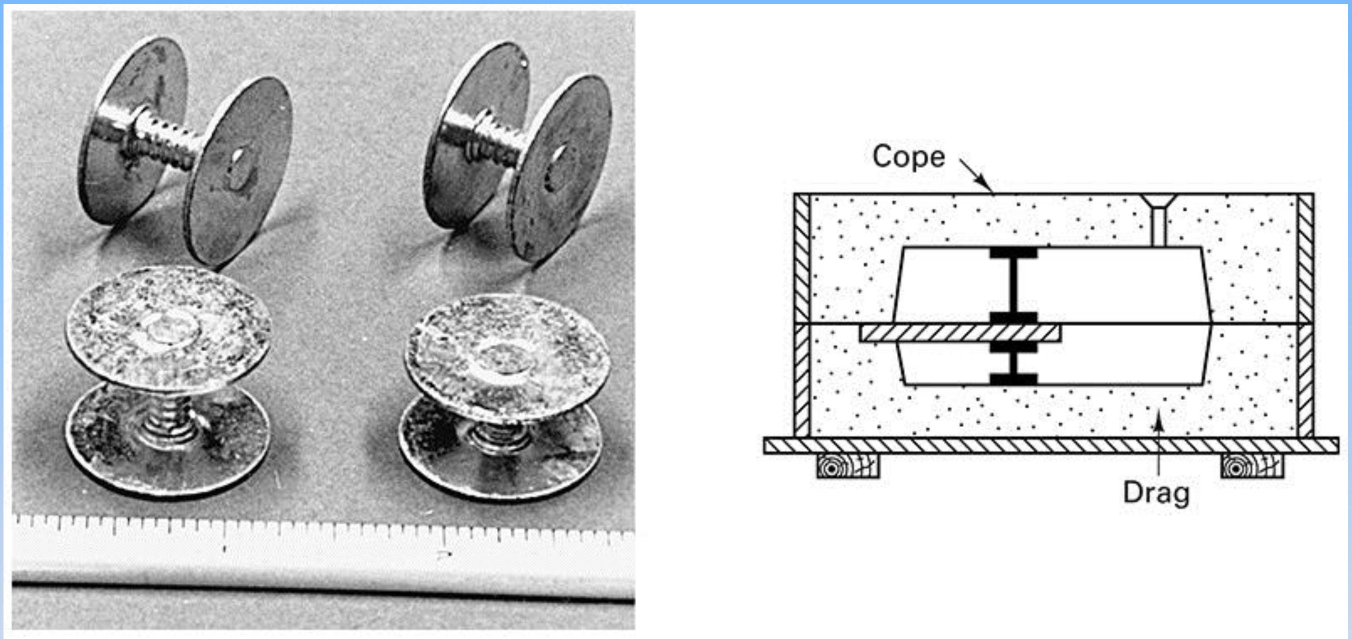
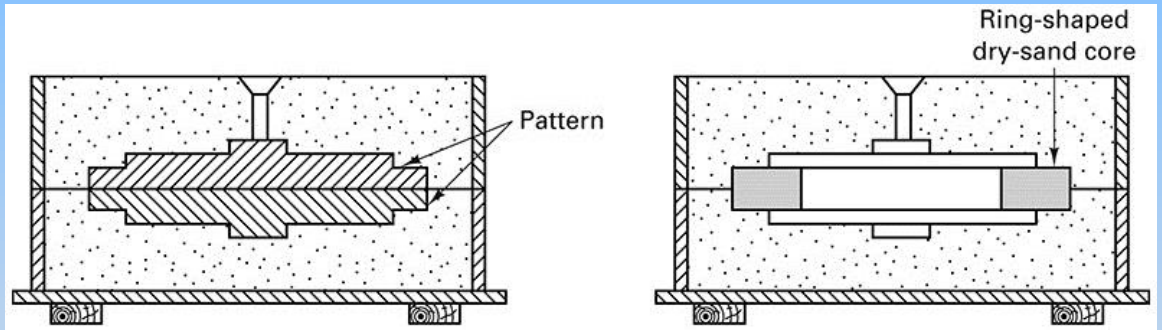


Figure 12-24 (Left) Typical chaplets. (Right) Method of supporting a core by use of chaplets (relative size of the chaplets is exaggerated).

Mold Modifications

- Cheeks are second parting lines that allow parts to be cast in a mold with withdrawable patterns
- Inset cores can be used to improve productivity

Figure 12-26 (Right) Molding an inset section using a dry-sand core.



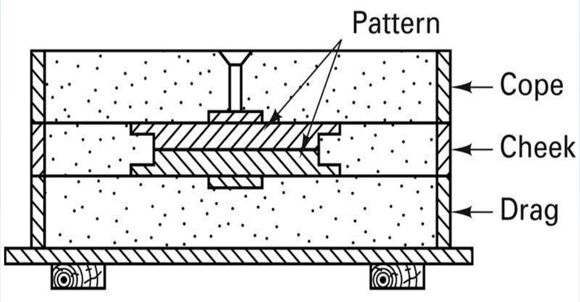


Figure 12-25 (Left) Method of making a reentrant angle or inset section by using a three-piece flask.

12.4 Other Expendable-Mold Processes with Multiple-Use Patterns

- Plaster mold casting
  - Mold material is made out of plaster of paris
  - Slurry is poured over a metal pattern
  - Improved surface finish and dimensional accuracy
  - Limited to the lower-melting-temperature nonferrous alloys
- Antioch process
  - Variation of plaster mold casting
  - 50% plaster, 50% sand

Plaster Molding

TABLE 12-4 Plaster Casting

Process: A slurry of plaster, water, and various additives is poured over a pattern and allowed to set. The pattern is removed, and the mold is baked to remove excess water. After pouring and solidification, the mold is broken and the casting is removed.

Advantages: High dimensional accuracy and smooth surface finish; can reproduce thin sections and intricate detail to make net- or near-net-shaped parts.

Limitations: Lower-temperature nonferrous metals only; long molding time restricts production volume or requires multiple patterns; mold material is not reusable; maximum size is limited.

Common metals: Primarily aluminum and copper.

Size limits: As small as 30 g (1 oz) but usually less than 7 kg (15 lb).

Thickness limits: Section thickness as small as 0.06 cm (0.025 in.).

Typical tolerances: 0.01 cm on first 5 cm (0.005 in. on first 2 in.), 0.002 cm per additional cm (0.002 in. per additional in.)

Draft allowance: $\frac{1}{2}$–1 degree.

Surface finish: 1.3–4 microns (50–125 μin.) rms.

Ceramic Mold Casting

- Mold is made from ceramic material
- Ceramics can withstand higher temperatures
- Greater mold cost than other casting methods
- Shaw process
  - Reusable pattern inside a slightly tapered flask
  - Mixture sets to a rubbery state that allows the part and flask to be removed
  - Mold surface is then ignited with a torch

Ceramic Mold Casting

TABLE 12-5 Ceramic Mold Casting

Process: Stable ceramic powders are combined with binders and gelling agents to produce the mold material.

Advantages: Intricate detail, close tolerances, and smooth finish.

Limitations: Mold material is costly and not reusable.

Common metals: Ferrous and high-temperature nonferrous metals are most common; can also be used with alloys of aluminum, copper, magnesium, titanium, and zinc.

Size limits: 100 grams to several thousand kilograms (several ounces to several tons).

Thickness limits: As thin as 0.13 cm (0.050 in.); no maximum.

Typical tolerances: 0.01 cm on the first 2.5 cm (0.005 in. on the first in.), 0.003 cm per each additional cm (0.003 in. per each additional in.).

Draft allowances: 1° preferred.

Surface finish: 2–4 microns (75–150 μin.) rms.

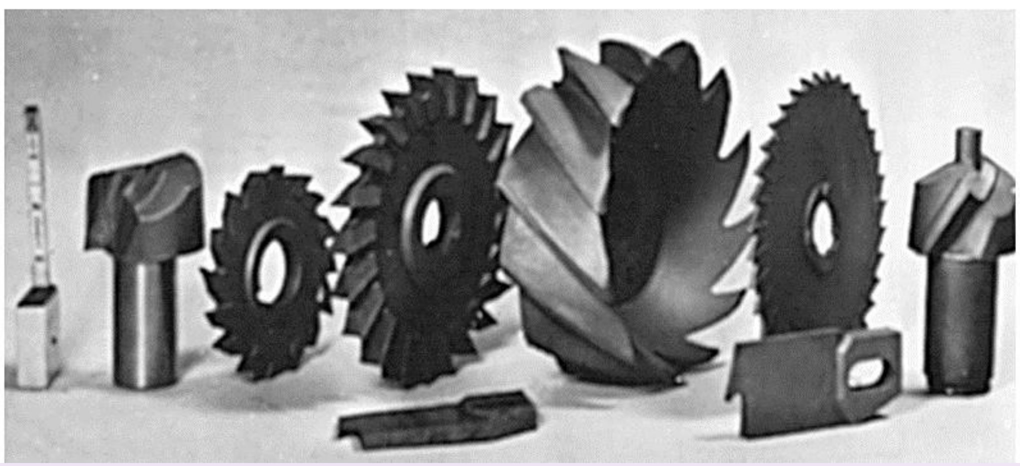


Figure 12-27 Group of intricate cutters produced by ceramic mold casting. (Courtesy of Avnet Shaw Division of Avnet, Inc., Phoenix, AZ)

Other Casting Methods

- Expendable graphite molds
  - Some metals are difficult to cast
    - Titanium
    - Reacts with many common mold materials
  - Powdered graphite can be combined with additives and compacted around a pattern
  - Mold is broken to remove the product
- Rubber-mold casting
  - Artificial elastomers can be compounded in liquid form and poured over the pattern to produce a semirigid mold
  - Limited to small castings and low-melting-point materials

12.5 Expendable-Mold Processes Using Single-Use Patterns

- Investment casting
  - One of the oldest casting methods
  - Products such as rocket components, and jet engine turbine blades
  - Complex shapes
  - Most materials can be casted

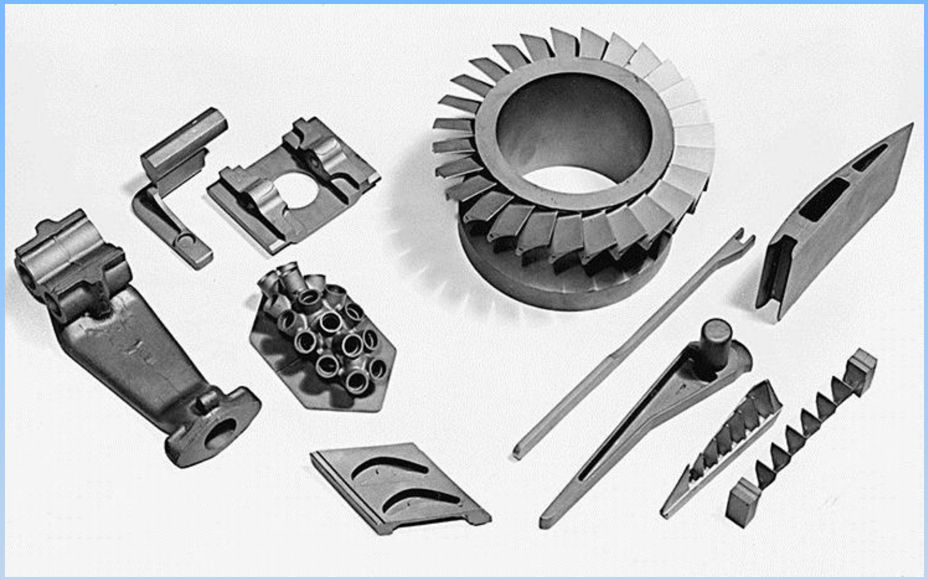


Figure 12-30 Typical parts produced by investment casting. (Courtesy of Haynes International, Kokomo, IN.)

Investment Casting

- Sequential steps for investment casting
  - Produce a master pattern
  - Produce a master die
  - Produce wax patterns
  - Assemble the wax patterns onto a common wax sprue
  - Coat the tree with a thin layer of investment material
  - Form additional investment around the coated cluster
  - Allow the investment to harden
  - Remove the wax pattern from the mold by melting or dissolving
  - Heat the mold
  - Pour the molten metal
  - Remove the solidified casting from the mold

Advantages and Disadvantages of Investment Casting

- Disadvantage
  - Complex process
  - Can be costly
- Advantage
  - Complex shapes can be cast
  - Thin sections can be cast
  - Machining can be eliminated or reduced

Investment Casting

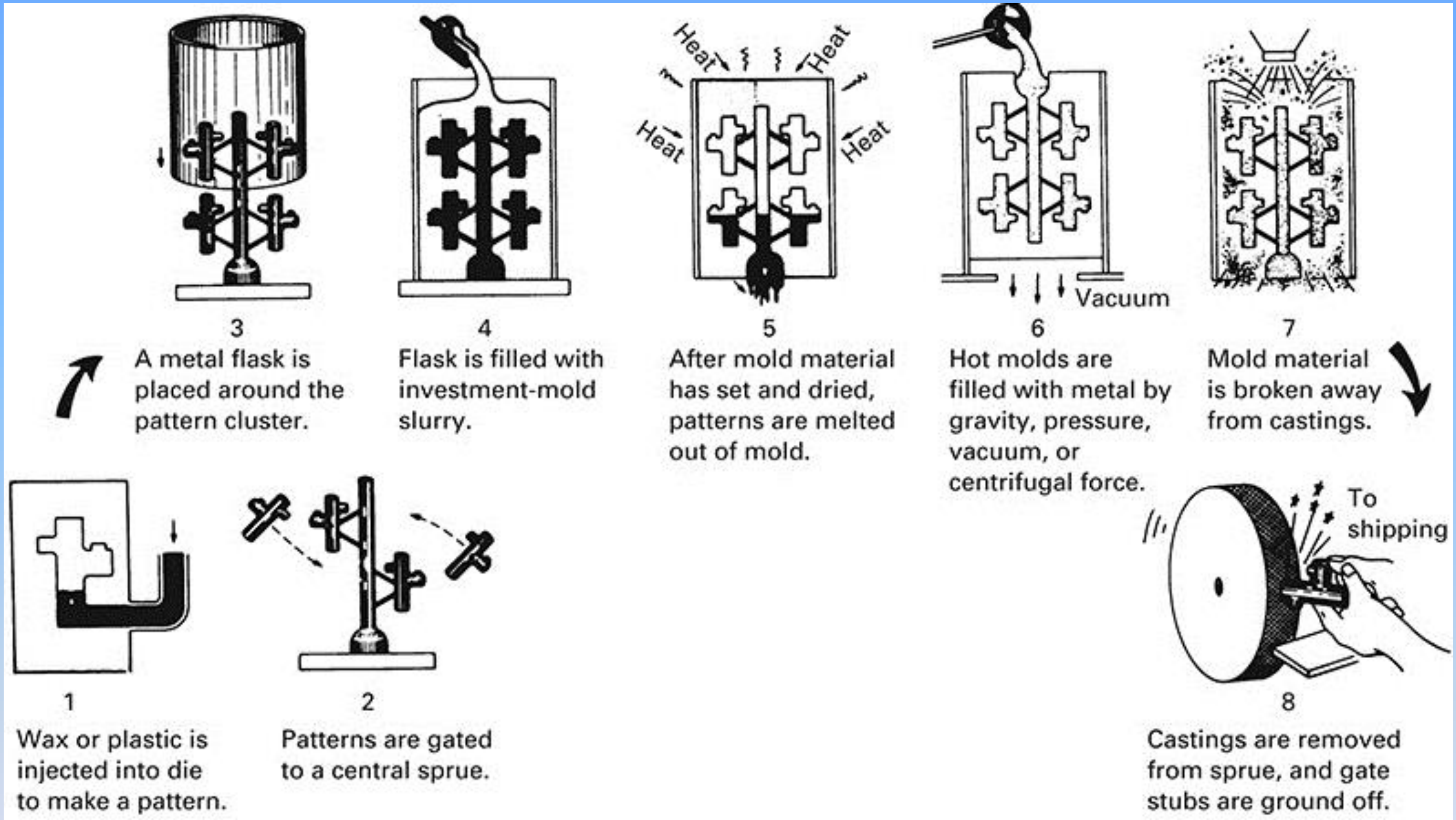


Figure 12-28 Investment-casting steps for the flask-cast method. (Courtesy of Investment Casting Institute, Dallas, TX.)

Investment Casting

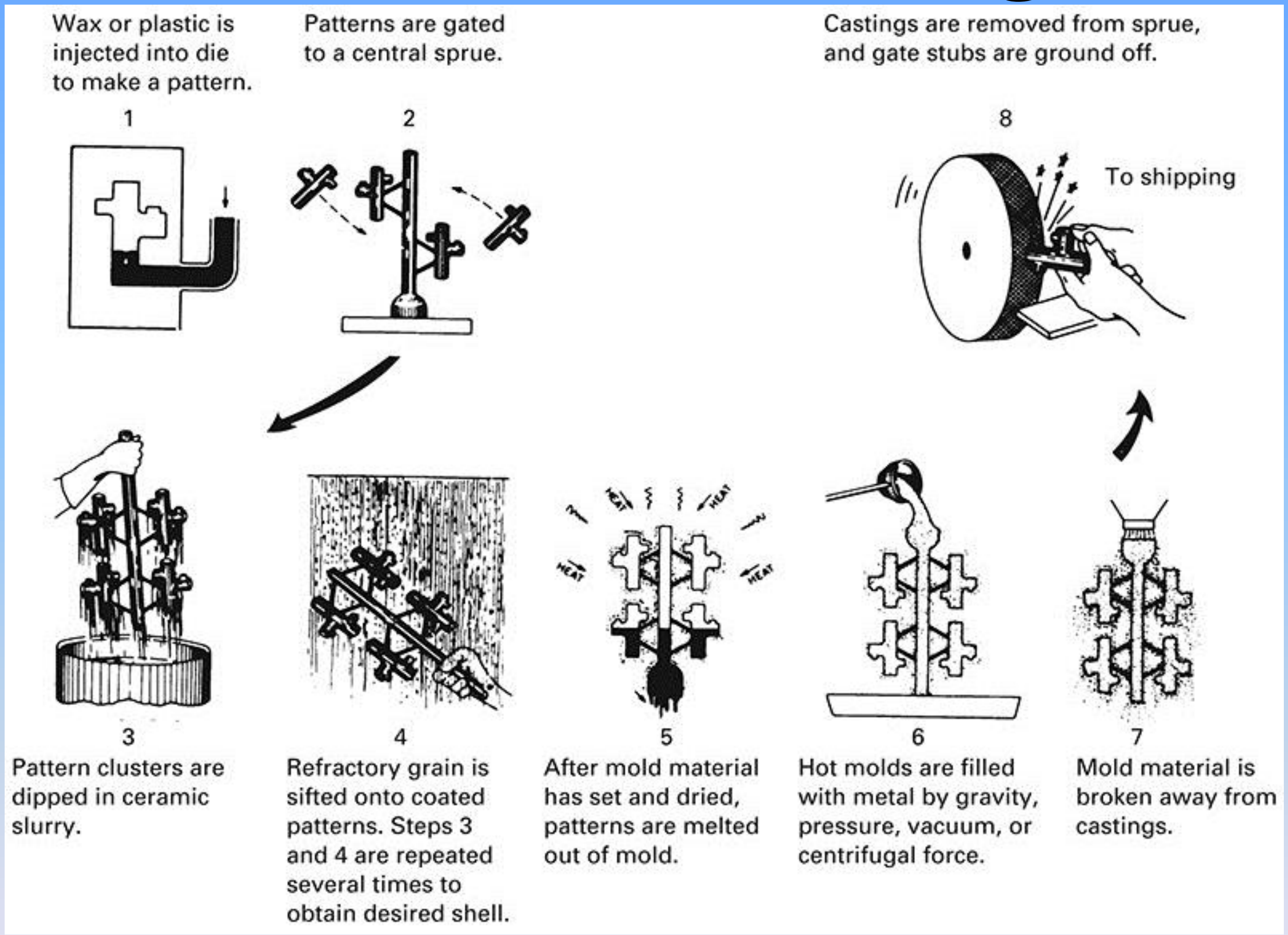


Figure 12-29 Investment-casting steps for the shell-casting procedure. (Courtesy of Investment Casting Institute, Dallas, TX.)

Investment Casting

TABLE 12-6 Investment Casting

Process: A refractory slurry is formed around a wax or plastic pattern and allowed to harden. The pattern is then melted out and the mold is baked. Molten metal is poured into the mold and solidifies. The mold is then broken away from the casting.

Advantages: Excellent surface finish; high dimensional accuracy; almost unlimited intricacy; almost any metal can be cast; no flash or parting line concerns.

Limitations: Costly patterns and molds; labor costs can be high; limited size.

Common metals: Just about any castable metal. Aluminum, copper, and steel dominate; also performed with stainless steel, nickel, magnesium, and the precious metals.

Size limits: As small as 3 g ($\frac{1}{10}$ oz) but usually less than 5 kg (10 lb).

Thickness limits: As thin as 0.06 cm (0.025 in.), but less than 7.5 cm (3.0 in.).

Typical tolerances: 0.01 cm for the first 2.5 cm (0.005 in. for the first inch) and 0.002 cm for each additional cm (0.002 in. for each additional in.).

Draft allowances: None required.

Surface finish: 1.3–4 microns (50 to 125 μin.) rms.

Counter-Gravity Investment Casting

- Pouring process is upside down
- Vacuum is used within the chamber
  - Draws metal up through the central sprue and into the mold
- Free of slag and dross
- Low level of inclusions
- Little turbulence
- Improved machinability
- Mechanical properties approach those of wrought material
- Simpler gating systems
- Lower pouring temperatures
- Improved grain structure and better surface finish

Evaporative Pattern (Full-Mold and Lost-Foam) Casting

- Reusable patterns can complicate withdrawal
  - May mandate design modifications
- Evaporative pattern processes
  - Pattern is made of polystyrene or polymethylmethacrylate
    - Pattern remains in the mold until the molten metal melts away the pattern
    - If small quantities are required, patterns may be cut by hand
    - Material is lightweight

Evaporative Patterns

- Metal mold or die is used to mass-produce the evaporative patterns
- For multiple and complex shapes, patterns can be divided into segments or slices
  - Assembled by hot-melt gluing
- Full-mold process
  - Green sand is compacted around the pattern and gating system

Lost Foam Process

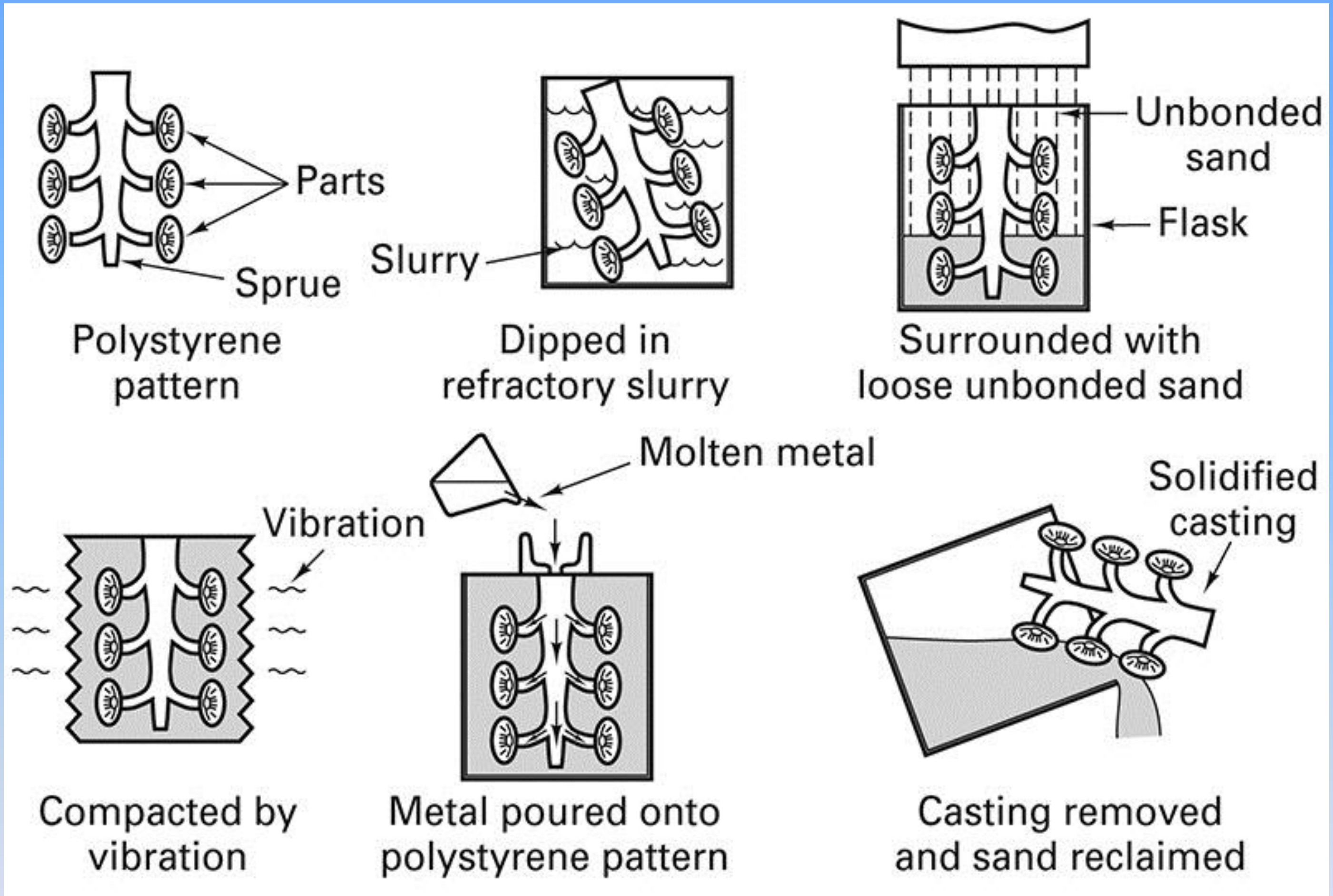


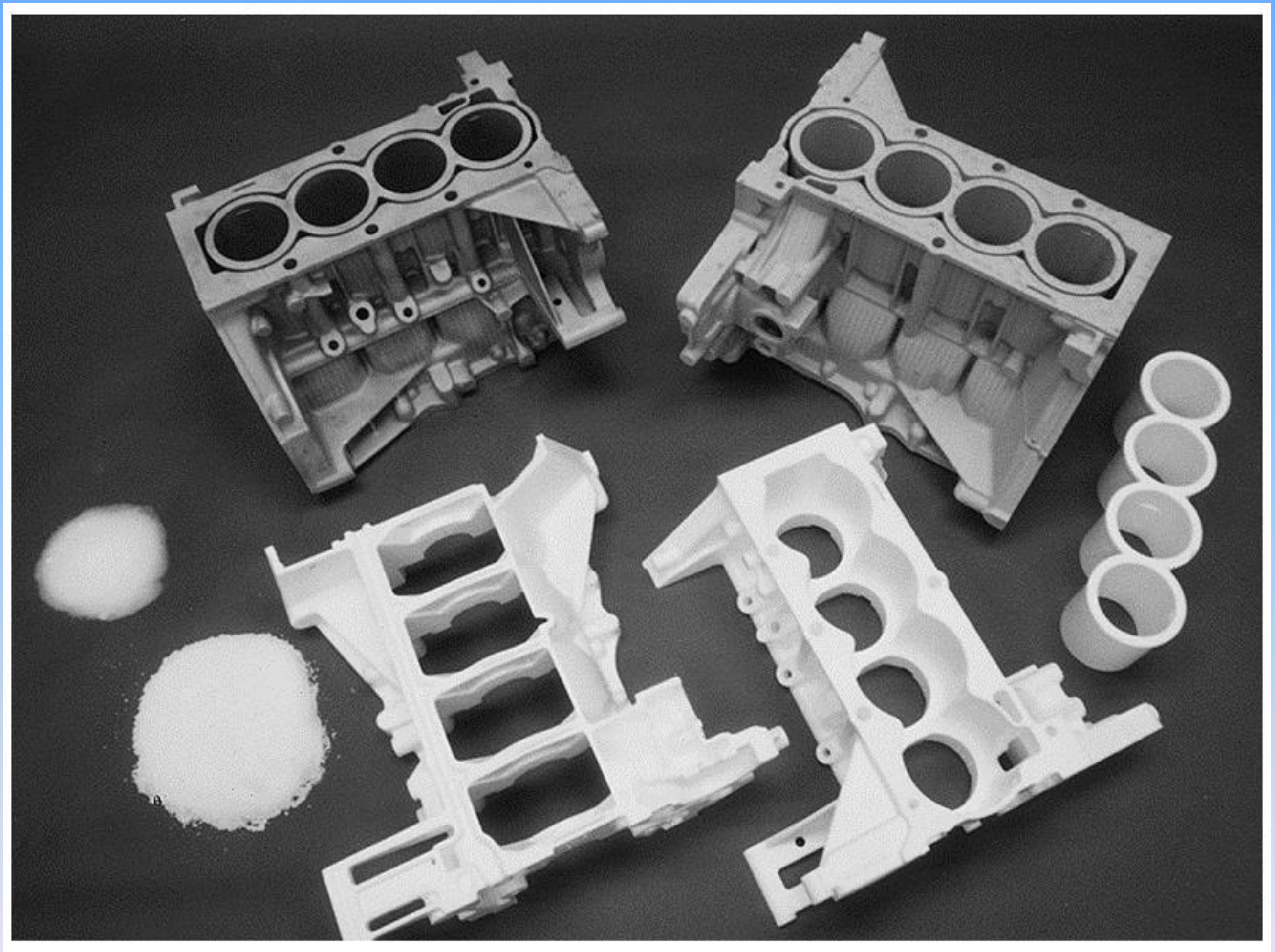
Figure 12-32 Schematic of the lost-foam casting process. In this process, the polystyrene pattern is dipped in a ceramic slurry, and the coated pattern is then surrounded with loose, unbonded sand.

Advantages of the Full-Mold and Lost-Foam Process

- Sand can be reused
- Castings of almost any size
- Both ferrous and nonferrous metals
- No draft is required
- Complex patterns
- Smooth surface finish
- Absence of parting lines

Lost-Foam Casting

Figure 12-33 The stages of lost-foam casting, proceeding counterclockwise from the lower left: polystyrene beads→ expanded polystyrene pellets → three foam pattern segments → an assembled and dipped polystyrene pattern → a finished metal casting that is a metal duplicate of the polystyrene pattern. (Courtesy of Saturn Corporation, Spring Hill, TN.)



Lost-Foam Casting

TABLE 12-7 Lost-Foam Casting

Process: A pattern containing a sprue, runners, and risers is made from single or multiple pieces of foamed plastic, such as polystyrene. It is dipped in a ceramic material, dried, and positioned in a flask, where it is surrounded by loose sand. Molten metal is poured directly onto the pattern, which vaporizes and is vented through the sand.

Advantages: Almost no limits on shape and size; most metals can be cast; no draft is required and no flash is present (no parting lines).

Limitations: Pattern cost can be high for small quantities; patterns are easily damaged or distorted because of their low strength.

Common metals: Aluminum, iron, steel, and nickel alloys; also performed with copper and stainless steel.

Size limits: 0.5 kg to several thousand kg (1 lb to several tons).

Thickness limits: As small as 2.5 mm (0.1 in.) with no upper limit.

Typical tolerances: 0.003 cm/cm (0.003 in./in.) or less.

Draft allowance: None required.

Surface finish: 2.5–25 microns (100–1000 μin.) rms.

12.6 Shakeout, Cleaning, and Finishing

- Final step of casting involves separating the molds and mold material
- Shakeout operations
  - Separate the molds and sand from the flasks
- Punchout machines
- Vibratory machines
- Rotary separators
- Blast cleaning

12.7 Summary

- Control of mold shape, liquid flow, and solidification provide a means of controlling properties of the casting
- Each process has unique advantages and disadvantages
- Best method is chosen based on the product shape, material and desired properties