Special Casting

By S K Mondal
Shell Moulding

- The sand is mixed with a thermosetting resin is allowed to come in contact with a heated metal pattern (200°C).
- A skin (shell) of about 3.5 mm of sand and plastic mixture adhere to the pattern.
- Then the shell is removed from the pattern.
- The cope and drag shells are kept in a flask with necessary backup material and the molten metal is poured into the mold.
• Can produce complex parts.

• A good surface finish and good size tolerance reduce the need for machining.

• Materials can be cast: CI, Al and Cu alloys.
Shell moulding process
Molding Sand in Shell Molding

- The molding sand is a mixture of fine grained quartz sand and powdered bakelite.
- Cold coating and Hot coating methods are used for coating the sand grains with bakelite.

  **Cold coating:** quartz sand is poured into the mixer and then the solution of powdered bakelite in acetone and ethyl aldehyde are added. (mixture is 92% quartz sand, 5% bakelite, 3% ethylaldehyde)
**Hot coating:** the mixture is heated to 150°C– 180°C prior to loading the sand. In the course of sand mixing, the soluble phenol formaldehyde resin is added. The mixer is allowed to cool up to 80 – 90°C. Hot coating gives better properties to the mixtures than cold method.
Advantages

- Dimensional accuracy.
- Smoother surface finish. (Due to finer size grain used)
- Very thin sections can be cast.
- Very small amount of sand is needed.
Limitations

- Expensive pattern
- Small size casting only.
- Highly complicated shapes cannot be obtained.
- More sophisticated equipment is needed for handling the shell moldings.
Applications

- Cylinders and cylinder heads for air-cooled IC engines
- Automobile transmission parts.
- Piston rings
IES-2005

In shell moulding, how can the shell thickness be accurately maintained?

(a) By controlling the time during which the pattern is in contact with mould
(b) By controlling the time during which the pattern is heated
(c) By maintaining the temperature of the pattern in the range of 175°C – 380°C
(d) By the type of binder used
The mould in shell moulding process is made up of which of the following?

(a) Gypsum + setting agents
(b) Green sand + clay
(c) Sodium silicate + dried sand
(d) Dried silica + phenolic resin
Investment Casting

Investment casting process or lost wax process

Basic steps:
1. Produce expendable wax, plastic, or polystyrene patterns.
2. Assemble these patterns onto a gating system
3. Investing or covering the pattern assembly with refractory slurry
4. Melting the pattern assembly to remove the pattern material
5. Firing the mould to remove the last traces of the pattern material
6. Pouring molten metal
Fig. Investment flask-casting procedure

1. Wax or plastic is injected into die to make a pattern
2. Patterns are gated to a central sprue
3. A metal flask is placed around the pattern cluster
4. Flask is filled with investment mold slurry
5. After mold material has set and dried, patterns are melted out of mold
6. Hot molds are filled with metal by gravity, pressure, vacuum or centrifugal force
7. Mold material is broken away from castings
8. Castings are removed from sprue, and gate stubs ground off
Ceramic Shell Investment Casting

- In ceramic shell investment casting a ceramic shell is built around a tree assembly by repeatedly dipping a pattern into a slurry (refractory material such as zircon with binder).
- After each dipping and stuccoing is completed, the assembly is allowed to thoroughly dry before the next coating is applied.
IES 2009

2 marks

In investment casting process two types of ceramic slurries are used. Why do we use them and in what sequence are they applied?
Advantages

- Tight dimensional tolerances
- Excellent surface finish (1.2 to 3.0 μm)
- Machining can be reduced or completely eliminated
- High melting point alloy can be cast, almost any metal can be cast
- Almost unlimited intricacy
Limitations

- Costly patterns and moulds
- Labour costs can be high
- Limited size
Applications

- Aerospace and rocket components.
- Vanes and blades for gas turbines.
- Surgical instruments
The proper sequence of investment casting steps is:

(a) Slurry coating – pattern melt out - Shakeout – Stucco coating

(b) Stucco coating – Slurry coating – Shakeout – Pattern melt out

(c) Slurry coating – Stucco coating – Pattern melt out – Shakeout

(d) Stucco coating – Shakeout – Slurry coating – Pattern melt out
Light and intricate parts with close dimensional tolerances of the order of ± 0.005 mm are produced by

(a) Investment casting
(b) Die casting
(c) Centrifugal casting
(d) Shell mould casting
Permanent Mould Casting

- The process in which we use a die to make the castings is called permanent mold casting or gravity die casting, since the metal enters the mold under gravity.
- Some time in die-casting we inject the molten metal with a high pressure. When we apply pressure in injecting the metal it is called pressure die casting process.
- Grey cast iron is used for mould material.
Advantages

- Good surface finish and dimensional accuracy
- Metal mold gives rapid cooling and fine-grain structure
- Multiple-use molds.
Disadvantages

- High initial mold cost
- Shape, size, and complexity are limited
- Mold life is very limited with high-melting-point metals such as steel.
- Low melting point metals can be cast
  - Aluminum
  - Zinc
  - Magnesium alloys
  - Brass
  - Cast iron
Applications

- Pistons/cylinders/rods
- Gears
- Kitchenware
Die Casting

- Molten metal is injected into closed metal dies under pressures ranging from 100 to 150 MPa.
- Pressure is maintained during solidification.
- After which the dies separate and the casting is ejected along with its attached sprues and runners.
- Cores must be simple and retractable and take the form of moving metal segments.
Video
Die casting machines can be

- Hot chamber
- Cold chamber
Hot chamber machines are

- Good for low temperature (approx. 400°C)
- Faster than cold chamber machines
- Cycle times must be short to minimize metal contamination
- Metal starts in a heated cylinder
- A piston forces metal into the die
- The piston retracts, and draws metal in
- Metal: Lead, Tin, Zinc
Hot Chamber
Cold chamber machines

- Casts high melting point metals ( > 600°C)
- High pressures used
- Metal is heated in a separate crucible
- Metal is ladled into a cold chamber
- The metal is rapidly forced into the mold before it cools
- Copper, Brass and Aluminium can cast.
Advantages

- Extremely smooth surfaces (1 µm)
- Excellent dimensional accuracy
- Rapid production rate
- Better mechanical properties compared to sand casting
- Intricate parts possible
- Minimum finishing operations
- Thin sections possible
Limitations

- High initial die cost
- Limited to high-fluidity nonferrous metals
- Part size is limited
- Porosity may be a problem
- Some scrap in sprues, runners, and flash, but this can be directly recycled
Applications

- Carburettors
- Automotive parts
- Bathroom fixtures
- Toys

Common metals

- Alloys of aluminum, zinc, magnesium, and lead
- Also possible with alloys of copper and tin
IES 2011

Consider the following advantages of die casting over sand casting:

1. Rapidity of the process
2. Smooth surface
3. Strong dense metal structure

Which of these advantages are correct?

(a) 1, 2 and 3
(b) 1 and 2 only
(c) 2 and 3 only
(d) 1 and 3 only
Consider the following statements:

1. Zinc die castings have low strength.
2. In the die casting process, very thin sections or complex shapes can be obtained easily.

Which of the statements given above is/are correct?

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2
IES 2011

Consider the following statements:
1. Hot chamber machine is used for casting zinc, tin and other low melting alloys.
2. Cold chamber machine is used for die casting of ferrous alloys.
3. Rapid cooling rate in die casting produces high strength and quality in many alloys.

Which of these statements are correct?

(a) 1, 2 and 3  
(b) 1 and 2 only
(c) 2 and 3 only  
(d) 1 and 3 only
Centrifugal Casting

**Process:** Molten metal is introduced into a rotating sand, metal, or graphite mould, and held against the mould wall by centrifugal force until it is solidified.

- A mold is set up and rotated along a vertical (rpm is reasonable), or horizontal (200-1000 rpm is reasonable) axis.
- The mold is coated with a refractory coating.
- During cooling lower density impurities will tend to rise towards the center of rotation.
Fig. True centrifugal casting
Properties

- The mechanical properties of centrifugally cast jobs are better compared to other processes, because the inclusions such as slag and oxides get segregated towards the centre and can be easily removed by machining. Also, the pressure acting on the metal throughout the solidification causes the porosity to be eliminated giving rise to dense metal.

- No cores are required for making concentric holes in the case of true centrifugal casting.
Advantages

- Fine grained structure at the outer surface of the casting free of gas and shrinkage cavities and porosity
- Formation of hollow interiors in cylinders without cores
- Can produce a wide range of cylindrical parts, including ones of large size.
- Good dimensional accuracy, soundness, and cleanliness
- There is no need for gates and runners, which increases the casting yield, reaching almost 100%.
Limitations

- More segregation of alloy component during pouring under the forces of rotation
- Contamination of internal surface of castings with non-metallic inclusions
- Inaccurate internal diameter
- Shape is limited.
- Spinning equipment can be expensive
- Poor machinability
Common metals

- Iron
- steel
- stainless steel
- alloys of aluminium, copper, and nickel
In hollow cylindrical parts, made by centrifugal casting, the density of the part is

(a) maximum at the outer region

(b) maximum at the inner region

(c) maximum at the mid-point between outer and inner surfaces

(d) uniform throughout
IES-2009

Which of the following are the most likely characteristics in centrifugal casting?
(a) Fine grain size and high porosity
(b) Coarse grain size and high porosity
(c) Fine grain size and high density
(d) Coarse grain size and high density
Semi-centrifugal Casting

- Centrifugal force assists the flow of metal from a central reservoir to the extremities of a rotating symmetrical mold, which may be either expendable or multiple-use.
- Rotational speeds are lower than for true centrifugal casting.
- Cores can be used to increase the complexity of the product.
Fig. Semi-centrifugal casting
Centrifuging

- Uses centrifuging action to force the metal from a central pouring reservoir into separate mold cavities that are offset from the axis of rotation.
- Low speed
- May used to assist in the pouring of investment casting trees.
Fig. Method of casting by the centrifuging process
Dry Sand Molding

- To reduce gas forming materials air dried mould used.

Types:

1. Skin drying and

2. Complete mold drying
Slush Casting

- Slush casting is a variation of the permanent mold process in which the metal is permitted to remain in the mold only until a shell of the desired thickness has formed.
- The mold is then inverted and the remaining liquid is poured out.
- When the mold halves are separated, the resulting casting is a hollow shape with good surface detail but variable wall thickness.
- Frequently used to cast low-melting-temperature metals into ornamental objects such as candlesticks, lamp bases, and statuary.
IES 2011

The method of casting for producing ornamental pieces are:

(a) Slush and gravity casting
(b) Pressed and slush casting
(c) Gravity and semi permanent mould casting
(d) Semi permanent mould and pressed casting
The process of making hollow castings of non-circular shape and desired thickness by permanent mould without the use of cores is known as
(a) Die casting       (b) Slush casting
(c) Pressed casting   (d) Centrifugal casting
Squeeze Casting

Process:
1. Molten metal is poured into an open face die.
2. A punch is advanced into the die, and to the metal.
3. Pressure (less than forging) is applied to the punch and die while the part solidifies.
4. The punch is retracted, and the part is knocked out with an ejector pin.

- Overcomes problems with feeding the die, and produces near net, highly detailed parts.
Single Crystal Casting

The process is effectively:

1. Prepare a mold so that one end is a heated oven, and the other end chilled. The part should be oriented so that the cooling happens over the longest distance.
2. Cast metal into the mold
3. Solidification will begin at the chill plate. These dendrites will grow towards the heated end of the part as long dendritic crystals. The part is slowly pulled out of the oven, past the chill plate.
4. Remove the solidified part.
Creep and thermal shock resistance properties.
What is achieved by using a metallic single crystal casting? Give one application of a single crystal casting made of wasp alloy.
Plaster Casting

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

- **Advantage:** High dimensional accuracy and smooth surface finish, thin sections and intricate detail can produce.

- **Limitations:** Lower-temperature nonferrous metals only:
  - **Common metals:** Primarily aluminium and copper
Pit Moulding

- This method is used for very large castings and is done on the foundry floor.
Which of the following pairs are correctly matched?

1. Pit moulding .................. For large jobs.
2. Investment moulding ... Lost wax process.

(a) 1, 2 and 3 (b) 1 and 2
(c) 1 and 3 (d) 2 and 3
Loam Moulding

- Moulding loam is generally artificially composed of common brick-clay, and sharp sand.
- Loam means mud.
- Loam Moulding is restricted to forms which cannot be cast conveniently in any other process.
- It is costly.
IES-1997

Which one of the following pairs is not correctly matched?

(a) Aluminium alloy piston ............Pressure die casting
(b) Jewellery............................Lost wax process
(c) Large pipes .........................Centrifugal casting
(d) Large bells .........................Loam moulding
List I
(A) Sand casting  
circular shapes only
(B) Plaster mould casting  
skins and soft interior
(C) Shell mould casting  
casting processing
(D) Investment casting

List II
(1) Symmetrical and
(2) Parts have hardened
(3) Minimum post-
(4) Parts have a tendency  
to warp
(5) Parts have soft skin  
and hard interior
(6) Suitable only for non-
ferrous metals
<table>
<thead>
<tr>
<th>Q. No</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
</tr>
<tr>
<td>11</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q. No</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>C</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
</tr>
<tr>
<td>15</td>
<td>D</td>
</tr>
<tr>
<td>16</td>
<td>B</td>
</tr>
<tr>
<td>17</td>
<td>B</td>
</tr>
<tr>
<td>18</td>
<td>B</td>
</tr>
<tr>
<td>19</td>
<td>D</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>21</td>
<td>A</td>
</tr>
<tr>
<td>Q. No</td>
<td>Option</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q. No</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>16</td>
<td>B</td>
</tr>
<tr>
<td>17</td>
<td>A</td>
</tr>
</tbody>
</table>