What is Sand Casting?

Sand casting is a manufacturing process in which molten metal is poured into a sand mold containing a hollow cavity of the desired shape. After a period of time, the casting cools and solidifies. The sand is then broken away and shaken out. Casting materials for sand casting include metal, concrete, epoxy, plaster, and clay.

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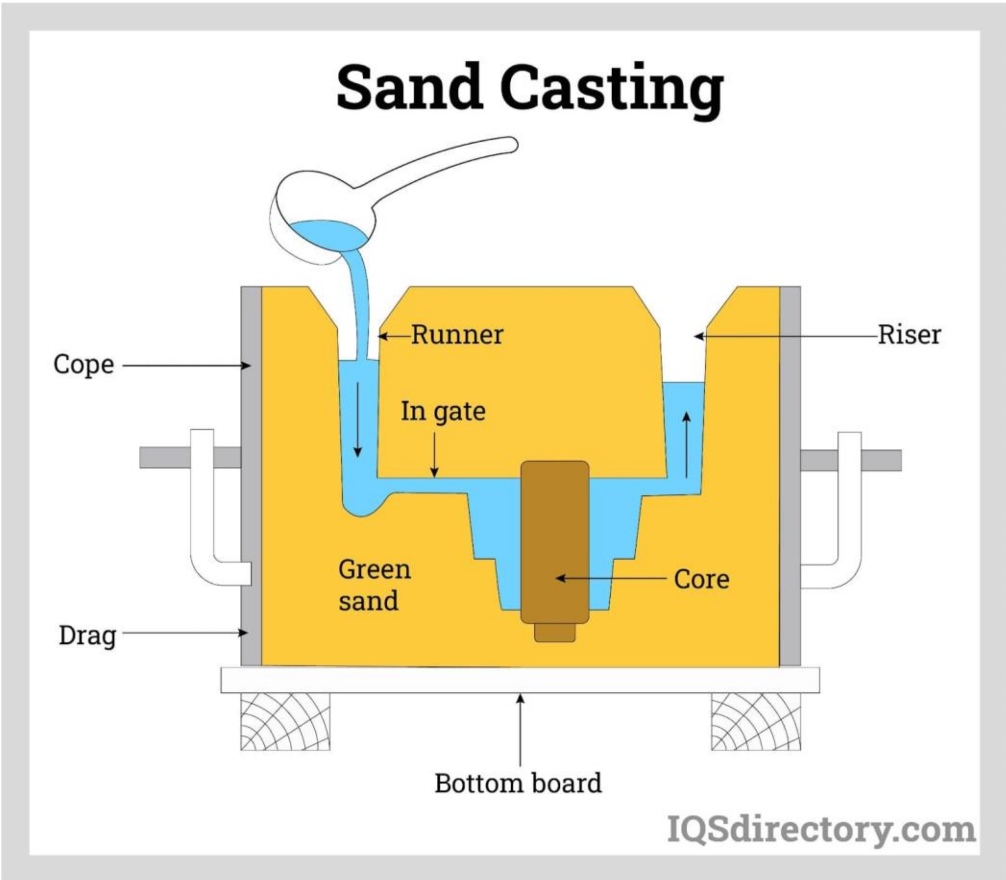
Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. Casting materials include metal, concrete, epoxy, plaster, and clay. This article will focus on sand casting.



Parts manufactured using sand casting come in a wide range of sizes and weights and have complex geometries using a variety of metals. The use of sand as the casting material significantly reduces the cost of the casting process. In the metal mold process, the machining of the molds accounts for a large portion of the costs.

With sand casting, the type of sand used in the process depends on whether the sand will be reused or disposed of. In green sand sand casting, the molds are reusable while in the dry sand casting process, the sand is thrown away.

Sand casting is used for metals with high melting temperatures, such as titanium, steels, and nickel and is the only casting process that can work with those materials. It is the choice of the aerospace and automotive industries for producing low cost, small series parts.

Components of a Sand Casting Mold

The making of the sand casting mold usually requires four components which are:

Base Sand

The base sand is the sand that is utilized to create the mold in its purest form. A binding agent is necessary to keep it together. The core is also made of base sand. The following are the most prevalent varieties of base sand:

- Silica sand
- Olivine sand
- Chromite sand
- Zircon sand
- Chamotte sand

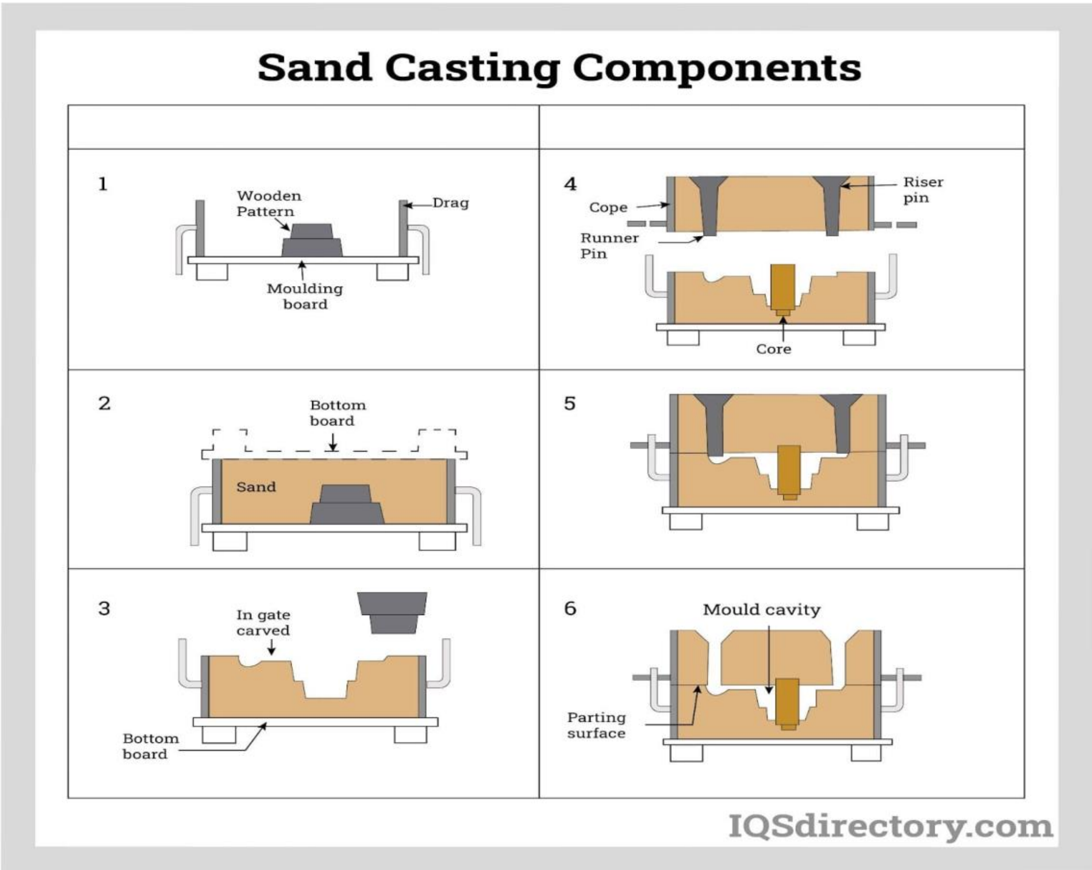
Binders or Binding Agents

The binding agents are the glue that holds the sand particles together. The following are the most frequent types of binders:

- Clay and water
- Oil
- Resin
- Sodium silicate

Improvement Through Additives

Additives are used to improve the mold surface finish, its strength, refractoriness, and cushioning.



Parting Compounds

This can be a fine powder or liquid used to facilitate pattern removal from the mold.

Sand Casting Methods

Sand casting is a centuries old manufacturing process that developed in China around 1600 BCE. At the time, it was used to produce statues, decorative ornaments, and artifacts. With the introduction of airplanes and automobiles in the 20th century, sand casting became an essential part for producing highly accurate parts with exceptional tolerances. Since then, ancient sand casting has been improved, adjusted, changed, and engineered to be a vital part of 21st century parts and components production.

It is estimated that 70% of metal castings in the world are completed using sand casting. It is an essential production method for the manufacturing of engine blocks, cylinder heads, pump housings, valve bodies, and gearboxes.

Bedding-In Sand Casting

The 'bedding-in approach' can also be used to form the solid cylindrical design. The drag is partially filled with molding sand and rammed in this technique. The pattern is driven into the sand after enough pounding. To ensure accurate sand ramming, the sand near the pattern is tucked and slammed tightly.

The pattern may be removed for the sand to be examined for soft patches on the surface. If there are any soft patches, ramming with more sand is done until the sand is tightly packed. To ensure a well rammed mold chamber, the pattern is forced downward, again.

The dividing line should be level with the surrounding smooth sand surface when bedding-in. The drag does not need to be rolled over when a pattern is bedded in. When employing pit molding to make larger molds, bedding-in can be used.

False Cope Sand Casting

Another method for molding the solid cylindrical design is the false cope technique. In this process, the sand is rammed tightly beneath the pattern. The design is bedded into the coping without regard for sand ramming beneath the pattern, resulting in a smooth parting surface.

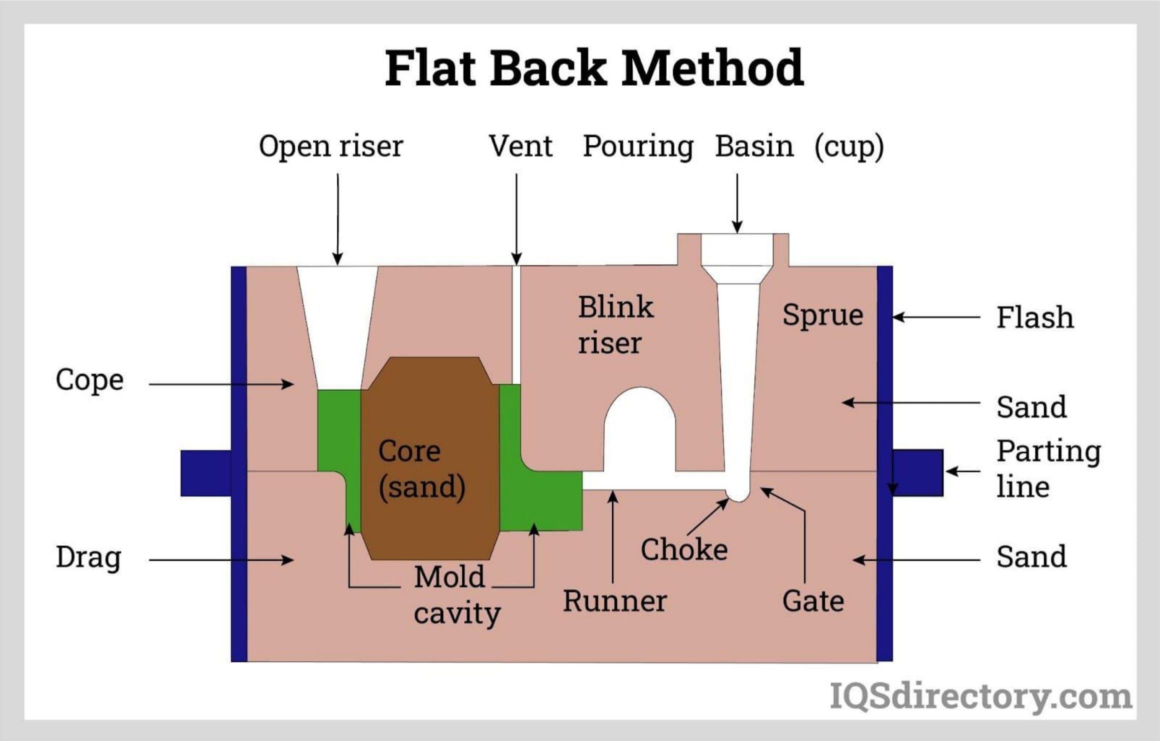
After dusting the cope and pattern with separating sand, the drag section of the flask is placed on top of the cope and is followed by the standard ramming procedure. The completed assembly is gripped and rolled over on a sand bed and the clamps, cope, and cope bottom board are removed and destroyed. The empty cope is placed on the drag and rammed. In this case, the cope is a dummy block that is used to create the drag and is referred to as a 'false cope.'

Flat Back Sand Casting

With flat back sand casting, the mold cavity is on the drag side, the cope side, or both. With an unmolded cope, a sprue is placed in the drag to form the flat back to help with the pouring and cooling of the molded part. The pattern is placed into the drag box, covered in sand, and rammed. This is used for simple flat back parts or for a flat back part that will be joined to its other half in the joining of the cope and drag.

With simple flat back parts, the rammed pattern is removed and gates and sprues are inserted to allow molten metal to be poured into the mold. When flat back sand casting has the pattern in the cope and drag box, the cope is placed over the drag box and an identical or similar pattern is placed over it and rammed such that the two patterns make a firm complete impression.

The cope and drag box are separated and the patterns are removed after which the cope and drag box are placed back together and tightly sealed to keep the upper box from floating. Gates and sprues are added for the pouring of the molten metal. Once the metal has cooled and solidified, the part is removed and finished.



Skin Dried Sand Casting

In skin dred sand casting, a thin layer of sand is placed over the mold cavity and dried by a heater, torch, heat lamp, or the ambient air. The dried skin layer provides an exceptionally smooth surface finish and is made up of fine grain sand mixed with a binder. Molten metal is poured into the mold cavity filling the space between the pattern and the skin sand layer.

As with all forms of sand casting, the sand is removed when the part cools and solidifies. The skin dried process is ideal for parts that require an extremely smooth and uniform surface, such as engine, aerospace, and machinery parts.

Water Glass or Sodium Silicate Sand Casting

Sodium silicate sand casting is a form of green sand casting where sodium silicate is used as the binder. The use of sodium silicate allows for rapid production of the casting mold and involves curing the sand and sodium silicate with carbon dioxide (CO_2), which instantly hardens the mold. Prior to the hardening process, other materials, such as resin, oil, cellulose, or polysaccharide, are mixed with the sodium silicate such that it will break down when removing the casting.

Sand is mixed with a sodium silicate solution and packed around the pattern for the casting. CO_2 quickly cures and hardens the mold. Once the mold is solidified, the pattern is removed from the hardened mold and molten metal is poured in. The cooled and solidified part is broken from the mold and the materials are disposed of.

Water glass sand casting is used for the manufacture of complex and intricate parts since the sand is capable of creating complicated shapes and patterns. It is an inexpensive process that involves little machinery but produces castings with rough uneven surfaces that require finishing.

Vacuum Sand Casting

Vacuum sand casting, known as the V-process, uses a thin sheet of plastic that is draped over the pattern that has been vented such that a vacuum can be pulled through it. A vacuum flask is placed over the plastic covered pattern and is filled with sand, which is vibrated to compact it. A sprue and pour cup are placed in the cope. A second sheet of plastic is placed over the sand, and a vacuum is drawn through the sand and plastic sheets that hardens and strengthens the sand.

The process is repeated for the formation of the drag. The molten metal is poured while the cope and drag are under the vacuum. During the process, the plastic vaporizes as the vacuum maintains the shape in the sand as the molten metal slowly solidifies. Once the part is cooled and set, the vacuum is removed.

Vacuum sand casting is known for tolerances of ± 0.01 in and ± 0.002 in with cross sections as thin as 0.090 in (2.3 mm). Surface finishes are excellent without moisture defects, the cost of a binder, and no toxic fumes.

Shell Sand Casting

Shell sand casting uses a resin coated sand to form a shell like mold, which is heated until it hardens. After the formation process, the shell is assembled and molten metal is poured into it and allowed to cool. Once the metal has cooled, the shell is broken and the part is removed.

The process for shell sand casting or molding is more expensive than traditional sand casting, which makes the cost of parts higher. Shell sand casting requires fewer steps, creates far less waste, and is cost effective for its accuracy and efficiency. Additionally, shell molding can produce parts at a faster rate in large quantities.

The main distinguishing feature of shell sand casting is its resin coated molds, which make shell sanding casting more precise and accurate than traditional sand casting. In a single step, intricate, complex, and detailed components are quickly manufactured with smooth even surfaces with exceptionally accurate dimensions and tolerances that removes the need for secondary finishing.

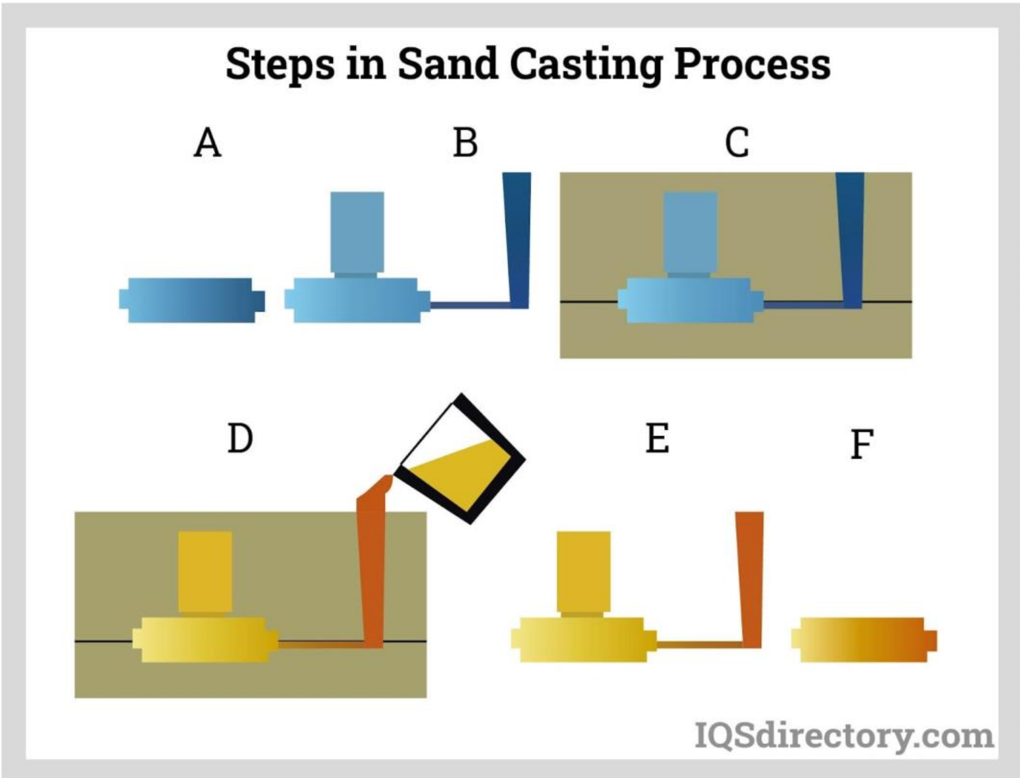
How Sand Casting is Done

When sand casting, several steps are followed which include:

Producing the Pattern – Desired Product

A reusable pattern with the same details as the desired completed product is used in the process. A pattern is always made larger than the final part to give an allowance for thermal contraction or shrink. Shrinkage allowance will account for the contractions that occur as a casting cools to room temperature.

Liquid shrinkage is a reduction in volume that occurs when a metal transitions from a liquid to a solid form. To compensate for this, the mold has a riser that feeds liquid metal to the casting. Solid Shrinkage: When a metal loses its solid state temperature, it shrinks in volume. To account for this, shrinkage allowance is included in the patterns.



The machining allowance will cover the extra material that will be eliminated in order to produce a completed product. The rough surface of the cast product will be eliminated in this process. The size, material properties, distortion, finishing accuracy, and machining method all influence the machining allowance. To ensure that the pattern is removed safely, all surfaces parallel to the pattern removal direction are tapered slightly inward. This is known as draft allowance.

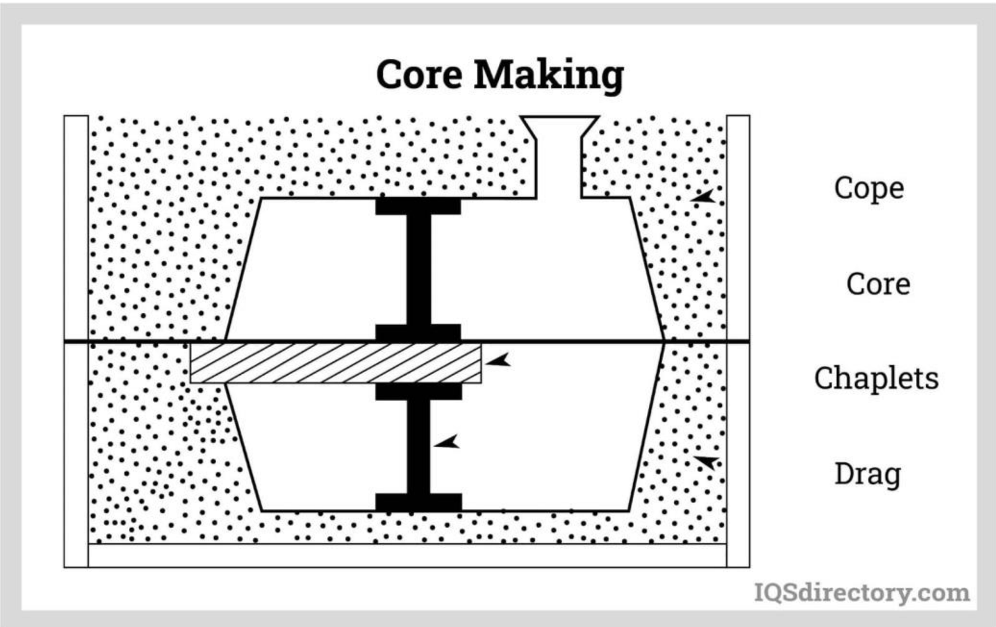
Pattern Creation – Gates and Risers: Metal Delivery System

The metal channels that will feed the required cast product design with proper gating and risers are also included in the pattern. This regulates the metal flow and requires gas venting while driving the unavoidable thermal contraction to acceptable places (other than the actual desired finished product).

Depending on the volume and tolerance required, patterns are manufactured of a variety of materials, including wood, metal, synthetics, expandable polystyrene (EPS), and others. In other circumstances, such as pipe fittings, the component's interior must be hollow. In such circumstances, extra patterns known as cores must be created.

Core Making

Cores are a separate portion of the mold that prevents the liquified material from filling in any gaps. They're utilized to make interior cavities and other things that the mold can't produce. A core box is the tooling used to build the core, which is just another name for the mold that makes the core.

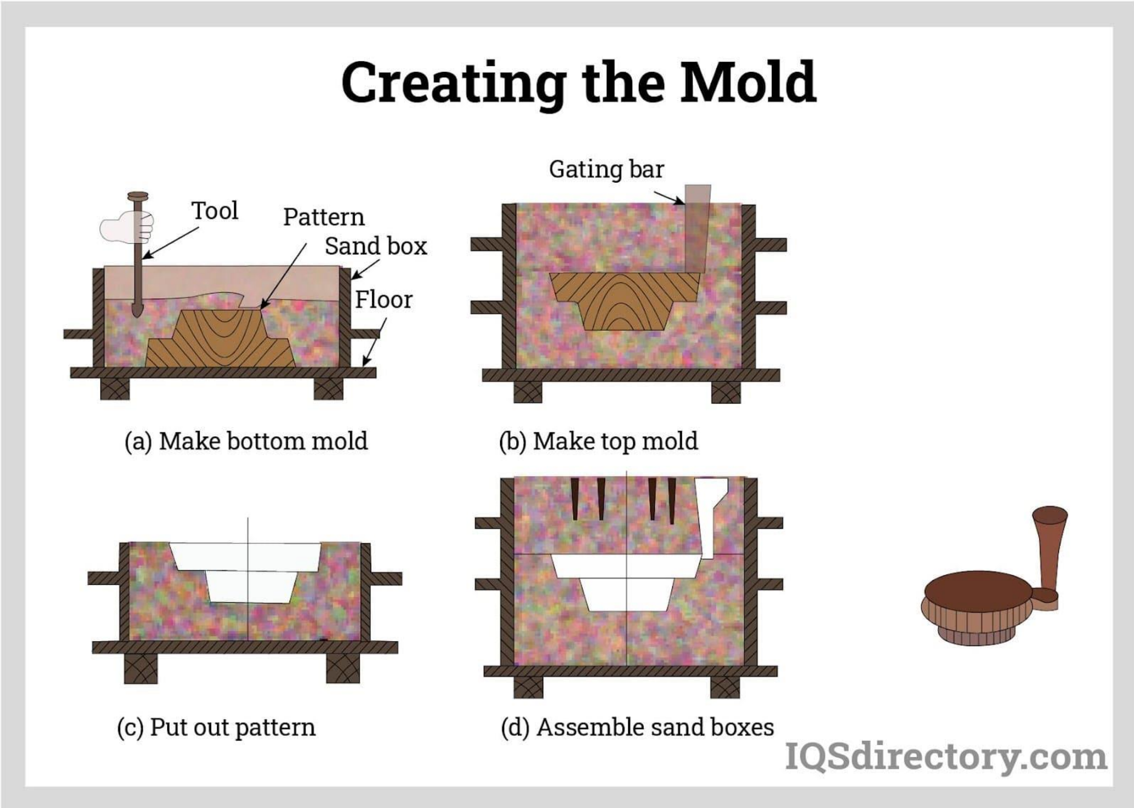


The materials used to make the core must meet certain criteria:

- It must be strong enough to withstand the turbulence caused by the molten material
- It must have a good hardness
- It must have a high permeability so that the gasses formed during the casting process can easily escape
- It must be able to withstand the high temperatures caused by the molten material
- Smooth surface finish
- Minimal gas formation when exposed to the molten material
- It must be weak enough to break while the molten material cools and shrinks, allowing it to be removed after solidification.

Creating the Mold

Around the design, a refractory substance that is stable at high temperatures (in our case, sand) is created. The material must be strong enough to support the weight of the liquid metal during casting. It should also be resistant to metal reaction but fragile enough to be separated after cooling of the casting.



The mold can be made out of a variety of different sand materials. Other elements, such as clay or a chemical bonding agent, are usually added to the sand to make it stronger so that it can withstand the pouring operation. The mold can also be made by drilling the necessary shaped hollow straight into a block of sand. Because design changes may be handled and applied quickly, the technology is extensively employed during product development, or for portions with infrequent usage to avoid the storage or maintenance of a physical pattern.

The top half of the mold, known as the "cope," and the bottom half, known as the "drag," are usually made in two sections. The parts are split and the pattern removed once the sand has set (using the traditional/non-machined procedure). To improve the surface finish and protect the mold from the turbulence of the poured metal, a refractory coating is applied. The halves are reassembled, resulting in a cavity in the pattern's form. Cores, a means of producing appropriate internal pathways in the final product, may be included in the mold.

Pouring the Metal into the Mold

Molten metal is injected into the static mold directly. It defines the finished portion and the risers by filling the void. A continuous liquid metal supply comes from the risers to the casting. Because they are meant to cool and solidify last, the shrinkage and potential void are concentrated in the riser rather than the targeted section.

Liquid metal can thus flow into the casting smoothly with less turbulence. Reduced turbulence can aid in the prevention of oxide formation and casting flaws. This method can be used to make almost any alloy. Almost any alloy can be made using this method. For extremely reactive materials to oxygen, an argon shielding process can be used to keep air away from the molten metal.

Shakeout Operation

The casting hardens and cools, containing both the desired item and the additional metal required to manufacture it. In a shakeout operation, the sand is split up. The sand used to make the mold is recovered, reconditioned, and reused in large quantities.

Casting Final Operations

The gates, runners, and risers are cut from the casting, and final post-processing such as sandblasting, grinding, and other methods are used if necessary to finish the casting dimensionally. To achieve final dimensions or tolerances, sand castings may require extra machining.

Heat treatment can be used to improve the dimensional stability or characteristics of parts. Non-destructive testing is another option. Fluorescent penetrant, magnetic particle, radiographic, and other inspections are examples. Prior to shipment, final dimensional inspections, alloy test results, and NDT are validated.