MF9254 ADVANCES IN CASTING AND WELDING PROCESSES

UNIT III RECENT TRENDS IN CASTING AND FOUNDRY LAYOUT

Syllabus

Shell moulding, precision investment casting, CO_2 moulding, centrifugal casting, Die casting, Continuous casting, Counter gravity low pressure casting, Squeeze casting and semisolid processes. Layout of mechanized foundry – sand reclamation – materialhandling in foundry pollution control in foundry — Computer aided design of casting.

Compiled by

VEERAPANDIAN.K
EGS PILLAY ENGINEERING COLLEGE, NAGAPATTINAM.
www.mechstudent.weebly.com

Shell Mold Casting

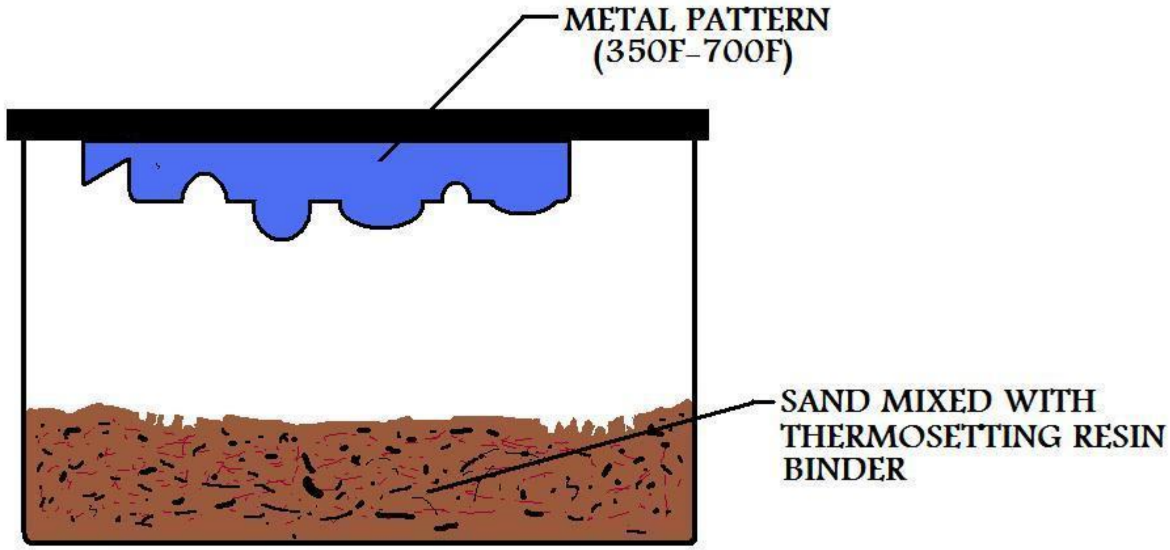
Shell mold casting or shell molding is a metal casting process in manufacturing industry in which the mold is a thin hardened shell of sand and thermosetting resin binder backed up by some other material. Shell molding was developed as a manufacturing process in Germany in the early 1940's.

Shell mold casting is particularly suitable for steel castings under 20 lbs; however almost any metal that can be cast in sand can be cast with shell molding process. Also much larger parts have been manufactured with shell molding. Typical parts manufactured in industry using the shell mold casting process include cylinder heads, gears, bushings, connecting rods, camshafts and valve bodies.

The Process

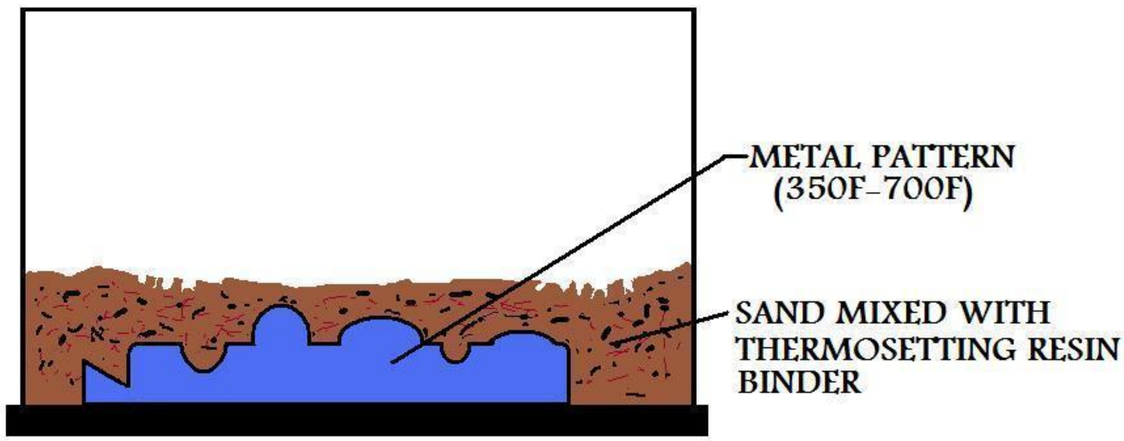
The first step in the shell mold casting process is to manufacture the shell mold. The sand we use for the shell molding process is of a much smaller grain size than the typical greensand mold. This fine grained sand is mixed with a thermosetting resin binder. A special metal pattern is coated with a parting agent, (typically silicone), which will latter facilitate in the removal of the shell. The metal pattern is then heated to a temperature of 350F-700F degrees, (175C-370C).

Figure:30



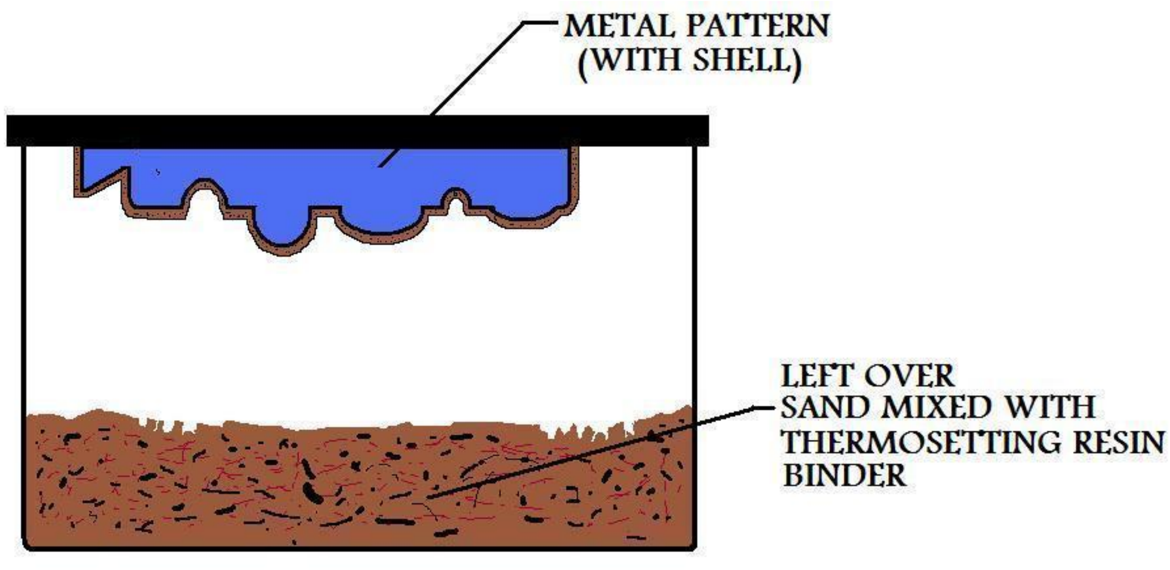
The sand mixture is then poured or blown over the hot casting pattern. Due to the reaction of the thermosetting resin with the hot metal pattern a thin shell forms on the surface of the pattern. The desired thickness of the shell is dependent upon the strength requirements of the mold for the particular metal casting application. A typical industrial manufacturing mold for a shell molding casting process could be .3in (7.5mm) thick. The thickness of the mold can be controlled by the length of time the sand mixture is in contact with the metal casting pattern.

Figure:31



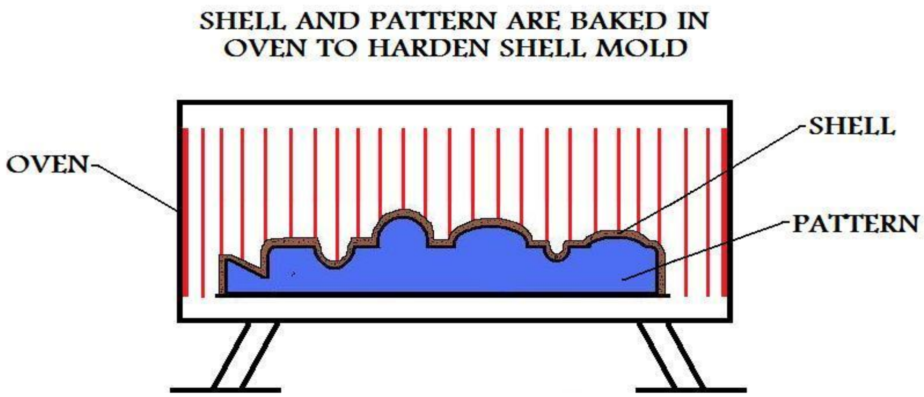
The excess "loose" sand is then removed leaving the shell and pattern.

Figure:32



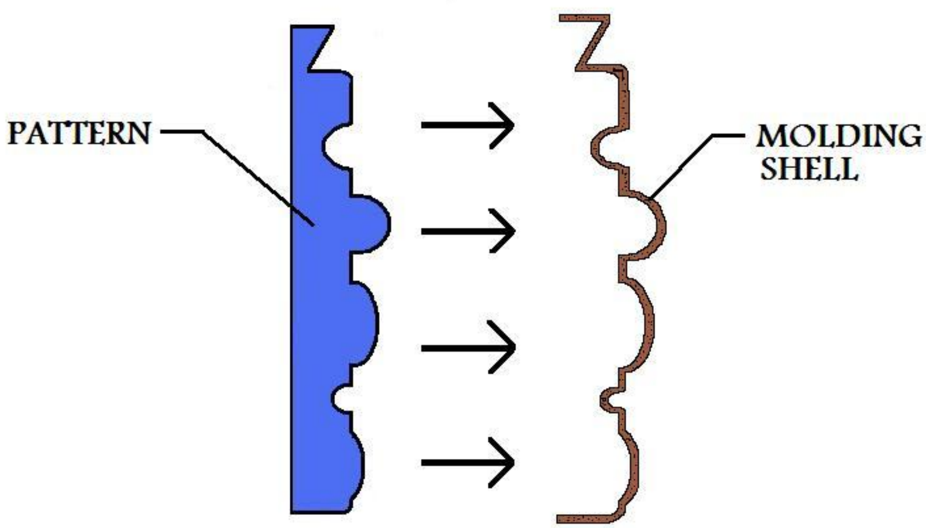
The shell and pattern are then placed in an oven for a short period of time, (minutes), which causes the shell to harden onto the casting pattern.

Figure:33



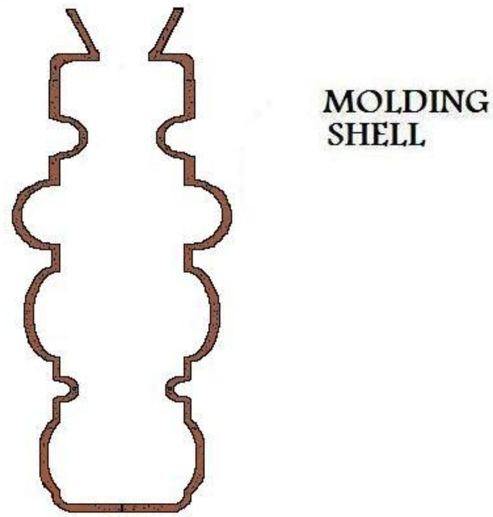
Once the baking phase of the manufacturing process is complete the hardened shell is separated from the casting pattern by way of ejector pins built into the pattern. It is of note that this manufacturing technique used to create the mold in the shell molding process can also be employed to produced highly accurate fine grained mold cores for other metal casting processes.

Figure:34



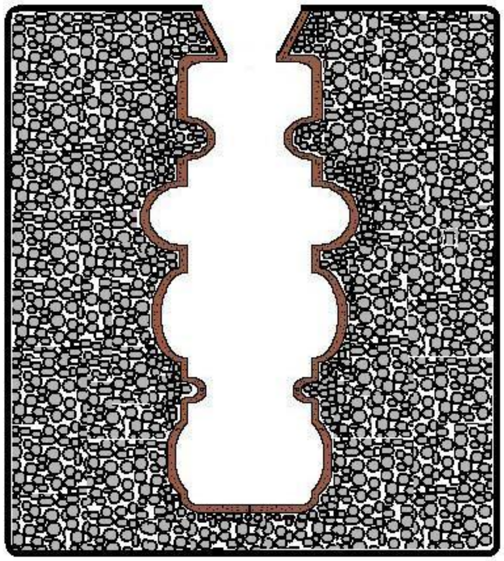
Two of these hardened shells, each representing half the mold for the casting are assembled together either by gluing or clamping.

Figure:35



The manufacture of the shell mold is now complete and ready for the pouring of the metal casting. In many shell molding processes the shell mold is supported by sand or metal shot during the casting process.

Figure:36



Properties and Considerations of Manufacturing by Shell Mold Casting

- The internal surface of the shell mold is very smooth and rigid. This allows for an easy flow of the liquid metal through the mold cavity during the pouring of the casting, giving castings very good surface finish. Shell Mold Casting enables the manufacture of complex parts with thin sections and smaller projections than green sand molds.
- Manufacturing with the shell mold casting process also imparts high dimensional accuracy. Tolerances of .010 inches (.25mm) are possible. Further machining is usually unnecessary when casting by this process.
- Shell sand molds are less permeable than green sand molds and binder may produce a large volume of gas as it contacts the molten metal being poured for the casting. For these reasons shell molds should be well ventilated.
- The expense of shell mold casting is increased by the cost of the thermosetting resin binder, but decreased by the fact that only a small percentage of sand is used compared to other sand casting processes.
- Shell mold casting processes are easily automated
- The special metal patterns needed for shell mold casting are expensive, making it a less desirable process for short runs. However manufacturing by shell casting may be economical for large batch production.

CO2 Molding

Introduction:Co2 Casting is a kind of sand casting process. In this process the sand molding mixture is hardened by blowing gas over over the mold. This process is favoured by hobby metal casters because a lot of cost cutting can be done. In addition, one can be sure of getting dimensionally accurate castings with fine surface finish. But, this process is not economical than green sand casting process.

Process: The Mold for **Co2 Casting** is made of a mixture of sand and liquid silicate binder which is hardened by passing Co2 gas over the mold. The equipment of the molding process include Co2 cylinder, regulator, hoses and hand held applicator gun or nozzle. Carbon di oxide molding deliver great accuracy in production.

Any existing pattern can be used for the molding purpose which can be placed in the mold before the mold is hardened. This method helps in producing strong mold and cores that can be used for high end applications. If the process is carefully executed then casting can be as precise as produced by the shell casting method.

Carbon di oxide casting is favored both by the commercial foundrymen and hobbyist for a number of reasons. In commercial operations, foundrymen can assure customers of affordable castings which require less machining. The molding process which can be fully automated is generally used for casting process that require speed, high production runs and flexibility. In home foundries this is one of the simplest process that improves the casting quality .

Applications:Co2 casting process is ideal where speed and flexibility is the prime requirement. molds and cores of a varied sizes and shapes can be molded by this process.

Advantages: This process has many advantages in comparison to other forms of castings some of them are as follows:

- Compared to other casting methods cores and molds are strong
- Reduces fuel cost since gas is used instead of to other costly heating generating elements
- Reduces large requirement for number of mold boxes and core dryers
- Provides great dimensional tolerance and accuracy in production
- Moisture is completely eliminated from the molding sand
- This process can be fully automated.

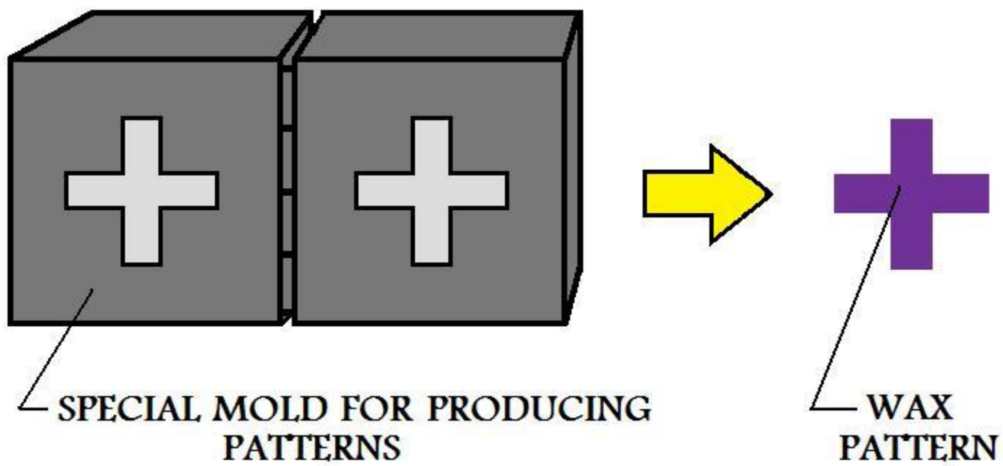
Investment Casting

Investment casting is a manufacturing process in which a wax pattern is coated with a refractory ceramic material. Once the ceramic material is hardened its internal geometry takes the shape of the casting. The wax is melted out and molten metal is poured into the cavity where the wax pattern was. The metal solidifies within the ceramic mold and then the metal casting is broken out. This manufacturing technique is also known as the lost wax process. Investment casting was developed over 5500 years ago and can trace its roots back to both ancient Egypt and China. Parts manufactured in industry by this process include dental fixtures, gears, cams, ratchets, jewelry, turbine blades, machinery components and other parts of complex geometry.

The Process

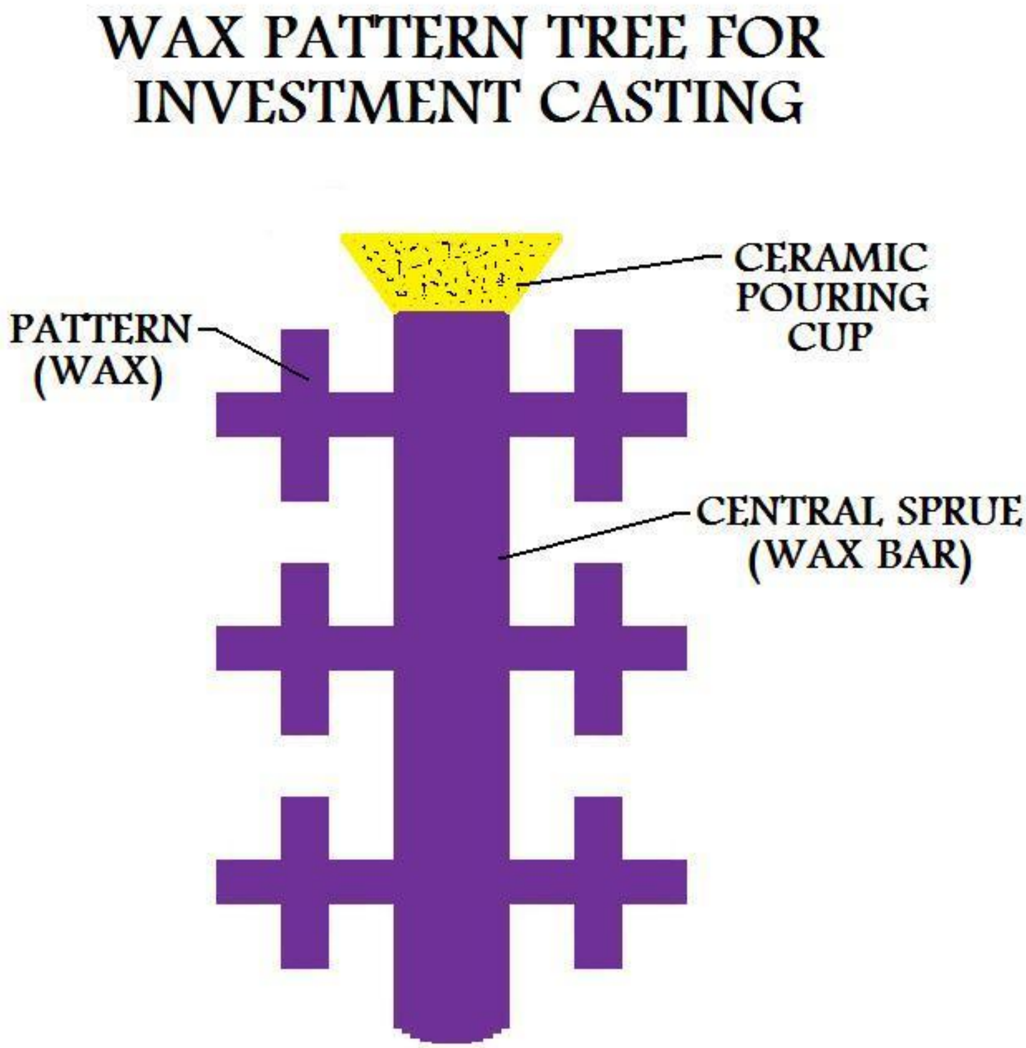
The first step in investment casting is to manufacture the wax pattern for the process. The pattern for this process may also be made from plastic; however it is often made of wax since it will melt out easily and wax can be reused. Since the pattern is destroyed in the process one will be needed for each casting to be made. When producing parts in any quantity a mold from which to manufacture patterns will be desired. Similar to the mold that may be employed in the expanded polystyrene casting process to produce foam polystyrene patterns, the mold to create wax patterns may be cast or machined. The size of this master die must be carefully calculated. It must take into consideration shrinkage of wax, shrinkage of the ceramic material invested over the wax pattern, and shrinkage of the metal casting. It may take some trial and error to get just the right size, therefore these molds can be expensive.

Figure:48



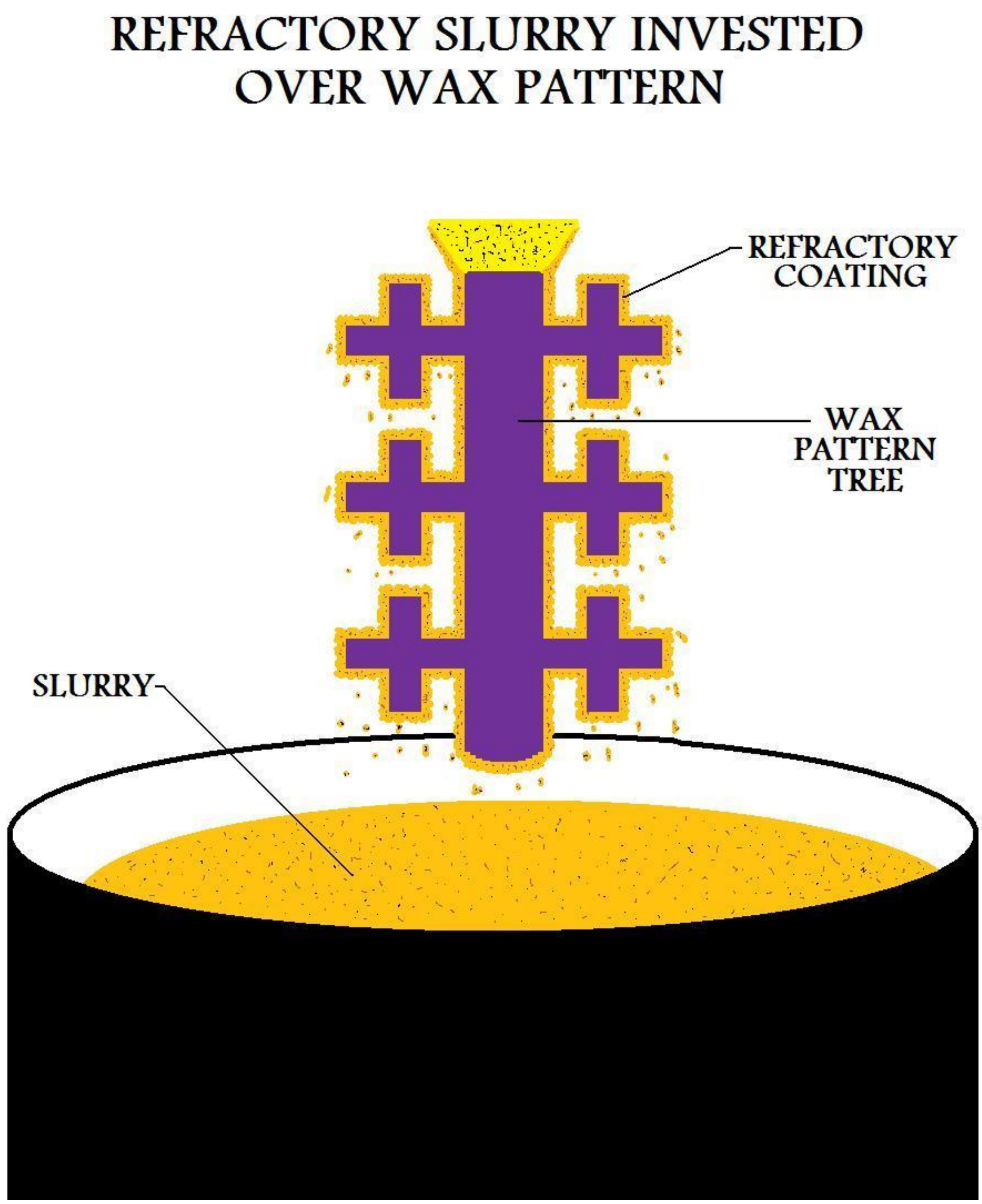
Since the mold does not need to be opened castings of very complex geometry can be manufactured. Several wax patterns may be combined for a single casting. Or as often the case, many wax patterns may be connected and poured together producing many castings in a single process. This is done by attaching the wax patterns to a wax bar, the bar serves as a central sprue. A ceramic pouring cup is attached to the end of the bar. This arrangement is called a tree, denoting the similarity of casting patterns on the central runner beam to branches on a tree.

Figure:49



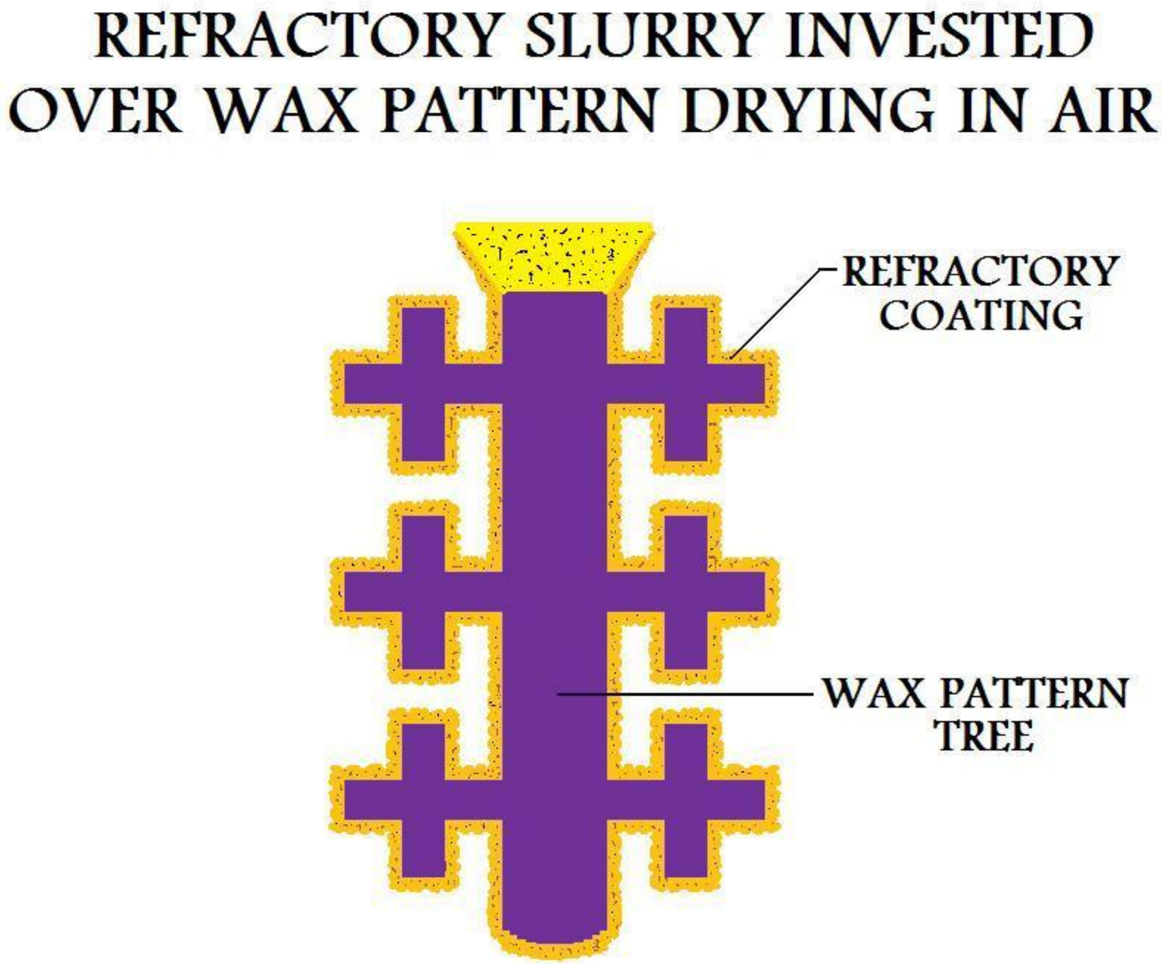
The casting pattern is then dipped in a refractory slurry whose composition includes extremely fine grained silica, water, and binders. A ceramic layer is obtained over the surface of the pattern. The pattern is then repeatedly dipped into the slurry to increase the thickness of the ceramic coat. In some cases the pattern may be placed in a flask and the ceramic slurry poured over it.

Figure:50



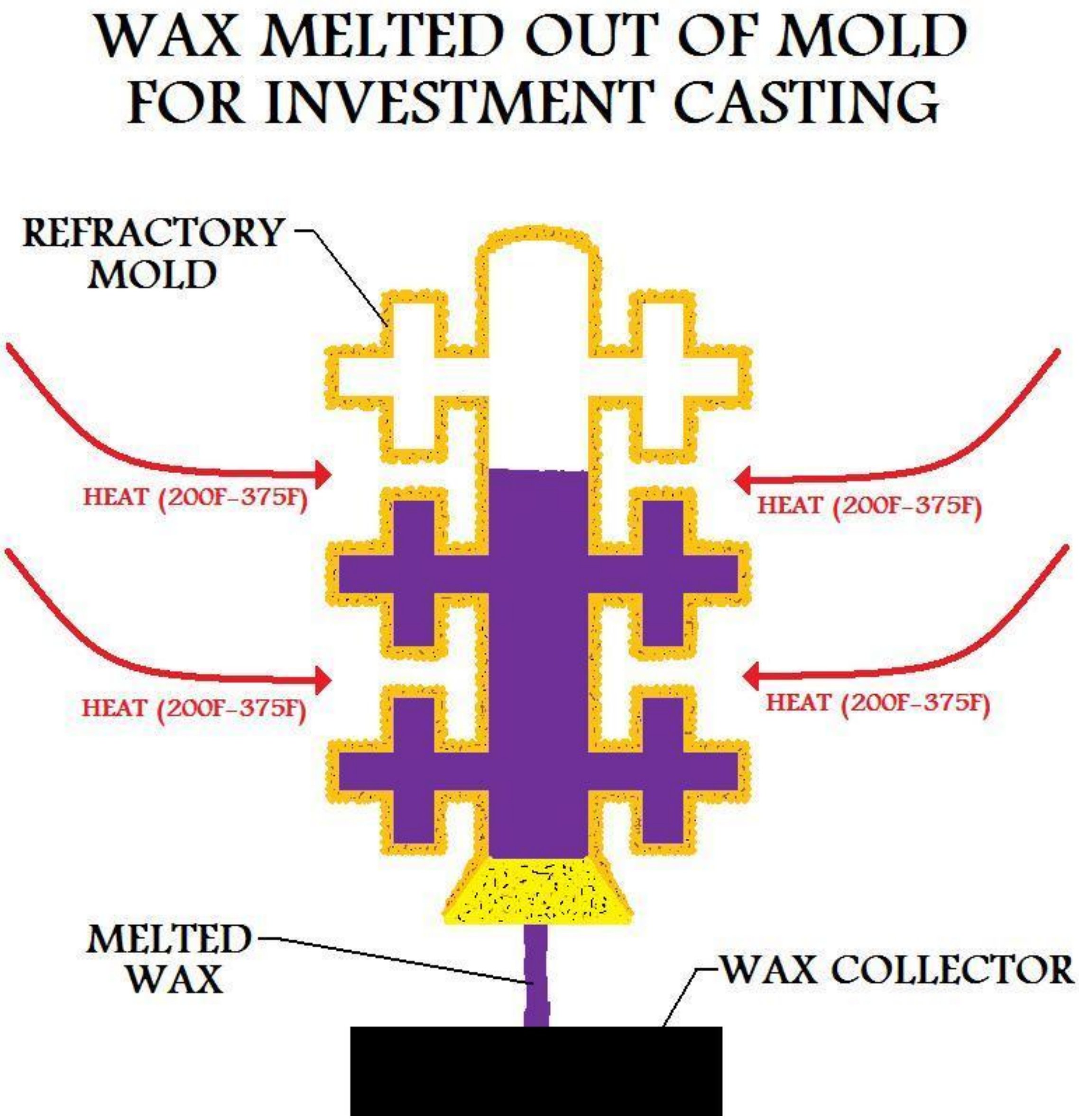
Once the refractory coat over the pattern is thick enough it is allowed to dry in air in order to harden.

Figure:51



The next step in this manufacturing process is the key to investment casting. The hardened ceramic mold is turned upside down and heated to a temperature of around 200F-375F (90C-175C). This causes the wax to flow out of the mold leaving the cavity for the casting.

Figure:52



The ceramic mold is then heated to around 1000F-2000F (550C-1100C). This will further strengthen the mold, eliminate any leftover wax or contaminants, and drive out water from the mold material. The casting is then poured while the mold is still hot. Pouring the casting while the mold is hot allows the liquid metal to flow easily through the mold cavity filling detailed and thin sections. Pouring the casting in a hot mold also gives better dimensional accuracy since the mold and casting will shrink together as they cool.

Figure:53

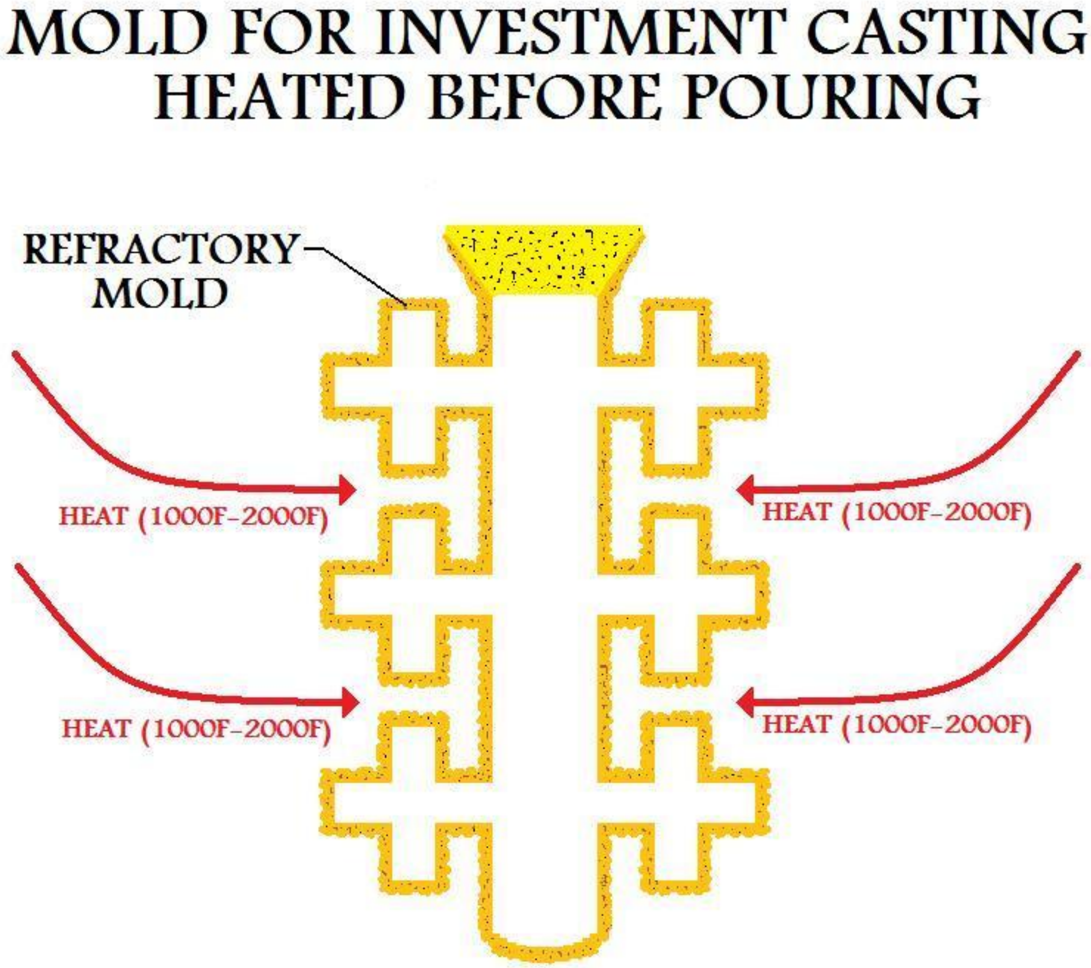
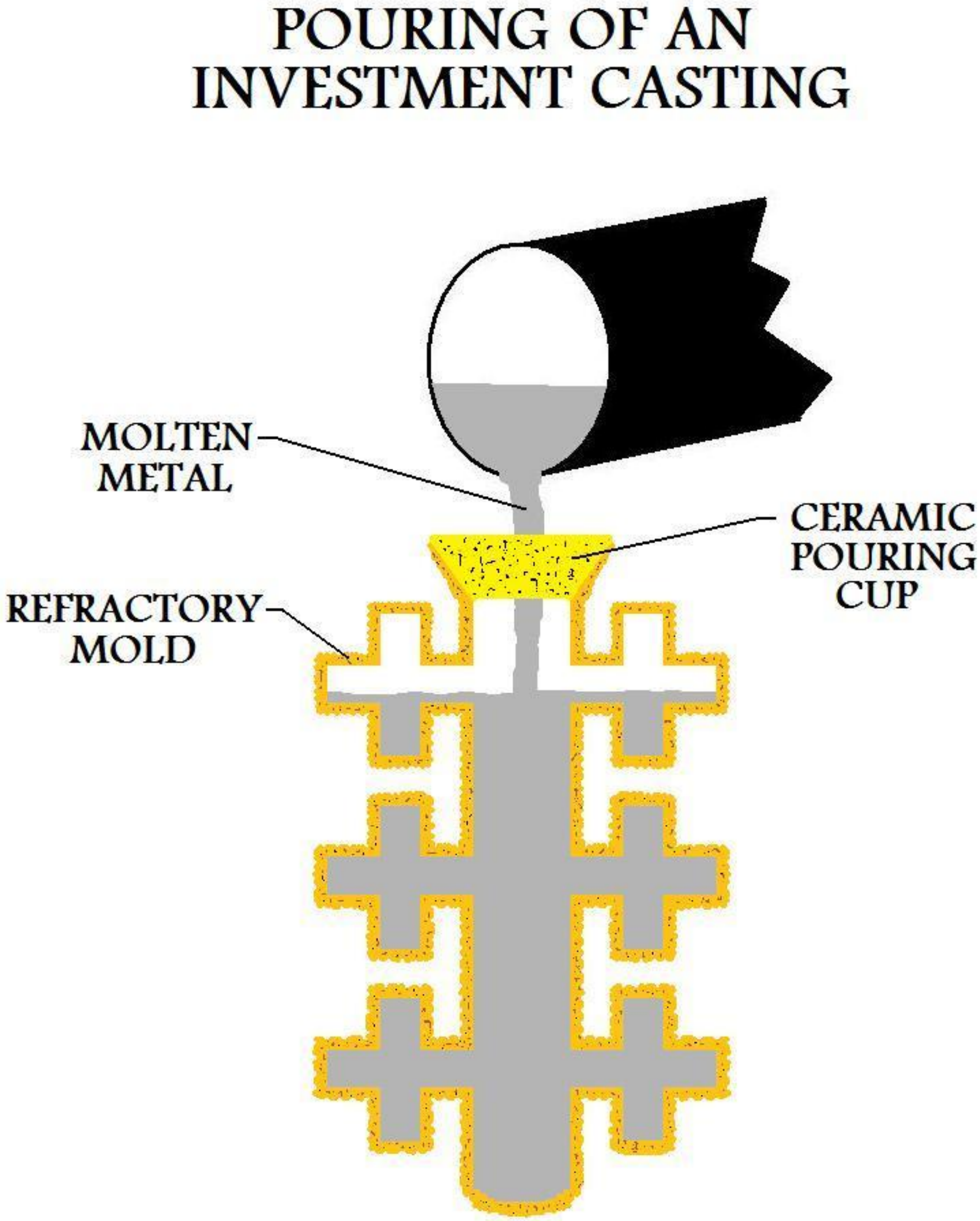
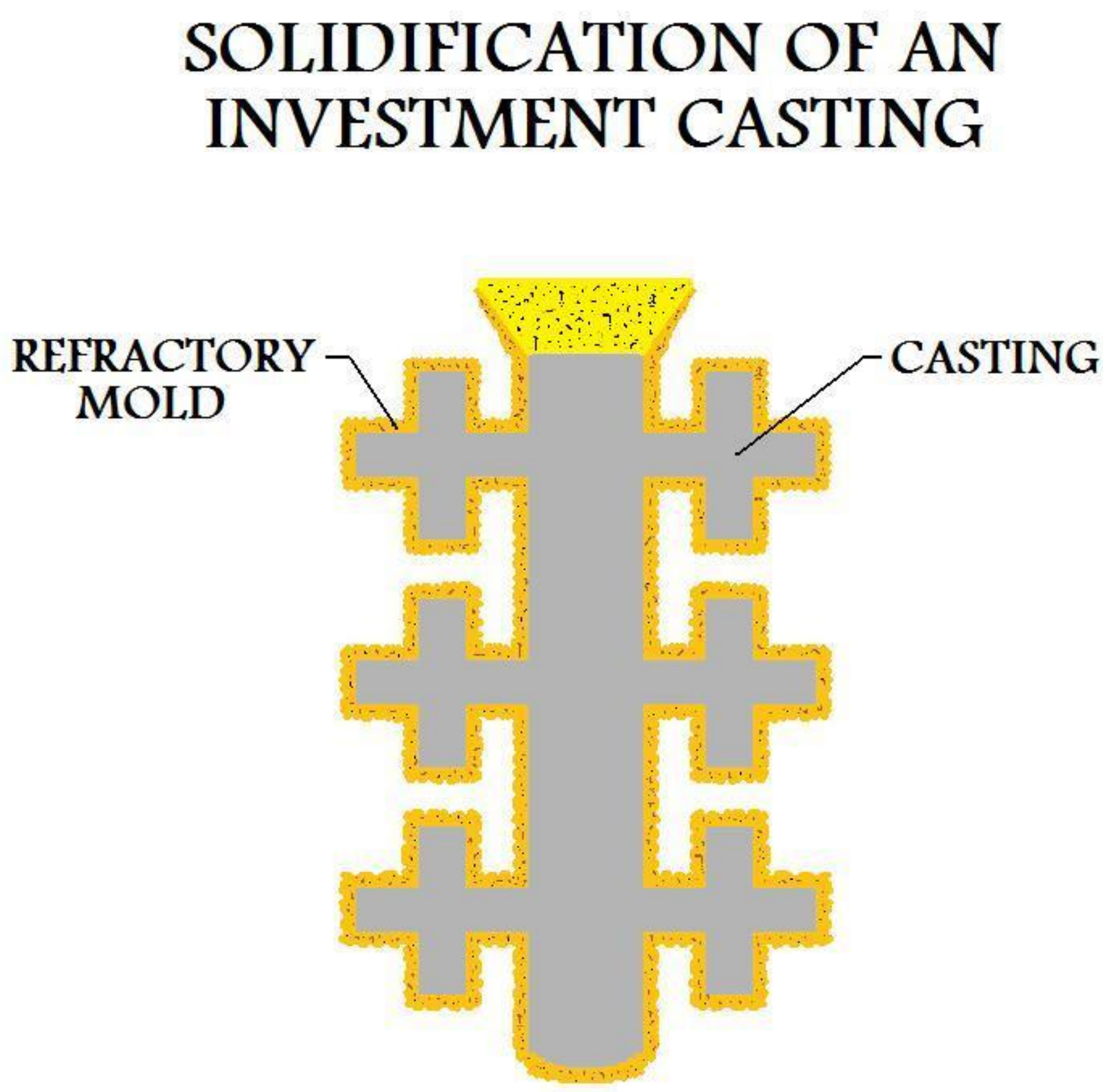

MOLD FOR INVESTMENT CASTING
HEATED BEFORE POURING
REFRACTORY MOLD
HEAT (1000F-2000F)
HEAT (1000F-2000F)
HEAT (1000F-2000F)
HEAT (1000F-2000F)

Figure:54



After pouring of the molten metal into the mold, the casting is allowed to set as the solidification process takes place.

Figure:55



The final step in this manufacturing process involves breaking the ceramic mold from the casting and cutting the parts from the tree.

Figure:56

BREAK UP OF THE MOLD FOR AN INVESTMENT CASTING

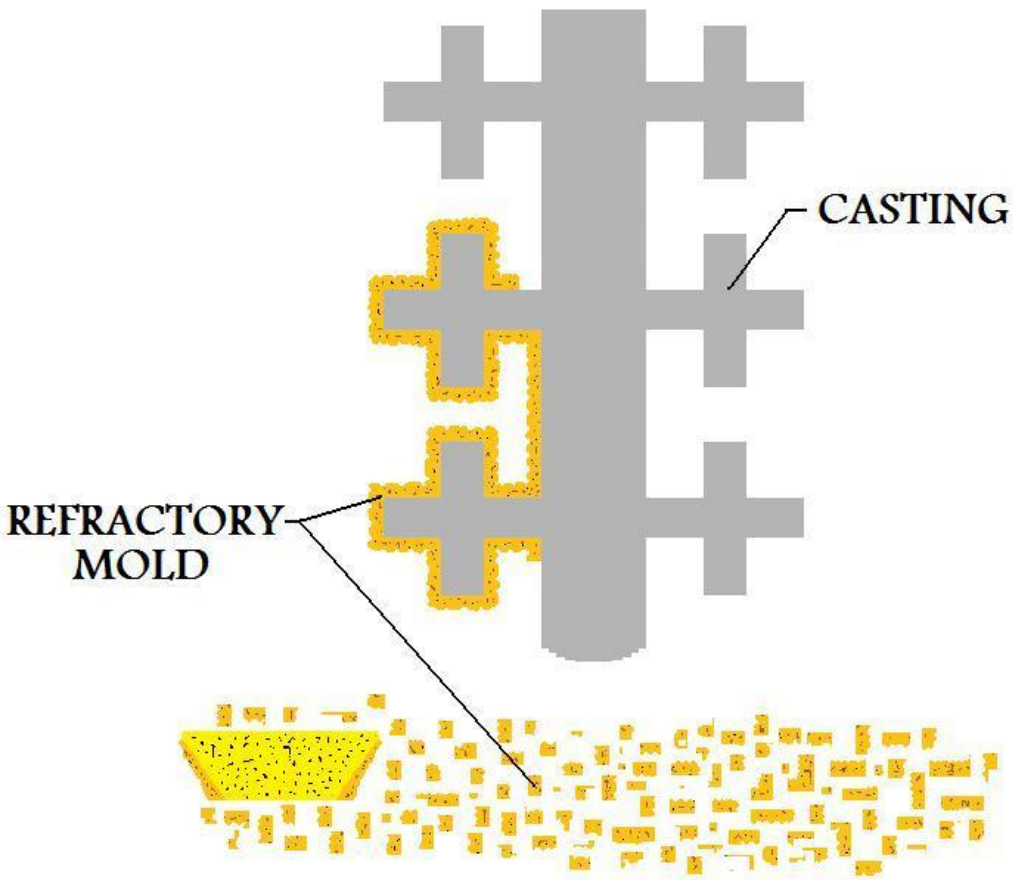
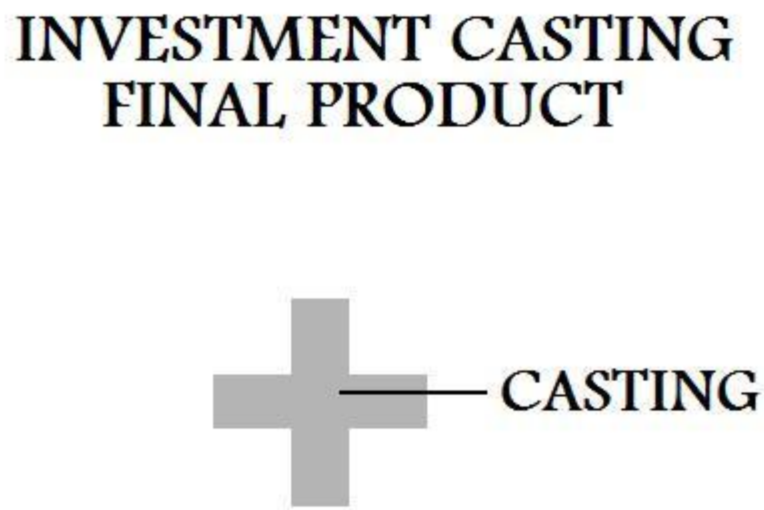


Figure:57



Properties And Considerations Of Manufacturing By Investment Casting

- Investment Casting is a manufacturing process that allows the casting of extremely complex parts, with good surface finish.
- Very thin sections can be produced with this process. Metal castings with sections as narrow as .015in (.4mm) have been manufactured using investment casting.
- Investment casting also allows for high dimensional accuracy. Tolerances as low as .003in (.076mm) have been claimed with this manufacturing process.
- Practically any metal can be investment cast. Parts manufactured by this process are generally small, but parts weighing up to 75lbs have been found suitable for this technique.
- Parts of the investment process may be automated.
- Investment casting is a complicated process and is relatively expensive.

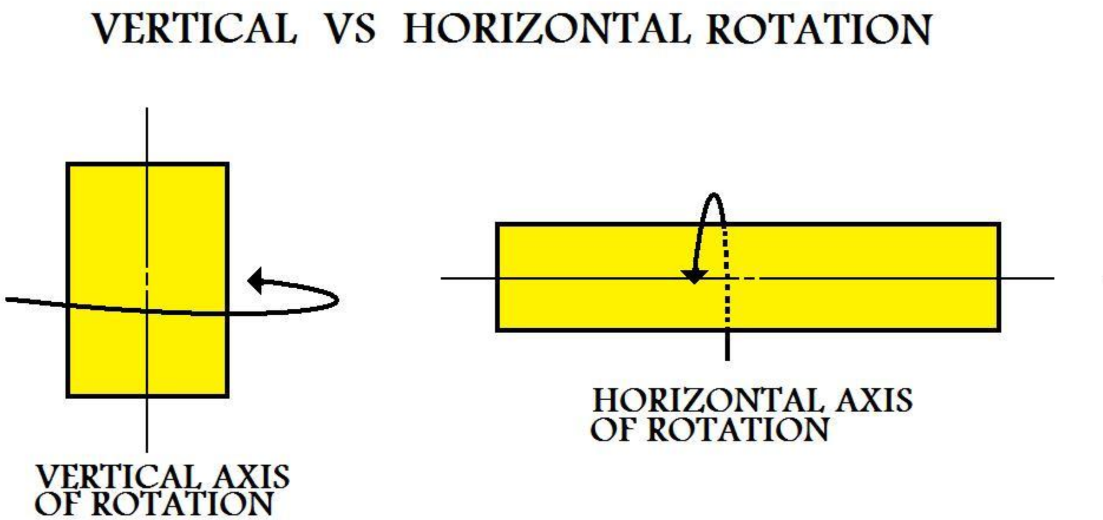
True Centrifugal Casting

The manufacturing process of centrifugal casting is a metal casting technique that uses the forces generated by centripetal acceleration to distribute the molten material in the mold. Centrifugal casting has many applications in manufacturing industry today. The process has several very specific advantages. Cast parts manufactured in industry include various pipes and tubes, such as sewage pipes, gas pipes, and water supply lines, also bushings, rings, the liner for engine cylinders, brake drums, and street lamp posts. The molds used in true centrifugal casting manufacture are round, and are typically made of iron, steel, or graphite. Some sort of refractory lining or sand may be used for the inner surface of the mold.

The Process

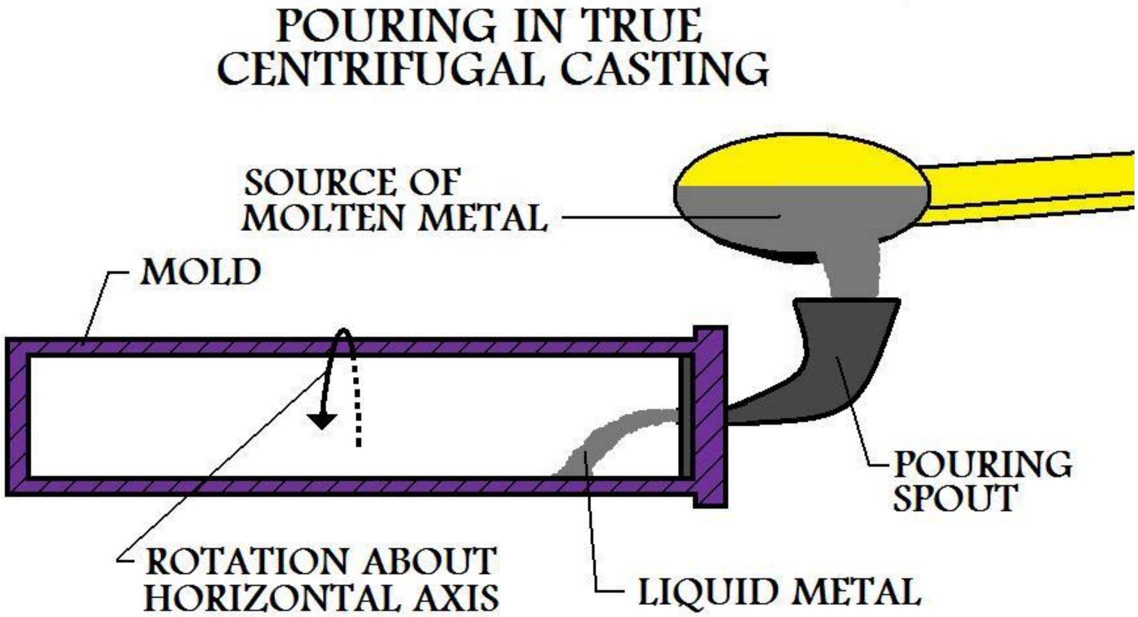
It is necessary when manufacturing a cast part by the true centrifugal metal casting process using some mechanical means, to rotate the mold. When this process is used for industrial manufacture, this is accomplished by the use of rollers. The mold is rotated about its axis at a predetermined speed. Molds for smaller parts may be rotated about a vertical axis, however most times in true centrifugal casting manufacture the mold will be rotated about a horizontal axis. The effects of gravity on the material during the metal casting process make it particularly necessary to cast longer parts with forces generated from horizontal rather than vertical rotation.

Figure:91



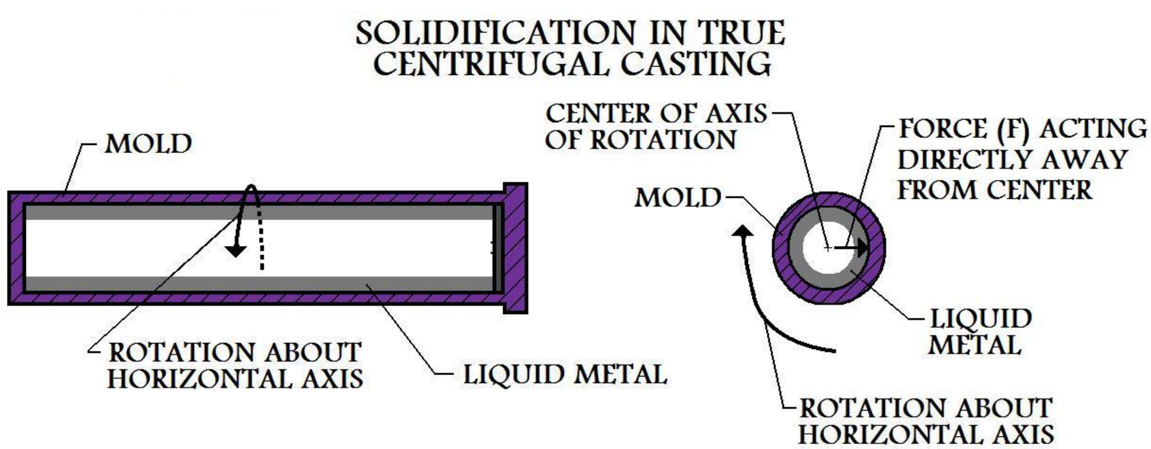
The molten material for the cast part is introduced to the mold from an external source, usually by means of some spout. The liquid metal flows down into the mold, once inside the cavity the centripetal forces from the spinning mold force the molten material to the outer wall. The molten material for the casting may be poured into a spinning mold or the rotation of the mold may begin after pouring has occurred.

Figure:92



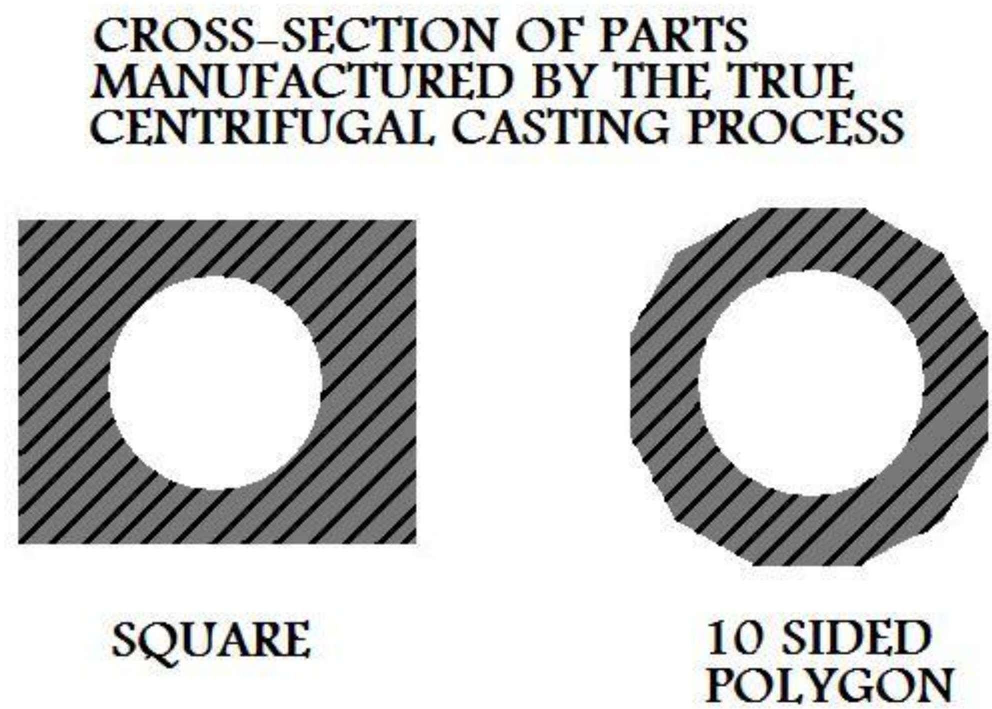
The casting will harden as the mold continues to rotate.

Figure:93



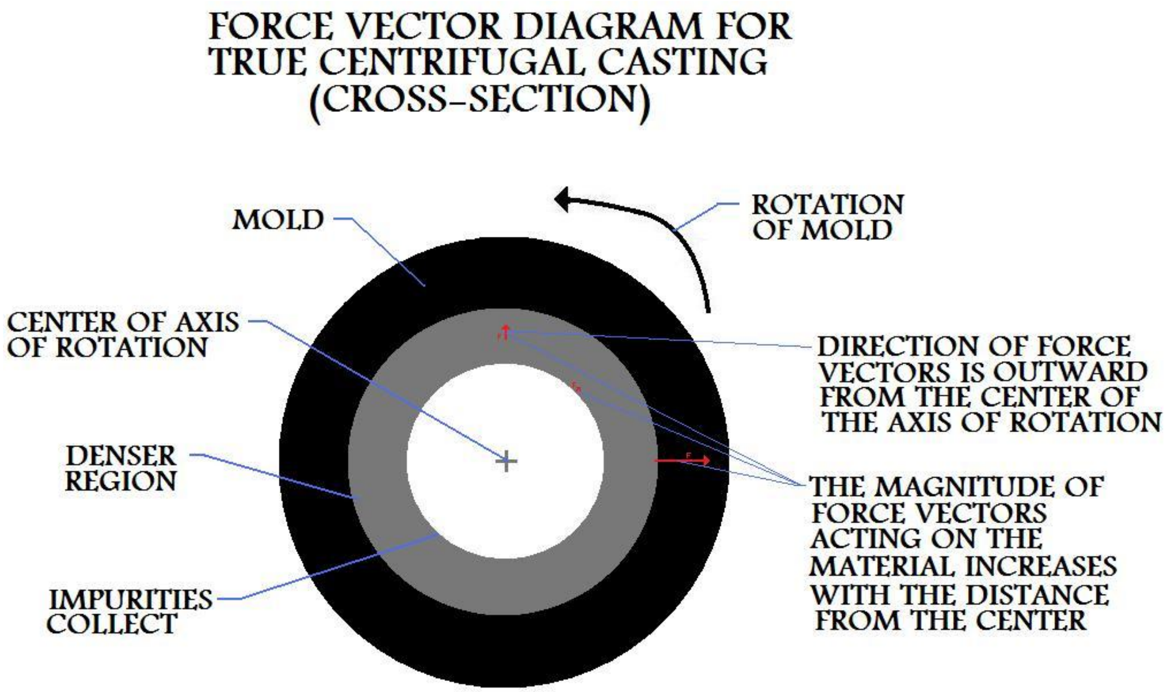
It can be seen that this casting process is very well suited for the manufacture of hollow cylindrical tubes. The forces used in this technique guarantee good adhesion of the casting material to the surface of the mold. Thickness of the cast part can be determined by the amount of material poured. The outer surface does not need to be round, square or different polygonal and other shapes can be cast. However due to the nature of the process the inner surface of a part manufactured by true centrifugal casting must always be round.

Figure:94



During the pouring and solidification phase of true centrifugal casting manufacture the forces at work play a large roll in the properties of castings manufactured by this process. It can be seen that forces will be greater in the regions further away from the center of the axis of rotation. The greater forces towards the rim will cause the regions of the casting nearer the outer surface to have a higher density than the sections located nearer the inner surface.

Figure:95



Most impurities within the material have a lower density than the metal itself, this causes them to collect in the inner regions of the metal casting closer to the center of the axis of rotation. These impurities can be removed during the casting operation or they can be machined off later.

Properties And Considerations Of Manufacturing By True Centrifugal Casting

- True centrifugal casting is a great manufacturing process for producing hollow cylindrical parts.
- The casting's wall thickness is controlled by the amount of material added during the pouring phase.
- Rotational rate of the mold during the manufacture of the casting must be calculated carefully based on the mold dimensions and the metal being cast.

- If the rotational rate of the mold is too slow the molten material for the casting will not stay adhered to the surface of the cavity. During the top half of the rotation it will rain metal within the casting cavity as the mold spins.

- This manufacturing operation produces cast parts without the need for sprues, risers, or other gating system elements, making this a very efficient casting process in manufacturing industry in terms of material usage.

- Since large forces press the molten material for the cast part against the mold wall during the manufacturing operation, great surface finish and detail are characteristic of true centrifugal casting.

- Quality castings with good dimensional accuracy can be produced with this process.

- Material of high density and with few impurities is produced in the outer regions of cylindrical parts manufactured by true centrifugal casting.

- Impurities, such as metal inclusions and trapped air, collect in the lower density inner regions of cylindrical parts cast with this process.

- These inner regions can be machined out of the cast part leaving only the dense, more pure material.

- Shrinkage is not a problem when manufacturing by true centrifugal casting, since material from the inner sections will constantly be forced to instantly fill any vacancies that may occur in outer sections during solidification.

- This method can produce very large metal castings. Cylindrical pipes 10 feet in diameter and 50 feet long have been manufactured using this technique.

- With the employment of a sand lining in the mold it is possible to manufacture castings from high melting point materials such as iron and steels.

- This is a large batch production operation.

- True centrifugal casting is a manufacturing process that is capable of very high rates of productivity.

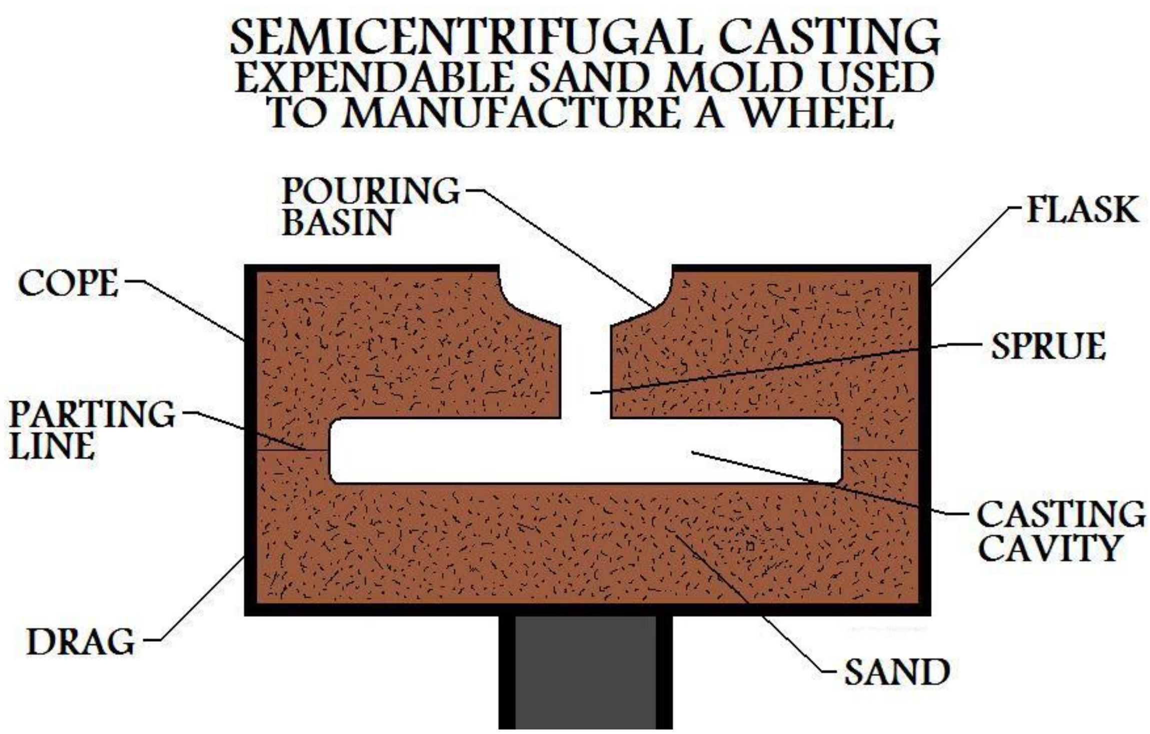
Semicentrifugal Casting

Semicentrifugal casting manufacture is a variation true centrifugal casting. The main difference is that in semicentrifugal casting the mold is filled completely with molten metal, which is supplied to the casting through a central sprue. Castings manufactured by this process will possess rotational symmetry. Much of the details of the manufacturing process of semicentrifugal casting are the same as those of true centrifugal casting. For a better understanding of this process and centrifugal casting manufacture in general see true centrifugal casting. Parts manufactured in industry using this casting process include such things as pulleys, and wheels for tracked vehicles.

The Process

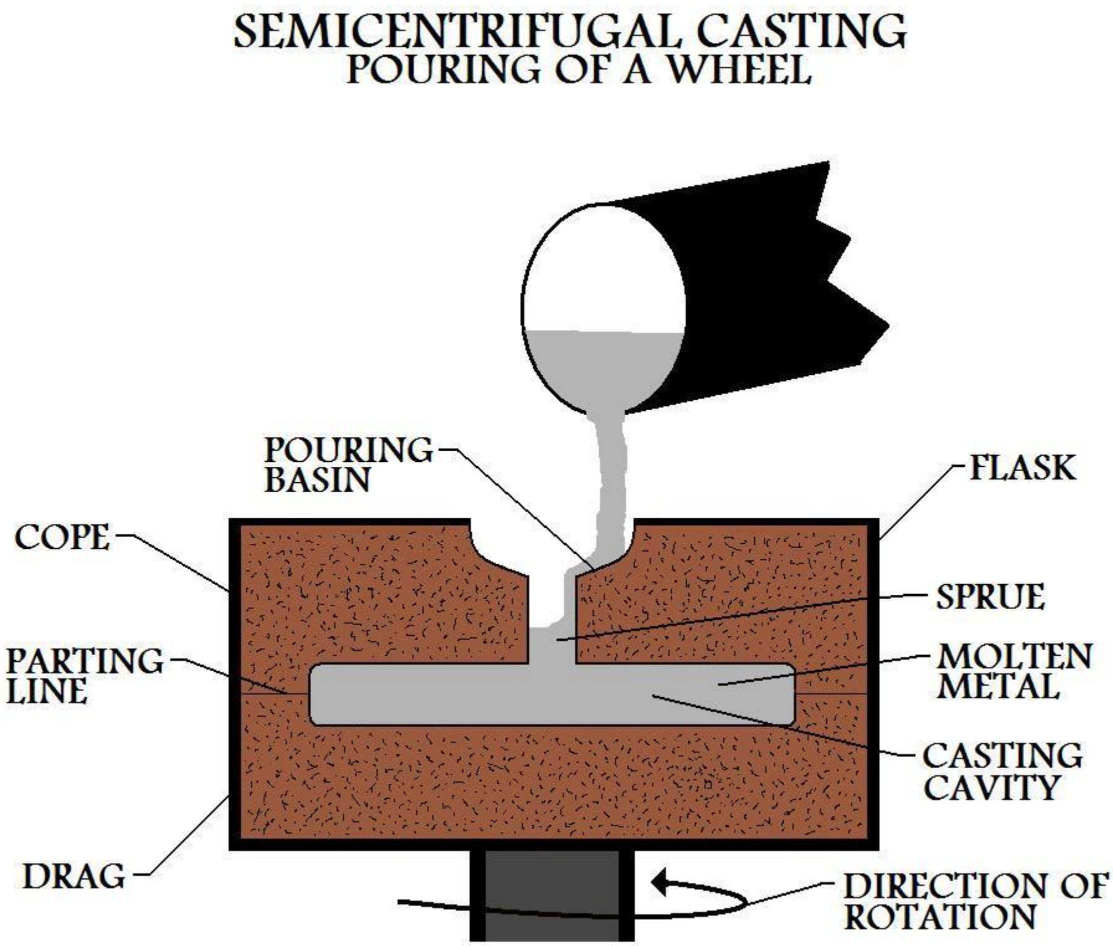
In semicentrifugal casting manufacture a permanent mold may be employed. However often industrial manufacturing processes will utilize an expendable sand mold. This enables the casting of parts from high temperature materials.

Figure:96



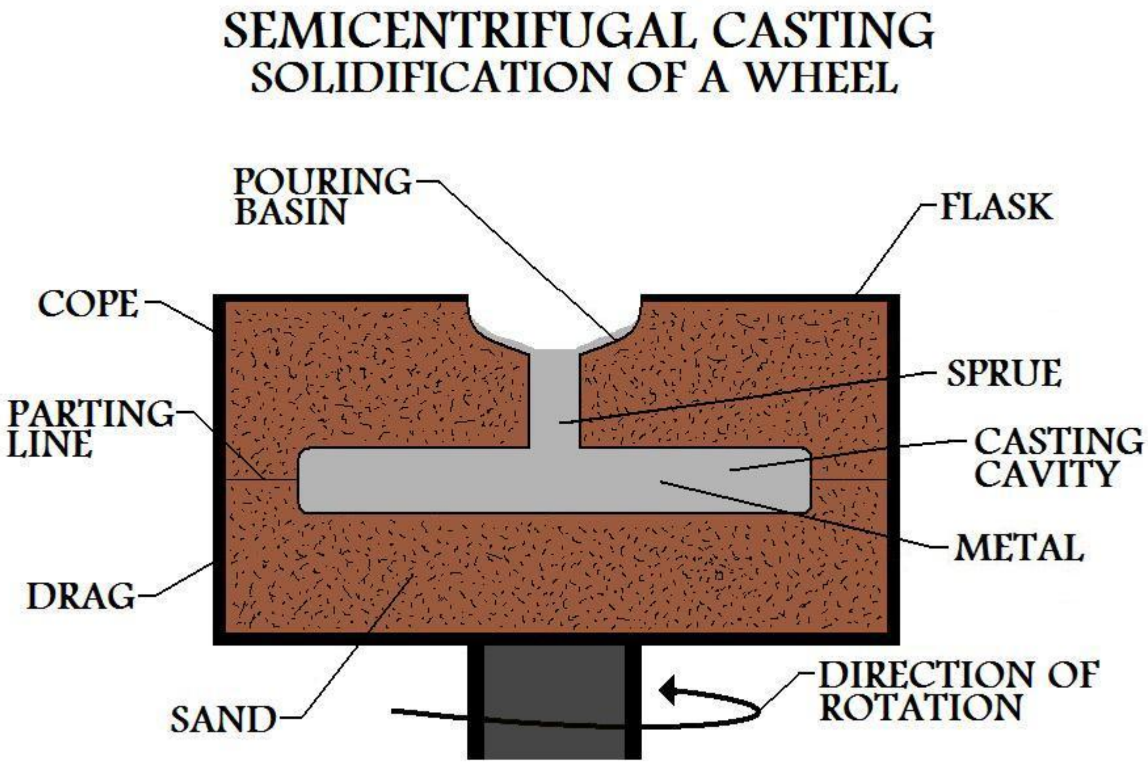
The molten material for the metalcasting is poured into a pouring basin and is distributed through a central sprue to the areas of the mold. The forces generated by the rotation of the mold ensure the distribution of molten material to all regions of the casting.

Figure:97



As the casting solidifies in a rotating mold, the centripetal forces constantly push material out from the central sprue/riser. This material acts to fill vacancies as they form thus avoiding shrinkage areas.

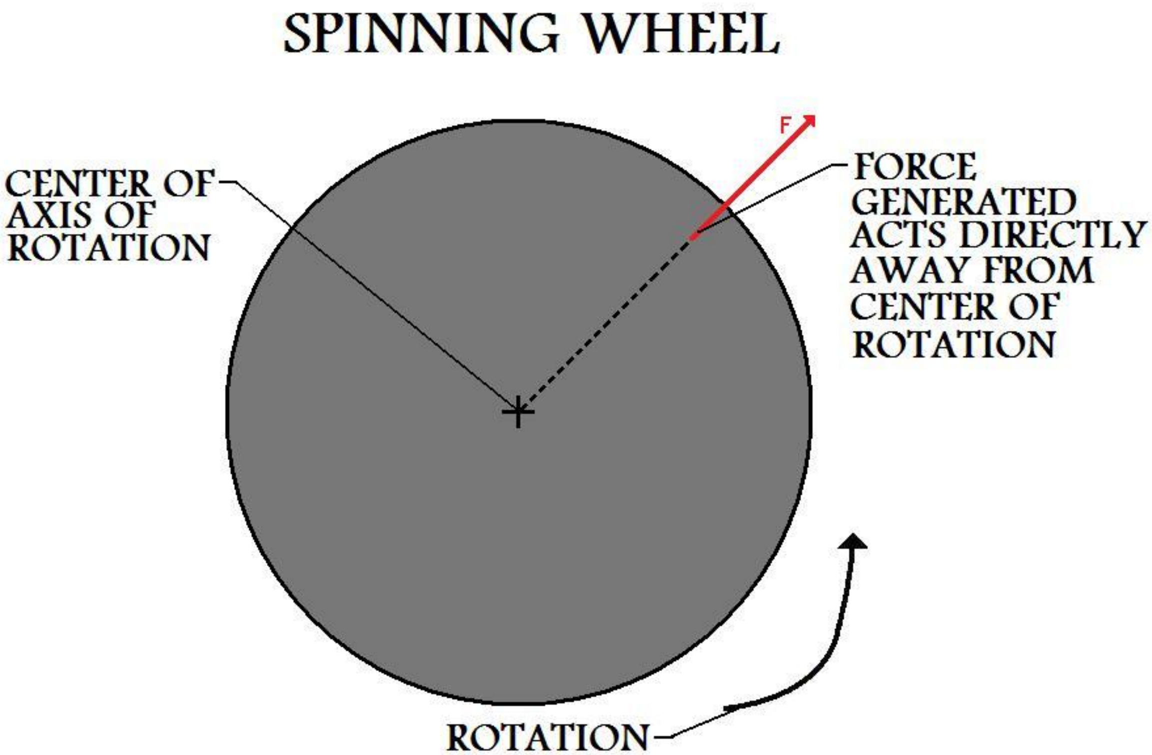
Figure:98



The centripetal forces acting on the casting's material during the manufacturing process of semi-centrifugal casting, play a large part in determining the properties of the final cast part. This is also very much the case with cast parts manufactured using the true centrifugal casting process. The forces acting in the true centrifugal process are similar to those that influence the material of a casting being manufactured by semi-centrifugal casting.

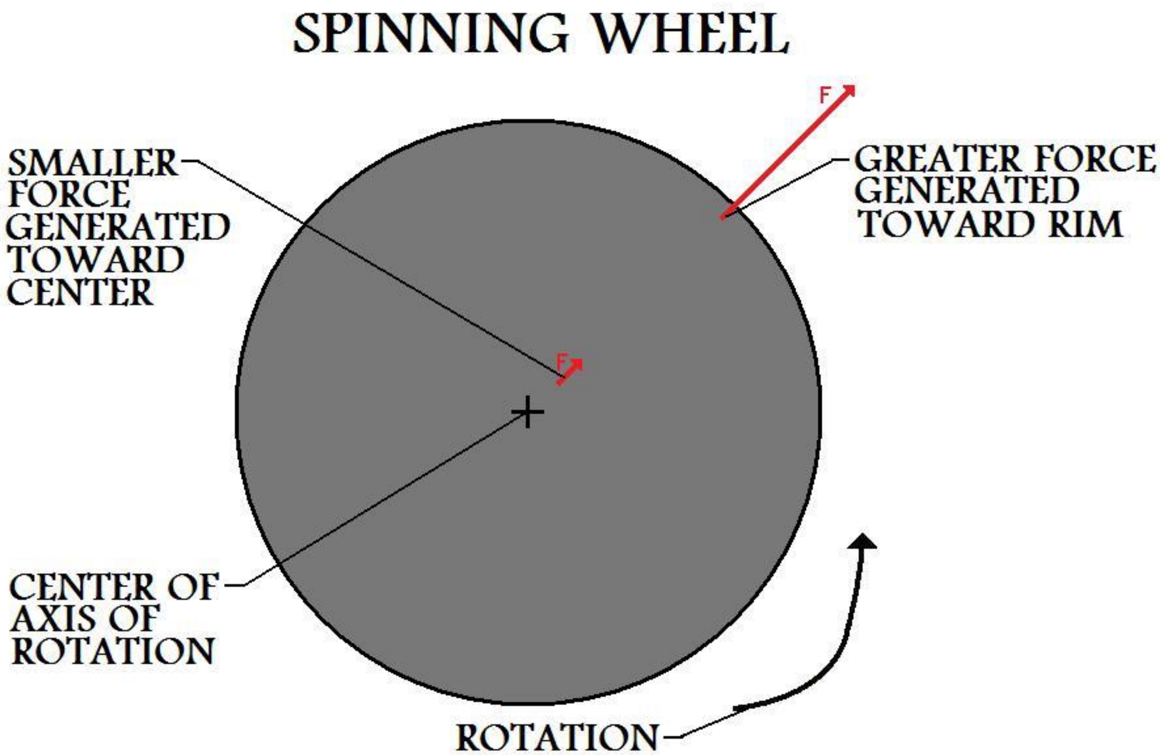
When manufacturing by semicentrifugal casting the centripetal acceleration generated on the mass of molten metal by a rotating mold is the force that acts to fill the casting with this molten metal. This is also the force that continues to act on the material as the casting solidifies. The main thing to remember about centripetal forces is that the force will push in a direction that is directly away from the center of the axis of rotation.

Figure:99



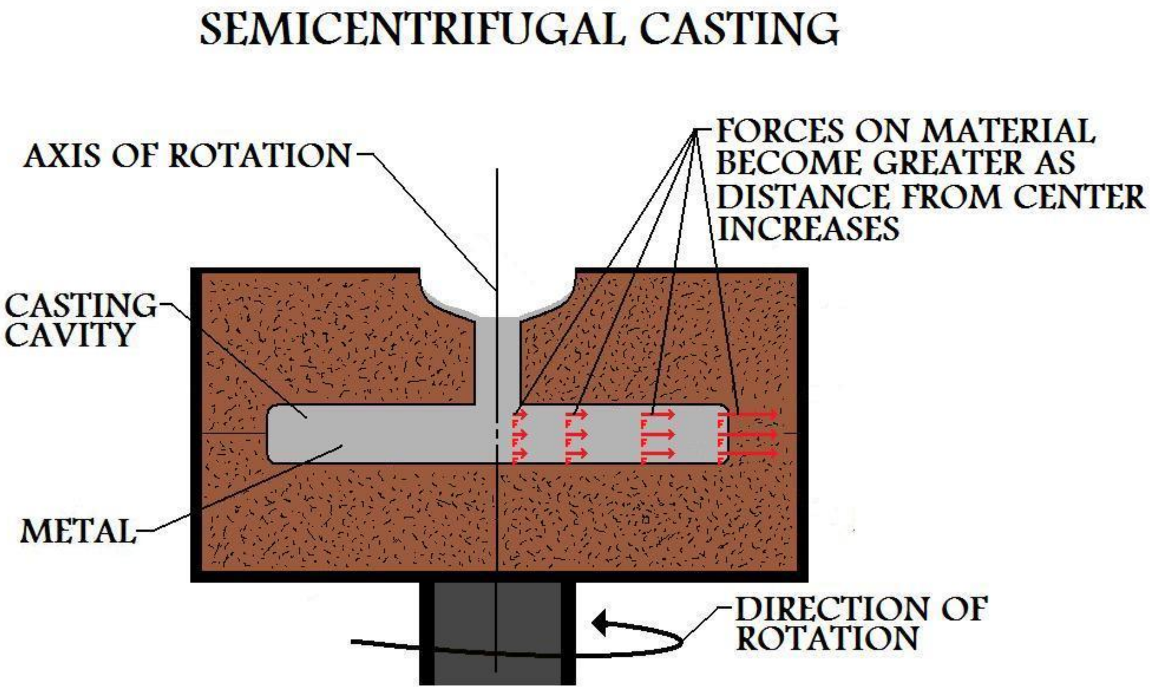
Also the farther away from the center of the axis of rotation the greater the force.

Figure:100



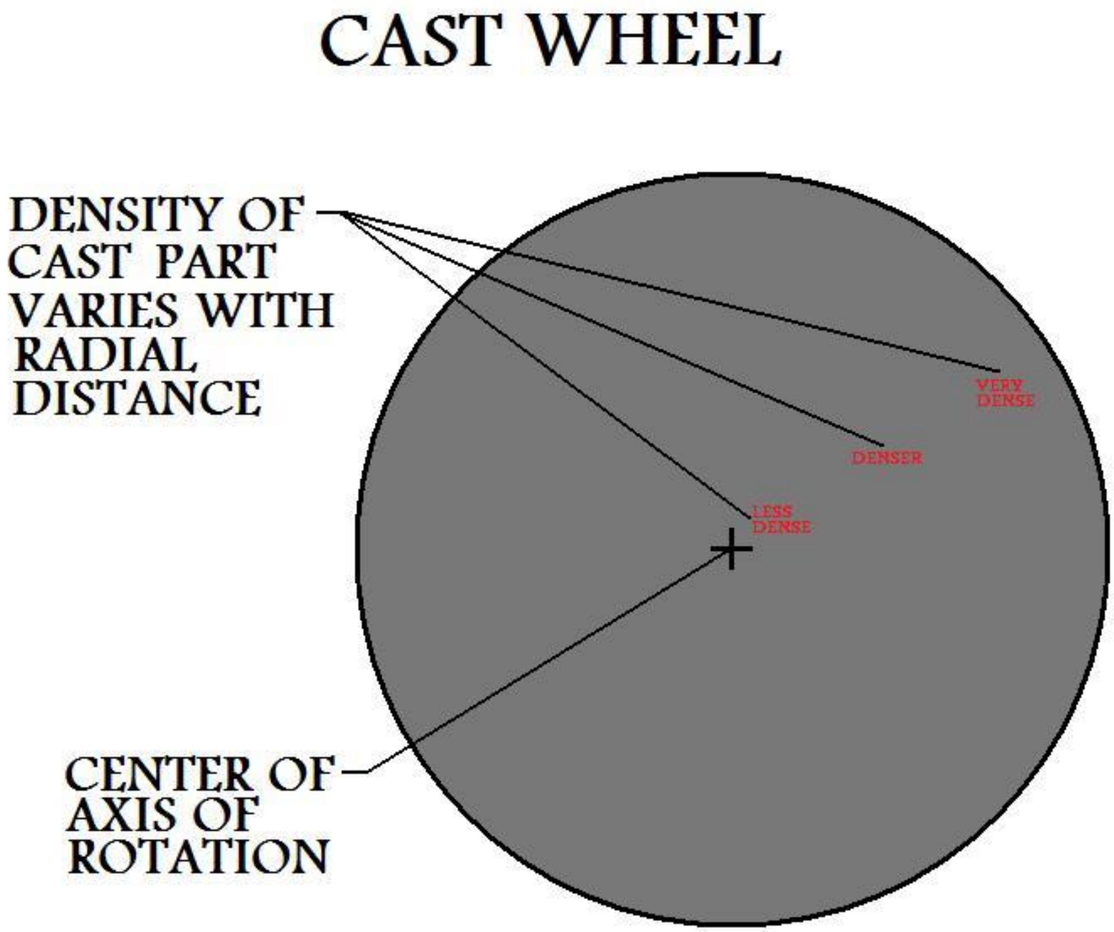
It can be seen that during the semicentrifugal manufacturing process the material in the outer regions of the casting, (further from the center of the axis of rotation), is subject to greater forces than the material in the inner regions.

Figure:101



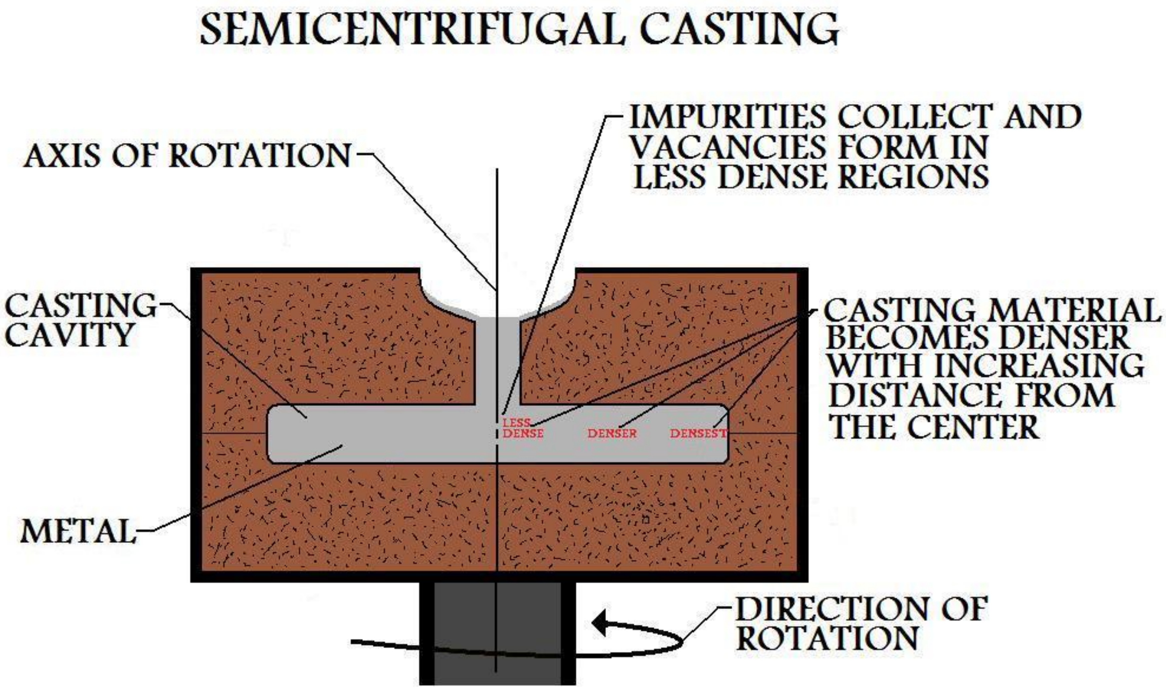
When the casting solidifies the outer region of the cast part forms of dense material. The greater the forces under which the molten metal solidified the denser the material in that region. So the density of a cast part manufactured by semicentrifugal casting will increase as you travel radially outward from the center.

Figure:102



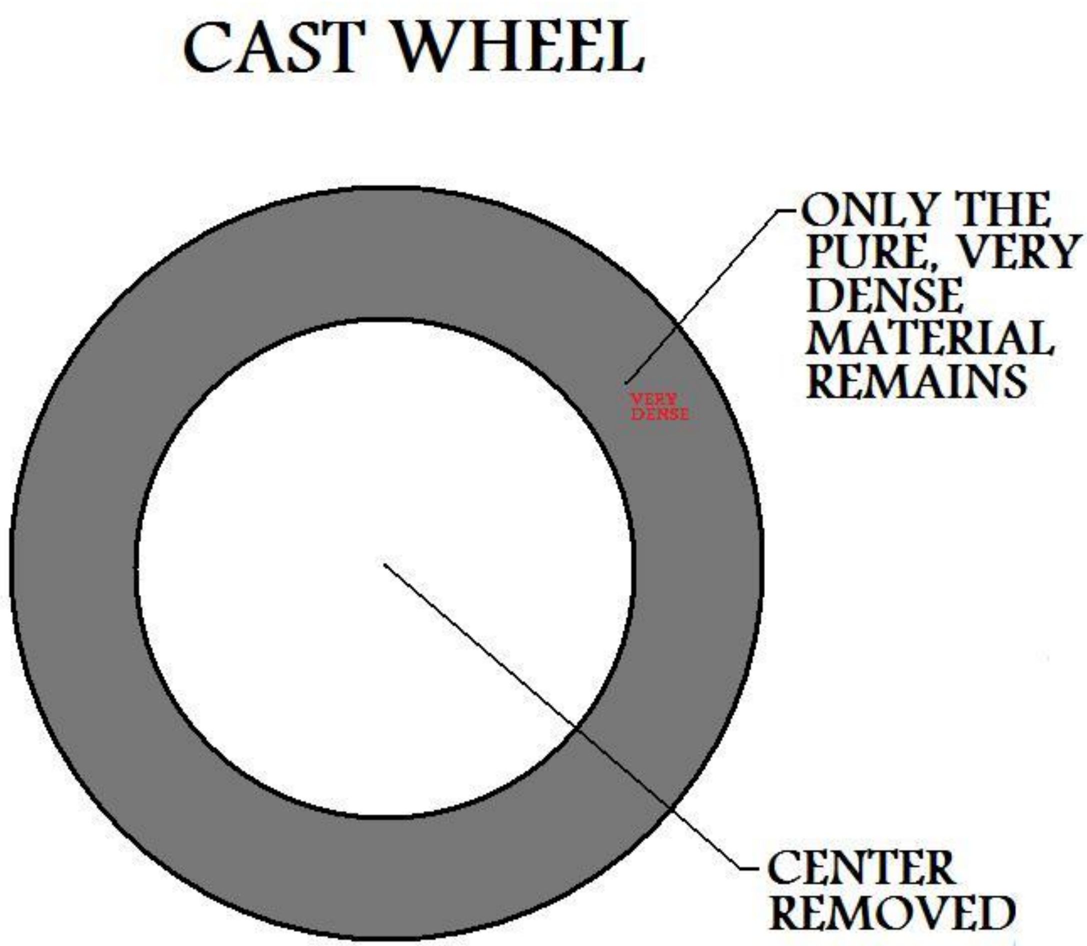
The high forces in the outer section that push the molten material against the mold wall also ensure a great surface finish of cast parts manufactured by semicentrifugal casting. Another feature of this process, attributed to the usage of centripetal forces, is that impurities within the metal, (such as solid inclusions and trapped air), will form towards the inner regions of the casting. This occurs because the metal itself is denser than the impurities, denser material subject to centripetal forces will tend to move towards the rim forcing less dense material to the inner regions. This particular detail is also a feature in other types of centrifugal casting manufacture.

Figure:103



In industrial manufacture of parts by semicentrifugal casting it is common to machine out the impurity filled center section, leaving only the purer, denser outer region as the final cast part.

Figure:104


CAST WHEEL
ONLY THE PURE, VERY DENSE MATERIAL REMAINS
VERY DENSE
CENTER REMOVED

Die Casting Manufacture

Die casting is a permanent mold manufacturing process that was developed in the early 1900's. Die casting manufacture is characteristic in that it uses large amounts of pressure to force molten metal through the mold. Since so much pressure is used to ensure the flow of metal through the mold, metal castings with great surface detail, dimensional accuracy, and extremely thin walls can be produced. Wall thickness within castings can be manufactured as small as .02in (.5mm). The size of industrial metal castings created using this process vary from extremely small to around 50lbs. Typical parts made in industry by die casting include tools, toys, carburetors, machine components, various housings, and motors.

The Process

The Mold

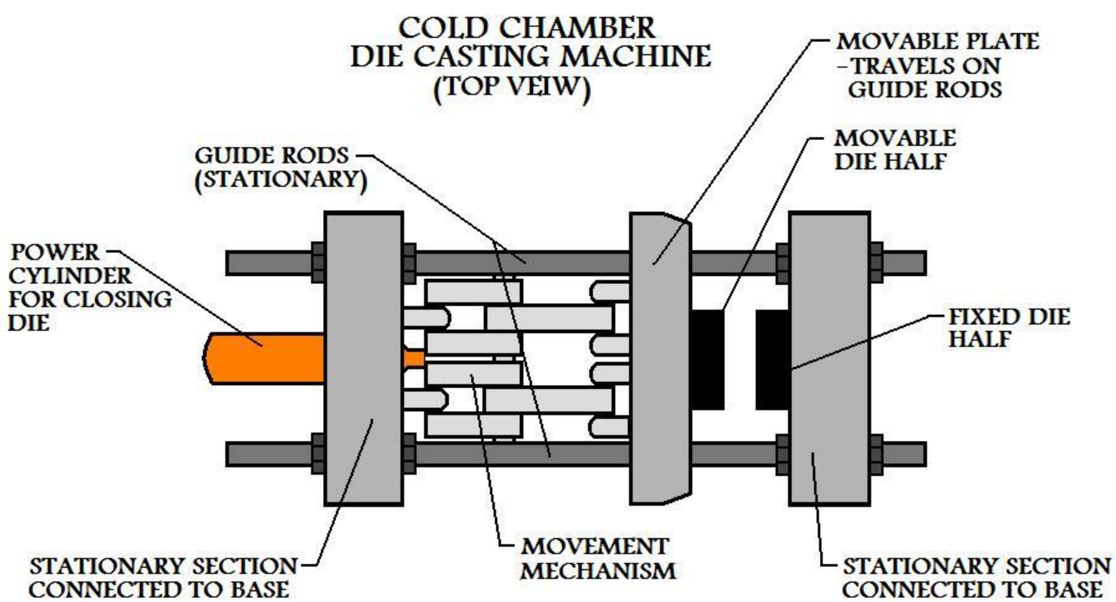
Like in all permanent mold manufacturing processes the first step in die casting is the production of the mold. The mold must be accurately created as two halves that can be opened and closed for removal of the metal casting similar to the basic permanent mold casting process. The mold for die casting is commonly machined from steel and contains all the components of the gating system. *Multi-cavity die* are employed in manufacturing industry to produce several castings with each cycle. *Unit dies* which are a combination of smaller dies are also used to manufacture castings in industry.

In a die casting production setup the mold, (or die), is designed so that its mass is far greater than that of the casting. Typically the mold will have 1000 the mass of the metal casting. So a 2 pound part will require a mold weighing a ton! Due to the extreme pressures and the continuous exposure to thermal gradients from the molten metal, wearing of the die can be a problem. However in a well maintained manufacturing process a die can last hundreds of thousands of cycles before needing to be replaced.

Die Casting Machines

In addition to the opening and closing of the mold to prepare for and remove castings, it is very important that there is enough force that can be applied to hold the two halves of the mold together during the injection of the molten metal. Flow of molten metal under such pressures will create a tremendous force acting to separate the die halves during the process. Die Casting Machines are large and strong, designed to hold the mold together against such forces.

Figure:81

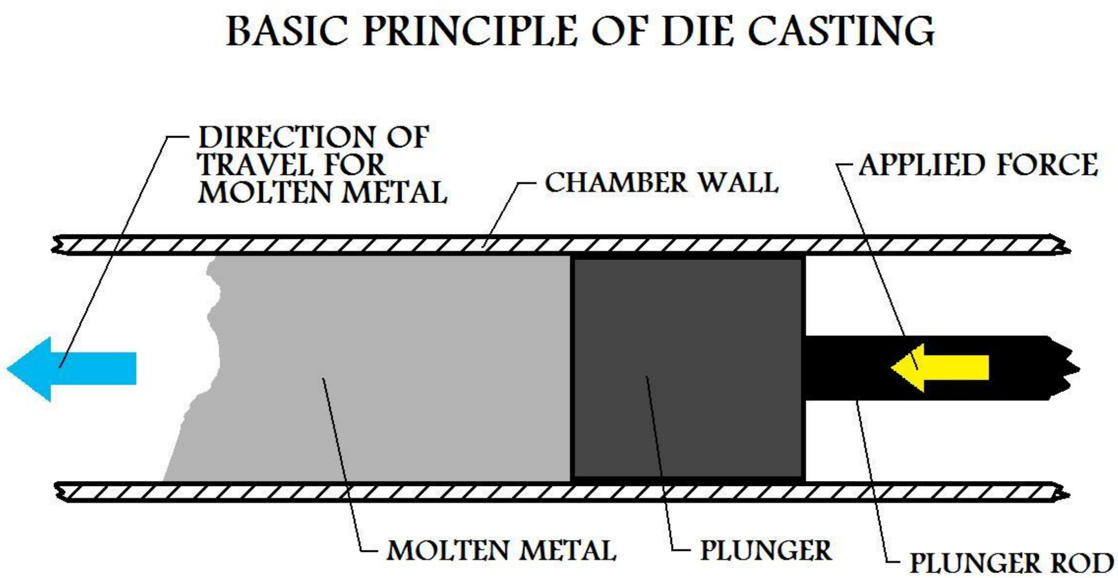


In manufacturing industry die casting machines are rated on the force with which they can hold the mold closed. Clamping forces for these machines vary from around 25 to 3000 tons.

Injection Of Molten Metal

In industrial manufacture the process of die casting falls into two basic categories hot chamber die casting and cold chamber die casting. Each process will be discussed specifically in more detail later. Although these processes vary from each other, both employ a piston or plunger to force molten metal to travel in the desired direction.

Figure:82



The pressure at which the metal is forced to flow into the mold in die casting manufacture is on the order of 1000psi to 50000psi (7MPa to 350MPa). This pressure is accountable for the tremendously intricate surface detail and thin walls that are often observed in castings manufactured with this technique.

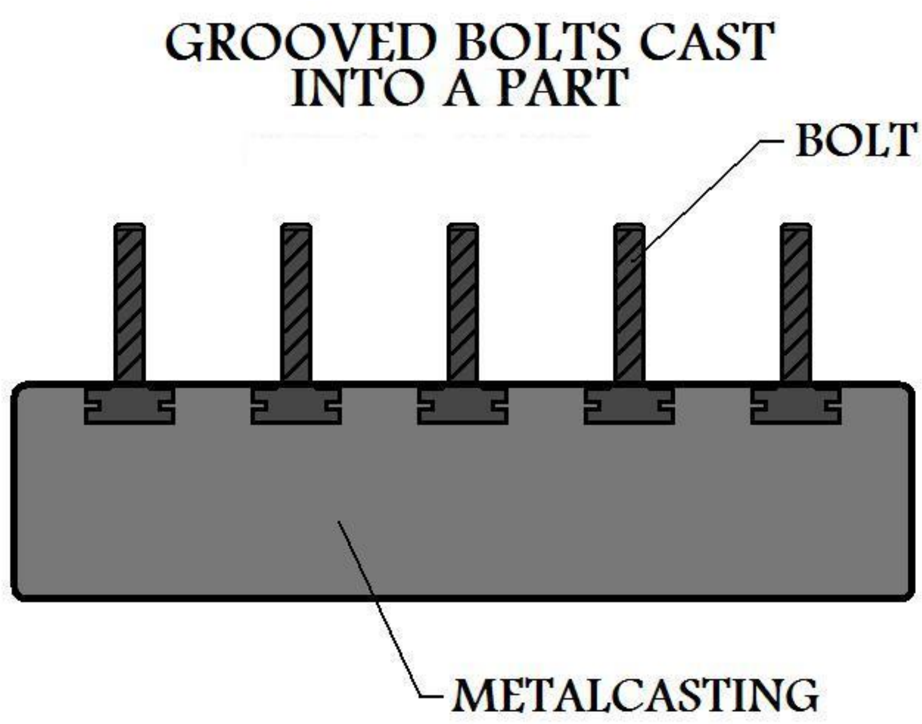
Once the mold has been filled with molten metal the pressure is maintained until the casting has hardened. The mold is then opened and the casting is removed. Ejector pins built into the mold assist in the removal of the metal casting. In most manufacturing operations the internal surfaces of the mold are sprayed with a lubricant before every cycle. The lubricant will assist in cooling down the dies as well as preventing the metal casting from sticking to the mold.

After the casting has been removed and the lubricant applied to the mold surfaces the die are clamped together again then the cycle will repeat itself. Cycle times will differ depending upon the details of each specific die casting manufacturing technique. In some instances very high rates of production have been achieved using this process.

Insert Molding

With the die casting process shafts, bolts, bushings, and other parts can be inserted into the mold and the metalcasting may be formed around these parts. This is called insert molding, once solidified these parts become one with the casting. To help with the integration of the part into the casting the part may be grooved or knurled providing a stronger contact surface between the part and the molten metal.

Figure:83



Properties And Considerations Of Manufacturing By Die Casting

- Castings with close tolerances, tremendous, surface detail, and thin intricate walls can be manufactured using this process.

- Due to the rapid cooling at the die walls smaller grain structures are formed resulting in manufactured castings with superior mechanical properties. This is especially true of the thinner sections of the casting.

- In manufacturing industry it is of concern to keep the mold cool. Die may have special passages built into them that water is cycled through in order to keep down thermal extremes.

- High production rates are possible in die casting manufacture.

- Since mold is not permeable adequate vents need to be provided for the elimination of gases during the casting process. These vents are usually placed along the parting line between the die.

- Due to the high pressures a thin flash of metal is usually squeezed out at the parting line. This flash has to be trimmed latter from the casting.

- Ejector pins will usually leave small round marks on the casting. These can be observed on the surfaces of manufactured parts.

- The need to open and close the mold limits some of the shapes and casting geometries that may be cast with this process.

- Equipment cost for die casting are generally high.

- Die casting manufacture can be highly automated making labor cost low.

- Die casting is similar to most other permanent mold manufacturing processes in that high set up cost, and high productivity make it suitable for large batch manufacture and not small production runs.

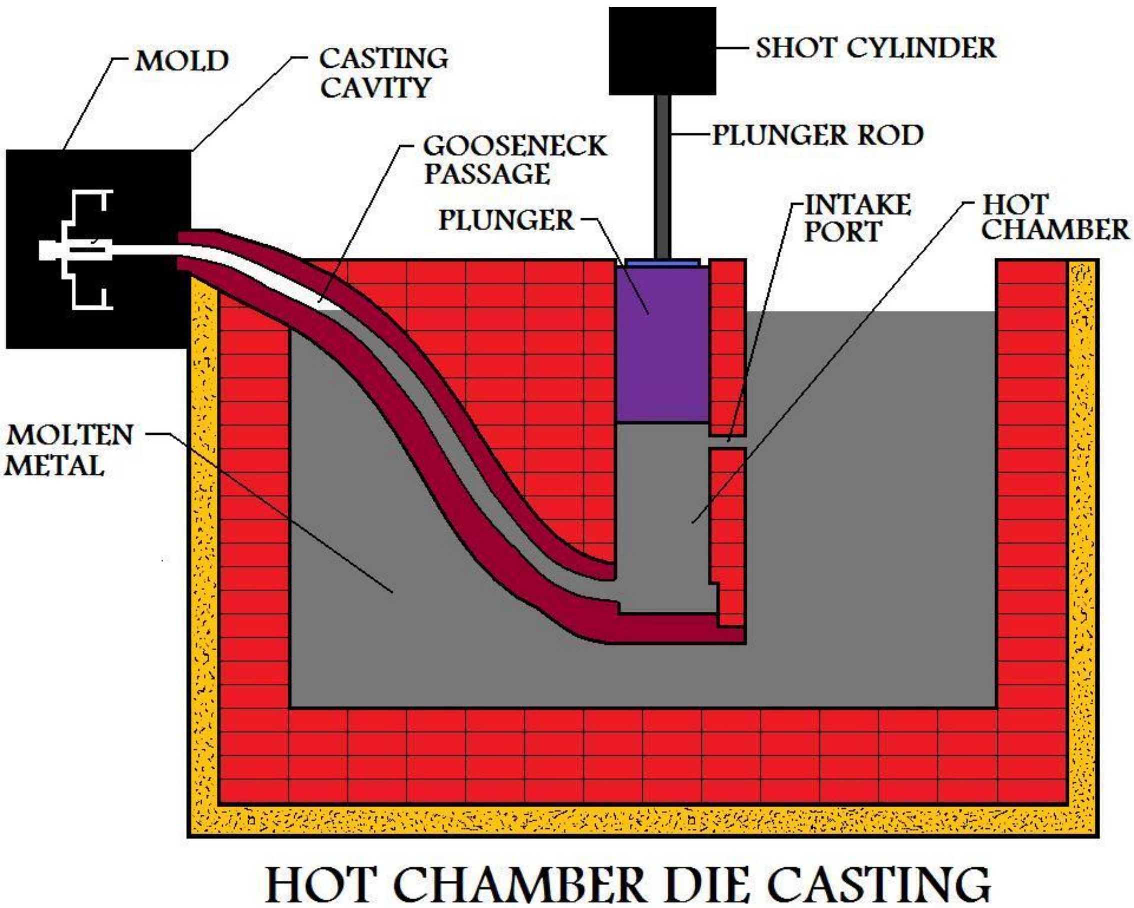
Hot Chamber Die Casting

Hot chamber die casting is one of the two main techniques in the manufacturing process of die casting. This section will primarily discuss the specific details of the hot chamber process and contrast the differences between hot chamber die casting and cold chamber die casting, which is the other branch of die casting manufacture.

Hot Chamber Process

A similar characteristic of either die casting process is the use of high pressure to force molten metal through a mold called a die. Many of the superior qualities of castings manufactured by die casting, (such as great surface detail), can be attributed to the use of pressure to ensure the flow of metal through the die. In hot chamber die casting manufacture the supply of molten metal is attached to the die casting machine and is an integral part of the casting apparatus for this manufacturing operation.

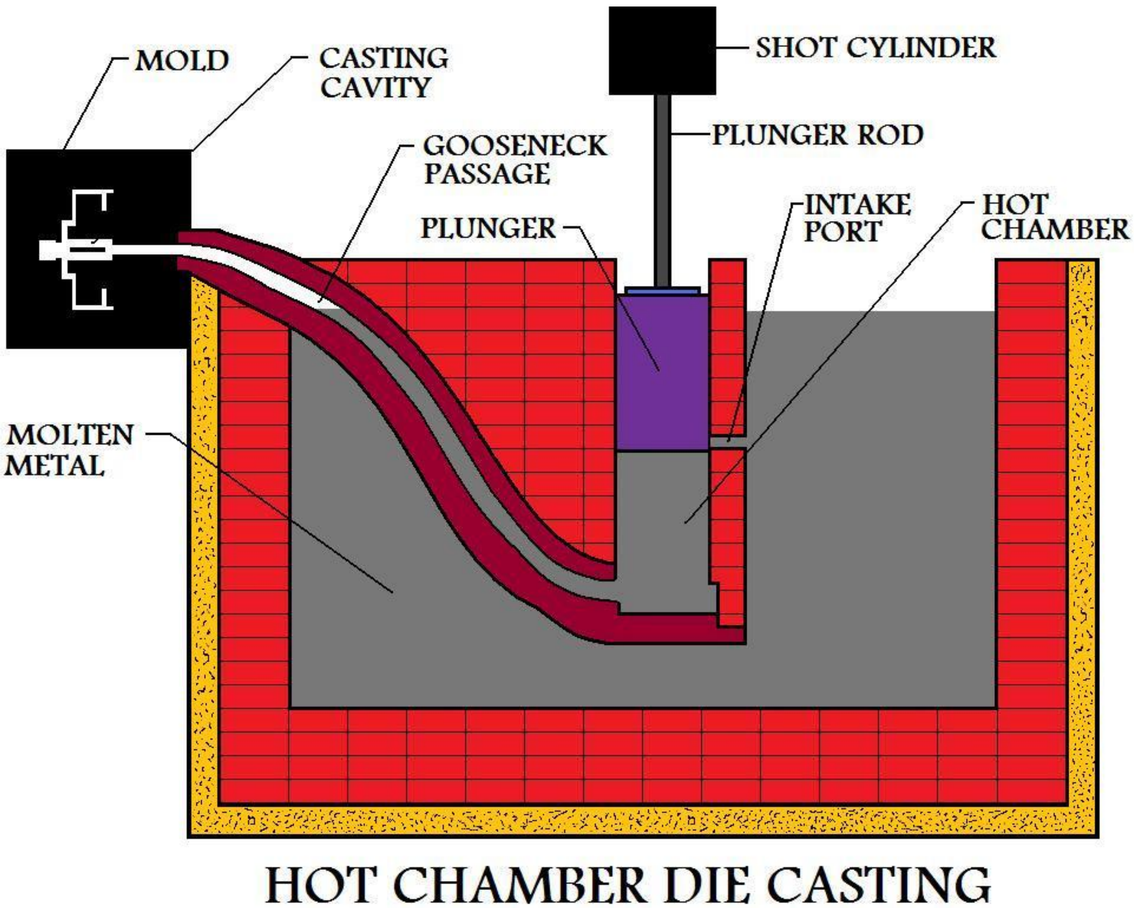
Figure:84



The shot cylinder provides the power for the injection stroke. It is located above the supply of molten metal. The plunger rod goes from the shot cylinder down to the plunger, which is in contact with the molten material. At the start of a casting cycle the plunger is at the top of a chamber (the hot-chamber). Intake ports allow this chamber to fill with liquid metal.

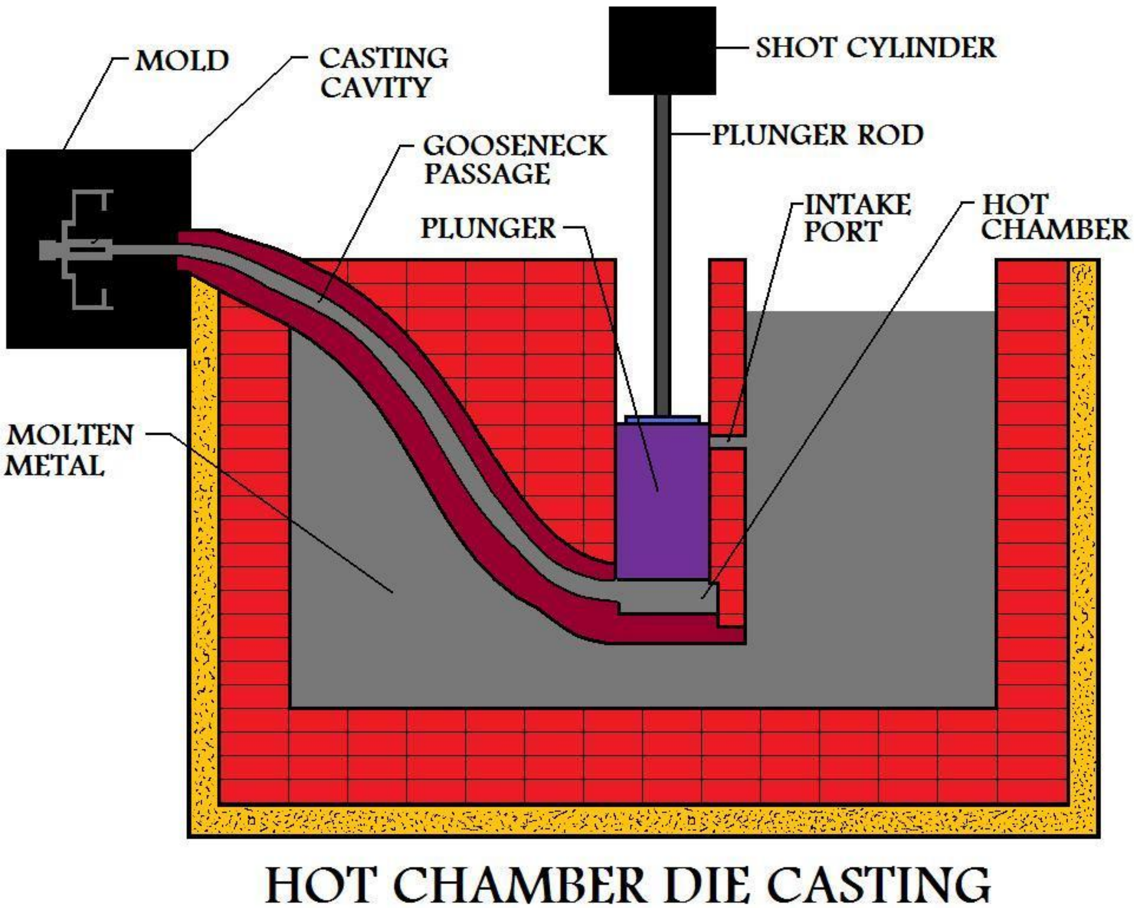
As the cycle begins the power cylinder forces the plunger downward. The plunger travels past the ports cutting off the flow of liquid metal to the hot chamber. Now there should be the correct amount of molten material in the chamber for the "shot" that will be used to fill the mold and produce the casting.

Figure:85



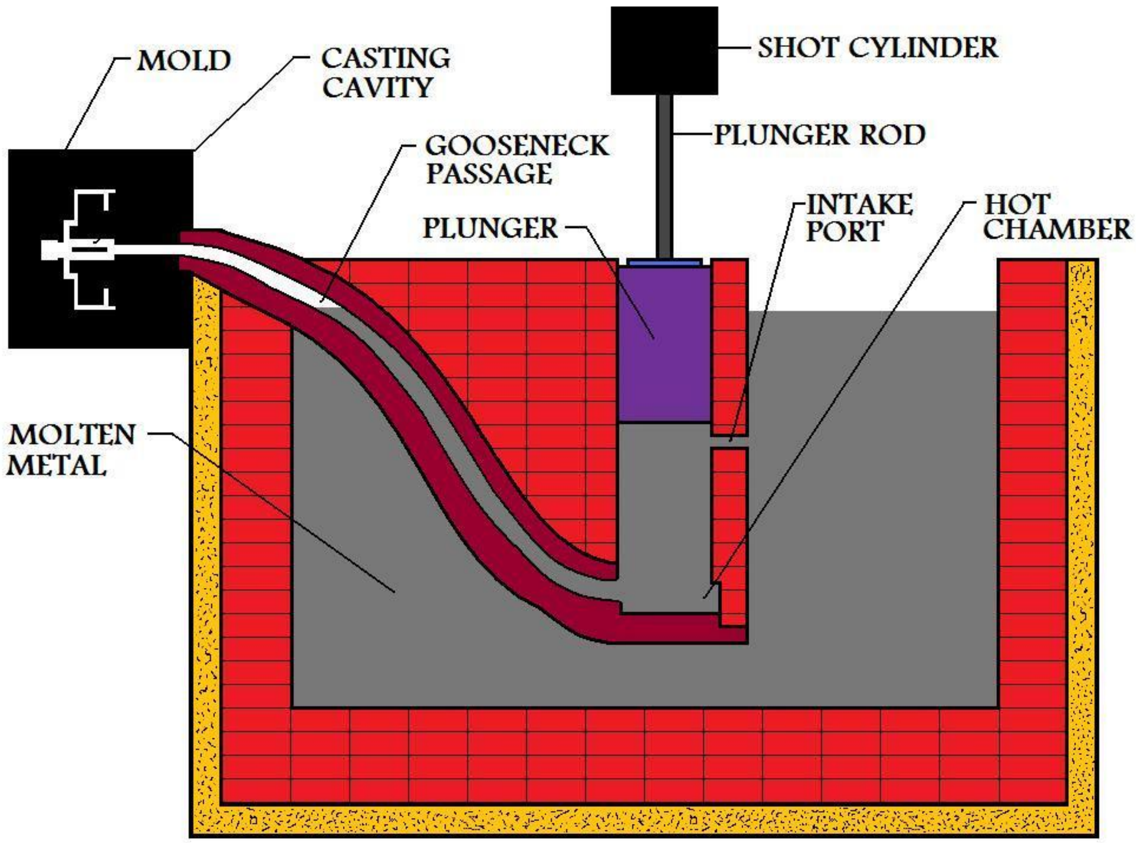
At this point the plunger travels further downward forcing the molten metal into the die. The pressure exerted on the liquid metal to fill the die in hot chamber die casting manufacture usually varies from about 700psi to 5000psi (5MPa to 35 MPa). The pressure is held long enough for the casting to solidify.

Figure:85



In preparation for the next cycle of casting manufacture the plunger travels back upward in the hot chamber exposing the intake ports again and allowing the chamber to refill with molten material.

Figure:86



HOT CHAMBER DIE CASTING

For more extensive details on the setup of the mold, the die casting process, or the properties and considerations of manufacturing by die casting see die casting for the basics of the process.

Hot chamber die casting has the advantage of a very high rate of productivity. During industrial manufacture by this process one of the disadvantages is that the setup requires that critical parts of the mechanical apparatus, (such as the plunger), must be continuously submersed in molten material. Continuous submersion in a high enough temperature material will cause thermal related damage to these components rendering them inoperative. For this reason usually only lower melting point alloys of lead, tin, and zinc are used to manufacture castings with the hot chamber die casting process.

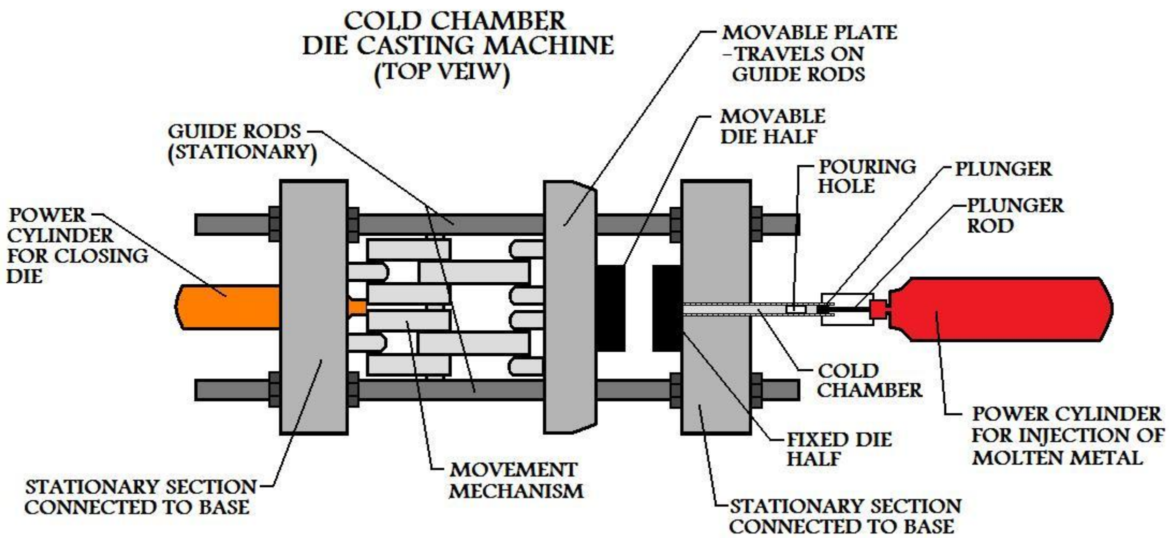
Cold Chamber Die Casting

Cold chamber die casting is the second of the two major branches of the die casting manufacturing process. This section will discuss cold chamber die casting specifically and contrast it with the hot chamber process discussed previously. For a basic view of die casting in general see die casting manufacture.

Cold Chamber Process

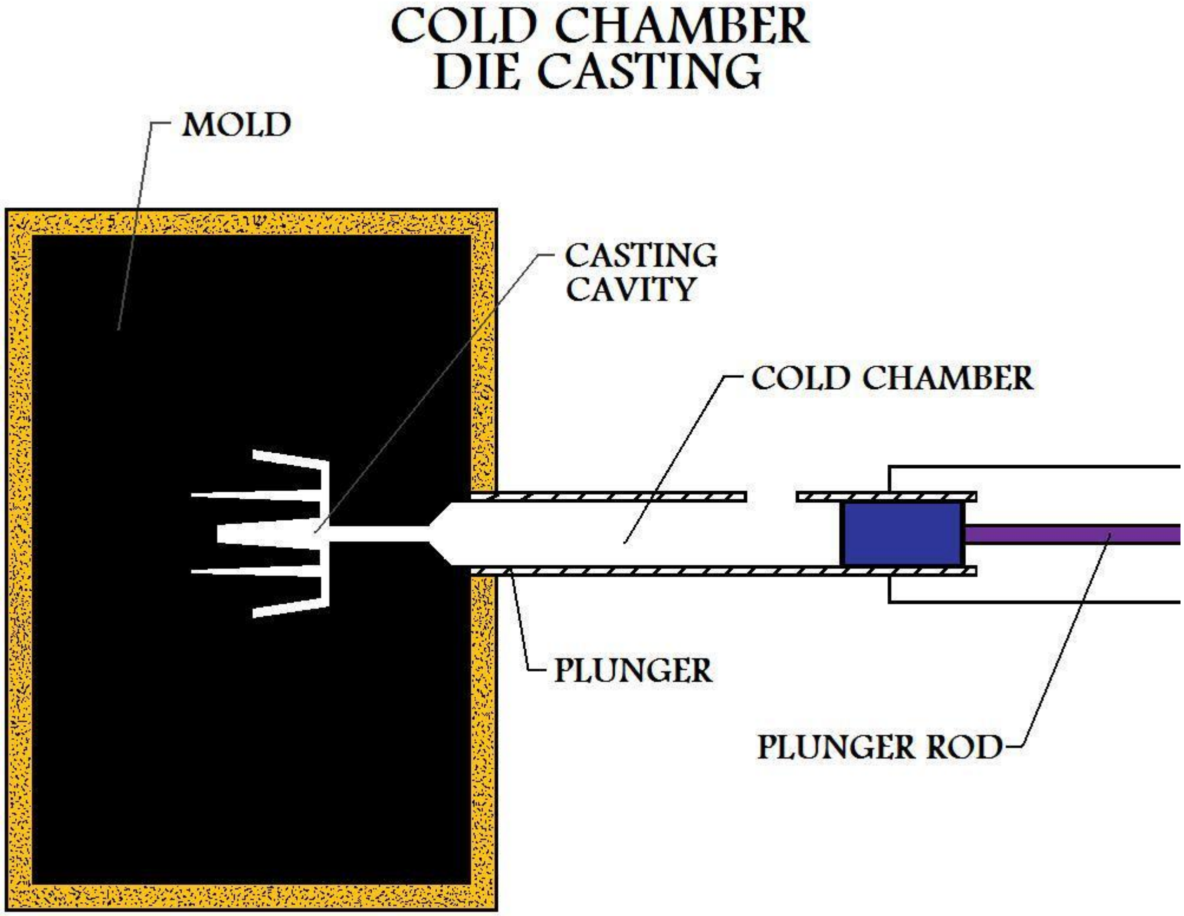
Cold chamber die casting is a permanent mold metal casting process, a reusable mold gating system and all is employed. It is most likely machined precisely from two steel blocks. Large robust machines are used to exert the great clamping force necessary to hold the two halves of the mold together against the tremendous pressures exerted during the manufacturing process.

Figure:87



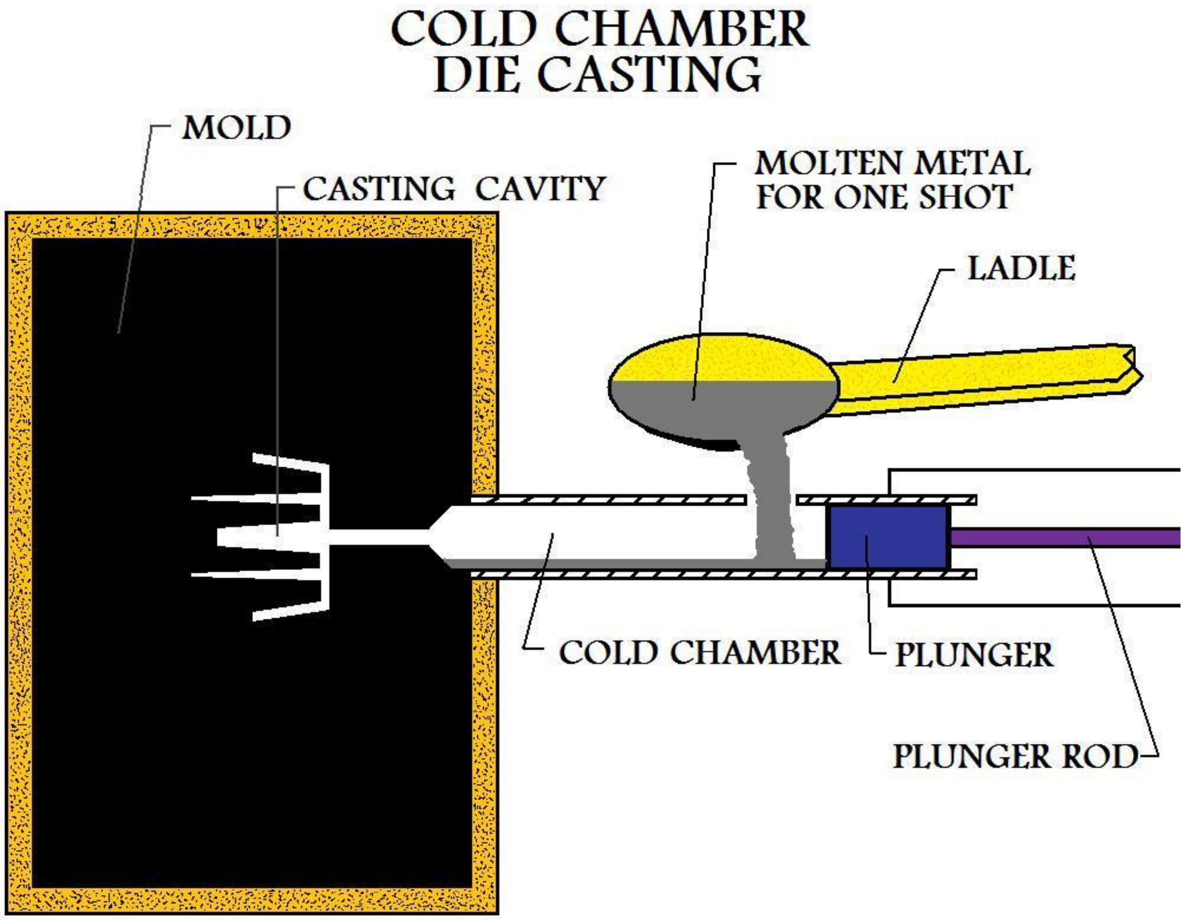
A metal shot chamber (cold-chamber) is located at the entrance of the mold. A piston is connected to this chamber which in turn is connected to a power cylinder.

Figure:88



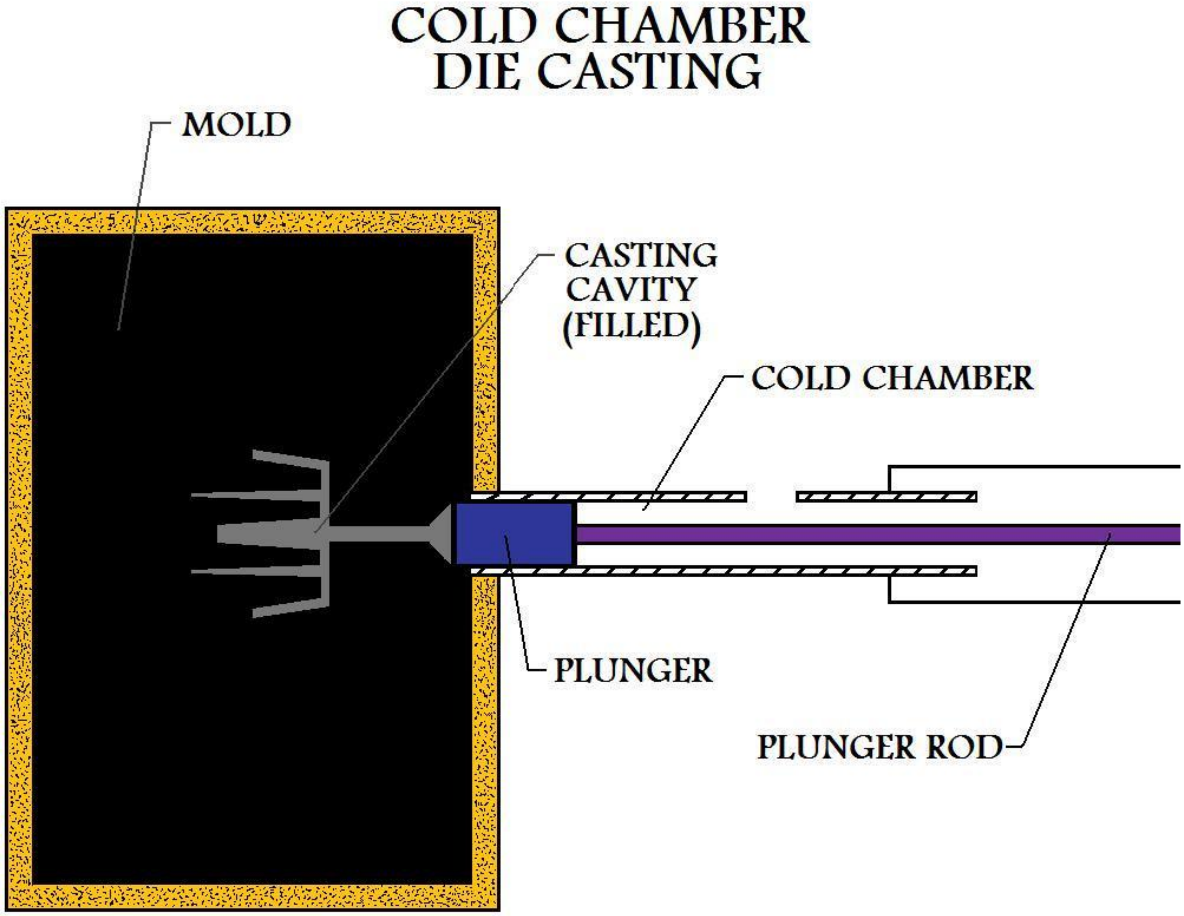
At the start of the manufacturing cycle the correct amount of molten material for a single shot is poured into the shot chamber from an external source holding the material for the metal casting.

Figure:89



The power cylinder forces the piston forward in the chamber cutting off the intake port. The power cylinder moves the piston forward which forces the molten material into the casting mold with great pressure. The pressure causes the liquid metal to fill in even thin sections of the metal casting and press the mold walls for great surface detail. The pressure is maintained even after the injection phase of casting manufacture.

Figure:90



Once the metal casting begins to solidify the pressure is released. Then the mold is opened and the casting is removed by way of ejector pins. The mold is sprayed with lubricant before closing again, and the piston is withdrawn in the shot chamber for the next cycle of production.

Cold Chamber Die Casting For Manufacture

The main difference between cold-chamber die casting and hot-chamber die casting manufacture is that in the cold-chamber process the molten metal for the casting is introduced to the shot chamber from an external source, while in the hot chamber process, the source of molten material is attached to the machine. In the hot-chamber process certain machine apparatus is always in contact with molten metal. For this reason higher melting point materials will create a problem for the machinery in a hot-chamber metal casting setup. Since the liquid metal is brought in from an outside source the die casting machinery is able to stay much cooler in a cold-chamber process.

Consequently higher melting point alloys of aluminum, brass, copper, and aluminum-zinc are often cast in manufacturing industry using cold chamber die casting. It is very possible to manufacture castings from lower melting point alloys using the cold-chamber method. When considering industrial metal casting manufacture however the advantages of production by the hot-chamber process usually make it the more suitable choice for lower melting point alloys.

In the cold chamber die casting process, material must be brought in for every shot or cycle of production. This slows down the production rate for metal casting manufacture. Where in the hot chamber process castings can be constantly outputted. Cold chamber die casting should still be considered a high production manufacturing process.

In comparison with the hot die casting process, the cold die casting process requires the application of more pressure. The pressure at which the molten metal is forced into and fills the die cavity in cold chamber metal casting manufacture typically outranks the pressure used to fill the die in hot chamber metal casting by about an order of magnitude. Pressures of 3000psi to 50000psi (20MPa to 350MPa) may be used in manufacturing industry to fill the mold cavities with molten material during cold chamber die casting manufacture. Castings manufactured by cold chamber die casting have all the advantages characteristic of the die casting process, such as intricate detail, thin walls, and superior mechanical properties. The significant initial investment into this manufacturing process makes it suitable for high production applications.

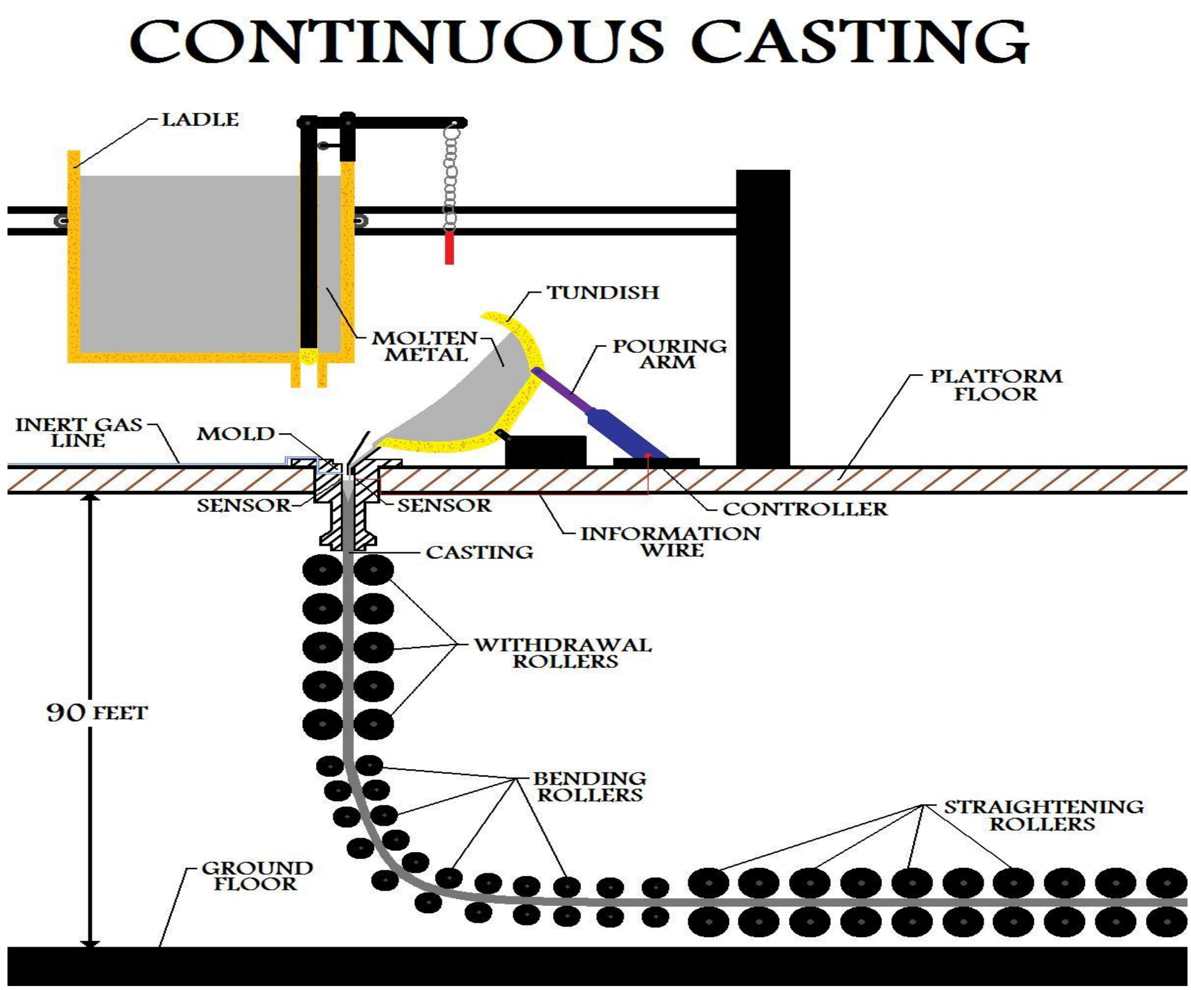
Continuous Casting

Continuous casting also referred to as strand casting is a process used in manufacturing industry to cast a continuous length of metal. Molten metal is cast through a mold the casting takes the two dimensional profile of the mold but its length is indeterminate, the casting will keep traveling downward its length increasing with time. New molten metal is constantly supplied to the mold at exactly the correct rate to keep up with the solidifying casting. Industrial manufacture of continuous castings is a very precisely calculated operation. Continuous casting can produce long slabs from aluminum and copper, also the process has been developed for the production of steel.

The Process

Molten metal from some nearby source is poured into a **Tundish**. A tundish is a container that is located above the mold, it holds the liquid metal for the casting. This particular casting operation uses the force of gravity to fill the mold and to help move along the continuous metalcasting. The tundish is where the operation begins and is thus located high above ground level, as much as eighty or ninety feet. As can be seen the continuous casting operation may require a lot of space.

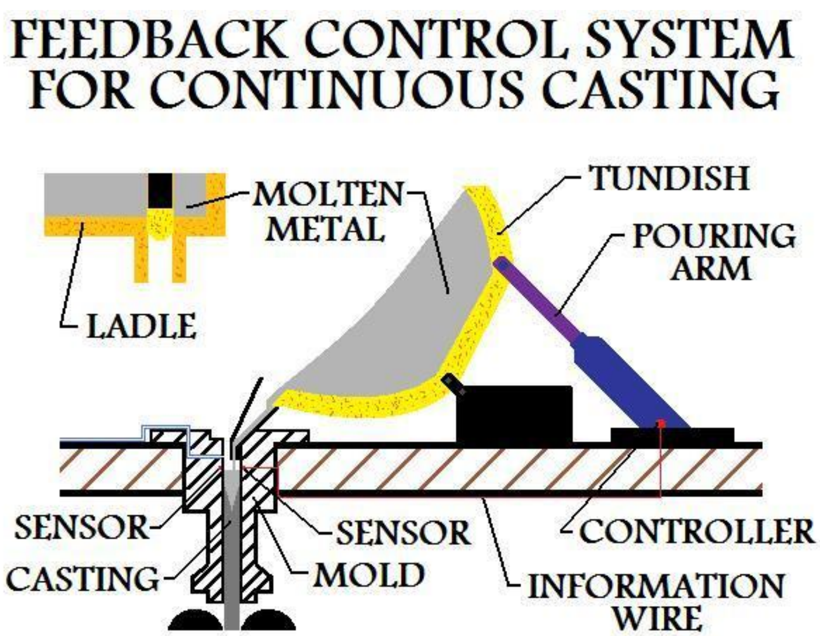
Figure:119



It is the job of the tundish to keep the mold filled to the right level throughout the manufacturing operation. Since the casting is constantly moving through the mold, the tundish must always be supplying the mold with more molten metal to compensate.

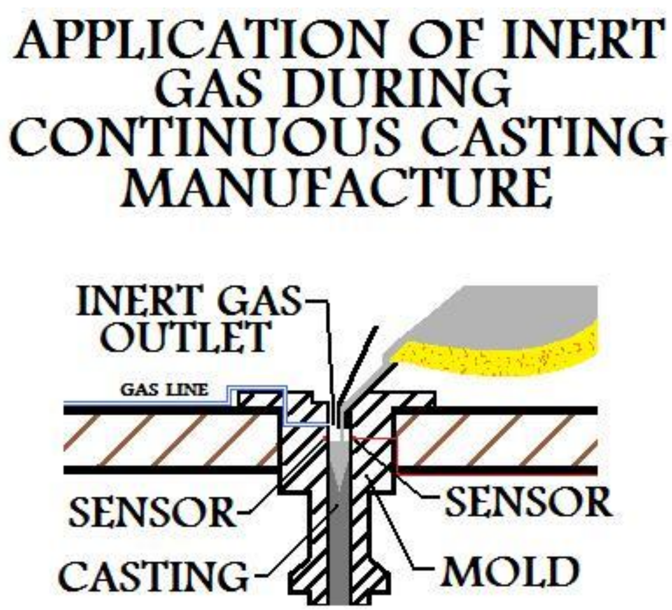
The supplying of metal to the mold is not only going on throughout the entire manufacturing operation, it must be carried out with accuracy. A control system is employed to assist with this task. Basically the system can sense what the level of molten metal is, knows what the level should be, and can control the pouring of the metal from the tundish to ensure the smooth flow of the casting process. Although the tundish can typically hold several thousand pounds of metal it too must be constantly resupplied from the source of molten material.

Figure:120



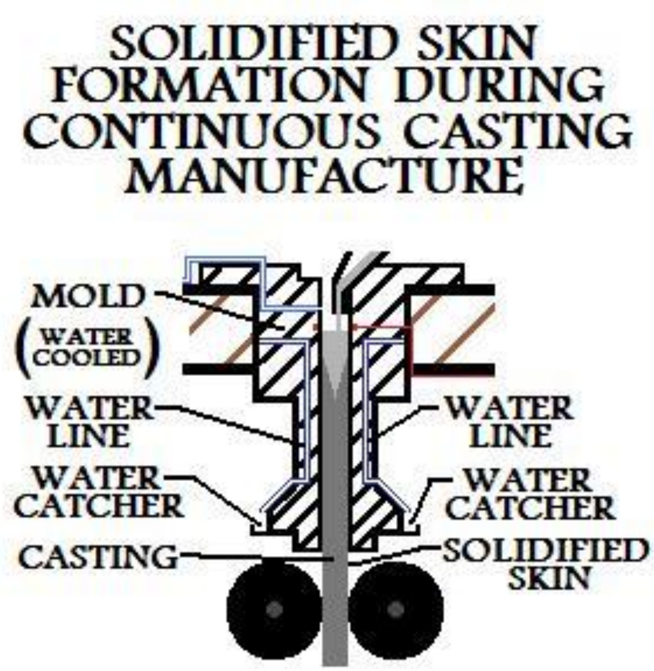
The tundish also serves as the place where slag and impurities are removed from the melt. The high melting point and reactive nature at high temperatures has always made steel a difficult material to cast. When a manufacturing operation is continuously casting steel, the reactivity of the molten steel to the environment needs to be controlled. For this purpose the mold entrance may be filled with an inert gas such as Argon. The inert gas will push away any other gases such as Oxygen that may react with the metal There is no need to worry about the inert gas reacting with a molten metal melt since inert gases do not react with anything at all.

Figure:121



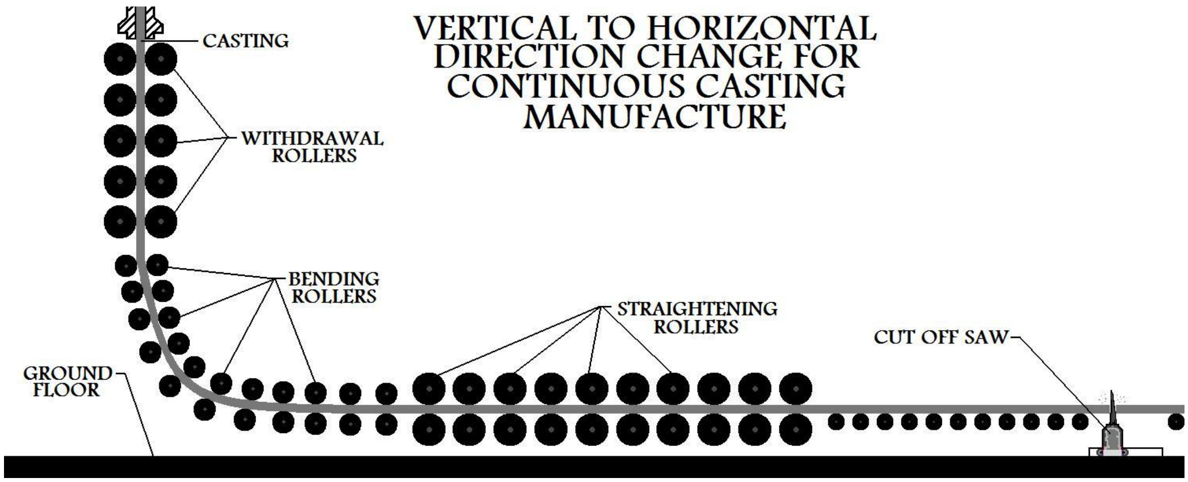
The metalcasting moves quickly through the mold in the continuous manufacture of the long slab. The casting does not have time to solidify completely in the mold. As can be remembered from our discussion on solidification, a metalcasting will first solidify from the mold wall or outside of the casting, then solidification will progress inward. The mold in the continuous casting process is water cooled, this helps speed up the solidification of the casting. As stated earlier the continuous metalcasting does not completely harden in the mold. It does however spend enough time in the water cooled mold to develop a protective solidified skin of an adequate thickness on the outside.

Figure:122



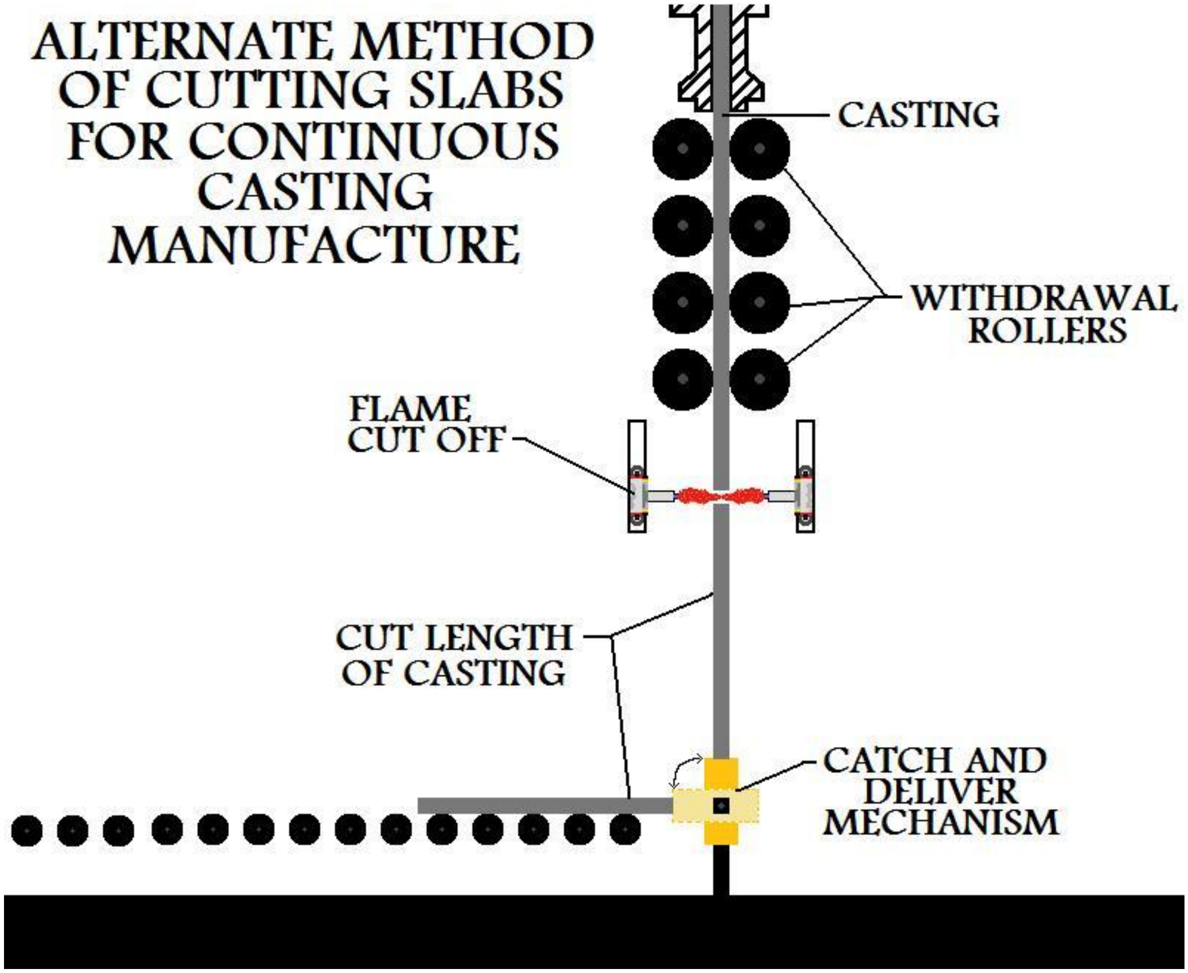
The long metal slab is moved along at a constant rate, by way of rollers. The rollers help guide the slab and assist in the smooth flow of the casting out of the mold and along its given path. A group of special rollers may be used to bend the slab to a 90 degree angle. Then another set will be used to straighten it once it is at that angle. Commonly used in manufacturing industry this process will change the direction of flow of the metal slab from vertical to horizontal.

Figure:123



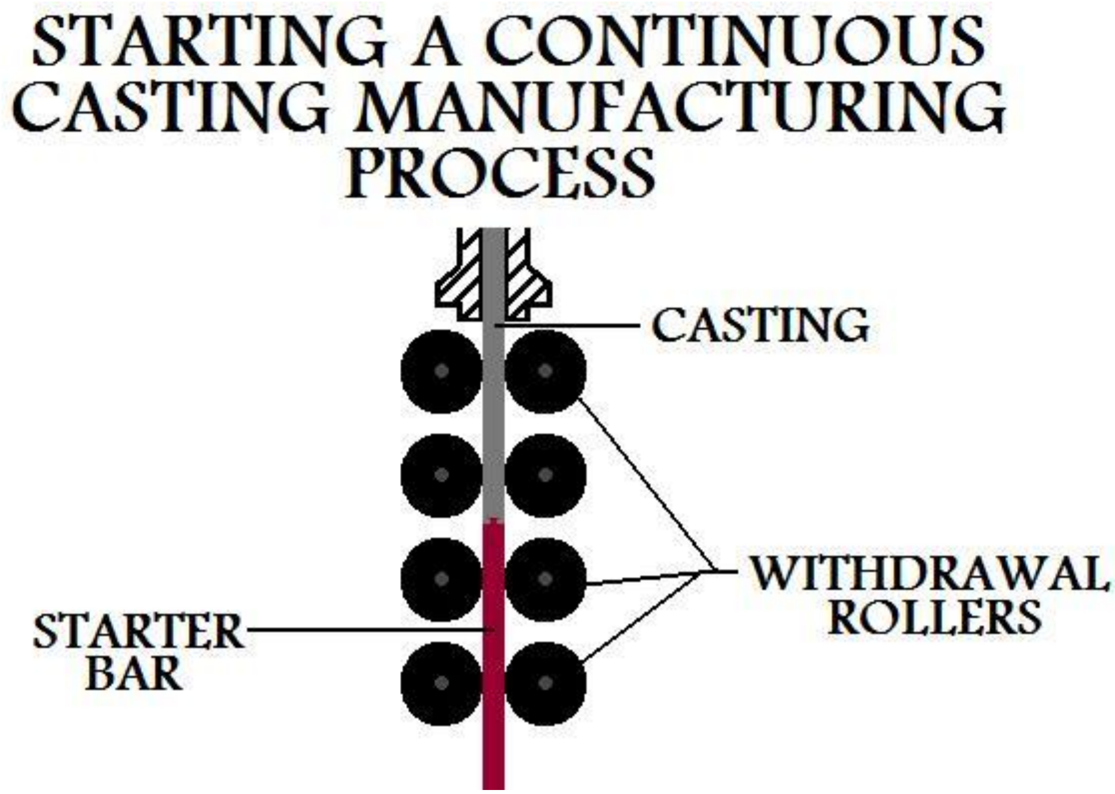
The continuous casting can now travel horizontally as far as necessary. The cutting device in manufacturing industry is typically a torch or a saw. Since the casting does not stop moving, the cutting device must move with the casting at the same speed as it does its cutting. Another setup for cutting lengths of metalcasting slab from a continuous casting operation is shown in figure:**119**. This particular manufacturing setup eliminates the need for bending and straightening rollers. It does, however, limit the length of metalcasting slab that may be produced, based in a large part on the height of the casting floor where the mold is located.

Figure:124



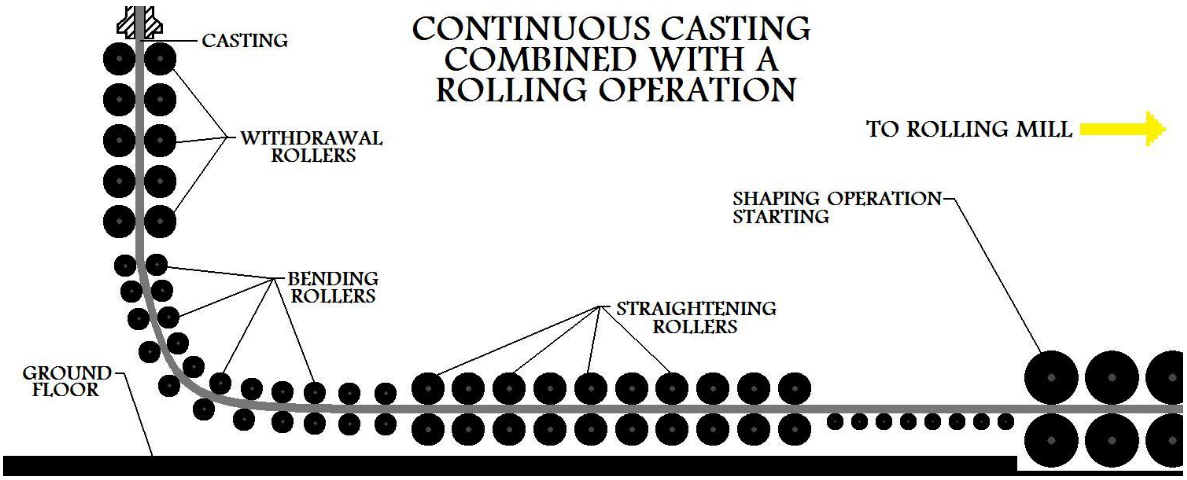
There needs to be an initial setup for a continuous casting operation since you can not just pour molten metal through an empty system to start off the process. To begin continuous casting manufacture a starter bar is placed at the bottom of the mold. Molten material for the casting is poured into the mold and solidifies to the bar. The bar gives the rollers something to grab onto initially. The rollers pull the bar, which pulls along the continuous casting.

Figure:125



In the manufacture of a product often two of more different kinds of operations may need to be performed. Such as a casting operation followed by a forming operation. In modern commercial industry the continuous casting process can be integrated with metal rolling. Do not confuse the *rolling operation* with the *rolls* used to guide the casting. The rolling operation is a forming process and it will change the material it processes. Rolling of the metal slab is the second manufacturing process and it must be performed after the casting operation. Continuous casting is very convenient in that the rolling mill can be fed directly from the continuously cast metalcasting slab. The metal slab can be rolled directly into a given cross sectional shape such as an I beam. The rate of the rolling operation is synchronized with the speed that the continuous metalcasting is produced and thus the two operations are combined as one.

Figure:126



Properties And Considerations Of Manufacturing By Continuous Casting

- Continuous casting manufacture is different from other casting processes, particularly in the timing of the process. In other casting operations the different steps to the process such as the ladling of material, pouring, solidification, and casting removal all take place one at a time in a sequential order. In continuous casting manufacture these steps are all occurring constantly and at the same time.

- This process is used in commercial manufacture as a replacement to the traditional process of casting ingots.

- Piping, a common problem in ingot manufacture, is eliminated with the continuous casting process.

- Structural and chemical variations in the material of the casting , often present in ingots, has been eliminated. When manufacturing with the continuous metalcasting process the casting's material will possess uniform properties.

- When employing continuous metalcasting manufacture the castings will solidify at 10 times the rate that a casting solidifies during ingot production.

- With less loss of material, cost reduction, higher productivity rate, and superior quality of castings, continuous casting manufacture is often the choice over ingot production.

- A continuous casting manufacturing process will take considerable resources and planning to initiate, it will be employed in only very serious industrial operations.

Pressure Casting

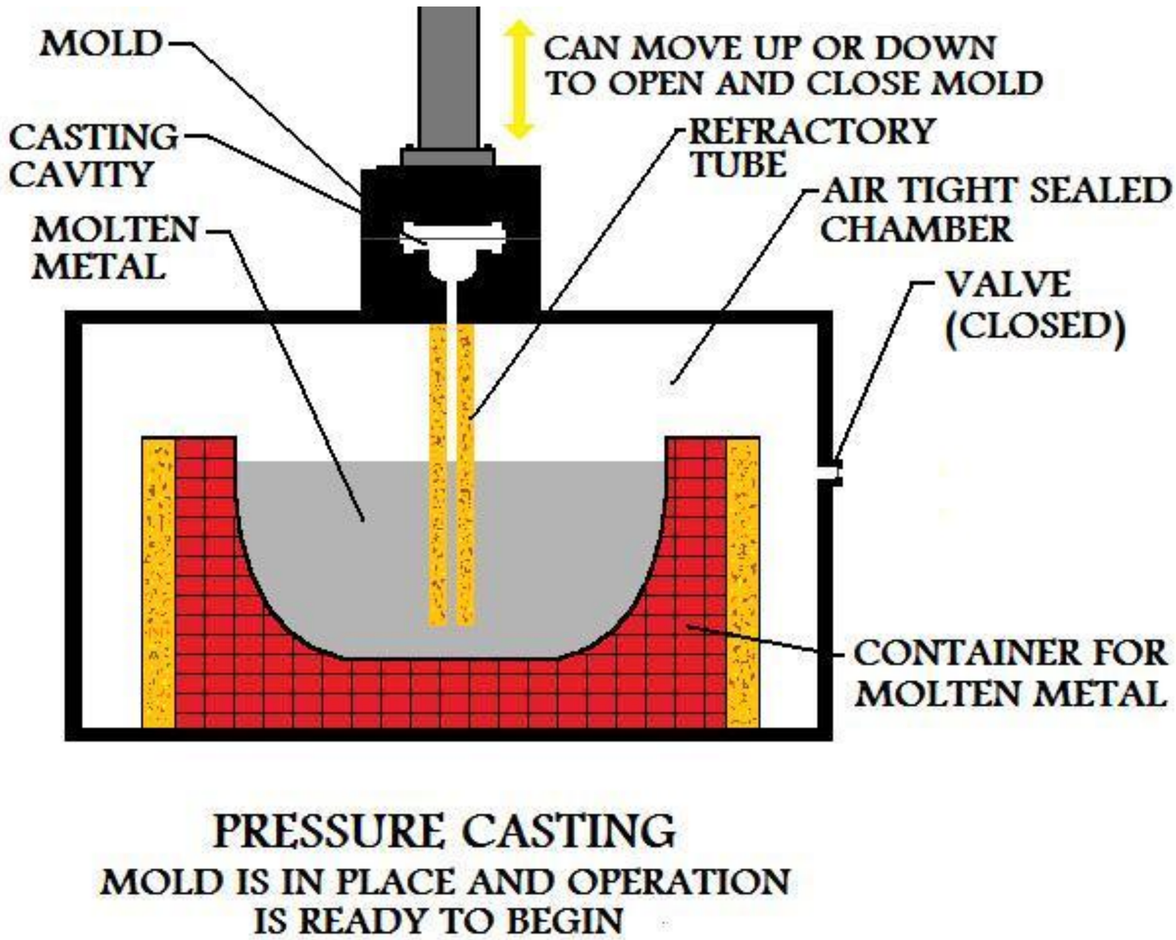
Pressure Casting also known in manufacturing industry as low pressure casting or pressure pouring is another variation of permanent mold casting. Instead of pouring the molten metal into the casting and allowing gravity to be the force that distributes the liquid material through the mold, pressure casting uses air pressure to force the metal through the gating system and the casting's cavity. This process can be used to cast high quality manufactured parts. Often steel metal castings are cast in graphite molds using this process. For example in industry steel railroad car wheels are cast with this method.

The Process

This is a permanent mold process and the manufacture of the mold in pressure casting is standard in most regards, see basic permanent mold casting. Two blocks are machined extremely accurately, and so they can open and close precisely for removal of parts. The casting's gating system is machined into the mold. The gating system is set up so that the molten material flows into the mold from the bottom instead of the top, (like in gravity fed processes).

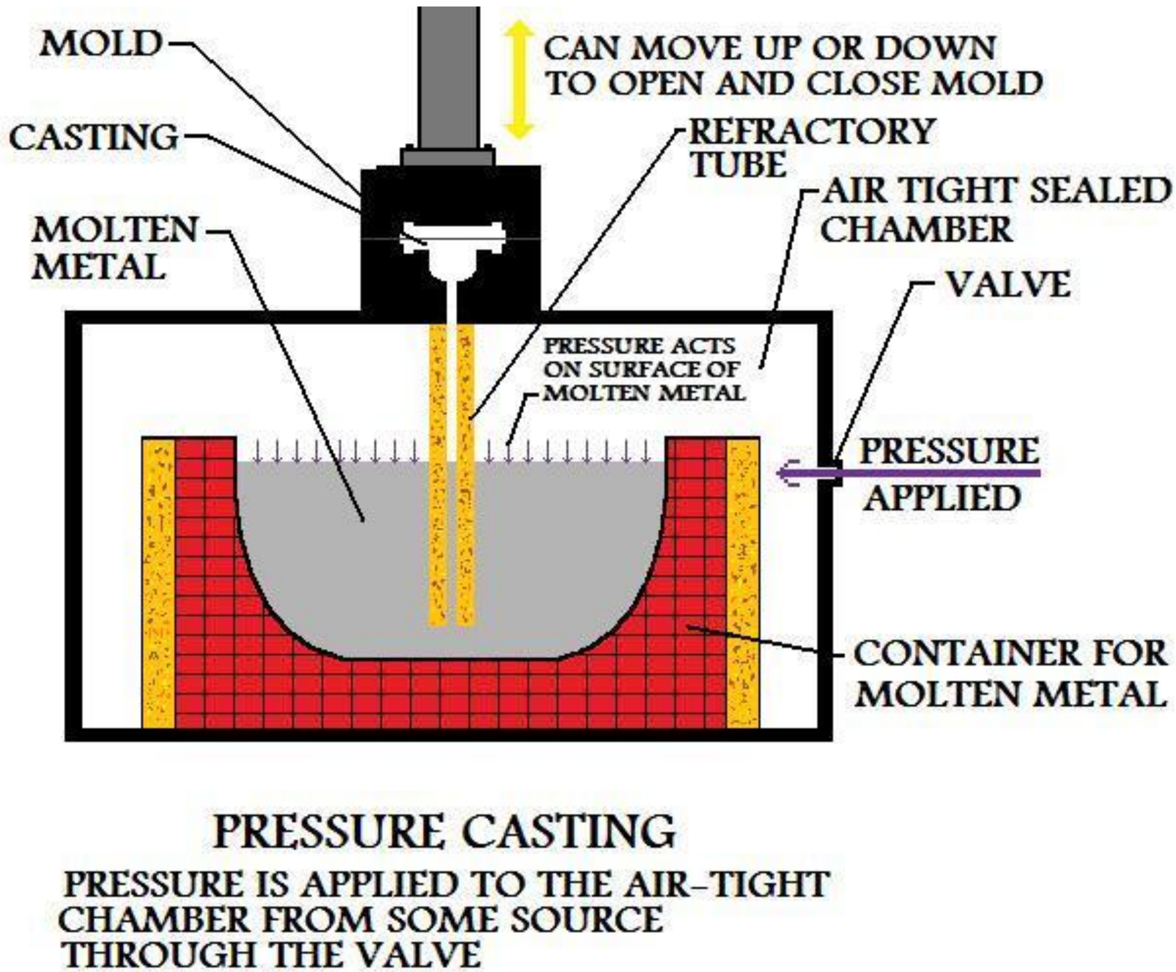
The mold is set up above the supply of liquid metal to be used for the casting. A refractory tube goes from the entrance of the gating system down into the molten material.

Figure:74



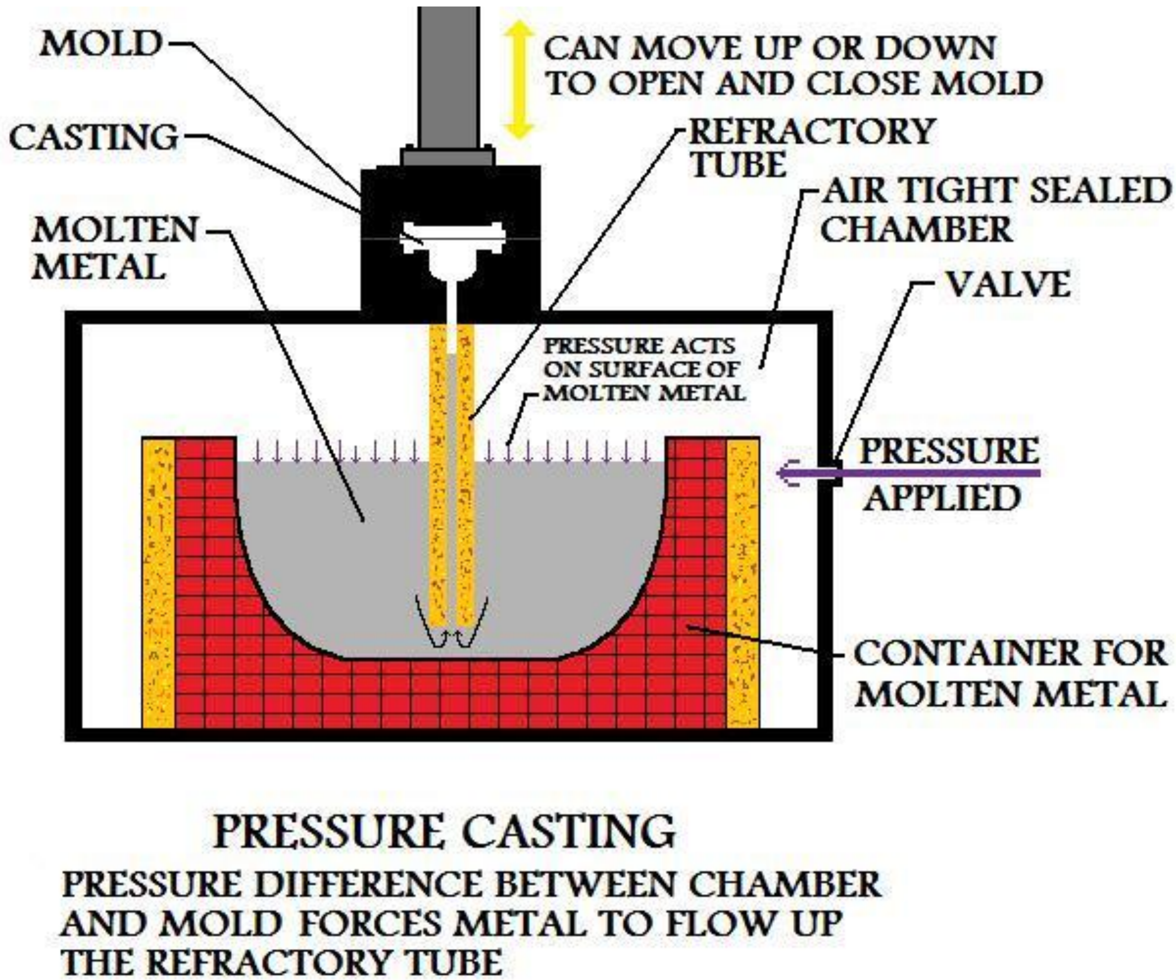
In manufacture by this process the chamber that the liquid material is in is kept air tight. When the mold is prepared and ready for the pouring of the metal casting, air pressure is applied to the chamber. This creates pressure on the surface of the liquid which in turn forces molten material up the refractory tube and throughout the mold.

Figure:75



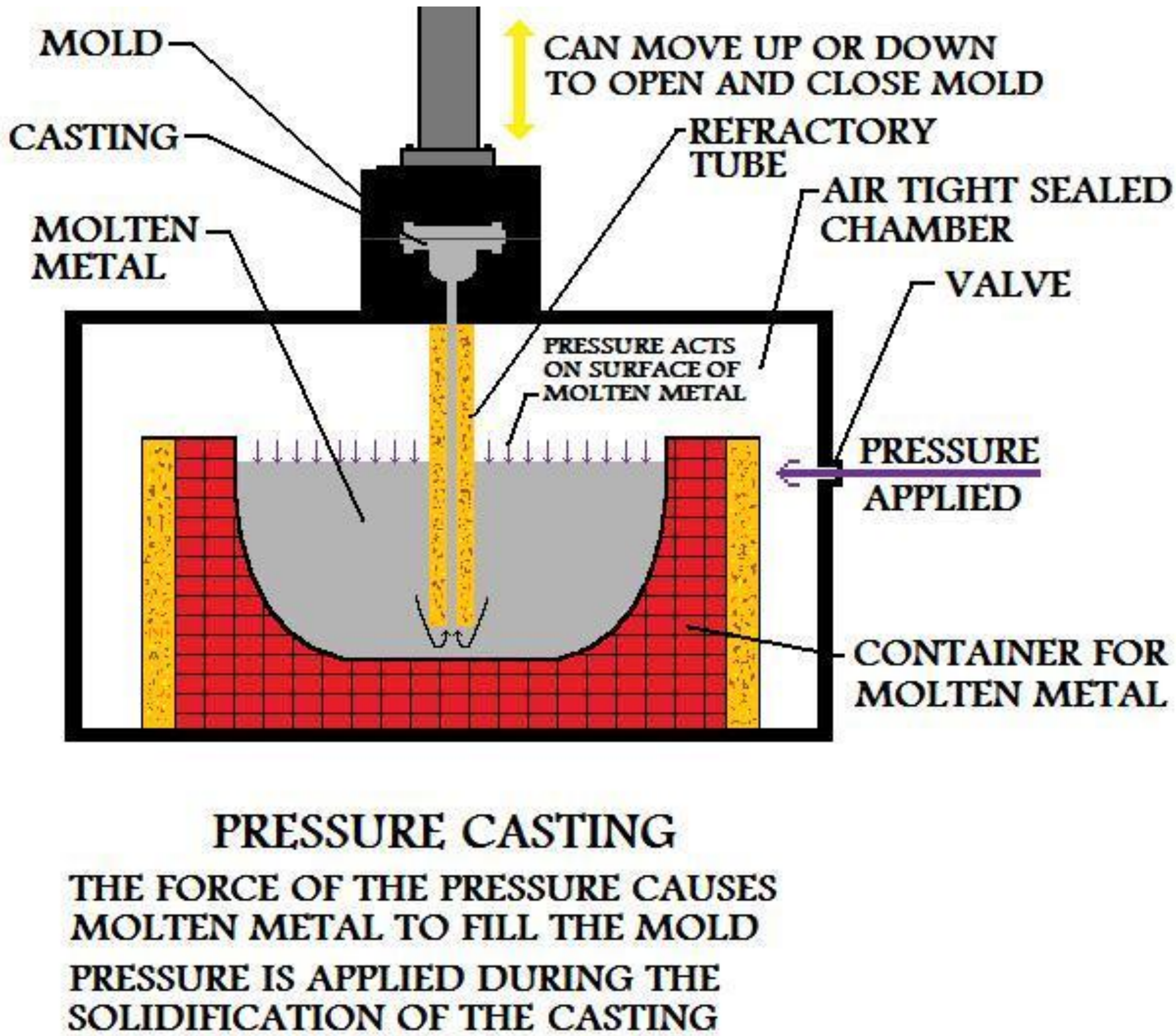
Pressure used in pressure casting is usually low, 15lbs/in^2 could be typical for industrial manufacture using this process.

Figure:76



The air pressure is maintained until the metal casting has hardened within the mold. Once the cast part has solidified the mold is opened and the part is removed.

Figure:77



Properties And Considerations Of Manufacturing By Pressure Casting

- Pressure casting manufacture can be used to produce castings with superior mechanical properties, good surface finish, and close dimensional accuracy.
- Like in other permanent mold methods the mold needs to be able to open and close for removal of the work piece. Therefore very complicated casting geometry is limited.

- Since the refractory tube is submersed in the molten material, the metal drawn for the casting comes from well below the surface. This metal has had less exposure to the environment than the material at the top. Gas trapped in the metal as well as oxidation effects are greatly reduced.

- The high setup cost makes pressure casting not efficient for small runs, but an excellent productivity rate makes it suitable for large batch manufacture.

Squeeze Casting

Squeeze Casting produces high-density castings for specific part applications. The process is distinguished by slow in gate velocities, minimum turbulence, with high pressure during solidification to consistently produce high integrity castings capable of solution heat treatment. Molten metal is transferred to a squeeze casting machine, where it is slowly pushed into a die cavity. The slow rate maintains a laminar flow and avoids turbulence within the die. When the cavity is filled, very high pressure is maintained while the metal solidifies. Hydraulic pressures are maintained during solidification and in result is near net shape aluminum casting with little porosity.

Sand Reclamation

Attrition Process

Environmental considerations and new molding sand costs make sand reclamation a necessity. To make quality molds, the reclamation system must produce sand with lower binder content, without foreign materials or metals, at low temperatures and with even grain size distribution.

Dependable systems achieve these results through attrition – by wearing binder from the sand grain through a series of mechanical processes. By keeping residual binder levels low, the Dependable process ensures sand of excellent rebondability with high tensile strength. In turn, casting surface finish and overall quality are improved.

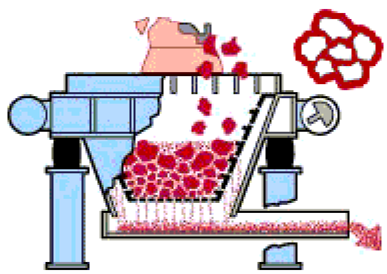
The beauty of the Dependable System is that it operates at a lower cost-per-ton than any method of comparable quality. To date, nearly 200 Dependable reclamation systems have been installed, allowing foundries in some cases to recycle up to 90% of their sand. The result: new sand additions of only 10% without a loss in mold quality.

Today's Dependable system is the result of 35 years of testing and experience. It includes five separate steps to meet the requirements for rebondability without damage to grain structure or adding dust to the sand mix. They handle up to 40 tph (36.4 mtph) and consist of shakeout/lumpreducing, scrubbing, screening, cooling and classifying to remove dust or broken grains.

The proven 5-step attrition process by Dependable recycles up tp 90% of used sand for rebonding:

Step 1:

Molds breaks down on Shakeout grid



Sand passes through shake out grid in lumps held together by binder and is then reduced to grain size.

VIBRACLAIM

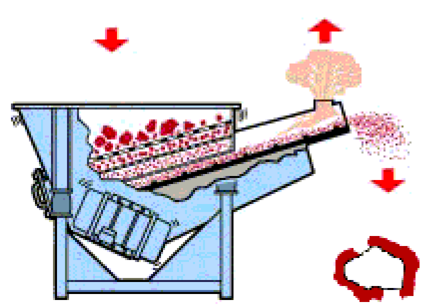
VIBRACLAIM – Hot castings are broken free of the mold upon a vibratory grid. Loose sand and lumps fall down through the grid along with risers and other tramp metal. The Vibraclaim's interior is lined with hard metal lugs and holes which help to break up the lumps and allow discharge of free-flowing sand to further processing. Large metallic pieces or unbroken lumps can be easily removed through a cleanout door.

Step 2:

Shakeout sand and lumps in

Dust out

Waste Discharge



To Rotaclaim

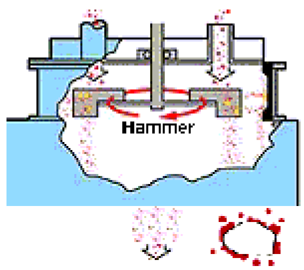
Sand exits Lumpreducer in granular form with most binder intact.

HLD LUMPREDUCER

LUMPREDUCER – Loose sand and lumps from the shakeout or other demolding process are fed into the Lumpreducer. Two vibratory motors shake the lumps and sand down through screening decks and up an inclined section of wear plates for initial binder removal. Only near-grain-size sand and particles under .06 inch (1.5mm) can successfully climb out to discharge. Other material is retained for periodic cleanout. Units are available with capacities to 20 tph (18.2 mtph).

Step 3:

Sand in **Sand in**



Liner plate

Sand exits Rotaclaim with reduced and fractured binder coat.

ROTACLAIM

ROTACLAIM – Sand conditioning or scrubbing performs the most significant single binder removal function. Here, sand is fed into a rotating array of hard cast chrome alloy hammers. Impact with the hammers fractures the sand's binder coating. The sand is then thrown outward at high speed against wear plates for further attrition. Additional binder is scrubbed away by thousands of impacts with other grains within the cyclonic Rotaclaim environment.

The speed of the spinning disc (in the Rotaclaim units) can be adjusted by changing a sheave. This enables us to alter the impact velocity of the sand grain on the inner liner plates. The ability to perform this adjustment is most advantageous when a foundry is using sub-angular sands that may otherwise fracture upon impact with a wear surface.

Compiled by

VEERAPANDIAN.K

EGS PILLAY ENGINEERING COLLEGE, NAGAPATTINAM.

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