

Basics of Mechanical Engineering-2

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Week 03

Lecture 12

Casting Process

Welcome to the next lecture on casting. In this lecture, we will try to see various processes of casting.

Classification



So, casting can be classified into two: expendable casting and non-expendable casting. Expendable mold castings are molds that are broken once you take a component or a part out of them. Non-expendable mold casting is used for mass production.

You can make a mold out of steel or metal and then keep using it multiple times. When we talk about expendable, there are permanent parts and castings. The pattern can be

made permanent, meaning it can be wood, iron, or a ceramic pattern. And you can use this for sand casting or plaster mold casting. Plaster mold casting—where have you seen it?

Plaster molds are used when you have a broken arm. So, you will always put on a Plaster of Paris. And the Plaster of Paris will take the shape of your arm. Plaster mold casting is used for making very fine-feature outputs. For example, you can make ceramic dolls with plaster mold casting.

Then, when we go into expendable, this is temporary pattern casting. In temporary pattern casting, the pattern will melt and get vaporized. So, you have evaporative casting and investment casting. When we talk about non-expendable mold casting, you have die casting, centrifugal casting, pressure casting, and many more. There are many more, but considering time as a limitation, if you understand these concepts, you can extrapolate the knowledge to new casting processes.

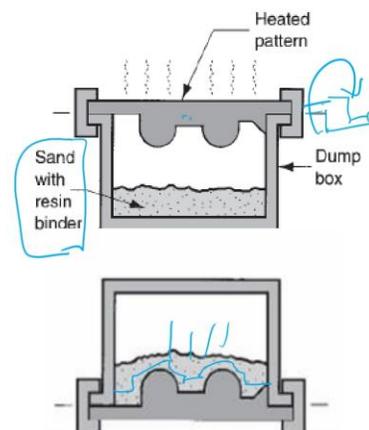
Types of Casting

(I) Expendable molding, (II) Permanent molding

(I) Expendable molding processes

Shell molding

- Shell molding uses a 9 mm thick sand shell with thermosetting resin.
- A heated metal pattern forms precise molds with sand and resin.



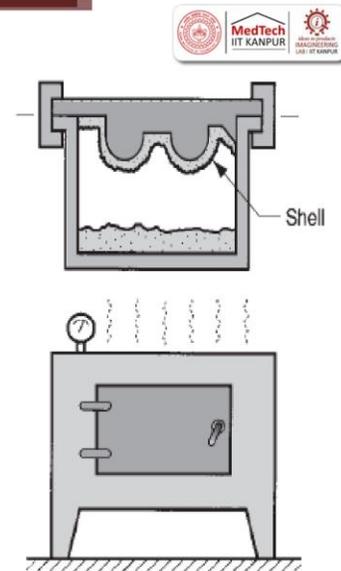
So now, let us look into expandable molding and permanent molding. What is expendable molding? Expendable molding means that it is made out of sand and is broken once the part is taken out. So here, we have a shell mold. What is a shell mold?

We have a pattern. This is a pattern. We heat the pattern and place it on top. In the dump box, we fill it with sand and resin. Now, what do we do?

We have a handle here, and then we rotate. The moment you rotate, the sand with the resin binder gets on top of the heated pattern. Now, when you rotate it back, the free sand with the resin will fall out, leaving a thin skin of the pattern that is generated.

Shell Moulding

- The dump box is inverted to allow the sand and resin mixture to fall on the hot pattern, forming a partial shell.
- The box is repositioned to remove loose particles, and the sand shell is then heated in an oven for complete curing.



So, you see a thin shell that is generated. Now, you take the shell and bake it in a furnace at the given temperature, whatever it is.

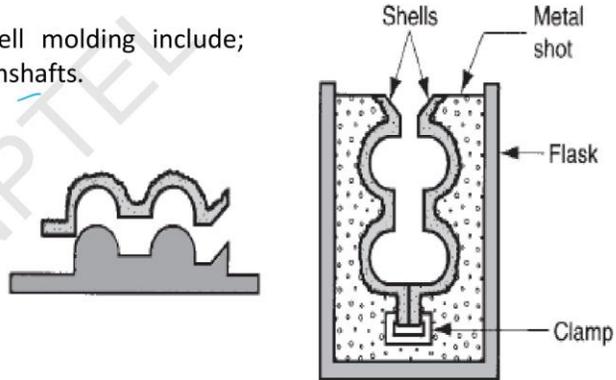
Now, what you get is a hardened shell. You remove the shell, and you get a hardened shell. Now, using that shell in sand, you can try to make a mold. So, that is called shell molding. So now, let us go through the text which is attached.

Shell molding uses a 9 mm thick sand shell with thermosetting resin. A heated metal pattern, precise molds with sand and resin, are made. The dump box is inverted to allow the sand and resin mixture to fall on the metal pattern or the hot pattern to form a partial shell. The box is repositioned to remove all the loose particles, and the sand shell is heated in an oven for complete curing.

Shell Moulding

- Pattern and two halves of the shell mold are assembled, supported by sand or metal shot in a box, and pouring is completed.

Examples of parts made using shell molding include; gears, valve bodies, bushings, and camshafts.



Patterns and two halves of the shell molds are assembled, supported by sand or metal shot in a box, and pouring is complete.

The examples of parts made using shell molding include gears, valve bodies, bushings, and camshafts. So, these are some of the examples of shell molding.

Shell Moulding ⇒ near net shaping method

Advantages

- Provides high precision and fine details
- Achieves high precision with minimal machining
- Reduces post-casting defects and rework

Disadvantages

- Expensive metal pattern
- Not suitable for small quantities



Here, the advantage is that it provides high precision and fine details. It achieves high precision with minimal machining. Very precise.

We will say it is a near-net shaping method. So, machining is also not required. Only minor finishing is required for assembly. It reduces post-casting defects and rework. It is expensive; metal patterns are required. It is not suitable for small quantities. For large quantities, yes, this can be used.

Vacuum Casting

- In this process, a sand mold is held together by vacuum pressure and not by a chemical binder.
- The term vacuum in this process refers to the making of the mold, rather than the casting operation.
- Casting operation is same as any other process.

M.P. Groover, *Fundamental of modern manufacturing Materials, Processes and systems*, 4ed

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Next is vacuum casting. In vacuum casting, what we do is place a plastic sheet. Then, we place the pattern on top of a box or surface.

Now, what we do is draw a negative vacuum or suck air from one side of the box. Now, what we do is draw a negative vacuum or suck air from one side of the box. So, there are vent holes through which the vacuum is created. So, the plastic sheet, it can be little heated. It is soft.

It can just go and wrap. This is almost like when you buy a mouse, you can see a plastic sheet on just on top of your mouse, right? It is almost like that. So, a plastic sheet and a pattern are placed, and then you vacuum suck it. So it tries to take the profile.

In the next step, once the pattern is made, we place a pouring cup and then fill it up with sand. In the next step, once the pattern is made, we place a pouring cup and then fill it up

with sand on top, and then, we try to again, suck through this. These are all vacuum drawn. So, we suck through this. What happens, now?

The top surface is also formed over it. So, now, what is happening? You will try to remove it. So, here, you will have a plastic film on top. Then, you will have a plastic film on the bottom.

Now, with this, you pour the liquid metal to obtain the shape or mold. From the mold, you try to get the part. This is known as vacuum casting. This is precisely used for high-precision feature items, and it can also be used for batch production. In this process, a sand mold is held together by vacuum pressure and not by a chemical binder.

Why? Because here, what they want to do is reuse the sand. The term 'vacuum' in the process refers to making the mold rather than the casting operation. The casting operation is the same as in other processes.

Vacuum Casting

Advantages

- No binders used, allowing easy sand recovery in vacuum molding
- Mechanical ramming is not required
- Absence of moisture prevents related defects in the product

Disadvantages

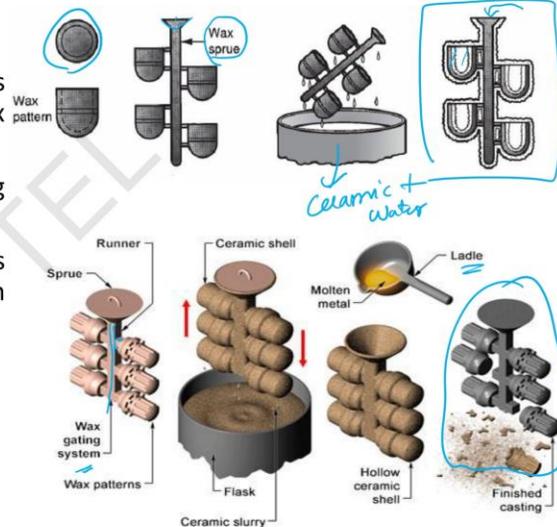
- Molds can be expensive, especially for complex designs
- Not suitable for materials with high melting points
- Not suitable for large castings due to size constraints



No binder is used, so the sand can be recovered. Mechanical ramming is not required. The absence of moisture prevents defects in the product. Molds are expensive and not suitable for materials with very high melting points because they will burn the plastic. They are also not suitable for large castings because of size constraints. Why? You need large vacuum suction pumps.

Investment Casting

- In investment casting, a wax pattern is coated with refractory material, and the wax is melted away during pouring.
- "Investment" refers to completely covering the wax pattern with refractory material.
- This is a precision casting process. Using this we can make castings of high accuracy with intricate details.



Next, let us see the investment casting process. In the investment casting process, what we do is create wax patterns. This is the top view; this is the side view. Such wax patterns are attached to a wax sprue.

This is the sprue—the pouring basin sprue. Now, at regular intervals, I attach the wax pattern. Now, what I do is immerse this wax pattern inside a slurry. This slurry is a ceramic slurry. With water added, you get a slurry.

What we do is immerse the pattern into the slurry, extract it, and dry the slurry that sticks to the part. Now, we have the wax pattern, and on top of the wax pattern, we have the slurry. Now, when I try to pour the hot liquid into it, the wax pattern melts and vaporizes. And the rest of the portion, where the mold is available, the part is made. So if you look at it, you will understand there is a long sprue.

There are runners which are attached and these are the pots. This is the wax gating system and these are wax patterns. Now they are pressed inside the slurry and you see the slurry shape is there. Now, what do they do? They heat it to melt and remove the wax.

Now, you have a mold ready. Onto the mold, they pour the molten metal, and you get the parts made from it. It is the best method for making intricate parts, small parts, and multiple parts in one stroke. So before pouring this, the slurry, they heat it and the wax is removed. Then, the mold is ready.

In investment casting, a wax pattern is coated with a refractory material, and the wax is melted away during pouring. Investment refers to completely covering the wax pattern with refractory materials. It is a precision casting process. Using this, we can make castings of high accuracy with intricate details.



Investment Casting

- Wax patterns are created and attached to a sprue to form a pattern tree, which is coated with refractory material to form a rigid mold.
- The mold is heated to melt the wax, preheated to remove contaminants, and then filled with molten metal to form the casting.

Advantages

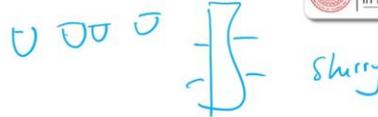
- Complex and intricate parts can be cast
- tolerances of 0.075 mm are possible
- good surface finish is possible
- In general, additional machining is not required – near net shaped part.



The wax patterns are created and attached to a sprue to form a pattern tree. So, this is a pattern tree. A pattern tree. To form a pattern tree, which is coated with refractory material to form a rigid mold. The mold is heated to melt the wax, preheated to remove contaminants, and then filled with molten metal to form the casting. Complex and intricate parts can be made. Tolerances of 0.075 millimeters are possible.

A good surface finish is possible. Additional machining is not required. So, we get the near-net shape done.

Investment Casting



Disadvantages

- Longer production cycle due to multiple steps.
- Not suitable for large components due to mold size limitations.
- Expensive tooling and patterns make it less cost-effective for low-volume production.

Applications

Steels, stainless steels, high-temperature alloys can be cast machine parts, blades, components for turbine engines, jewelry, dental fixtures, etc

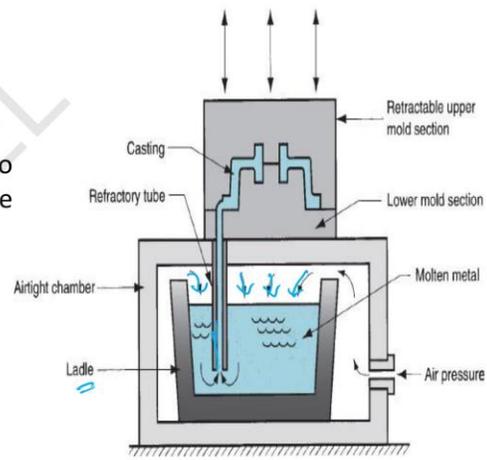


What are the disadvantages? A longer production cycle due to multiple steps. Because you make one pattern, then multiple patterns, and attach them to a sprue. Then, you dip them in a slurry, forming a shape. After heating the slurry, the wax is removed, leaving a mold. So, multiple steps are involved. Not suitable for large components due to mold size limitations. Expensive tooling and patterns make it less cost-effective for low-volume production.

Stainless steel, high-temperature alloys, machined parts, blades, turbine engine components, jewelry, and dental fixtures are made using this process. Please make a note, friends: dental fixtures and jewelry, goldsmith and dental fixtures, crowns are made out of investment casting.

Low-Pressure Casting

- In low pressure casting, liquid metal is forced into the cavity under low pressure, app. 0.1 MPa, from beneath the surface so that metal flow is upward.
- Advantages molten metal is not exposed to air; gas porosity and oxidation defects are minimized



qsdirectory.com/articles/permanent-mold-castings.html 12

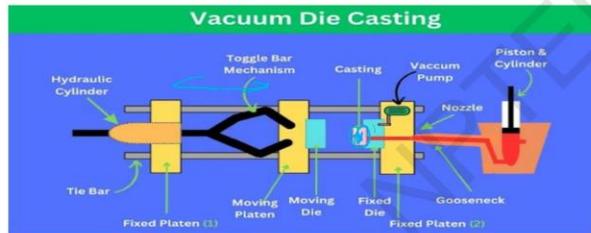
Low-pressure casting is when we use a ladle, which is a container, to hold the liquid metal. Now, what do I do? I pressurize the liquid metal. When I do this, there is an orifice or a tube.

So, through this tube, due to the pressure, the liquid metal rises. The liquid flows through the tube and then enters the casting. The liquid flows through the tube and then enters the casting. Now, you have a cast part. So, here, we pressurize it from the outside atmosphere.

In low-pressure casting, the liquid metal is forced into the cavity under a low pressure of approximately 0.1 MPa from beneath to the surface, allowing the metal to flow upward. Once the part is made, it is retracted. Advantages: the molten metal is not exposed to air, so gas porosity and oxidation defects are minimized.

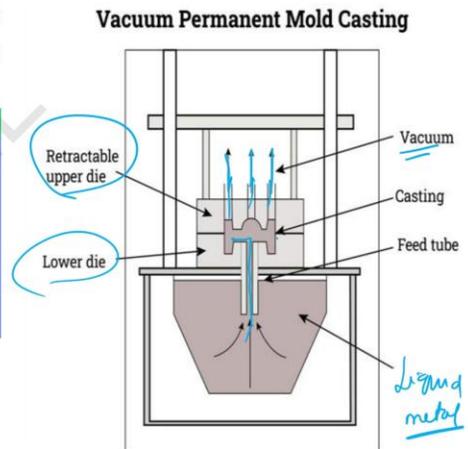
Vacuum Casting

- The variation of low-pressure casting, but in this vacuum is used to draw the molten metal into the mold cavity.



Applications

Automotive, turbine blades, valve bodies, defense parts, and industrial components.



The other one is vacuum casting. In vacuum casting, what we do is a variation of low-pressure casting, but here, a vacuum is used to draw the molten metal into the mold cavity.

So, what we do is have a lower die—this is the lower die. So, here we try to create a vacuum, which is sucking. So, because of the suction, the molten metal enters and fills the mold, right? And then, from the mold, you will have three outputs. So, these are vacuums that are created.

This is the casting. So, there is a retractable upper die, a lower die, and the liquid metal present. So, if you look into it, this is vacuum die casting. So, you have a toggle bar mechanism for opening and closing. So, this will be moved back and forth, right?

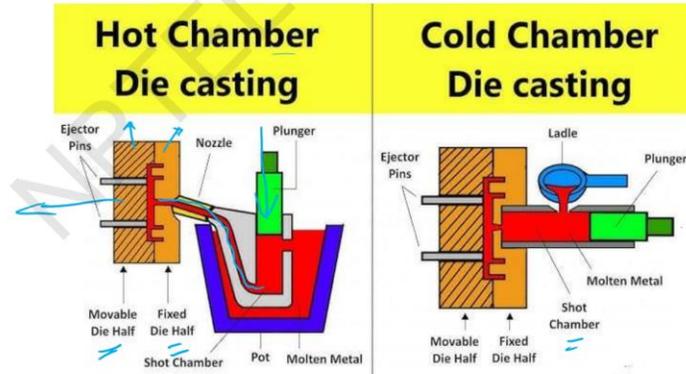
Here you have a die, and then you have a casting. So applications include automobiles, turbine blades, valve bodies, defense parts, and industrial components.

Die Casting

- In this process, high pressure of app. 7 to 350 MPa is used to pressurize the molten metal into die cavity. The pressure is maintained during solidification.

Category:

- Hot chamber die casting
- Cold chamber machines



Die casting is the most advanced process, and it is the latest process wherein we are now trying to make all metal parts by die casting. So, the mass production rate is very high. So, the process involves high pressure, approximately 7 MPa to 350 MPa, which is used to pressurize the molten metal into the die.

The pressure is maintained during solidification. Hot chamber die casting and cold chamber die casting are two different things. In hot chamber die casting, the molten metal is present. What you do is use a plunger to pressurize the liquid. So, the liquid flows through the sprue or nozzle and then gets injected into the mold.

So, once you have one half of the mold, this is the other half. Once solidification happens, we use an ejector pin to move the die back; it ejects, and the component falls down. So, this is the movable die half, and this is the fixed die half.

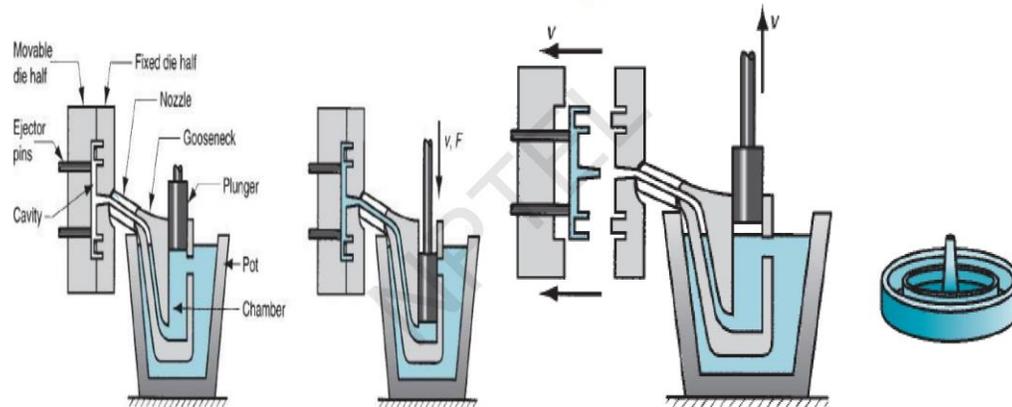
Hot Chamber Die Casting

- In hot chamber die casting, molten metal is melted in a container attached to the machine, and a piston is used to pressurize metal under high pressure into the die.
- Typical injection pressures are between 7 and 35 MPa.
- Production rates of 500 parts/hour are common.
- The injection system is submerged in the molten metal and hence poses the problem of a chemical attack on the machine components. Suitable for zinc, tin, lead, and Mg.

There is hot chamber die casting and cold chamber die casting. This is hot chamber die casting. In cold chamber die casting, we pour the liquid metal into a ladle and then pressurize it. This is the molten metal. You have a short chamber here. You pour it, then it is pushed, and finally, you get the component out. In hot chamber die casting, the molten metal is melted in a container attached to the machine, and a piston pushes the pressurized metal into the die under high pressure.

The pressure varies from 7 to 35 MPa. A production rate of 500 parts per hour is very common. In hot chamber die casting, the molten metal is melted in a container attached to the machine, and a piston pushes the pressurized metal into the die under high pressure. It is suitable for zinc, tin, lead, and magnesium.

Hot Chamber Die casting



This is the hot chamber die casting process, where the plunger pushes the molten metal, and then you get the part. This is the hot chamber die casting process, where the plunger pushes the molten metal, and then you get the part.

Hot Chamber Die Casting

Advantages

- Faster production with high precision in complex shapes.
- Ideal for high-volume production with low-melting point metals.
- Better surface finish and lower initial tool cost.

Disadvantages

- Limited to low-melting-point metals.
- Die wear due to high temperatures
- Not suitable for large castings



Applications: Electrical connectors, hardware, consumer products, medical instruments, and small mechanical parts.

Faster production with high precision in complex shapes. Ideal for high-volume production with low-melting-point metals. Better surface finish and lower initial tool cost. These are the advantages.

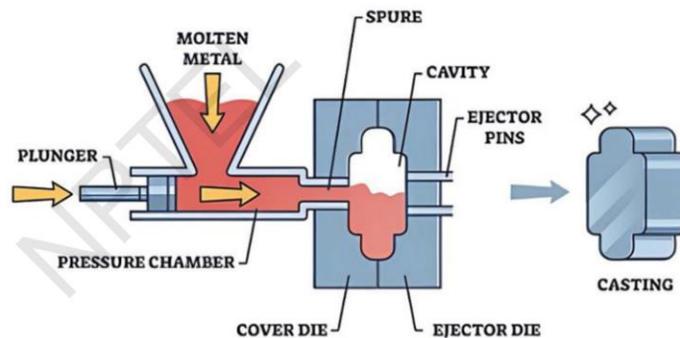
What are the disadvantages? The disadvantages of hot chamber die casting is, limited to low melting point metal. Die wear out due to high temperature and not suitable for large casting. So these are all the problems. So, you can see that electrical connectors, hardware, consumer products, medical instruments, and small mechanical parts are all made using hot chamber die casting.

Hot chamber die casting. The pot holds the liquid metal, the plunger pushes it, the liquid metal flows through the gooseneck into the nozzle, and then it enters the die.

Cold Chamber Die Casting



- Molten metal is poured into the mold cavity and injected under high pressure using a piston.
- The process involves injecting molten metal into a mold under high pressure.



Cold chamber die casting, the molten metal is poured into the mold cavity, and the injected under high pressure, using a piston. The process involves injection molten metal into the mold such that you try to get the part out.

Cold Chamber Die casting



- Metal is poured into a cold chamber, and a hydraulic plunger forces it into the die cavity, ideal for high-melting point metals.
- Produces high-strength, durable parts with fine details, but has a slower cycle time than hot chamber die casting.

Advantages

- Ideal for high-melting-point metals like aluminum and copper alloys.
- Longer die life due to lower thermal stress.
- Produces strong, durable parts with a smooth finish.



So, the metal is poured into the cold chamber, and the hydraulic plunger forces it into the die cavity, making it ideal for high melting point metals.

It produces high-strength, durable parts with fine details but has a longer cycle time than hot chamber die casting. Ideal for high melting points, it ensures longer die life and produces strong, durable parts with a smooth finish.

Cold Chamber Die casting



Disadvantages

- Slower production cycle than hot chamber die casting.
- Higher tooling, machine costs, and complex setups.
- Less efficient for high-volume small parts and limited to high-melting alloys.

Applications

Military hardware, consumer products, automotive components, aerospace parts.

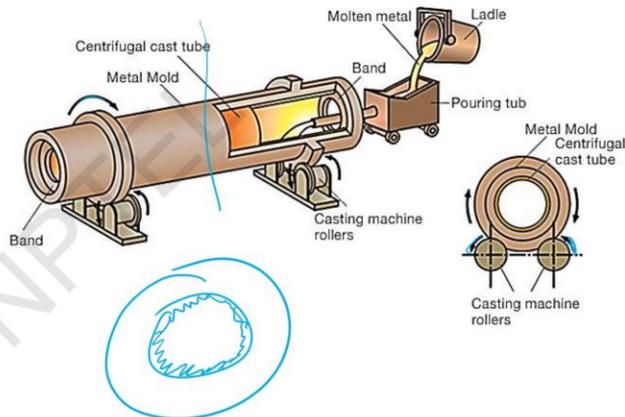


The disadvantages are a slower production cycle time compared to hot chamber die casting, higher tooling costs, and reduced efficiency for high-volume small parts.

Centrifugal Casting



- The mold is rapidly rotated, and centrifugal force acts on the metal, causing impurities to segregate towards the center,
- Used for producing hollow, axisymmetric components like pipes, tubes, and hollow bushes without the need for a core.



Centrifugal casting is another interesting process in which cylindrical tubes or barrels are produced. So, here, we pour the molten metal from the ladle into a pouring tub. From the pouring tub, it flows into the metal mold. Now, we rotate the metal mold.

So, here, we pour the molten metal from the ladle into a pouring tub. From the pouring tub, it flows into the metal mold. Now, we rotate the metal mold. So, the mold is rapidly rotated, and the centrifugal force acts on the metal, causing impurities to segregate toward the center. So, what we are trying to say is that if you have a cylindrical barrel-like structure, the segregated impurities will accumulate toward the center. This section can then be machined and removed. So, if you look at the cross section, it will look like this. So, the metal mold is this centrifugal cast tube which is getting formed as this.

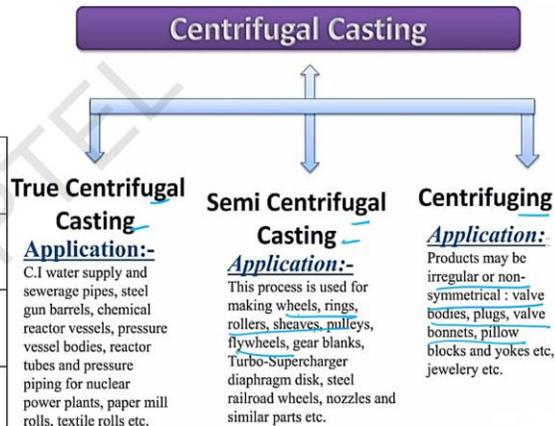
The roller is rotated on two casting machining rollers. So, you rotate the rollers, which can freely rotate, and this mold is rotated. It is used for producing long, hollow, axisymmetric components like pipes, tubes, and hollow bushes without the need for a core. All sewage pipes are made using this process.

Centrifugal Casting

There are three types of centrifugal casting:

- True centrifugal casting
- Semi centrifugal casting
- Centrifuging casting

Types of Centrifugal Casting	Applications
Centrifugal casting	Used for making a pattern in investment casting
True centrifugal casting	Used for making jet engine compression cases.
Semi centrifugal casting	Used for making a wheel, pulley, spoke wheel, alloyed wheels



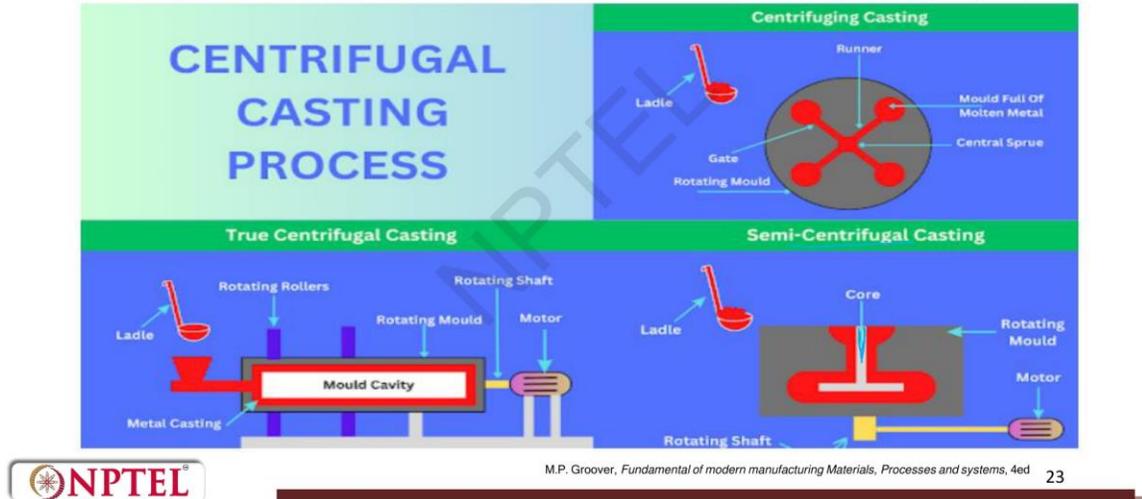
There are three types of centrifugal casting: true centrifugal casting, semi-centrifugal casting, and centrifuging.

Centrifugal casting is used for making patterns in investment casting and for centrifugal casting itself. True centrifugal casting is used for making jet engine components and compression cases. Semi-centrifugal casting is used for making wheels, pulleys, spoked wheels, and alloyed wheels. So, if we look into the applications, cast iron water supply and sewage pipes are made using true centrifugal casting. So, in semi-centrifugal casting, it is used for making wheels, rings, rims, pulleys, fly weights, etcetera.

Centrifuging is used for producing irregular and non-symmetrical components such as valve bodies, plugs, valve pillow blocks, and yokes.

Centrifugal Casting

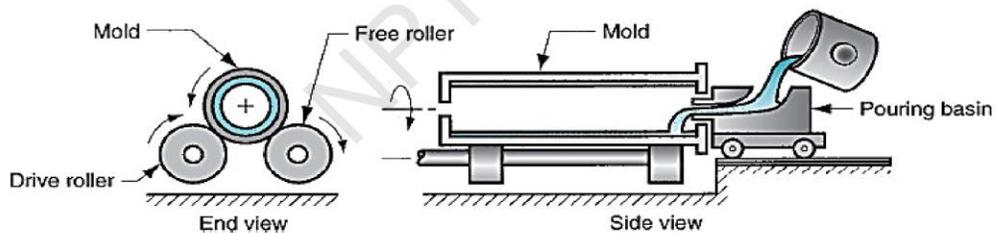
Centrifugal casting is also called roto-casting or centrifugal casting technique (CCT).



Centrifugal casting is also called Roto Casting or the Centrifugal Casting Technique - (CCT). So, what we do is use a ladle to pour the molten metal. It flows through a runner, filling the mold. When the mold is rotated, the metal distributes evenly.

True Centrifugal Casting

- Molten metal is poured into a rotating mold to form tubular parts like pipes, tubes, bushings, and rings.
- Centrifugal forces shape the casting, making the inside perfectly round while the outside can be non-round.



This is true centrifugal casting. The liquid metal is poured, it is rotated, so you get a centrifugal casting. In semi-centrifugal casting, a core is used, and the liquid metal is

filled around it before rotating. This process is used for making wheels, rings, rollers, sheaves, pulleys, flywheels, and gear blanks. We have already discussed true centrifugal casting in detail.

So, centrifugal casting shapes the casting, making the inner surface perfectly round, while the outer surface can be non-round.

True Centrifugal Casting



Advantages

- Produces dense, high-strength parts with minimal porosity.
- Provides excellent dimensional accuracy.
- Ideal for producing long, hollow, cylindrical parts.
- Can produce parts with uniform wall thickness.

Disadvantages

- Precise control of rotational speed and temperature.
- Higher initial investment in equipment and setup.
- Limited to cylindrical or tubular shapes.

Applications-Pipes, Tubes, Cylindrical, Gears, Bearings, bushings, Rings, rollers, sleeves etc.



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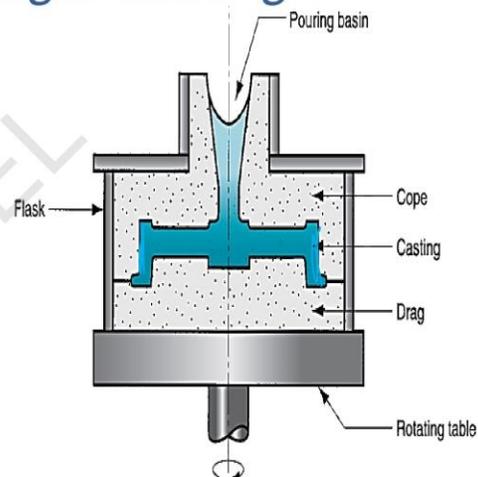
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So, we have browsed through examples. So, we do not have to repeat it this is for your study purpose.

Semi centrifugal Centrifugal Casting



- Semi-centrifugal casting involves a partially rotated mold with slower speed than full centrifugal casting.
- It creates a denser outer layer and a less solid inner core due to moderate centrifugal forces.



So, in semi-centrifugal casting, the mold is partially rotated at slower speeds compared to true centrifugal casting. This creates a denser outer layer and a less solid inner core due to moderate centrifugal force.

A dense outer layer forms here, while the inner core is less solid due to moderate centrifugal forces. So, when the table is rotated, you get injected.

Semi centrifugal Centrifugal Casting



Advantages

- Produces dense outer layers and stronger parts.
- Suitable for parts requiring high strength.
- Better material utilization than full centrifugal casting.
- Capable of casting non-symmetrical shapes.

Disadvantages

- More complicated process for axially-symmetric jobs.
- Limited to vertical axis rotation.
- Limited to vertical axis rotation.

Applications -Wheels, pulleys, gears, flywheels, crankshafts, brake drums, machine components etc.



Gear wheels Fly wheels Track wheels

Semi centrifugal casting applications



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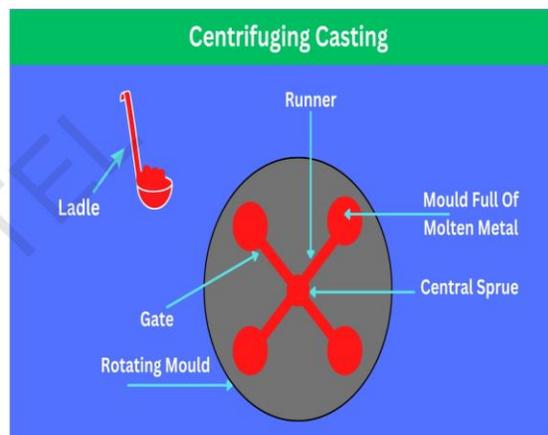
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So, these are some of the examples we have gone through in details. I don't have to read it, again.

Centrifuging Casting



- Centrifuging is a casting process where a rotating mold shapes molten metal, using centrifugal force to create dense, high-quality
- Parts with minimal porosity.
- **Advantages:**
- Produces dense, high-quality castings with minimal porosity.
- Suitable for smaller, complex castings with various metals.



<https://www.mechgrace.com/2023/12/centrifugal-casting.html>

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Centrifuging Casting. Centrifuging is a casting process where a rotating mold shapes molten metal using centrifugal force to create dense, high-quality castings. You pour the molten metal and rotate the mold. These are the runners and gates, and you will see the metal flow through them before forming the final casting.

Centrifuging Casting

Disadvantages:

- Limited to smaller castings.
- Requires precise mold rotation for consistent results.

Applications:

Gears, bearings, bushings, precision components, automotive parts, aerospace parts, rings, cylinders.



<https://dir/palghar/die-centrifugal.casting.html>

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These are some parts produced by centrifuging.

Comparative Table

Types	Process	Advantages	Limitations	Cost-Effectivity	Range of Alloys	Application
Die Casting	Injection of molten metal into moulds	High precision, intricate designs, fast production rates	Limited to non-ferrous alloys, higher initial tooling costs	Moderate to high costs, efficient for mass production	Primarily non-ferrous alloys, aluminium, zinc, and magnesium alloys	Automotive components, electronics, consumer goods
Investment Casting	Wax model covered in ceramic shell	Excellent detailing, intricate components, versatile	Slower production rates compared to die casting, higher costs	Moderate to high costs, suitable for complex shapes	Broad range including ferrous and non-ferrous alloys, commonly used in aerospace	Aerospace components, Jewelry, artistic metal sculptures
Sand Casting	Creation of moulds using sand	Versatile, suitable for large parts, cost-effective	Lower precision compared to die casting, rougher surface finish	Generally cost-effective, ideal for large parts	Wide range including ferrous and non-ferrous alloys	Various industries, especially for large and complex parts
Permanent Mold Casting	Employing reusable metal molds	Good precision, balanced cost and precision, versatile	Limited to non-ferrous alloys, tooling costs, less intricate details	Moderate costs, balanced precision and efficiency	Commonly non-ferrous alloys, aluminium, and copper alloys	Automotive parts, aerospace components, industrial applications



<https://www.mahadeverrocast.com/how-to-choose-the-suitable-types-of-casting-process/>

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Here are the comparative tables. I have listed various processes and categorized them by the type of casting. We have die casting, investment casting, sand casting, and permanent mold casting. The process here involves injecting molten metal into the mold, which is die casting. Investment casting uses a wax model covered with a ceramic shell. In sand casting, a mold is created using sand, while in permanent mold casting, a reusable metal mold is used. The advantages of die casting are high precision, intricate design capability, and fast production rates.

Investment casting offers excellent detail, is ideal for intricate components, and is highly versatile. Sand casting is versatile, suitable for large parts, and cost-effective. Permanent mold casting offers good precision, a balance between cost and precision, and versatility. Now, what are the limitations of die casting? It is limited to non-ferrous alloys. Higher investment is required for tooling in die casting.

When we look at investment casting, it has a slower production rate compared to other casting techniques. Sand casting has lower precision compared to die casting and results in a rough surface finish. In permanent mold casting, limited to non-ferrous alloys, tooling casts less intricate details. So, this was permanent mold casting. When we look into cost-effectiveness, it ranges from moderate to high, but it is effective for mass production.

Investment casting has moderate to high costs but is suitable for producing complex shapes. Sand casting is generally cost-effective and ideal for producing large parts. Permanent mold casting has a moderate cost, offering a balance between precision and efficiency. Permanent mold casting is very good. The primary range of alloys for die casting includes non-ferrous alloys such as aluminum, zinc, and magnesium.

Investment casting can be used for a broad range of ferrous and non-ferrous alloys. Sand casting is used for both ferrous and non-ferrous alloys, whereas permanent mold casting is commonly used for non-ferrous alloys, including aluminum and copper. Die casting is generally used for automobile components, electronics, and consumer goods. Investment casting is used for artifacts, jewelry, and aerospace components where precision is required. Sand casting is used in various industries, especially for large and complex parts. Permanent mold casting is used for automotive parts, aerospace components, and industrial applications.

Comparative Table



Types	Process	Advantages	Limitations	Cost-Effectivity	Range of Alloys	Application
Shell Mold Casting	Utilizing efficient moulding methods	Efficient for medium to high-volume production, cost-effective	Limited precision, depending on the method used, may have size constraints	Cost-effective for medium to high-volume production	Adaptable to various alloys, often used with ferrous metals	Medium to high-volume production, specific industrial applications
Centrifugal Casting	Using centrifugal force to shape metal	Specialized for cylindrical shapes, good for large parts	Limited to cylindrical components, may have limited versatility	Moderate costs, efficient for specific applications	Commonly non-ferrous alloys, often used for pipes and tubes	Pipe and tube manufacturing, cylindrical components
Continuous Casting	Continuous flow of molten metal	Efficient for continuous lengths, consistent quality	Limited to continuous shapes, less versatile, tooling and setup complexity	Efficiency depends on application, continuous process	Commonly ferrous and non-ferrous alloys, used for metal sheets and rods	Metal sheet and rod production, specific applications in manufacturing



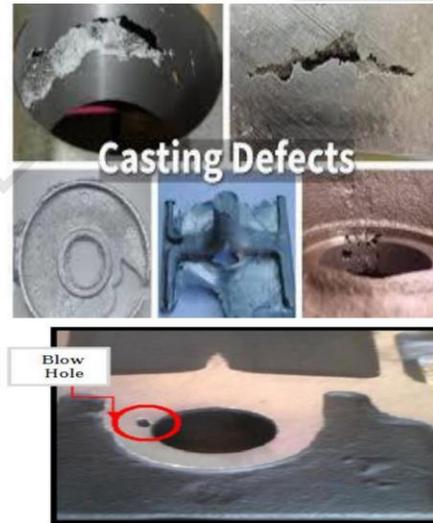
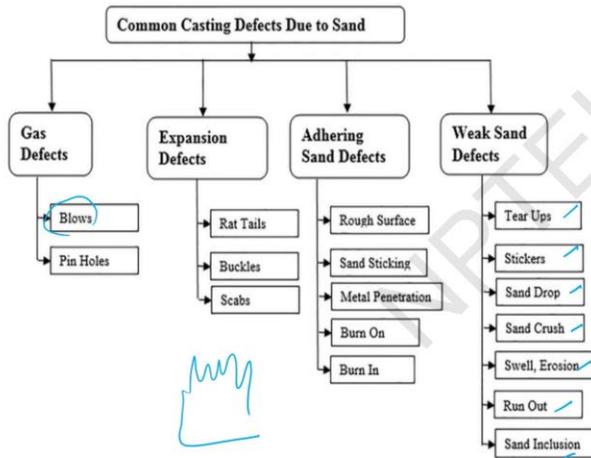
When comparing with other processes, we consider shell molding, centrifugal casting, and continuous casting. Shell molding is an efficient and effective molding method. It is effective for medium to high production volumes. Precision is limited depending on the methods used. Shell molding is cost-effective for medium to high production volumes.

It is adaptable for a wide range of alloys. So, these were the applications. Centrifugal casting uses centrifugal force to rotate the mold and form the desired shape. Centrifugal casting is predominantly used for cylindrical components, which is its primary limitation. Centrifugal casting offers moderate cost-effectiveness.

Centrifugal casting can be used for a wide range of alloys, including ferrous and non-ferrous materials. Centrifugal casting is primarily used for manufacturing cylindrical parts. Friends, I have not covered continuous casting, but I will try to compare it here and share the reading material with you. Continuous casting involves a continuous flow of molten metal, making it effective for producing continuous lengths with consistent quality. It is limited to continuous shapes, with efficiency depending on the application and process.

It is commonly used for both ferrous and non-ferrous alloys, primarily for manufacturing metal sheets and rods.

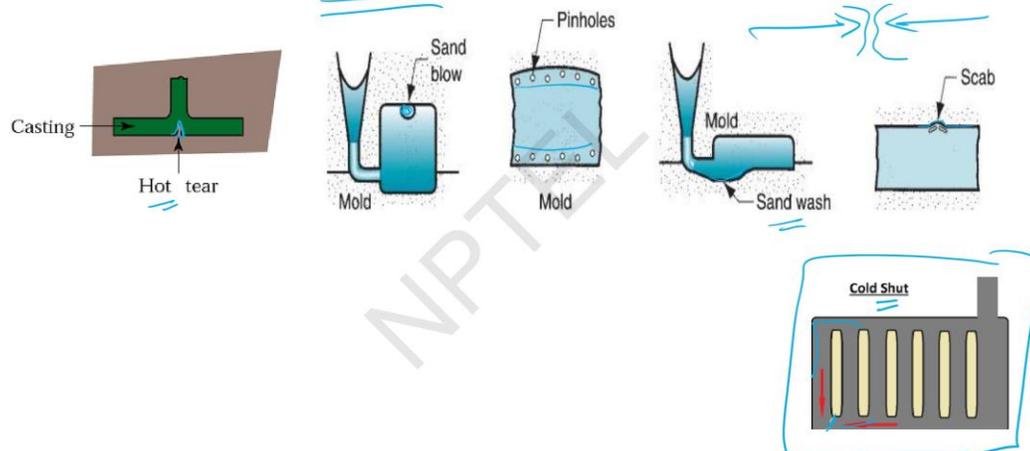
Comparative Table



Some common defects in sand casting include gas defects, expansion defects, adhering sand defects, and weak sand defects. In gas defects, blow holes and pinholes are the most prominent issues. Pinholes are small holes that appear on the surface of the casting. Expansion defects include rat tails, buckles, and scabs.

These are surface projections formed due to expansion issues in the mold. Adhering sand defects include rough sand, sand sticking, and metal penetration. Weak sand defects include tearing up, sticking, sand drop, sand crush, erosion, runout, and sand inclusion. These are all some of the sand defects that are possible.

Types of Casting Defects

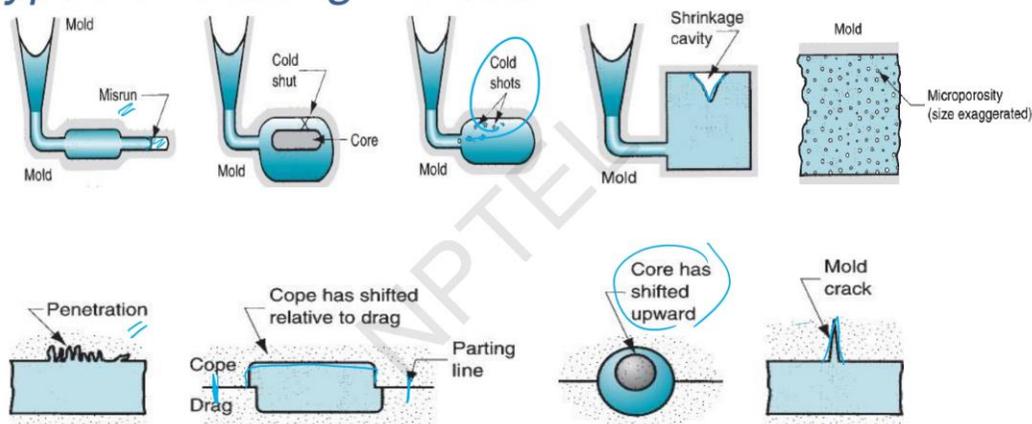


So when we look at the possible casting defects, the cast is there. If there is improper filling and a void is created, this defect is called a hot tear defect.

Sand blow occurs when gas gets trapped in the liquid metal, forming a cavity or bubble in the casting. Pinholes are always seen on the surface of the product. Sand wash occurs when the liquid flows, creating turbulence. The mold material is removed; this is called a sand wash. Scabs are formed on the surface of the sand. These are all cold shuts.

So, a cold shut occurs when liquid flows from one direction and another liquid flows from the opposite direction, but they do not merge properly before solidifying. This is called a cold shut. So, you move from here, and you have an improper filling called, cold shut.

Types of Casting Defects



So, you can have misruns. When the liquid tries to flow through the mold and reaches the end, an air trap can form. This is called a misrun. So, this is cold shut which I have already explained. These are cold shuts which are there on the surface.

This is the shrinkage cavity, or micro porosity, which occurs due to air being released from the sand. These are all penetration defects from sand casting, where the liquid penetrates inside and then solidifies. The cope and drag, when the mold is not properly pinned or tightened, can shift, causing a misalignment. So, you have an offset. Then, the core, due to buoyancy, shifts upward.

These are micro cracks. These are penetrations. These are one single crack which is there from the part which is made. And here is the sand. These are mold cracks.

These are some of the defects, and these defects have to be avoided. Almost all the defects are more focused toward sand casting.

Types of Casting Defects



Defects	Descriptions	Causes	Remedies
Sand Blow	Balloon-shaped gas cavity near surface.	<ul style="list-style-type: none"> Gas trapped during pouring. High moisture content in sand 	<ul style="list-style-type: none"> Improve mold venting Dry sand properly
Pinholes	Small holes due to trapped gases.	<ul style="list-style-type: none"> Gas trapped in metal Low pouring temperature 	<ul style="list-style-type: none"> Improve mold venting Increase pouring temperature
Sand Wash	Erosion of mold surface by molten metal	<ul style="list-style-type: none"> Metal erodes sand surface High pouring speed 	<ul style="list-style-type: none"> Improve sand compaction Slow pouring rate

When we look at the types of defects, sand blow is a balloon-shaped gas cavity near the surface. The gas is trapped during pouring, or it can be due to excess moisture. Improving mold venting and drying sand can help prevent this. Pinhole defects are small holes caused by trapped gases that rise to the top and form in the part. Gas trapped in the metal, low pouring temperature.

Here, improving mold venting and increasing pouring temperature can help. Sand wash refers to the erosion of the mold surface by molten metal. Here, the metal erodes the sand due to high pouring speeds. Improve sand compaction. You will not have sand washing.

Types of Casting Defects



Defects	Descriptions	Causes	Remedies
Pouring	Problems during metal pouring	<ul style="list-style-type: none"> Incorrect pouring rate Poor gating system design 	<ul style="list-style-type: none"> Optimize pouring technique Improve gating design
Scab	Metal sticking to the mold.	<ul style="list-style-type: none"> Metal sticks to mold High mold temperature 	<ul style="list-style-type: none"> Apply mold coatings Lower mold temperature
Penetration	Metal penetrates mold surface	<ul style="list-style-type: none"> Metal penetrates mold Low mold compaction 	<ul style="list-style-type: none"> Strengthen mold material Increase mold compaction

Pouring defects occur due to issues during metal pouring. Pouring defects occur due to issues during metal pouring. The remedies are to optimize the pouring temperature and improve the gating design. Scab, which is there on top of a surface. Scab occurs when metal sticks to the mold due to high mold temperature.

Apply mold coating and lower the temperature. Penetration occurs when metal penetrates the mold surface. Metal penetrates the mold due to low mold compaction. The mold compaction has to be strengthened.

Types of Casting Defects



Defects	Descriptions	Causes	Remedies
Microporosity	Small voids within the casting	<ul style="list-style-type: none"> Gas bubbles trapped in metal Rapid solidification 	<ul style="list-style-type: none"> Optimize pouring speed Increase pouring temperature
Mold Shift	Misalignment of mold halves	<ul style="list-style-type: none"> Misalignment during pouring Vibration or movement 	<ul style="list-style-type: none"> Secure mold halves tightly Improve mold clamping
Core Shift	Movement of core during pouring	<ul style="list-style-type: none"> Core movement during pouring Insufficient core clamping 	<ul style="list-style-type: none"> Reinforce core support Secure core better

Microporosity refers to small voids within the casting caused by trapped gas bubbles. Rapid solidification can also lead to microporosity.

Mold shift is the misalignment of mold halves, so they must be properly pinned, and vibrations and other factors should be minimized. Core shift occurs if the core print does not hold properly and if there is a buoyancy force acting, which tries to shift. Movement of the core during pouring can occur. Here, it is better to reinforce the core structure or secure the core more effectively.

Types of Casting Defects



Defects	Descriptions	Causes	Remedies
Mold Crack	Cracking of the mold due to stress	<ul style="list-style-type: none"> Rapid temperature changes Weak mold material 	<ul style="list-style-type: none"> Use controlled cooling Use stronger molds
Misrun	Incomplete casting due to early solidification	<ul style="list-style-type: none"> Metal solidifies before mold fills Slow metal flow 	<ul style="list-style-type: none"> Increase pouring temperature Improve gating design
Cold Shut	Incomplete fusion of metal streams	<ul style="list-style-type: none"> Interrupted flow during pouring Low pouring temperature 	<ul style="list-style-type: none"> Ensure uninterrupted pouring Increase pouring temperature

Microcracks are cracks in the mold caused by stresses and rapid temperature changes, which weaken the mold material. Using stronger molds can help prevent this. Misruns are incomplete castings due to early solidification. To prevent this, improve the gating system and control the solidification rate.

Types of Casting Defects

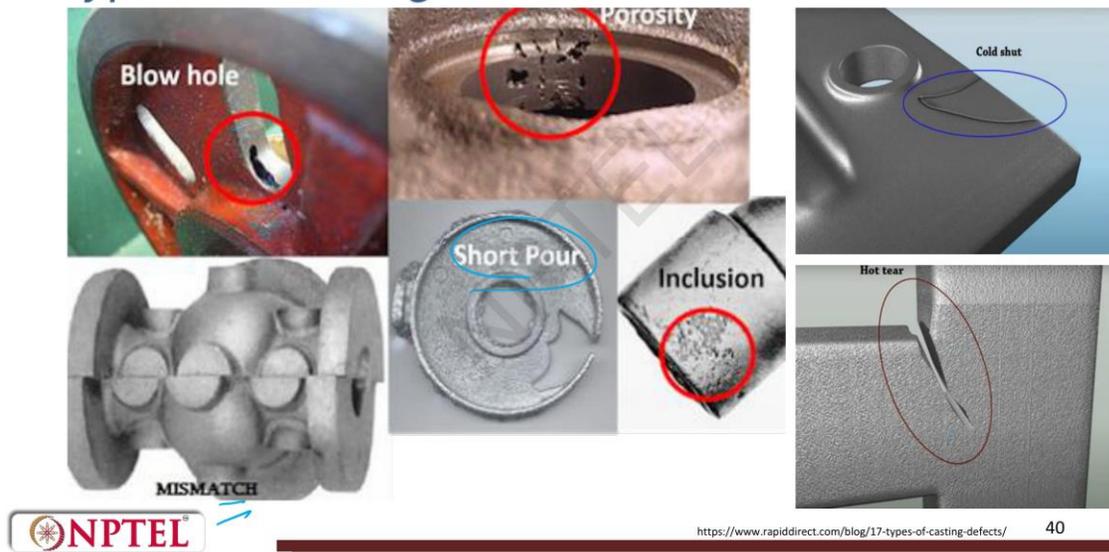


Defects	Descriptions	Causes	Remedies
Cold Shot	Small solidified metal particles in casting	<ul style="list-style-type: none">• Metal solidifies before mold fills• Slow pouring causing solidification	<ul style="list-style-type: none">• Increase pouring temperature• Increase pouring speed
Shrinkage Cavity	Hollow cavity due to contraction	<ul style="list-style-type: none">• Metal contracts too much during cooling• Inadequate feeding during solidification	<ul style="list-style-type: none">• Use risers and feeders• Ensure proper feeding
Sand Burn-on	Metal adhering to the mold surface	<ul style="list-style-type: none">• Metal sticks due to high temperature• Excessive oxidation	<ul style="list-style-type: none">• Use mold coatings• Reduce pouring temperature

Cold shots occur due to incomplete fusion of metal streams. Interrupted flow during pouring and low pouring temperature can lead to cold shots. Ensure uninterrupted pouring and increase the pouring temperature. Cold shots refer to small solidified metal particles in the casting. The metal solidifies before filling, and slow pouring causes this solidification. Cold shots—let us look at the figure.

A shrinkage cavity is a hollow cavity caused by contraction. You can see it on the top, right. The metal contracts too much during cooling. Inadequate feeding also leads to solidification. Sand burnout occurs when metal adheres to the mold surface. Metal sticks due to high temperature. Excessive oxidation occurs. It leads to mold coating and pouring at low temperature.

Types of Casting Defects



These are some of the defects you can see. What I showed was a schematic diagram. You can see here, blow holes are present.

These are all porosities that are present. A cold shut is present. This is a hot tear. These are sand inclusions that are present. This is a mismatch, and you can have a short pour.

To Recapitulate

- Casting classification.
- Types of casting?
- Sand casting, die casting, etc
- Terms related to casting?
- Application of casting in different sectors
- Defects in casting.

To recap, what did we see in this particular lecture? We saw casting classifications and types of casting: sand casting, die casting, permanent mold, expandable mold, permanent pattern, and expandable patterns. Then, we saw various casting techniques, applications of casting in different segments, and defects in casting. Then, we tabulated a comparison between various processes. Now, I will give you an exercise so that you can try doing this and see the importance of casting.

Here, you can try to produce the output using any of the casting methods. There is nothing universal. I want to make a camera lens cover. By cover, I mean there is a lens, a camera, and a tube that encloses the lens. Now, I want to produce the camera, the tube, and the front end where I can press-fit a lens. I hope I'm clear.

I have a camera, assuming this is a camera. So, in the camera, you have a tube, which is like this; and then, in the front part, I would like to press-fit a lens so that I can use it like a camera. So, I need to determine a casting process that allows me to produce the entire camera with the tube in one shot. This is the first example. Now, the second example is that I want to make a lens. I want to make a lens for a camera.

Which casting process should I choose? The third question is: I want to manufacture a contact lens that is placed in your eye. Which casting process would you choose? So, I have given three examples. So, with these three examples, I should identify the appropriate manufacturing process based on books and what has been taught, without referring to Google, to determine the best method for making each specified product.

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We have used all these references for making these slides.

Thank you very much.