Manufacturing Processes - I
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Lecture - 5
Metal Casting

Good morning. In the earlier episodes, we have seen that metal casting was the oldest manufacturing technique. Even today, it is the primary manufacturing technique. The principle of making a component by metal casting is very simple. Whenever we want to make a component, a similar cavity we create in the moulding medium and the moulding medium is made up of sand or metal or an alloy, or a plaster or wax. The shape of the cavity will be similar to the shape of the component which we want. We melt the metal and we pour the liquid metal into the cavity. After sometime, the molten metal will be solidified and we can take the casting outside. So, this is the simple principle of the metal casting. To create that cavity we use a model; we call it as the pattern.

The pattern is the replica of the component which we are going to manufacture. And in the earlier episodes, we have seen the pattern material, pattern allowances, and different types of patterns. We have also seen different ingredients of the moulding sand and different properties of the moulding sand.

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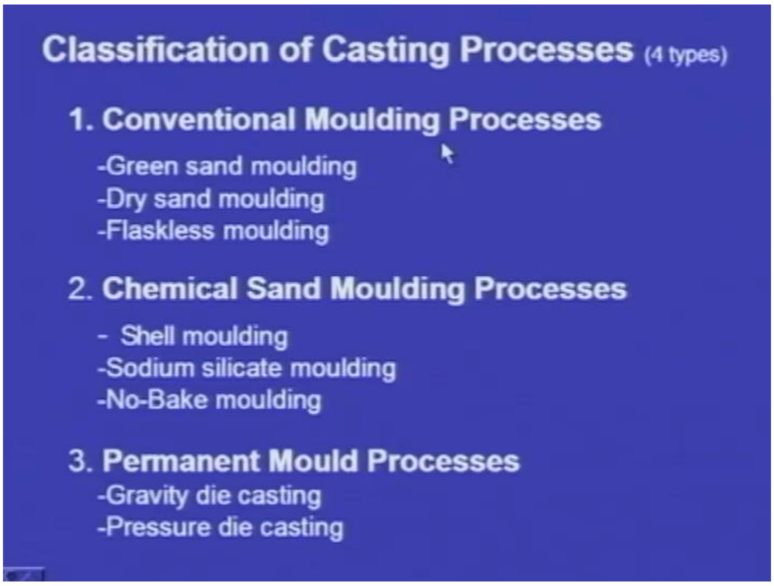

We have seen different types casting processes broadly classified into four types. One is conventional moulding processes, second one chemical sand moulding processes, third one permanent mould processes and fourth one special casting process. And in the conventional moulding processes, we use green sand or the dry sand as the moulding medium and the ingredients of this green sand are silica sand or olivine sand or zircon sand, and some amount some proportion of clay and moisture. One of the drawbacks of the green sand moulding is vapors are generated or hot gases are generated when we pour the molten metal. So, these hot vapors, if they do not escape from the mould, they create defects; pin porosity or blue holes will result because of this moisture, because of this vapors.

To overcome this problem, we incorporate dry sand moulding in which we dry the mould. Again, there are two types in which we only dry the skin or the surface of the cavity; in the other case, we completely dry the mould. And the third one also we have seen the flaskless moulding in which we do not use any flask. One of the drawbacks of the green sand moulding and dry sand moulding is it offers poor surface finish and the dimensional tolerance is poor.

To overcome these drawbacks, we have developed shell moulding in which the moulding medium is made up of resin that is the mixture of Phenol Formaldehyde plus fine Silica sand. The pattern is made up of metal and the pattern will be heated. When we place the moulding medium, that is the mixture of Phenol Formaldehyde and sand over the pattern, a thin layer of the resin melts and it forms a shell. Thus, we make two shells and we clamped them together, and there will be a cavity inside; we pour the molten metal. So, that is the special feature of shell moulding.

However, this is limited to small castings. Maximum weight of the casting that can be made by the shell moulding is about 10 kgs. Of course, this offers very good surface finish, dimensional tolerance is very good, but this cannot be used to make large castings. Another drawback of the green sand moulding is, sometimes when we make the course, the course break because of the poor strength. To overcome this drawback, people have developed Sodium Silicate moulding, in which the moulding medium is the fresh Silica sand and we add Sodium Silicate.

And again, this is classified in to two: one is self-hardened and another one is Carbon dioxide hardened. In the self-hardened process, we add Portland cement or blast furnace slag and we allow it to set. It takes about 24 hours time. Sometimes, we used to bake it to get additional hardness. And in the Carbon dioxide hardened sodium silicate process, we pass Carbon dioxide gas through the mixture of fine Silica sand and Sodium Silicate.

This Carbon dioxide hardens the mixture and we have seen no bake moulding in which without any baking, within few minutes, the system hardens. Ee use Urethane and fine Silica sand. We have also seen permanent mould process. In the case of the conventional moulding process, the moulding medium is made up of sand. Another drawback of this conventional moulding process is, after solidification, we have to break the mould; we have to take the casting outside. If we have to make one more casting, again we have to make the mould. The mould is not permanent; every time we will be breaking. So, again and again making a mould takes lot of time and the productivity goes down.

To overcome this drawback, permanent mould processes have been developed in which the moulding medium is made up of metal or an alloy. The cavity will be engraved in the metallic boxes or the alloy boxes. The moulding boxes are made up of metallic alloys. When we close the boxes, there will be cavity inside. Then we pour the molten metal. After solidification, we take the casting outside.

In the case of green sand moulding, we are breaking the mould. Here, we are not breaking. So, this is the permanent moulding process and again this is classified into gravity die casting or pressure and pressure die casting. This permanent moulding process is also known as die casting. In the case of the gravity die casting, the molten metal flows into the cavity by virtue of gravity, and in the case of the pressure die casting, we use external pressure to inject the molten metal into the mould cavity. So, this is the pressure die casting.

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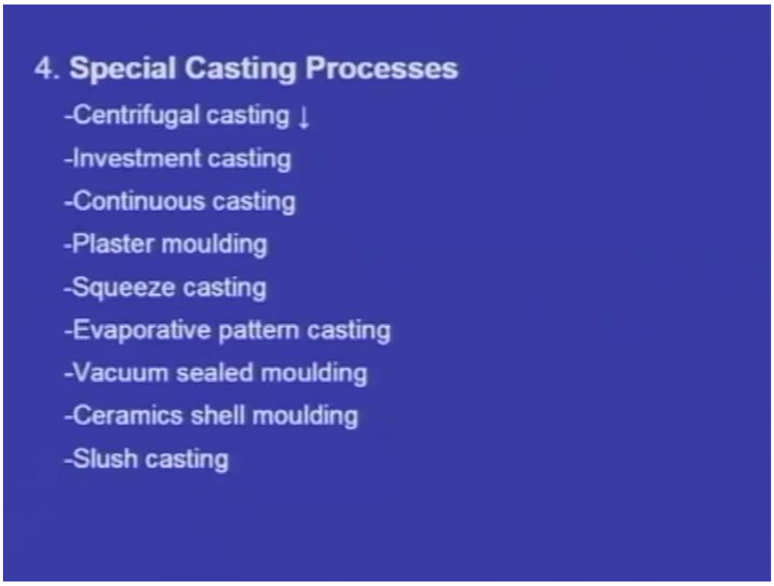

And we have seen different types of special casting processes: One is centrifugal casting; another one is investment casting; another one is continuous casting; another one is plaster moulding; another one squeeze casting; another one evaporative pattern casting; another one vacuum sealed moulding; another one ceramics shell moulding; another one slush casting. So, these are all come under special casting processes.

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Now, let us see the centrifugal casting.

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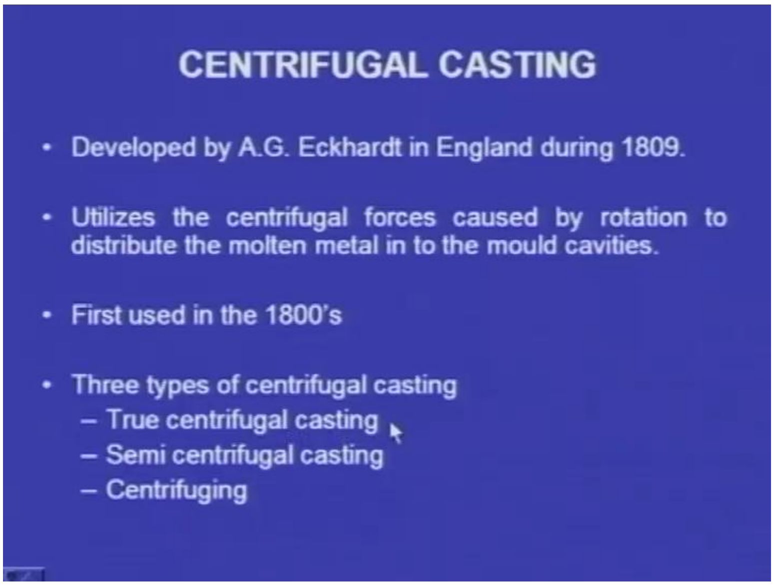

Centrifugal casting: This was developed by A G Eckhardt in England during 1809. In the case of the green sand moulding, the molten metal flows into the cavity by virtue of gravity. In the case of the pressure die casting, the molten metal flows into the cavity by virtue of the external pressure that we applied. Here, the molten metal occupies into the cavity by virtue of the centrifugal force. We cause centrifugal force on the molten metal. The molten metal goes because of the centrifugal force and it occupies on the mould cavity. So, this is the principle of the centrifugal casting. This was first used in the eighteen hundreds. There are three types of centrifugal casting: One is true centrifugal casting, second one - semi centrifugal casting, and the third one - centrifuging. First, let us see, true centrifugal casting.

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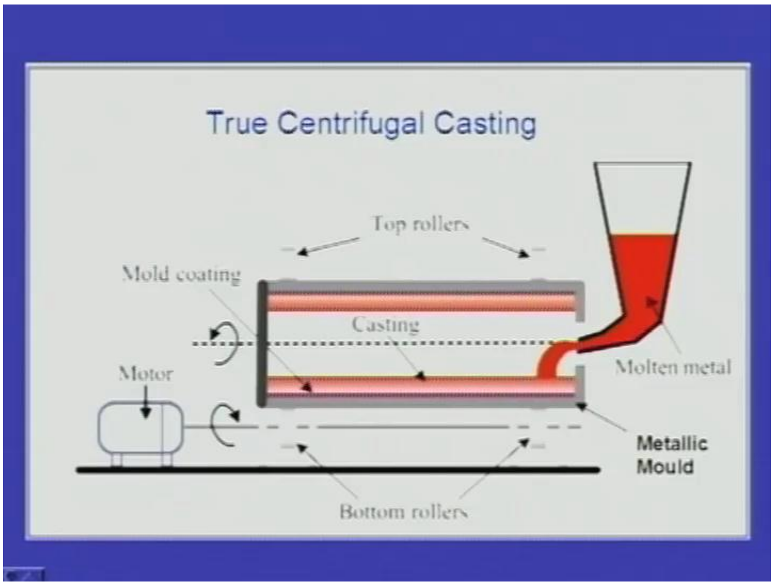

So, this is the diagram of the true centrifugal casting. Here, we can see the metallic mould. Here, we can see the dark one that is the metallic mould, and this metallic mould will be rotating. This is driven by a motor used here. A motor is driving and here we can see bottom rollers; here one bottom roller and here one bottom roller. And there are also rollers, top rollers; here one top roller and here one top roller. So, this will be rotating at predetermined speed and we pour the molten metal here, through this pouring cup, and the molten metal flows and it flows into the cavity inside the metallic mould. And it rotates and the metallic mould metal spreads all over, and the metallic mould continuous to rotate until it completely solidifies. After solidification is over, we stop the motor and we can take the casting outside. So, this is the basic principle. Let us see the step by step procedure.

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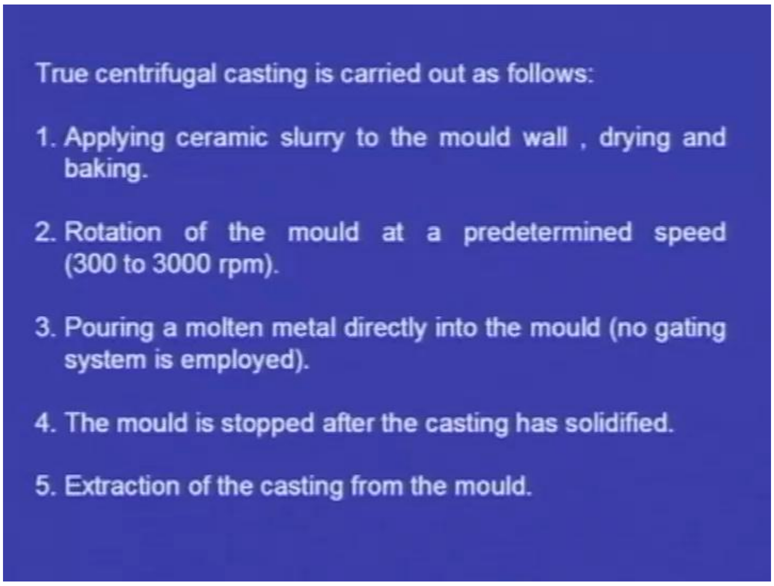

First one - we have to apply ceramic slurry to the mould wall. So, this is the mould; this is the mould and here we have to apply ceramic slurry because the molten metal should not be sticking to the metallic mould. And this ceramic slurry should be dried and after the ceramic slurry is dried, it should be kept in an oven for baking. The mould should be rotated at a predetermined speed and the speed will be 300 to 3000 rpm. During that time, we pour the molten metal. The molten metal flows into the mould, metallic mould, and the mould is stopped after the casting is solidified. So, until casting is solidified, we should continuously rotate the mould and we should note that no gating system is required.

In the other casting process, gating system is required, but here no gating system is required; directly we can pour the molten metal into the metallic mould. And after solidification, after stopping of the moulding box, we can extract the casting from the metallic mould.

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So, here I am showing a photograph where the centrifugal casting is in progress. So, here we can see the metallic mould and here we can see the rollers, and the molten metal is poured through this end and it will be occupying all over all along the length.

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So, these are some of the components manufactured by true centrifugal casting. Here we can see thick shells and inside there is hallow cavity. So, these are manufactured by true centrifugal casting.

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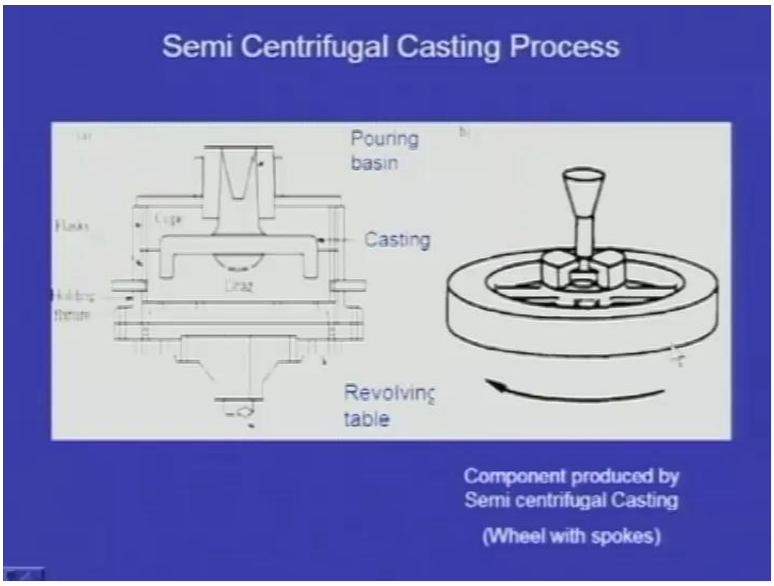

And the other type of centrifugal casting process is semi centrifugal casting. In the case of the true centrifugal casting, the axis of the moulding boxes or the axis of the metallic moulds is horizontal; here the axis is vertical. Here, we can see a pouring basin and this is the casting to be obtained and this will be rotating along a vertical axis. And this is the typical component manufactured by semi centrifugal casting process - A wheel with some spokes. This kind of wheel is manufactured by semi centrifugal casting process.

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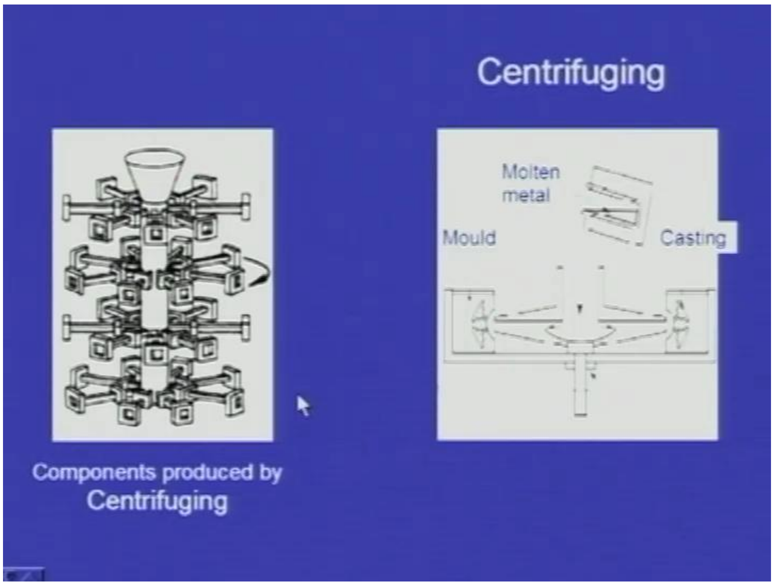

The next one is Centrifuging. This is the third type of the centrifugal casting processes. So, here we are going to manufacture small small components. All are joined together and all are gated together. This is a central sprue and we can see so many castings are there, and we pour the molten metal. As the molten metal is poured, the mould is rotating along a vertical axis. The molten metal, because of the centrifugal force falling on it, it goes and occupies the extreme end of the mould cavity. We continue to pour the molten metal until all the cavities are completely filled with the molten metal. We continue to rotate the mould until the molten metal is solidified. After the molten metal is solidified, we can take the casting outside. Here, we can manufacture number of components, small small components at a time. So, this is the centrifuging process, the third type of the centrifugal casting process.

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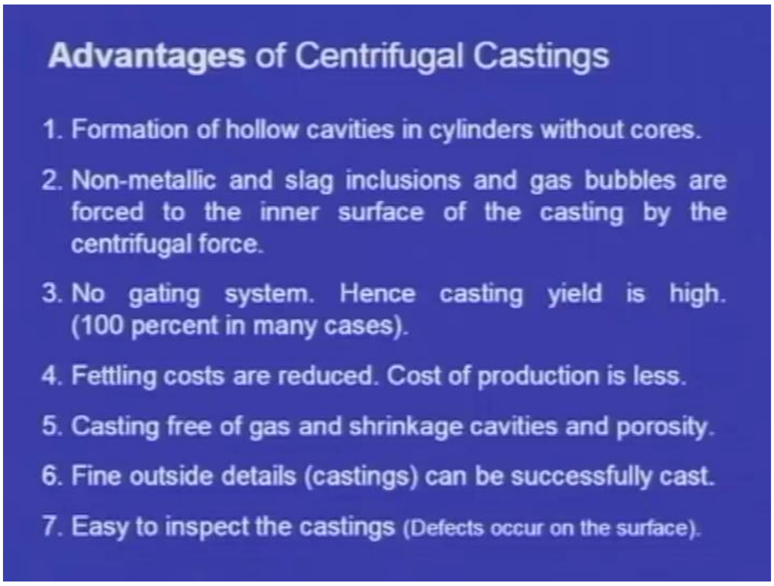

Now, let us see the advantages of centrifugal casting processes. Formation of hallow cavities without cores: In the case of the conventional sand casting process, if we have to make a casting with some hole, we have to use a core. And to make that core we have to put extra efforts; sometimes it may break; that increases the production time. But in the case of the centrifugal casting processes, there is no need for any core; this simplifies the process and it reduces the cost of production. So, that is the primary advantage of the centrifugal casting process and second advantage is regarding the elimination of slags and impurities.

In the case of the conventional casting processes, we make the cavity and we pour the molten metal. The molten metal is tapped from a furnace and inside the furnace there is every chance that the molten metal may be mixed up with the slag and other impurities. Though we take certain measures to segregate these slags and impurities from the molten metal, still there will be some slag and some impurity mixing with the molten metal. These small traces of the slags and impurities come inside the cavity and sometimes they lead to defects. But here, in the case of the centrifugal casting process, what is happening?

The molten metal is subjected to centrifugal force; it is rotating. And if there are any slags present in the molten metal, the slags are also subjected to centrifugal force. Molten metal is subjected to centrifugal force; slag is also subjected to centrifugal force. The density of the molten metal is high; the density of the slag is less. The centrifugal force falling on the molten metal is high; the centrifugal force falling on the slag particles and impurities is less. Because of this difference in the centrifugal force, the metal will be going towards the outer portion of the metallic mould, whereas the slags and impurities, they are subjected to small centrifugal force. So, they will be inside the cavity or they are along the inner surface of the cavity.

So, in the case of the conventional sand casting process, we have to take extra efforts to segregate slags from the molten metal. Here, because of the centrifugal force, the slags are automatically eliminated; automatically they are segregated and they are corrected at the inner surface of the casting. So, they can be removed very easily; they are at the surface only. And in the case of the centrifugal casting process, there is no need for gating system, what is… hence casting yield is very high.

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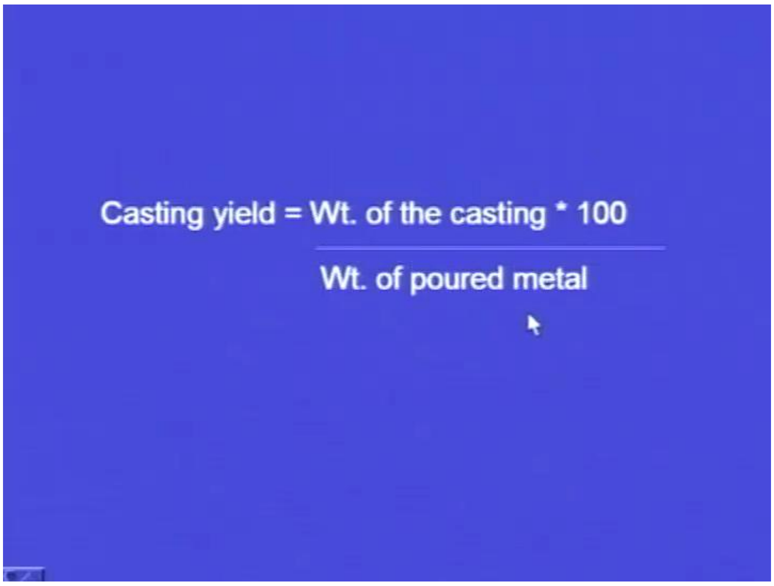

What is this casting yield? Casting yield is the weight of the casting multiplied by 100, whole divided by the weight of the poured metal. Suppose if we are making a casting of 10, kgs we have to pour more molten metal because molten metal has to occupy in the sprue passes, molten metal has to occupy in the runner, molten metal has to occupy in the raiser in the gating system. So, more molten metal is poured than the weight of the casting. So, the casting yield is the weight of the casting multiplied by 100, whole divided by the weight of the poured metal. So, this is always less than 100 percent. Usually, it will be between 70 percent to 80 percent.

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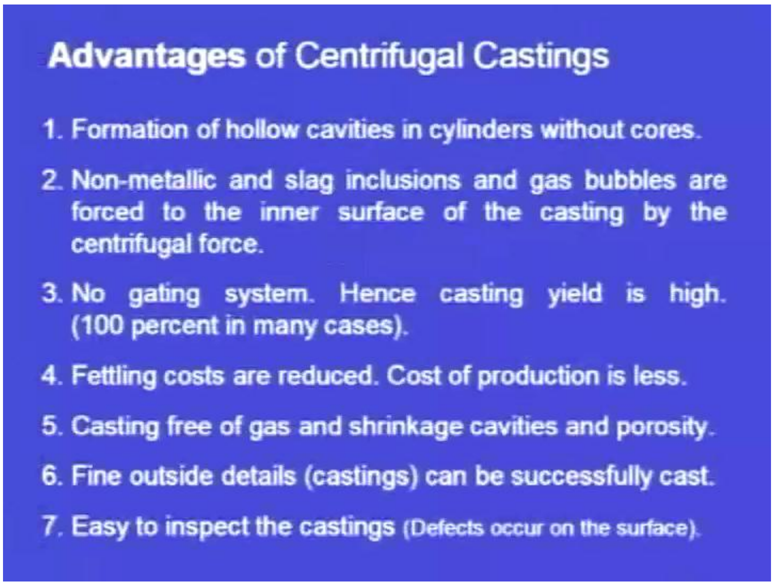

But here, in the case of the centrifugal casting, there is no gating system. So, casting yield is 100 percent. Of course, in centrifuging, there will be a central sprue; so, casting yield may be a little. But in this in the case of these true centrifugal casting and semi centrifugal casting, the casting yield is 100 percent. And in the case of the other processes, we use to fettle cut the sprue; we use to cut the runner; we use to cut the raiser. So, this is known as the fettling process. So, this increases the cost of the production. But here, in the centrifugal casting process, there is no sprue; there is no racer; there is no gating system; so, no fettling process. So, the cost involved for the fettling process is zero and the casting is free of gas and shrinkage cavities in the centrifugal castings.

Another one, fine outside details can be successfully casted. If the outer portion of the casting contains small details sometimes it is difficult, but here we are applying centrifugal force. Because of the centrifugal force, the molten metal goes and occupies even into the small cavities. So, fine details can be successfully cast. And finally, it is easy to inspect the castings because most of the defects, they occur on the inner surface; So, it is easy to inspect the castings.

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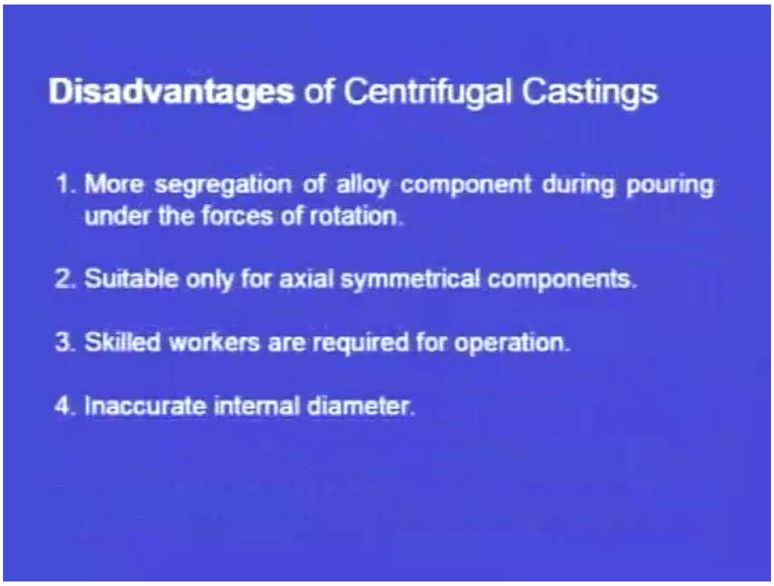

Disadvantages of the centrifugal casting: Here, the segregation of the alloy component takes place. Suppose, if we are making a casting of an alloy, alloy means two or more metals may be present; the densities may be different. If the densities are different, the centrifugal forces falling on each and every element will be different. The centrifugal force falling on the metal which is having higher density, the centrifugal force will be more. If the other metal is having lesser density, the centrifugal will be less.

As we keep rotating as the centrifugal force, force is falling on the molten metal. Because of the difference in the densities, because of the difference in the centrifugal forces, the alloy components may get segregated. So, we have to deal this situation very carefully.

Suitable only for axially symmetrical components: Of course, in this centrifuging, it may be little exception from this point, but generally, these casting process are suitable only for axially symmetrical components and skilled workers are required for the operation, and sometimes inaccurate internal diameter arises.

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These of the applications of the centrifugal castings: Cast iron pipes with holes we can manufacture without using any core. Liners of IC engines, bushings, wheels, we can manufacture by centrifugal casting. Pulleys and bi metal steel bronze bearings we can manufacture by centrifugal castings and other parts possessing axial symmetry can be cast successfully by centrifugal casting processes.

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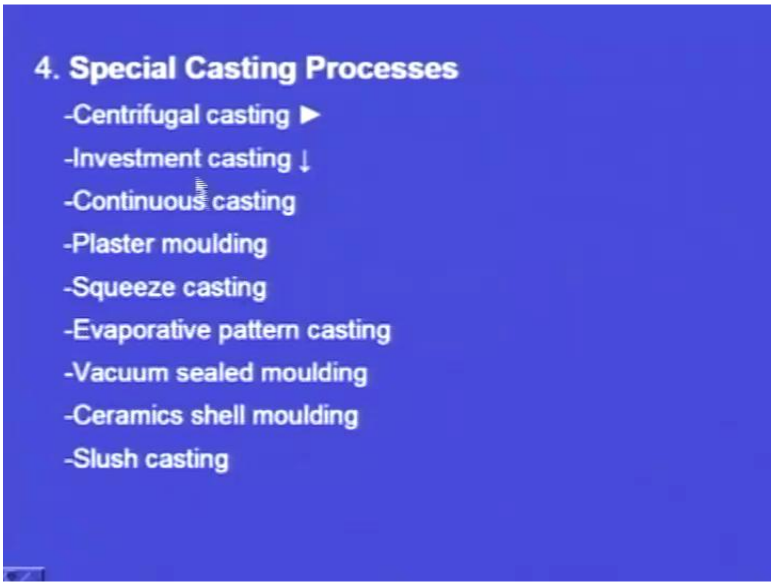

So, we have, now we are studying the special casting processes. We have seen the centrifugal casting processes. Now, let us see the investment casting.

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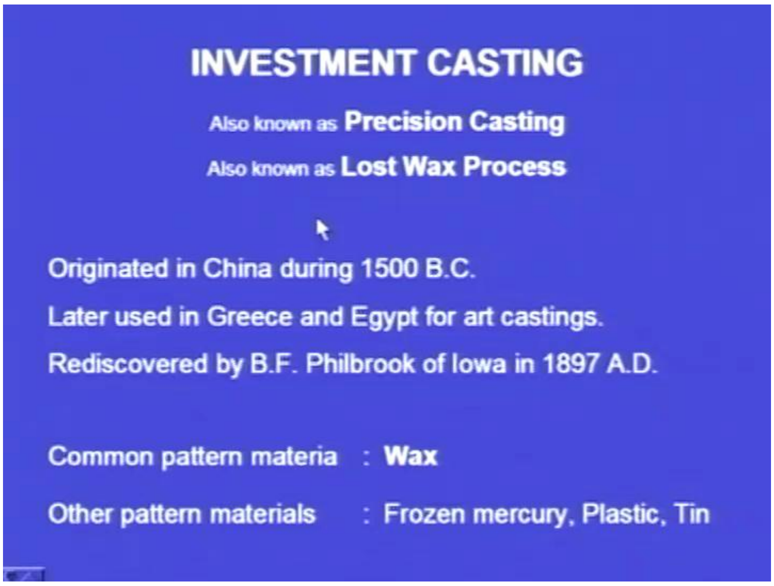

Investment casting: This investment casting process is one of the important casting processes where extreme precision is important. We use investment casting process. That is why we also call it as precision casting. The pattern material used in this process is wax; most of the cases. So, we also call this process as Lost Wax Process. This process was originated in China during 1500 B.C. Later, this was improved in Greece and Egypt.

They used this technique for making art castings. This was rediscovered by B.F. Philbrook of Iowa in 1897 A.D. As I have already mentioned, the common pattern material is the wax and in special cases we also use frozen mercury plastic and Tin. Let us see how to make an investment casting.

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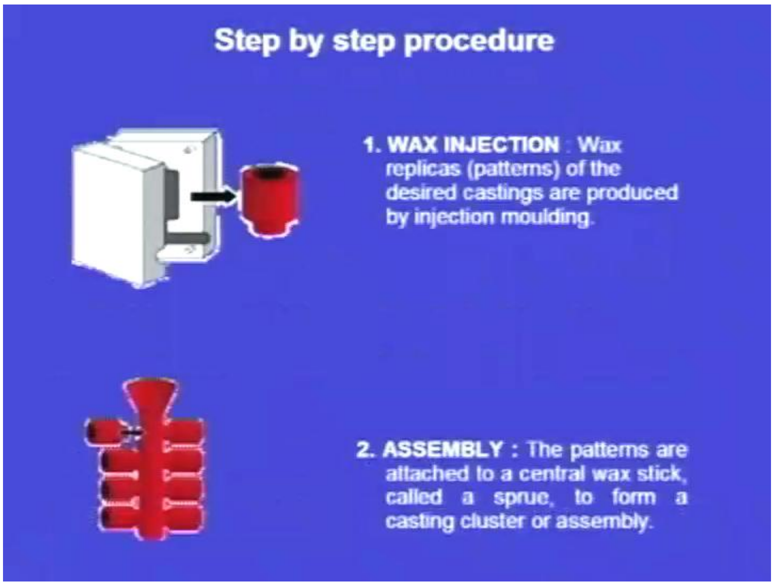

Step by step procedure. So, this is the component which we want to manufacture. So, this is the component. So, first we have to make the wax pattern. So, here is the metallic mould inside which there is a cavity, and the cavity inside this metallic mould is similar to this component, and we inject wax into this metallic mould. After wax is solidified, we take this piece outside.

Next one, Assembly. And if we have to make only one component, so, that is not economical. We make several components together with a common sprue. So, here we have taken say eight pieces, wax pieces, and we have assembled them. These patterns are assembled with a central sprue.

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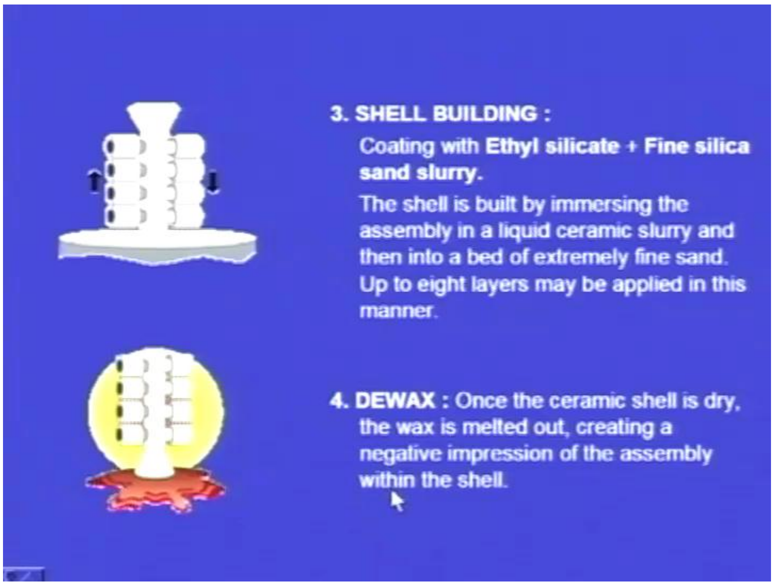

Next one shell building. We have to use one slurry. This slurry is made up of Ethyl Silicate plus fine Silica sand; very fine silica sand. So, when we add this very fine silica sand with the Ethyl silicate, it forms a fine slurry. We make a coating to this assembly with this fine slurry. Now, what happens? Over surface of these pieces, wax pieces, the slurry coating is there. This fine slurry coating will help us to get the very fine surface finish or its forms a fine shell outside the wax pieces.

Next one, we make another shell; that is, we use another ceramic slurry. Here, we have used slurry made up of Ethyl Silicate plus fine Silica sand, that is one slurry, and here we are using another slurry, that is the ceramic slurry. We dip this assembly into the ceramic slurry and we place it in the fine Silica sand or we sprinkle fine Silica sand, and it is dried. Again we dip this assembly in the ceramic slurry. We take it and we sprinkle the Silica sand and this process is to be repeated about 8 times; means, we dip it in the ceramic slurry and apply Silica sand; dip it in the ceramic slurry, apply Silica sand, and this cycle has to be repeated for about 8 times.

Now, what happens? A thick shell is created around the wax patterns.A thick shell is created above, around the Ethyl Silicate slurry coating. So, now, the next process is we have to dewax. In this assembly now, there is thick shell made up of ceramic slurry and sand; inside there is wax pattern; wax assembly is there; that we have to dewax it. So, we will be heating with the system. The wax will be melting. The wax will be flowing out from the assembly and we heat it such that even the small piece of the wax will not be present inside. The system is heated completely so that the wax is completely drained out. Now, inside what is there? Hollow cavity is there; that is the negative impression of the system; negative impression of the assembly is inside.

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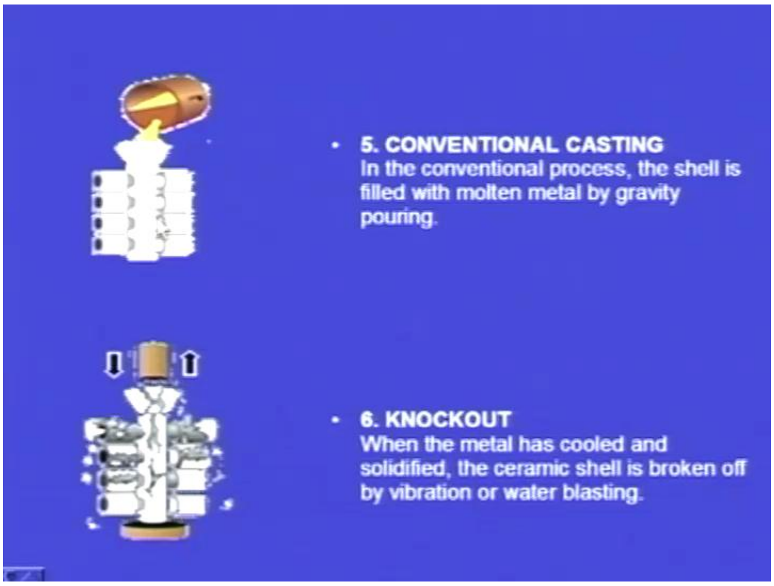

Next step: Now we make a pouring cup. Now, we pour the molten metal. The molten metal flows through the central sprue and it flows into each and every cavity, and it is filled with all the cavities, and after sometime the molten metal will be solidified. After solidification is over, the next step, the knockout; means we break these shells and the casting comes out.

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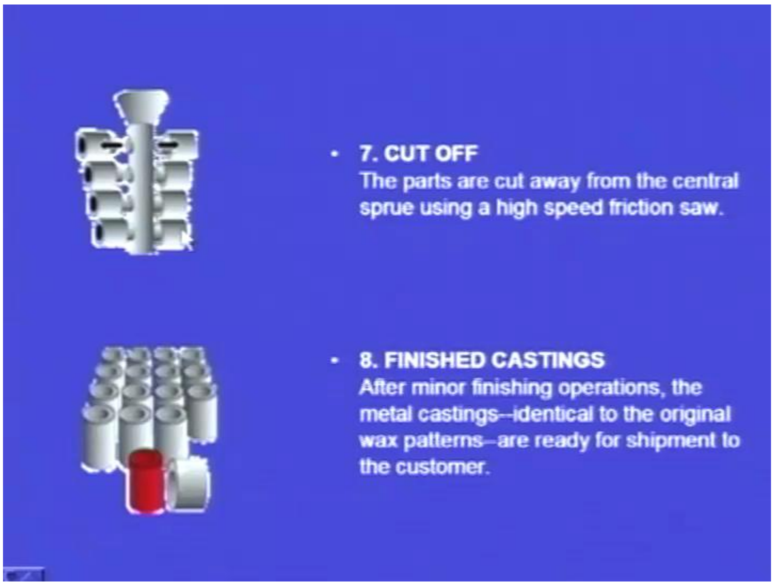

Next one we have to cut off. Actually our intention is not to produce this assembly; we want individual castings; so, we want to separate this. So, we will cut off using high speed friction saw, we will cut them; each and every component. Now, these are the components. These are to be given minor finishing operations. Once we give the minor finishing operations, the castings are ready.

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Advantages of the investment casting: This process offers excellent surface finish; very very excellent surface finish; produces very fine details. Especially, if we examine some jewellery castings, the profile of some jewellery castings of or some jewellery items, the profile will be very complex. These complex details are cast by investment casting.

The next one is, very thin sections can be made of the order 0.75 mm and we obtain close dimensional tolerance. In the case of the conventional sand casting process, if we want to manufacture a certain component, the final casting that we will be obtaining will be little larger; the dimensional tolerance is not good, but here the dimensional tolerance is good. That is the dimensional tolerance will be 0.08 to 0.1 mm.

Complex shapes can be made; that is another advantage and no finishing operation is required. Sometimes finishing operation may be required; that is very negligible. And casting obtained by investment casting, they are sound; usually they are free from defects.

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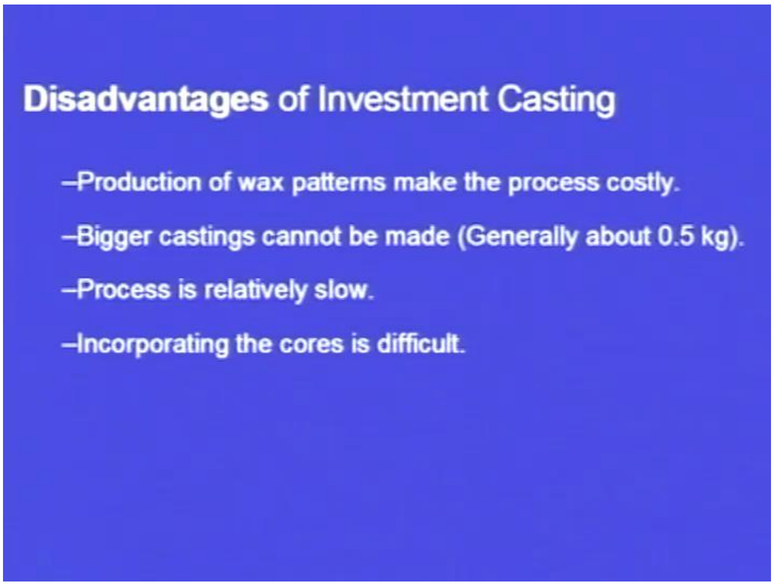

Let us see the disadvantages of the investment casting. Production of wax patterns makes the process costly. Yes, every time we have to make the wax patterns and this increases the cost of production. Second disadvantage is the limitation - bigger castings cannot be made. The maximum size that we can make by investment casting is about 0.5 kg; beyond 0.5 kg, it is difficult to make the casting and the process is relatively slow.

What is the process? First, we have to make the wax patterns. Next, we have to assemble them. Next, we have to give a fine slurry coating; the slurry is made up of Ethyl Silicate and fine Silica sand. Next we have to make another slurry, ceramic slurry. We have to dip the assembly in the ceramic slurry and we have to give the Silica sand coating. Again, dip it in the ceramic slurry; give the silica sand coating. Then we have to dewax it. Then finally, we have to pour the molten metal. So, this takes a lot of time. The process is slow and incorporating the cores is difficult in the case of the investment casting.

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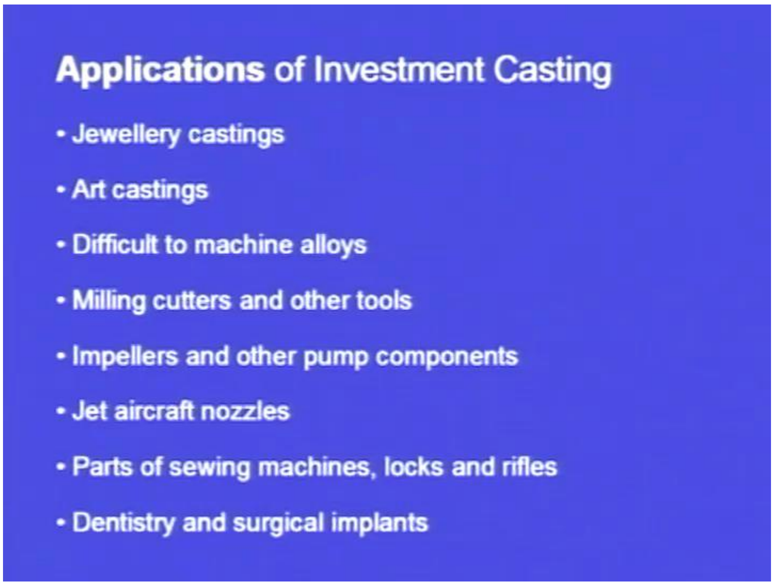

Applications - Jewellery castings: In the jewellery castings, the profile of jewellery castings or the jewellery items, they are very complex. So, we have to use investment casting and they are made up of Gold or Silver, and we cannot machine it. If we machine it, the chips will be lost; the chips of the valuable metal will be lost. So, we cannot machine it. The dimensional tolerance should be high. So, we have to use investment casting. Very high surface finish is required. So, that is why for making jewellery art items, we use investment casting and for making art castings also we use investment casting.

And there are certain alloys which are very difficult to machine. These alloys can be successfully cast by investment casting. And milling cutters and other tools, they are made up of high speed steel; this high speed steel is very hard. Once we cast the milling cutter, if there is any irregularity, it is very difficult to machine it; that is why, we cast the milling cutter by investment casting. Impellers and other components, they have very complex profile. So, these impellers can be cast by investment casting successfully.

Jet aircraft nozzles can be cast successfully by investment casting. Parts of sewing machines, locks, and rifles can be successfully cast by investment casting. Also this process is widely used in dentistry and for making other surgical implants.

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We can see here some examples of investment casting. We can see few components and the shape is very complex, and in some cases the thickness is very small. So, all these can be successfully cast by investment casting.

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Here, another example for the investment casting. So, this is the milling cutter. This milling cutter is made up of high speed steel. This milling cutter is cast by investment casting process. So, if it is made by other process, if there is any irregularity, if there is any extra metal, how can we machine it? It is very difficult. So, we do not want any irregularity; we do not want any extra projection; we do not want any extra material. So, this milling cutter is made by investment casting by which we get the highest dimensional accuracy; we get the highest surface finish; so, no need to machine it. We only sharpen it before use.

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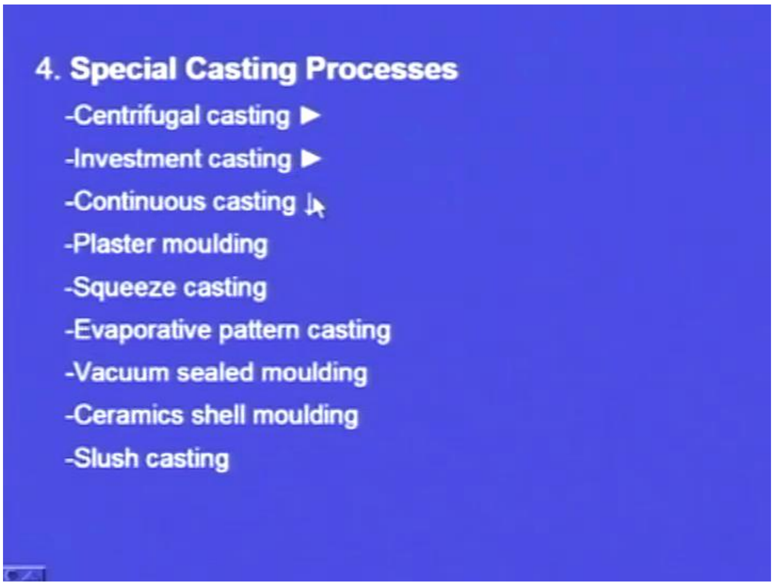

So, among the special casting process, so far we have seen centrifugal casting, investment casting.

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Now, let us see the continuous casting.

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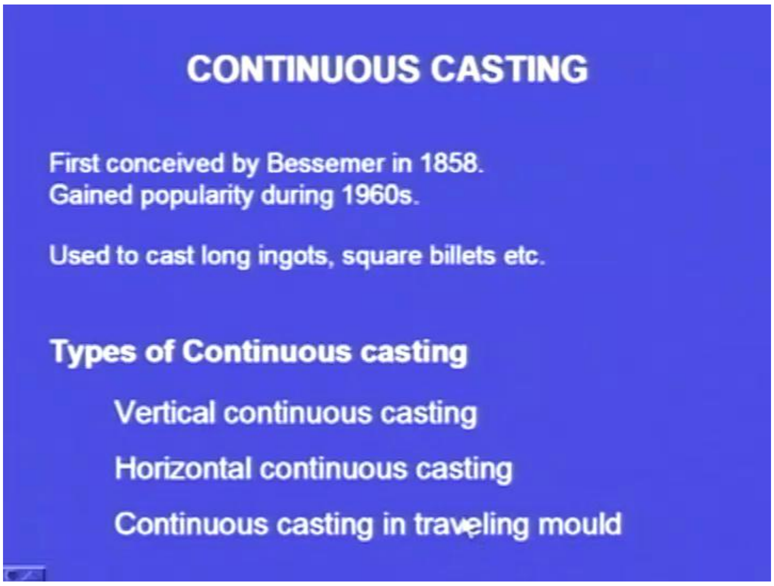

Continuous casting: So, this was first conceived by Bessemer in 1858 and this gained popularity during 1960s. This is used to cast long ingots, square billets, etcetera. This continuous process is three types: Vertical continuous casting, horizontal continuous casting, and continuous casting in travelling mould. Let us see this process in detail.

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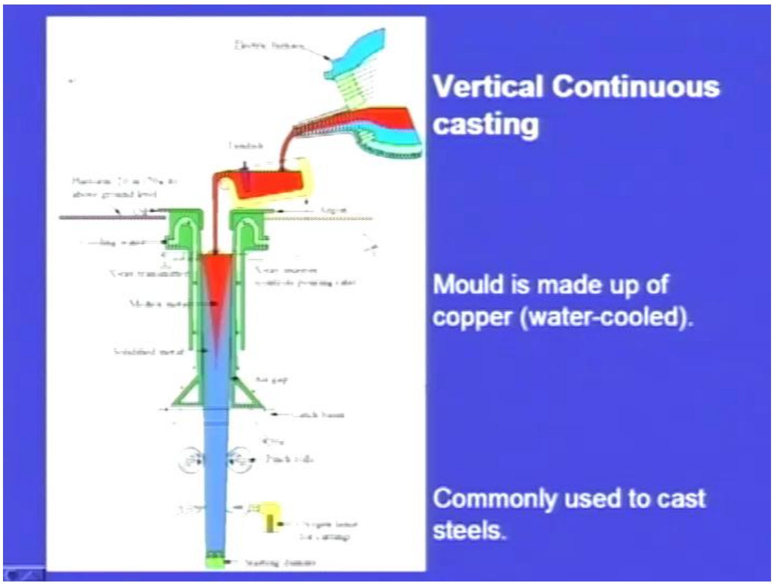

Vertical continuous casting: So, this is the vertical continuous casting system. The mould is made up of Copper. Here, we can see the mould. So, this is made up of Copper and this is water cooled. This vertical continuous casting is commonly used to cast steels.

Let us examine the different components. So, here, we can see the mould which is made up of Copper and it is water-cooled, and its height is above 20 meters from the ground level. So, here, we can see one X ray transmitter and here we can see X ray receiver.

As here is the tundish, tundish means a special pouring cup or the special pouring basin, and we are pouring molten metal into this tundish. The molten metal from this tundish is flowing into the mould. As the molten metal flows into the mould, it is cooled and it solidifies. Here, we can see this red portion is in the molten state and this blue portion is in the solidified state. So, as it solidifies, it continuously goes down. We can see. Here we can see the rolls. These rolls will be rotating and the solidified casting goes continuously. Here, there is X ray transmitter and X ray receiver and inside there are any defects, any blow holes and these will be detected online. So, this is the purpose of the X ray transmitter and X ray receiver.

And here is the starting dummy. Initially this starting dummy it is at the top. So, over this starting dummy, we pour the molten metal and this starting dummy slowly comes down. As it slowly comes down, the molten metal is solidified. And as it is solidified, it is rolled. Slowly it is rolled and the whole structure comes down. When we are pouring molten metal into the mould, there is a chance that the atmospheric oxygen may react with the molten metal and oxides will be formed. So, this has to be avoided; this has to be prevented. So, we are passing Argon gas over this, over this mould. So, this Argon gas prevents oxidation and also we use some lubricating oil. We send lubricating oil so that the molten metal will not be sticking to the mould. So, this is the system of the vertical continuous casting.

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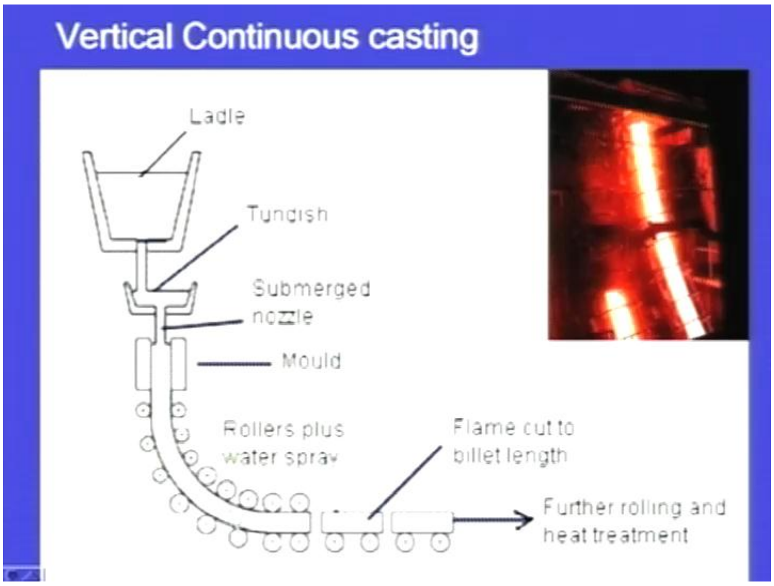

And here we can see the process in further. So, here is the ladle and this is the tundish, and we are pouring molten metal here and it is solidified. We can see so many rollers and here it is cut. It is cut and they are sent for further heat treatment operations, and here we can see the way the solidified billet is coming down. It is solidified and it is coming down continuously. Sometimes, even parallelly more than two billets will be coming down; two, three, or four, five billets will be parallelly cast.

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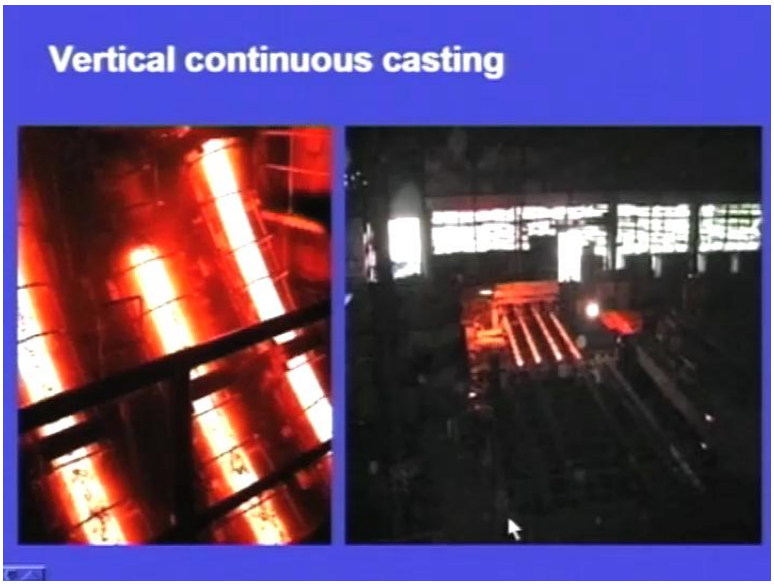

Yes, here we can see. Here we can see four billets are continuously cast, parallelly cast and they are coming down. As they come down, they are cut and they are sent for heat treatment operations.

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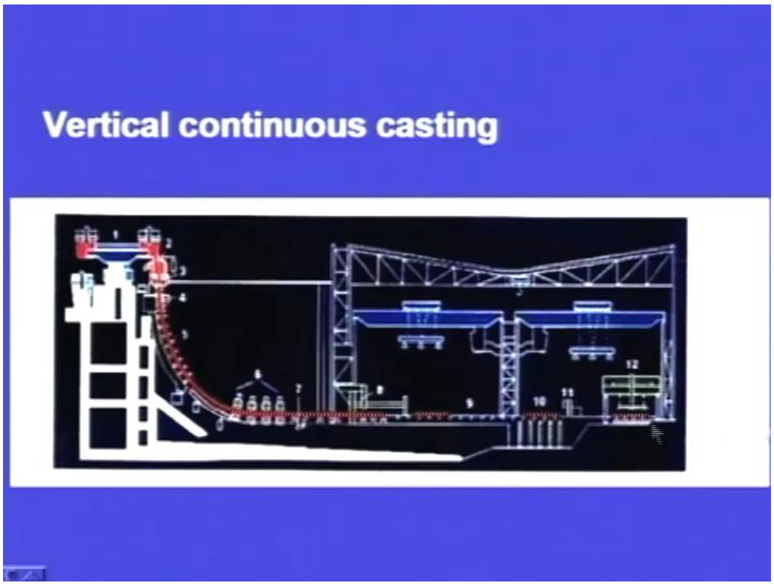

So, this is the plant. So, here we can see, the mould is kept at an elevated position and it is solidified and it is slowly coming down, and here it is cut and they are sent for further heat treatment operations.

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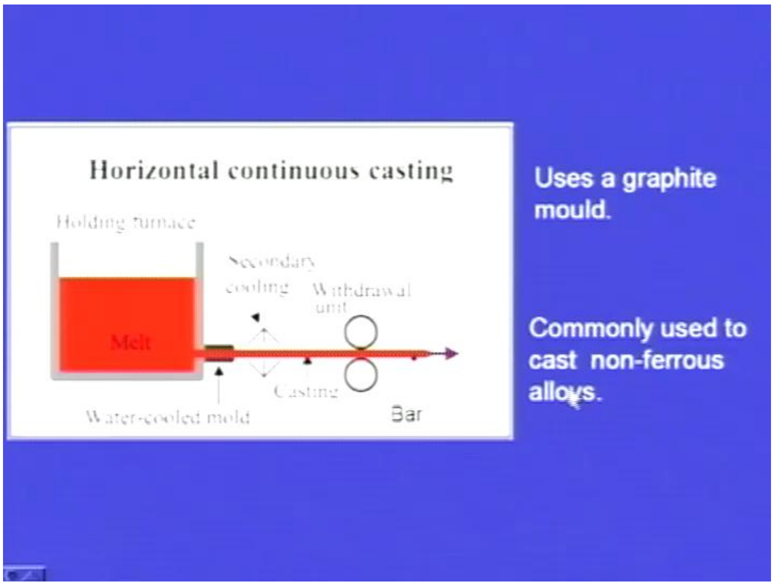

Next one - the horizontal continuous casting: This process uses a Graphite mould and this is commonly used to cast non-ferrous alloys. Here is the holding furnace. There is molten metal here and this is the mould. This is water cooled. And here there is another cooling system and here we can see as the molten metal is passing through the mould a bar is generated. So, this bar is fed continuously outwards by these rollers. So, this is the horizontal continuous casting.

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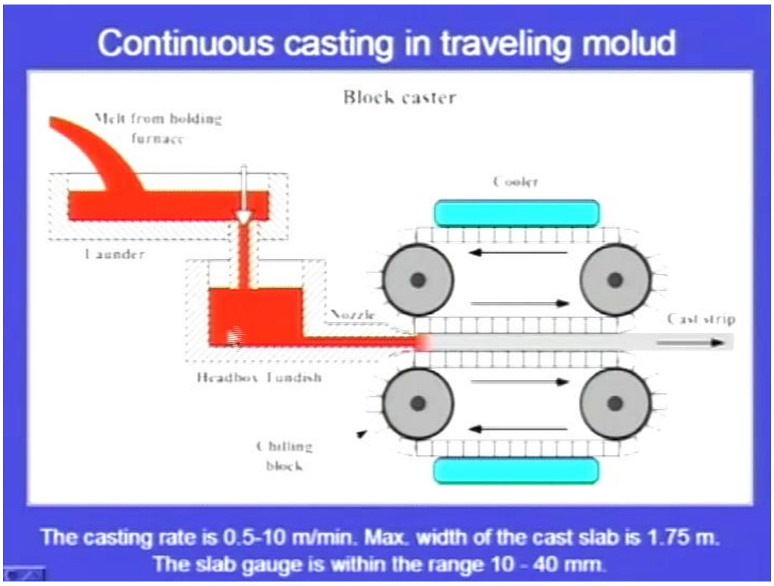

Continuous casting in travelling mould: In the case of the vertical continuous casting and horizontal continuous casting, the mould is stationary, and here in the continuous casting in travelling mould, let us examine. So, here is the molten metal coming from the furnace and this is the tundish, and here we can see a nozzle. Where is the mould?

So, here we can see belts. These belts are rotating like a caterpillar. Slowly they will be rotating. This is rotating in this direction; this is rotating in this direction; these two rotate like a caterpillar. So, the molten metal is trapped between these two belts and slowly they will be advancing. As they advance, it will be cooled. By the time it comes out, it will be solidified. We can see, cast strip is coming out and the casting rate is 0.5 to 10 meters per minute. Maximum width of the cast slab is 1.75 meters. The slab gauge is within the range of 10 to 40 mm. So, this is about the continuous casting in travelling mould.

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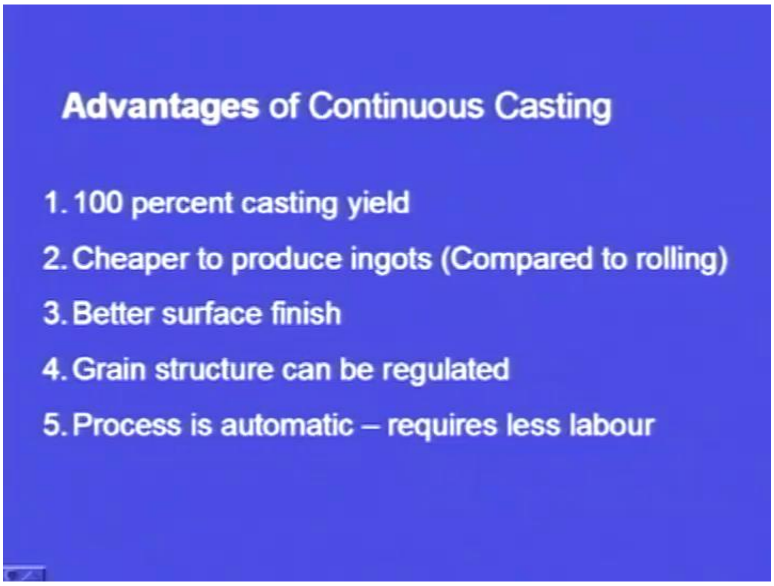

Advantages of the continuous casting process: First advantage is 100 percent casting yield. What is this casting yield? We have already seen; again I will tell you.

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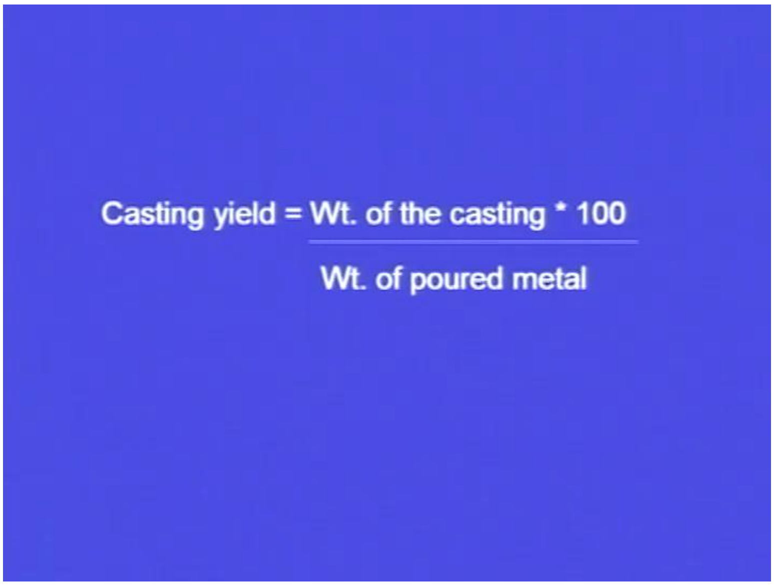

Casting yield is the weight of the casting multiplied by 100 divided by weight of the poured metal. Yes, weight of the poured metal is always more than the weight of the casting in the case of the conventional casting process and many casting processes. But here, there is no gating system; there is no sprue; there is no runner; no racer.

Whatever we are pouring is becoming part of the casting. So, here we are getting 100 percent casting yield; that decreases the cost of production and it is cheaper to produce the ingots. Ingot can be produced by rolling also, but the cost involved in rolling operation is more compared to the continuous casting process, and here we get better surface finish. Grain structure can be regulated. Process is automatic. Here, we have seen, the process is automated. So, less labor are required. A stage may come where there will be scarcity of labor. At such times, this process will be highly useful.

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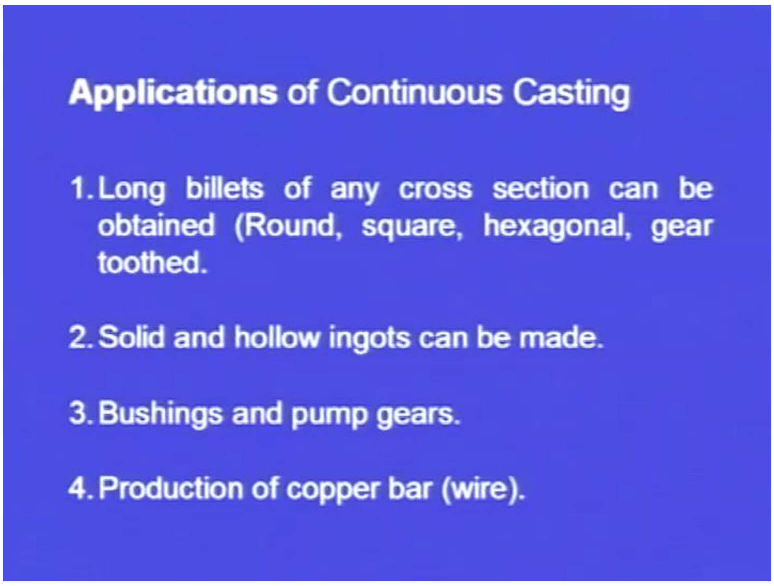

Applications: Long billets of any cross section can be obtained, whether it may be round or square or hexagonal or gear toothed; any shapes ingots can be obtained by continuous casting. Solid castings can be obtained and hollow castings also can be obtained. Bushings and pump gears can be made by continuous casting. Production of Copper bar or wire can be manufactured by continuous casting.

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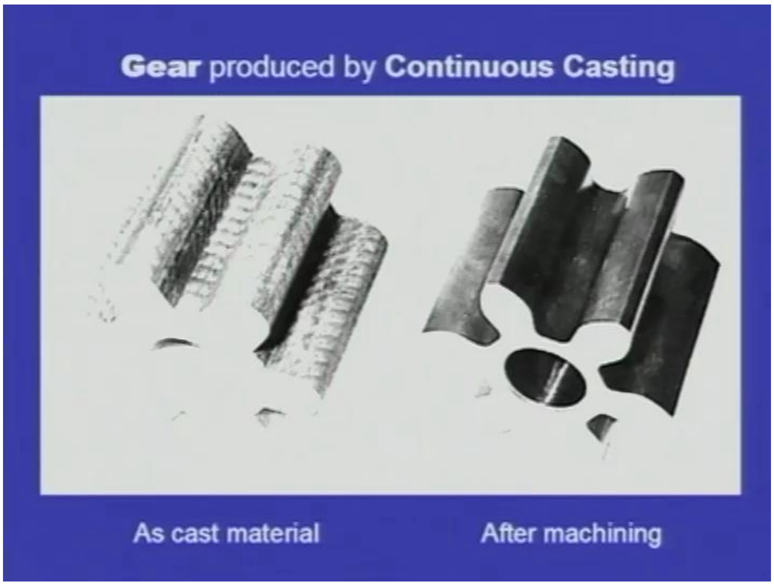

And here I am showing you an example. So, this is an example. This is the gear produced by continuous casting. It means we can see so many teeth for this scale; means this kind of long billet is produced by continuous casting. So, this is without machining. Immediately after casting, we have cut it. But after machining, we get a fine surfaced gear. So, this gear ingot is manufactured by continuous casting.

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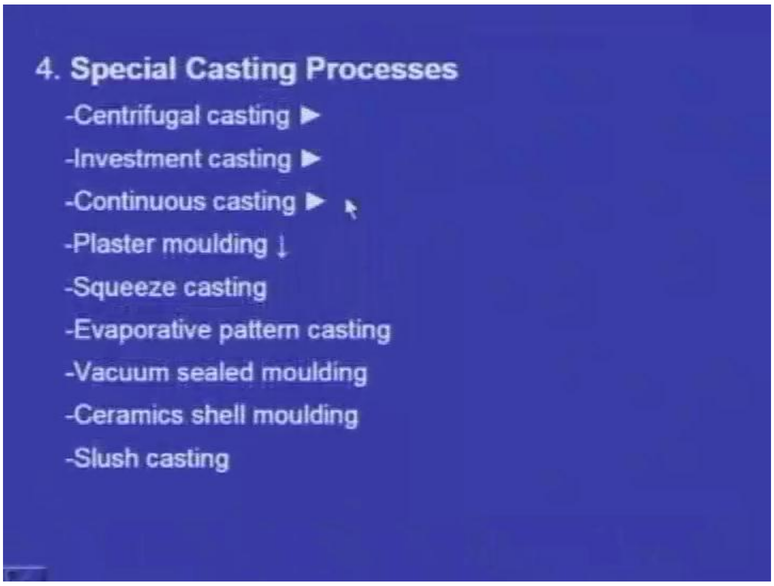

So, among the special casting processes, we have seen centrifugal casting; we have seen investment casting; we have seen continuous casting. And in the centrifugal casting, we have seen that it is of three types: one is true centrifugal casting, semi centrifugal casting, and centrifuging.

We have seen investment casting and its special features. We use investment casting where extreme precision is important. Where extreme surface finish is important, we use investment casting. We have also seen continuous casting and its three types: one - vertical continuous casting, other one - horizontal continuous casting, and the third one - continuous casting in travelling mould. We have seen its applications.

In the next episode, we will be seeing the other special casting process like plaster moulding and squish casting, etcetera.

Thank you.