Manufacturing Processes - I

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Module - 2
Lecture - 7
Metal Casting

Good morning. We have been learning the metal casting process which is the primary manufacturing process. We have, in the earlier episodes we have been learning the principles and the applications and different types of these metal casting process. These metal casting process are mainly classified into four types.

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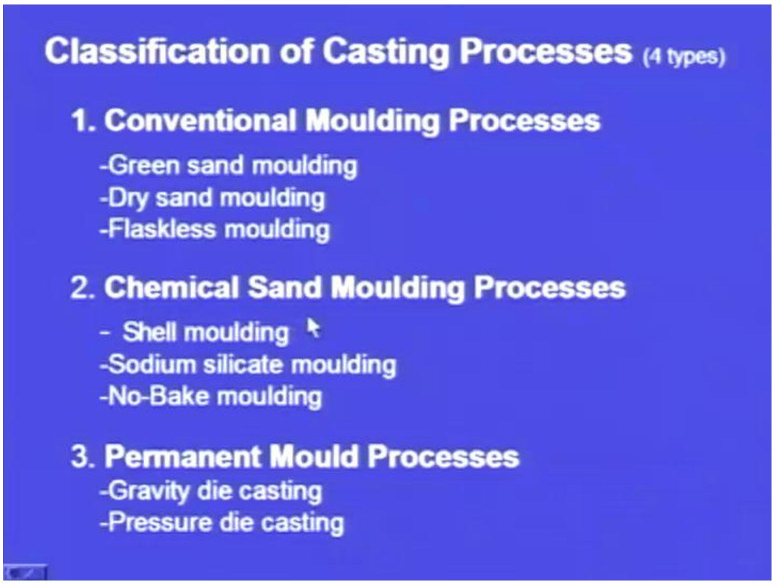

The first one is the conventional moulding process which is sub classified as green sand moulding, dry sand moulding, and flaskless moulding. The second type is the chemical sand moulding process and which is sub classified as shell moulding, Sodium silicate moulding and No-bake moulding. And the third type is permanent moulding process which is sub classified as gravity die casting and pressure die casting.

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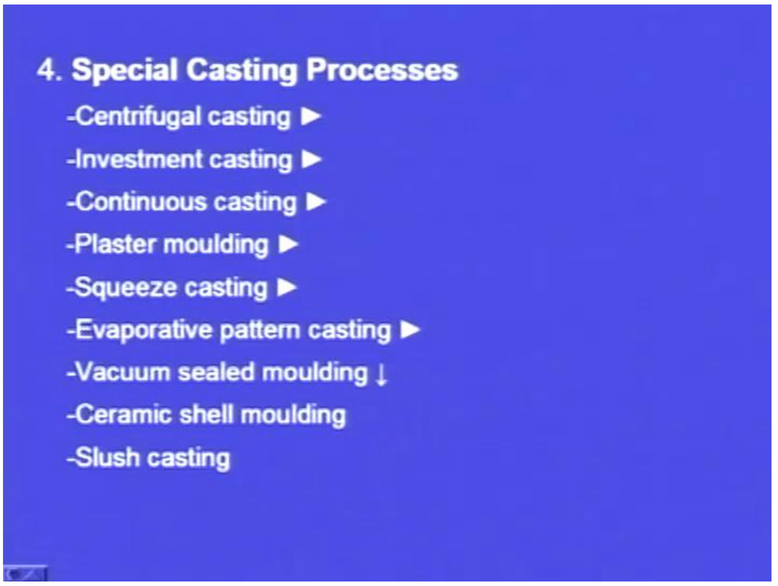

The fourth type is the special casting process in which there are nine processes. One is the centrifugal casting process which we have already learnt in the previous episodes, in which the molten metal occupies the mould cavity by virtue of the centrifugal force falling on it. And in this process, we have seen that the casting yield is very high. In most of the cases it is 100 percent. We have also learnt the investment casting process which is also known as the precision casting or the lost wax process in which we get the extreme precision and extreme surface finish, and we have seen its applications.

We have also learnt the continuous casting process in which the casting is continuously produced. Again, it is classified as vertical continuous casting, horizontal continuous casting, and continuous casting in travelling mould. In this case also, the casting yield is 100 percent.

We have also learnt the plaster moulding in which the mould is made up of the Plaster of Paris and this process offers us very good surface finish, and again this is classified into three types. We have seen the three classifications and we have also seen the squeeze casting which is the combination of the casting and forming technology. And in this process we get good mechanical properties and also the production rate is very fast. Also we have also seen the evaporative pattern casting in which we use a polystyrene pattern and using that polystyrene pattern we make the mould.

We compact the sand around the polystyrene pattern and unlike other process we do not with draw the pattern before pouring. We pour the molten metal. As we keep pouring, the polystyrene pattern evaporates and the liquid metal replaces the pattern. So, in this case making the mould is very easy. Here we use only one flask. The moulding process is very simple and this process also offers us very good surface finish and dimensional accuracy. And in this episode, let us see the vacuum sealed moulding.

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Vacuum sealed moulding: So, this is one of the recent process which has been developed and it is gaining momentum.

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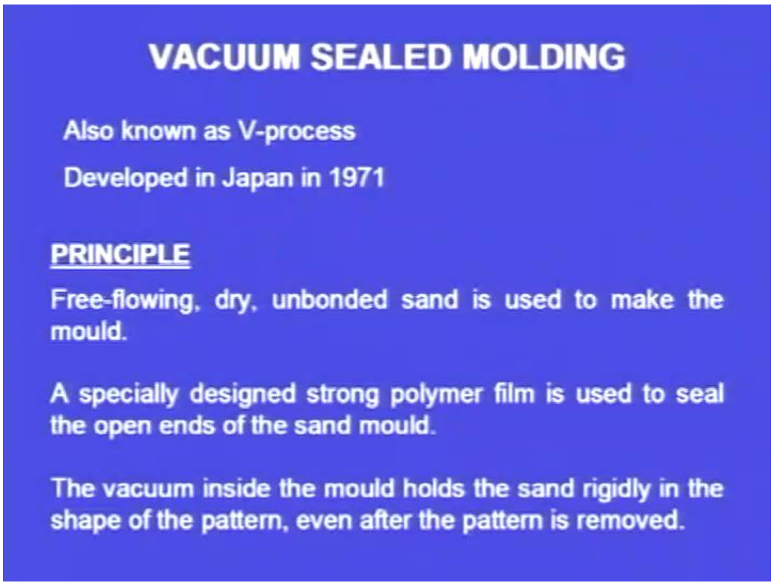

This process is also known as V process. This was developed in Japan in 1971. What is the principle involved in this vacuum sealed moulding or V process? Here, free flowing, dry and unbounded sand is used to make the mould.

In the case of the conventional sand moulding process, we use sand made up of we use moulding sand made up of silica sand or jargon sand or olivine sand mixed with clay and moisture and other binders, but here we are using free flowing and dry and unbounded sand for making the mould, and a specially designed strong polymer film is used to seal the open ends of the sand mould.

We use a strong polymer; with that, we seal the mould and we apply vacuum. The vacuum inside the mould holds the sand rigidly. In the case of the conventional sand casting process, we add clay and binders. This clay and binders will hold the sand together and retain the shape. Here, the vacuum rigidly holds the sand so that the given shape is retained. Even after the pattern is removed, the vacuum retains the shape.

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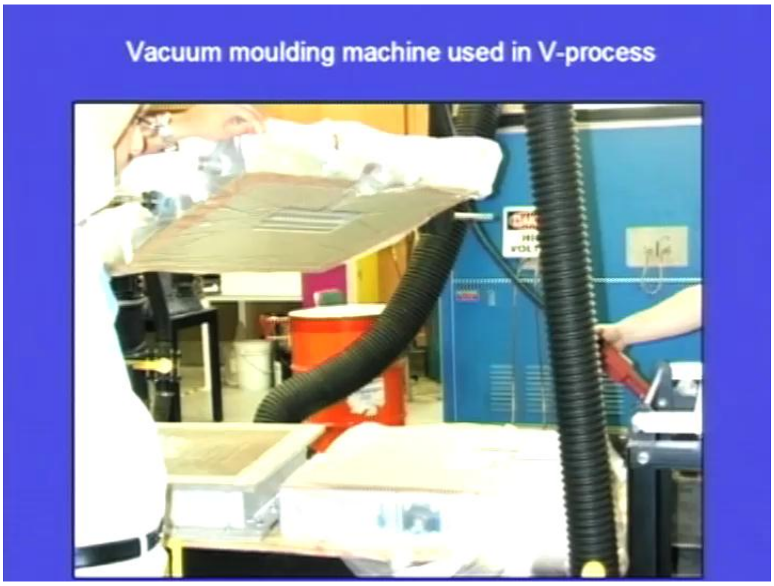

Here we use a vacuum moulding machine. So, this is the vacuum moulding machine. We can see this is a very sophisticated machine and here we can see the strong polymer will be covered, and this is the machine which is used in the V process. Here we can see arrangement for applying vacuum. Let us see the step by step involved in this V process. First, say we have to use a precision pattern. The pattern should be of extreme precision and no allowances are required.

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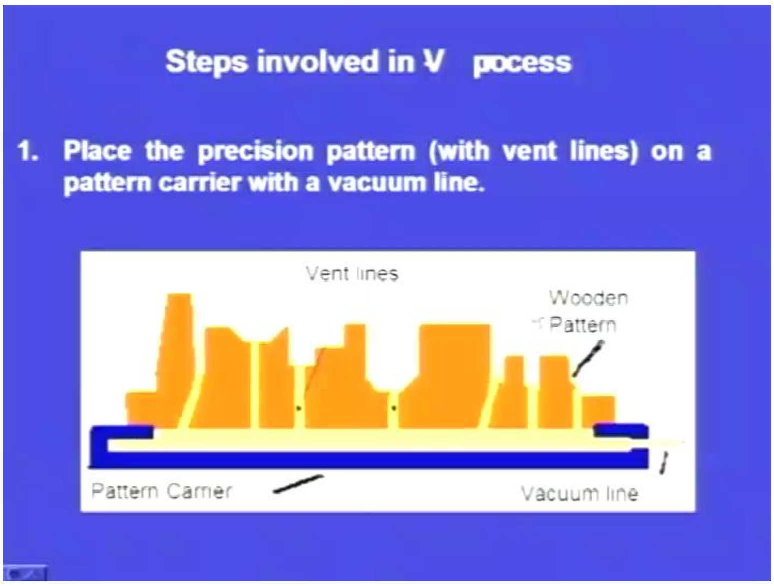

And this pattern has got some vent holes. We can see so many holes are there. Here one hole, here one hole, here one hole, here one hole, here one hole, here one hole, here one hole. So, these are the vent holes for the pattern and this pattern we have to place it on a pattern carrier; so, this is the pattern carrier. So, over this pattern carrier, we place the pattern and this pattern carrier has got a vacuum line through which we can apply vacuum.

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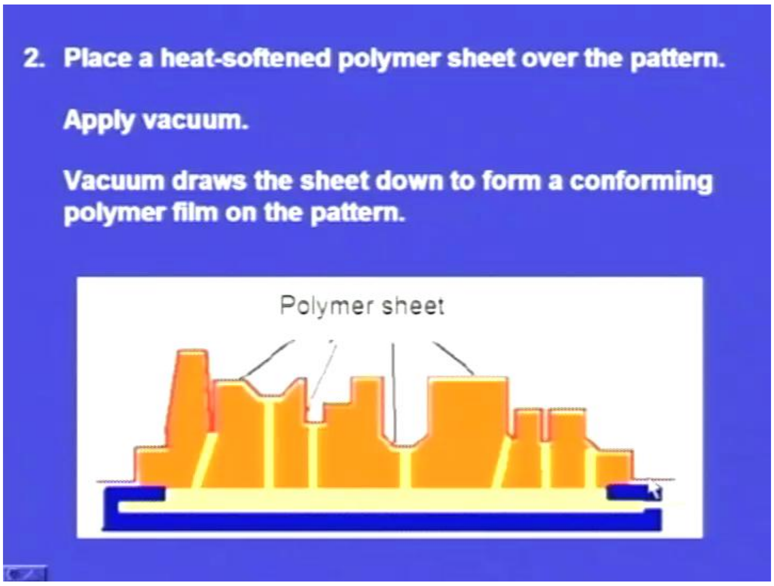

Next, we have to take a strong polymer and that strong polymer we have to soften by heat. After softening the polymer sheet by heat, we have to place it over the pattern like this. Here we can see this red color one; so, that is the strong polymer, polymer sheet. And at the end, we have to seal it.

Now, there is a vacuum line is there. Through the vacuum line, we have to apply vacuum. Then what happens? Vacuum sucks the polymer sheet and the polymer sheet will be occupying each and every detail which is there over the pattern. It will be exactly occupying all the details. That way the vacuum will help us.

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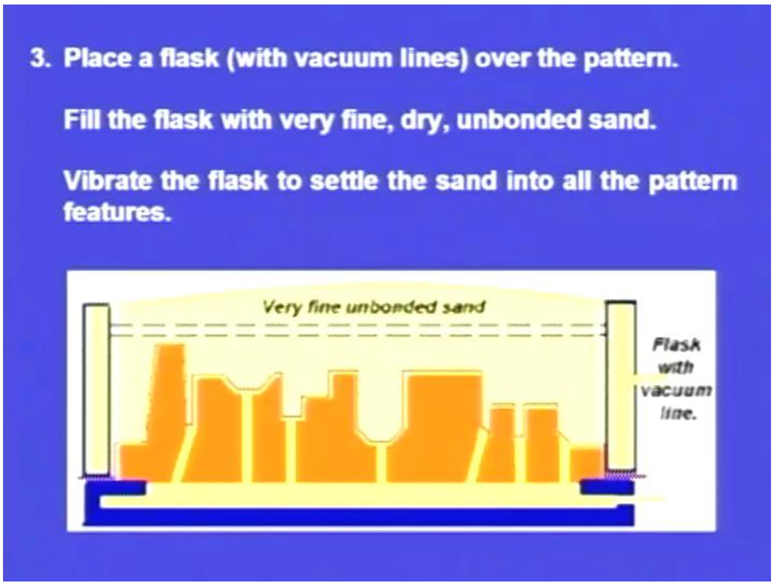

Next, we have taken the pattern in which there are vent holes. Next, we have placed the polymer sheet and using the vacuum we made the polymer sheet occupy all the details on the pattern. Next, we have to place the fine unbounded sand here. And before that, we have to place the flask over this pattern carrier and this flask has got a vacuum line. Here we can see vacuum line through which we can apply vacuum, and this flask we will fill with the fine and dry and unbounded sand. Next we have to vibrate the flask so that the sand will be settling in the flask; so that the sand will be settling over the pattern; so that the sand will be occupying around all the details of the pattern. That way we have to vibrate the flask.

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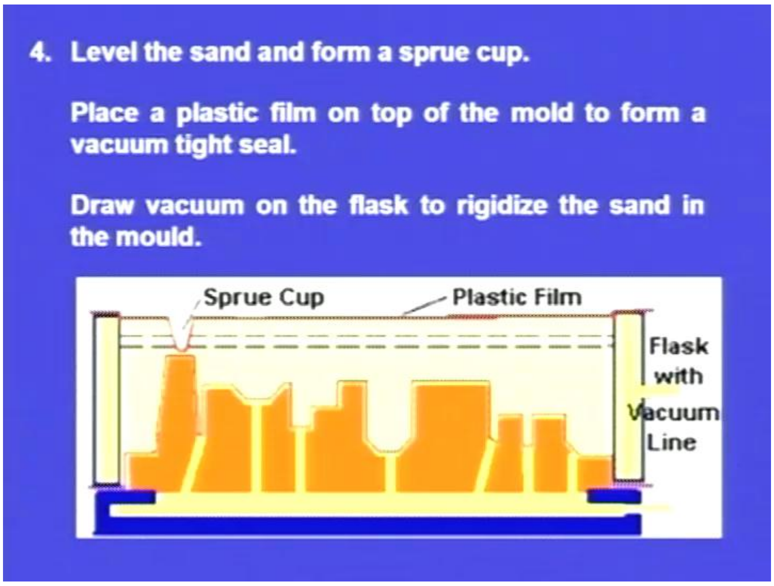

Next one, we have placed excess of sand. That sand, now we have to remove by leveling; we will we will level it and we remove the excess sand. And here, we have to form the sprue cup. Next one, we will take another polymer sheet, strong polymer sheet. That we will soften by applying heat and we will place it over the sand. So, this is the plastic film. So, the red colored one is the plastic film and at the end we will seal it. Here, we will seal and here we will seal it. Next one heat has got a vacuum line. Through this vacuum line, we apply vacuum. Then what happens? Vacuum we will be applying and this vacuum holds the sand tightly around the pattern because it is sealed. At the top it is sealed; at the bottom it is sealed; so, it will be tightly holding the sand. Next one, after the sand is held tightly inside the flask because of the vacuum, now what happened is here we are using two vacuums; I mean vacuum at two places.

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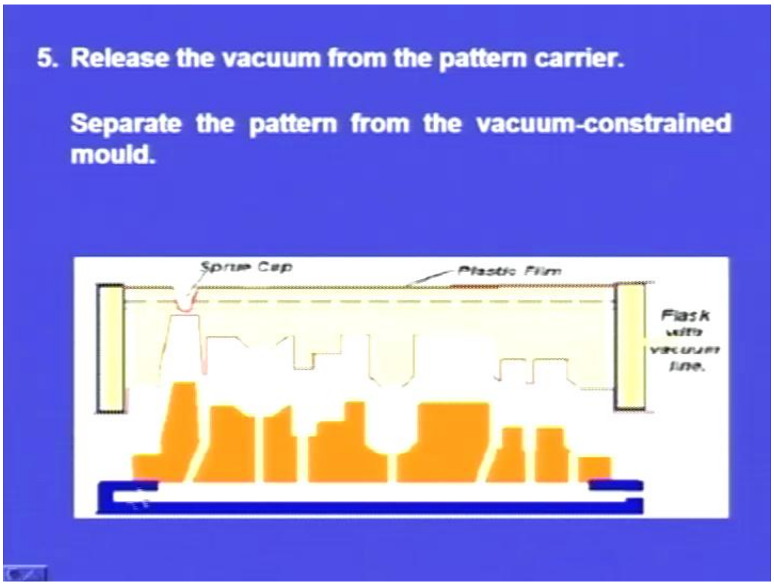

Vacuum, here we have applied at the pattern carrier. This vacuum has enabled us so that the polymer sheet will be occupying exactly over the pattern. So, that is the purpose of applying the vacuum here. We have applied vacuum at another place that is in the flask; this vacuum has helped us to hold the sand tightly inside the flask.

So, this vacuum will continue. The vacuum which we have applied in the flask will continue to hold the sand. We are not with, but this vacuum which we have applied through the pattern carrier we are releasing. When we are releasing this vacuum, the pattern is free from this polymer sheet. Here we can see the polymer sheet, the red coloured one. Now, you separate the pattern from the vacuum constraint mould. We can separate it. Yes, it is separated now.

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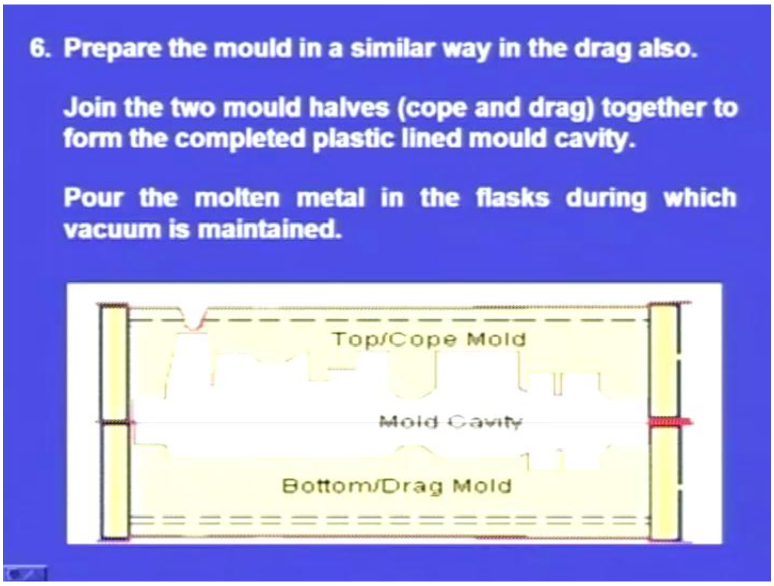

Next one, prepare the mould in a similar way in the drag box also. So, far we have seen preparing the mould using this polymer sheet and vacuum in the cope box, that is the upper moulding box. Now, we have to prepare the mould in the drag box also, that is the lower moulding box. So, this is the drag box; the lower moulding box. This one also, in the same way, we have to prepare using vacuum and polymer sheet.

Next one, join the two moulding halves cope and drag together to form the completed plastic lined mould cavity. Yes, we are joining the cope and drag. Inside we can see the complete mould cavity and inside there is mould cavity; there is plastic film is there. And outside the boxes, there is plastic film is there and the sand in the upper box that is the cope box is held together tightly because of the vacuum we are applying here. And sand in the drag box here in this drag box, it is held tightly rigidly because of the vacuum we are applying here. So, this is the complete mould, and at this stage pour the molten metal in the flask. While pouring the vacuum has to be maintained; that will continue.

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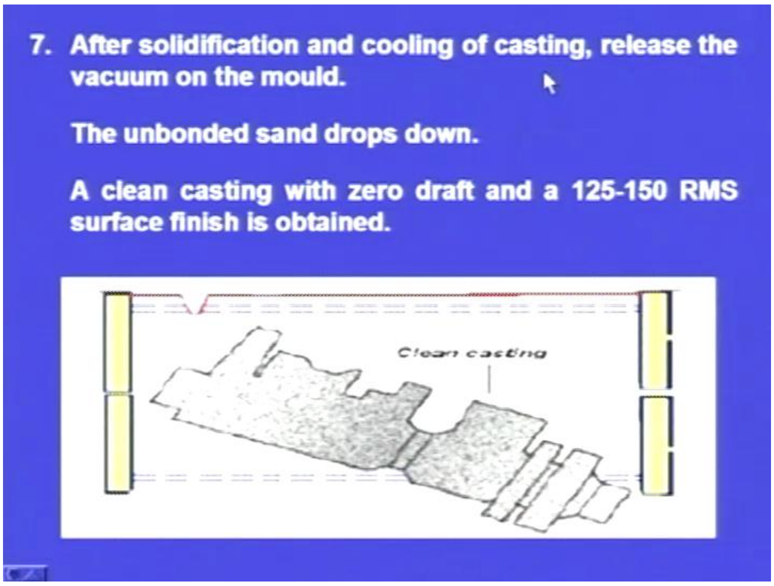

After solidification and cooling of the casting, release the vacuum on the mould.

What happens when we release the vacuum from the moulding boxes? Until now, the vacuum sorry the sand is held tightly. The sand is held rigidly because of the vacuum that we have applied. Now, we have withdrawn the vacuum. The sand can no more held together rigidly. Now, it will be free sand; it will be collapsed; it will be falling down. The unbounded sand drops down because of the withdrawal of the vacuum. A clean casting with zero draft and a 125 to 150 RMS means very high surface finish will be obtained; that will be dropping down.

Let us see. Yes, when we withdraw the vacuum, the sand collapses. That is the fine sand; there is no moisture in it; there is no sand in it; no clay in it. So, it drops down. When the sand drops down, even the casting is dropping down. Yes, the casting is dropping down.

This is the final casting that we are obtaining. This fine casting, it has got zero draft and it has got fine surface finish, and it is dimensional accuracy is very high. Such a casting we are obtaining.

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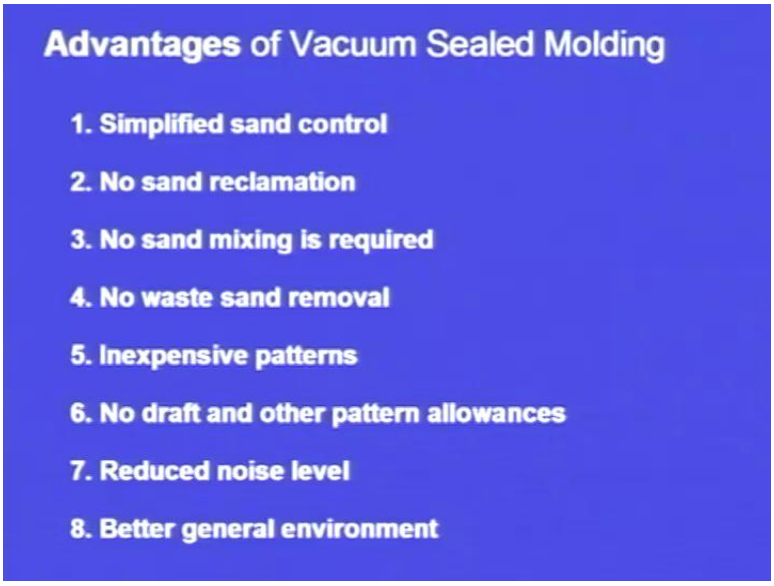

And what are the advantages of this vacuum sealed moulding? First one is simplified sand control. In the case of the conventional sand casting process, before making the mould, we prepare the sand moulding sand very carefully. We add predetermined clay, predetermined amount of moisture, predetermined amounts of other additives, and carefully we prepare the mixture, sand mixture. And if the proportion is not good, it will result in defects. We have to control the ingredients very carefully. Here, there is no control.

What are the ingredients? Only fine sand, clean sand without any clay, without any moisture, without any ingredients, without any other additives; so, there is no control; so, simplified sand control. Only thing is we have to take fresh fine silica sand and there is no sand reclamation difficulty. In the case of the conventional sand casting process, after the mould is prepared, we pour the molten metal; after solidification is over, we have to break the sand. And after breaking the sand, we have to reclaim this sand. That takes time, that takes efforts, but here that reclamation problem is not there and no sand mixing is required; that is another in advantage.

In the case of the conventional sand casting process, we take all the ingredients and we have to mix it. We use to put the sand in the sand mullers and we mix it thoroughly. That takes time, that requires skill, but here there is no such mixing is required; this is another advantage. No waste sand removal: In the case of the conventional sand casting process, small quantity of sand is going to be wasted. Here, there is no such waste of sand. So, we do not have to remove the waste sand and the patterns are not so expensive.

Next one, no draft and other pattern allowances are required. In the case of the conventional sand casting process, the pattern will be given draft allowance. It will be given machining allowances. It will be given rapping allowances. Because of that, the pattern has to be bigger. And after getting the casting, we use to machine it. Here no pattern allowances are required. So, this is another advantage.

Reduced noise level: In the case of the conventional sand casting process, when we are preparing the sand, there is noise because we put the sand in the sand muller and when we are making the mould, sometimes we use machines. Machines make noise. Here, there is no such thing. The mould preparation is very simple. The sand inside the flask is held rigidly because of the vacuum. So, no noise is generated. This is another advantage.

Next advantage - better general environment. In the case of the conventional sand casting process, we add clay; that leads to poor environment. The environment will be polluted. Especially after solidification, when we break the mould, dust will be rising. And here there is no such thing; we are not adding any clay; so, here the environment will be clean.

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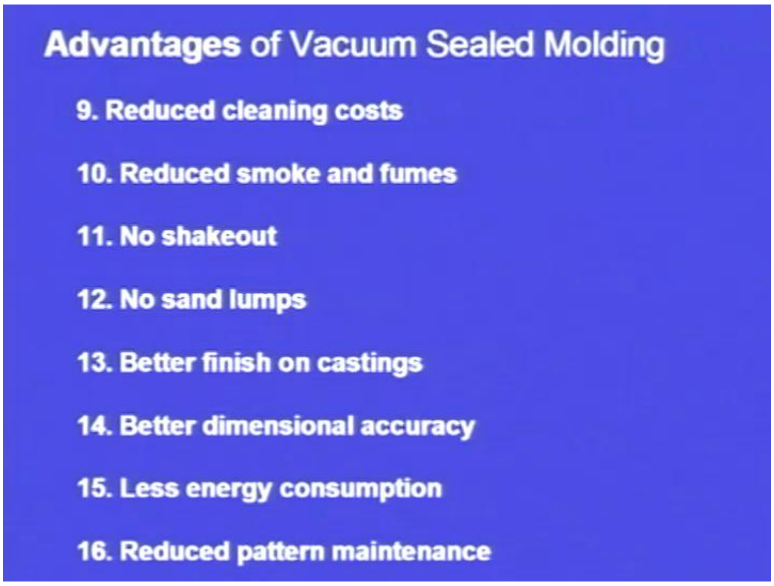

Next one, reduced cleaning cost: In the case of the conventional sand casting process, after solidification we have to break the mould. When we break the mould and take the casting outside, the casting will not be clean sand will be sticking to the casting. That sand we have to clean. Clay will be sticking to the casting; that clay we have to clean. But here what is happening? The casting will be clean, and reduced smoke and fumes; that is the next advantage.

In the case of the conventional sand casting process, there is moisture in the moulding sand. When we pour the molten metal, the moisture will turn into vapour and sometimes even smoke is generated; fumes are generated. And here, there is no smoke; no such fumes; that is another advantage.

In the case of the conventional sand casting process, there is shakeout. After solidification is over, we have to break the sand. Here, there is no question of breaking the sand; only thing is we have to withdraw the vacuum. Automatically, the sand will be falling down; the sand will be collapsed; clean sand. After that, the casting will be dropping down. So, no shakeout is required; that is another advantage.

Next one, no sand lumps. In the case of the conventional sand casting process, you will be beware. There will be big sand lumps will be there. At one place, people will be preparing the sand; they will be adding clay; they will be adding moisture; they will be preparing the sand. So, there will be one lump. At another stage, they will be recovering the sand and they will be testing the sand; so, there will be another lump. Here, there is no sand lump; so, this is another advantage.

Next advantage is better surface finish. In the case of the sand casting, conventional sand casting process, the casting that we obtain will have poor surface finish; that we have already learned. And for that, to get a better surface finish, we have to machine. That takes time, but here we are getting very fine surface finish on the casting straight away. So, this is another advantage and the dimensional accuracy will be high.

Next one is less energy consumption. Yes, in this process, we are using vacuum. In the case of the conventional sand casting process, everywhere we have to use power. We use for moulding, there will be machines; we use power. For sand mixing we use sand mullers; for that power is required. And here, less energy consumption; this is another advantage.

And finally, reduced pattern maintenance; the pattern life will be more. In the case of the conventional sand casting process, the life of the pattern will be less because every time the life is coming down. The moulding sand is placed over this pattern and it is subjected to wear and tear. Every time it is undergoing abrasion. So, every time we are shaking, we are rapping and it is dimensions are deteriorated every time, but here the maintenance is very good; the life will be more for the pattern. So, this is another advantage.

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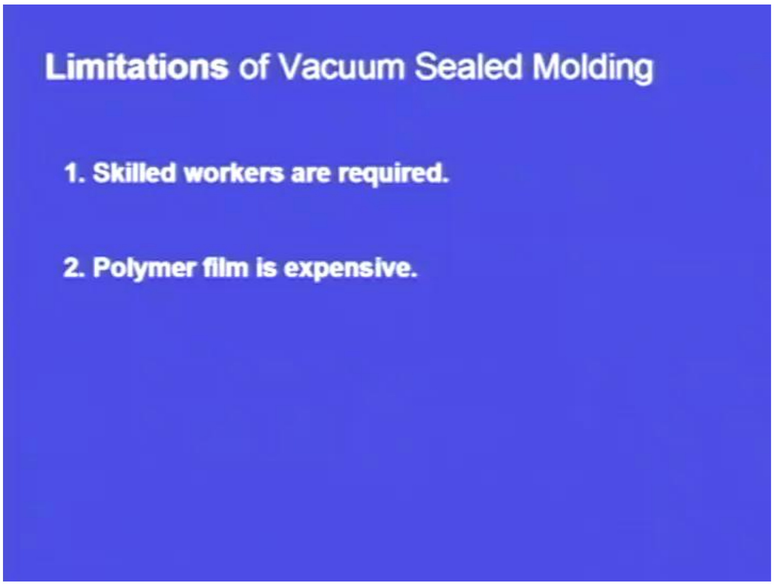

And this process has got some limitations. Here we have to apply vacuum and this vacuum should be controlled very carefully. It the vacuum is not controlled very carefully, the sand which is held rigidly inside the moulding flask will be collapsing at any stage; that may be a failure. So, for this, we require skilled workers. And the polymer film which we are using is expensive. So, these are the limitations of the vacuum sealed moulding process.

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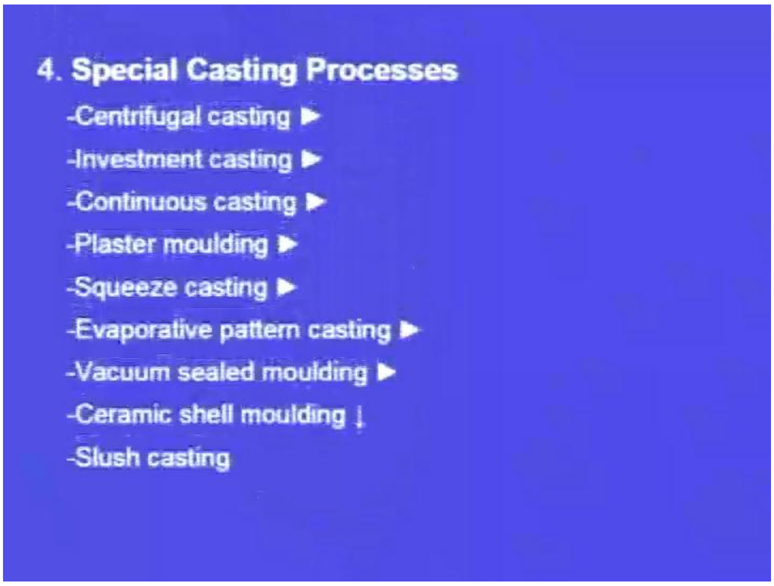

So, among the special casting process, we have seen vacuum sealed moulding in this episode.

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Next let us see the ceramic shell moulding.

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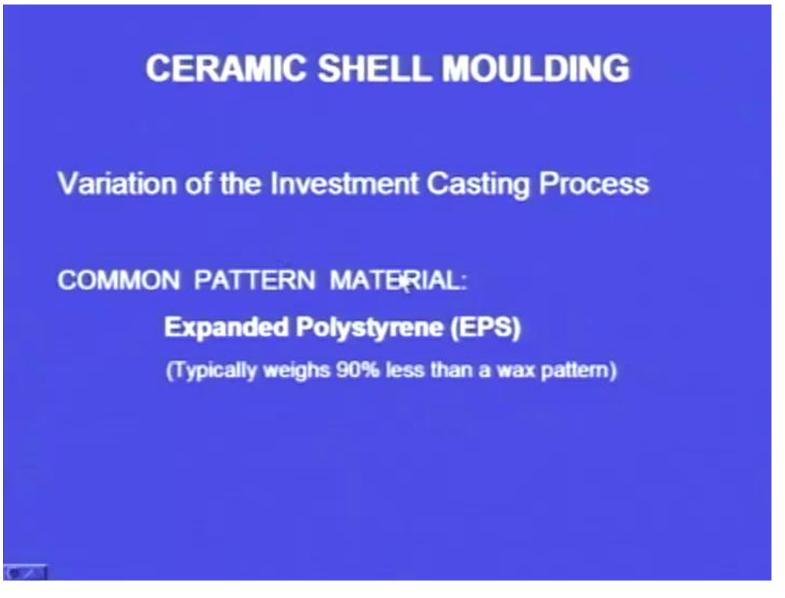

Ceramic shell moulding: So, this ceramic shell moulding. It is similar to investment casting process. Of course, there are some differences which we will be seeing later and it is similar to investment casting process and the common pattern material is the expanded polystyrene, and this weighs 90 percent less than a wax pattern. In the investment casting, we use wax as the pattern material. And in this process, the common pattern material is the expanded polystyrene that is the EPS; this weighs 90 percent less.

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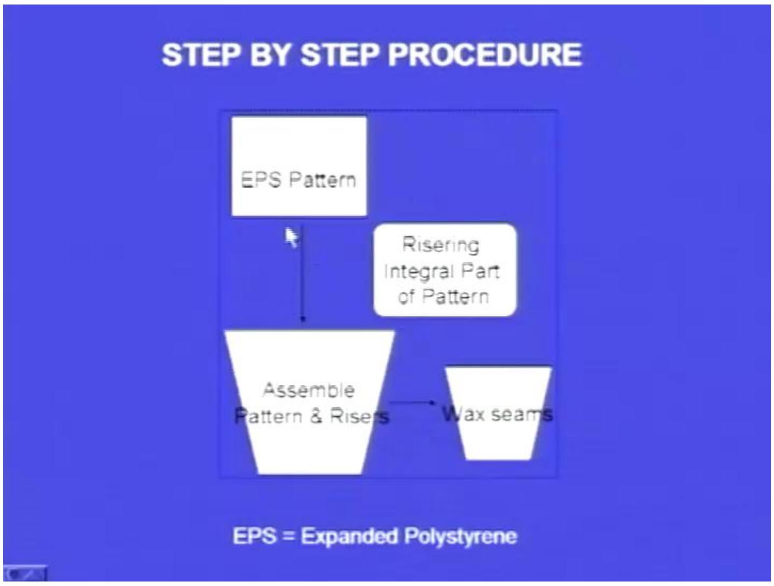

Let us see the step by step procedure in this process.

First one: We have to make the EPS pattern that is the expanded polystyrene pattern and the pattern and the riser and even the gating system, they should be joined together; that is the risering is the integral part of the pattern. Riser is the integral part of the pattern and the riser the pattern thus proved, the gating system, all will be assembled together and they will be assembled by wax. So, this is the first step in the ceramic shell moulding.

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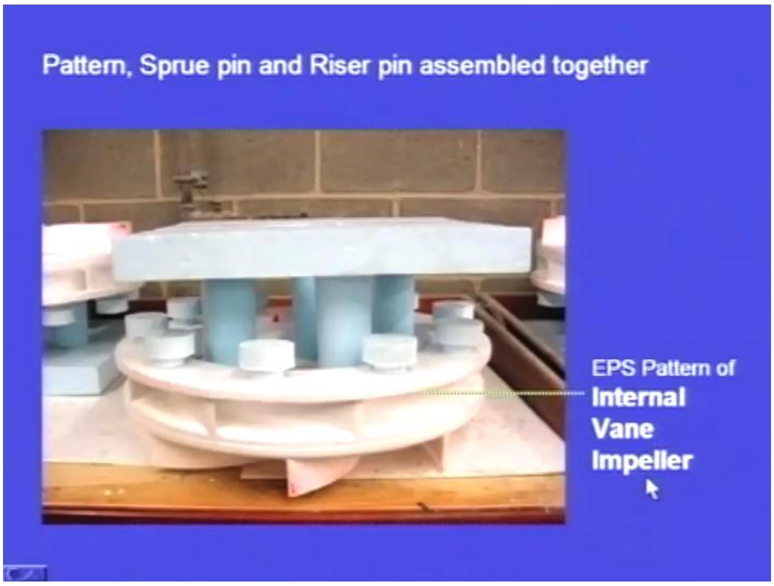

So, here we are seeing one practical example and we are going to see the step by step procedure in making an Internal Vane Impeller. So, this is the EPS pattern of internal vane impeller. So, this is the pattern for the internal vane impeller and we can see here these are all the risers and we can also see the sprue. So, this whole system is made up of EPS, that is the expanded polystyrene and all these - the pattern, the riser, and the sprues, they are all joined together by wax.

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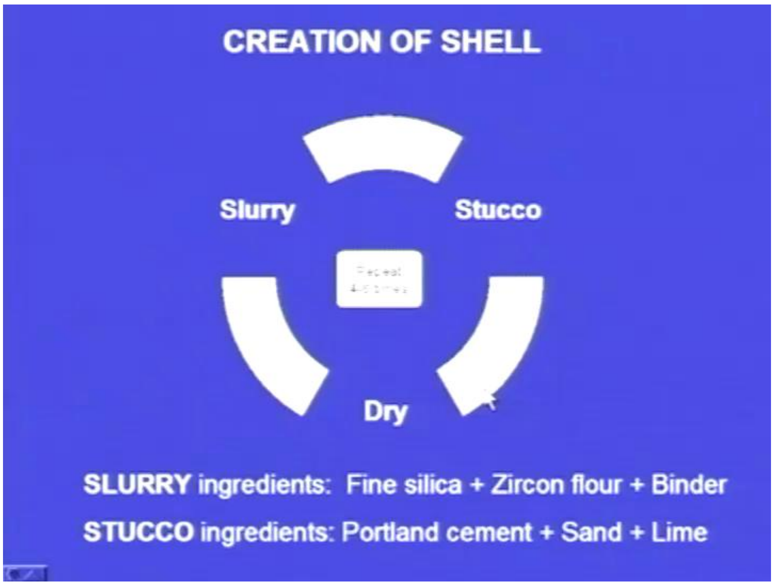

Next one, creation of the shell. After we make the EPS pattern and after the pattern, the riser sprue and the gating system, after they are all joined together, we have to create a shell. First one we have to give a slurry coating. This slurry is made up of fine Silica plus Zircon flour plus Binder. So, this slurry coating we have to give to the pattern assembly; then we have to dry it; after drying we have to give the stucco coating. The stucco coating is made up of Portland cement plus sand plus lime. After stucco coating, again slurry coating; again it will be dried; again stucco coating. So, this way we have to repeat the cycle 4 to 6 times. Then a shell will be created over the pattern assembly.

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So, we can see, a shell is created over the pattern assembly. So, this is the pattern and these are the risers.

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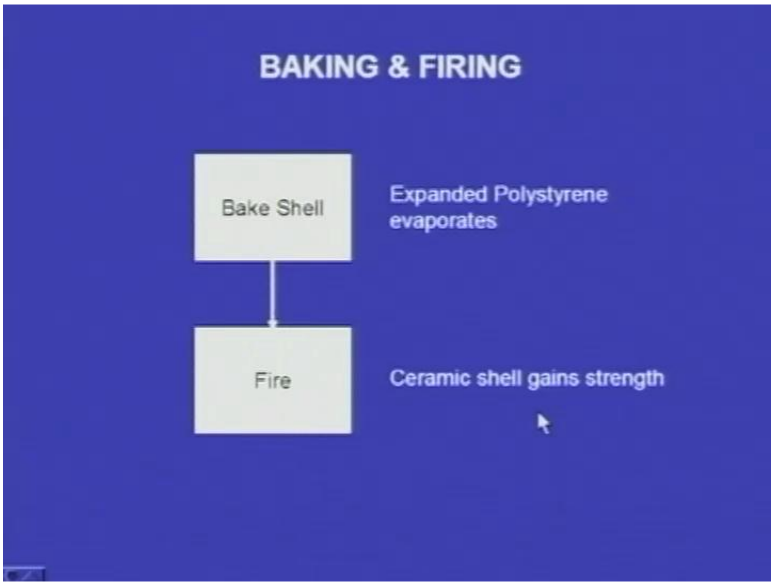

Next one is baking and firing. The expanded polystyrene pattern will be evaporating while we are baking. Yes, we will place the pattern assembly in an oven and we will bake it; we will dry it. Next one, it will be fired. The ceramic shell will be getting strength when we fire it. So, this is about baking and firing.

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Yes, when we bake and fire, the shell looks like this. This is the shell and inside the EPS pattern has been evacuated. Now, we can see the shell; the bake and fired shell.

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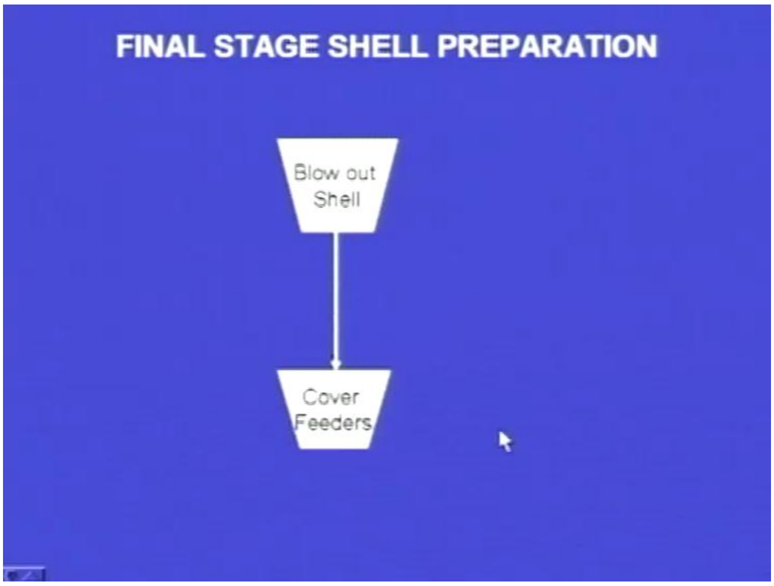

Next one is final stage of the shell preparation. So, we have heated the pattern in an oven. The EPS pattern has evaporated and it has gone. It has escaped from the shell. Still small traces of the pattern may be inside. So, we have to blow out. We send pressurized air through the shell. Then, any small amount of pattern that is left inside the cavity will be thrown out will be coming out. Next one is the feeders. Feeders means this. Risers we will be covering.

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Yes, these are the feeders. These feeders will be covered. So, this is the final shell preparation.

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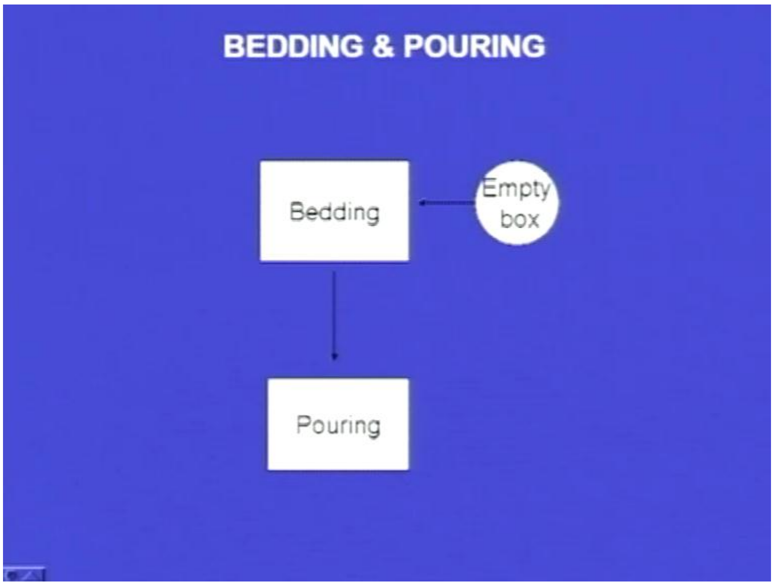

Next one bedding and pouring. So, we have to place this mould, the shell in a box where there is sand; may be sometimes we may pour more than one box or more than one shell. So, all these shells we have to place in a moulding box. So, that is the bedding. Then, we pour the molten metal into the shells.

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Yes, this way we have kept. This is one shell; so, this is one shell. These shells, we have kept over this above the sand. Then we pour the molten metal.

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Yes, pouring is done.

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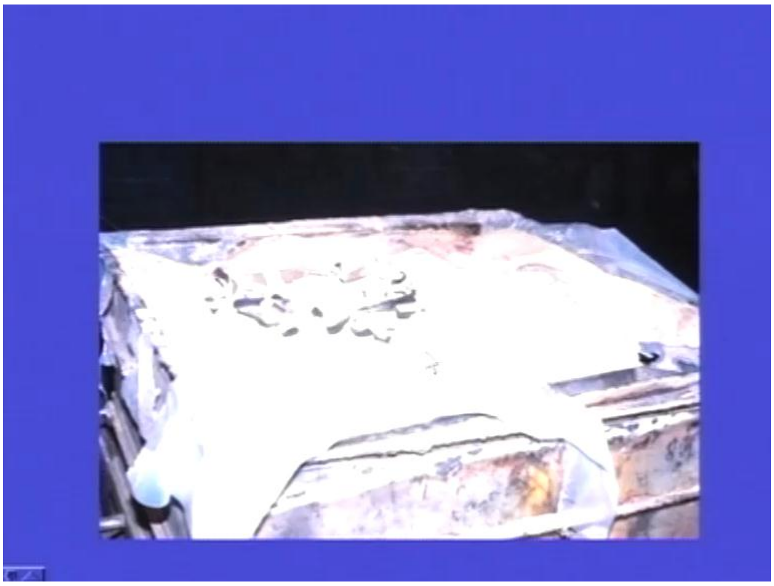

Yes, this is after pouring.

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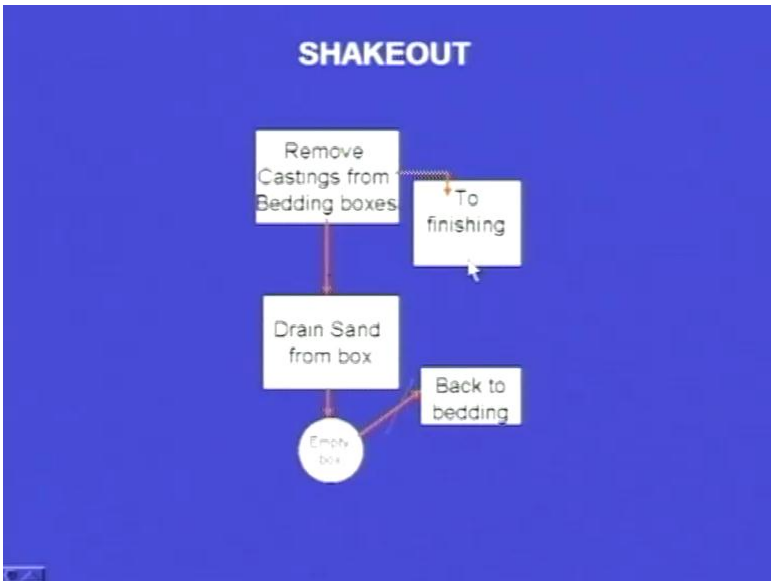

Next one is shakeout. After solidification is over, we have to remove the casting from the bedding boxes and the sand will be broken. The sand has to be drained from the boxes and the boxes will be empty. Again they will be going to the bedding and here the castings will be going for finishing the operations. So, this is the shakeout.

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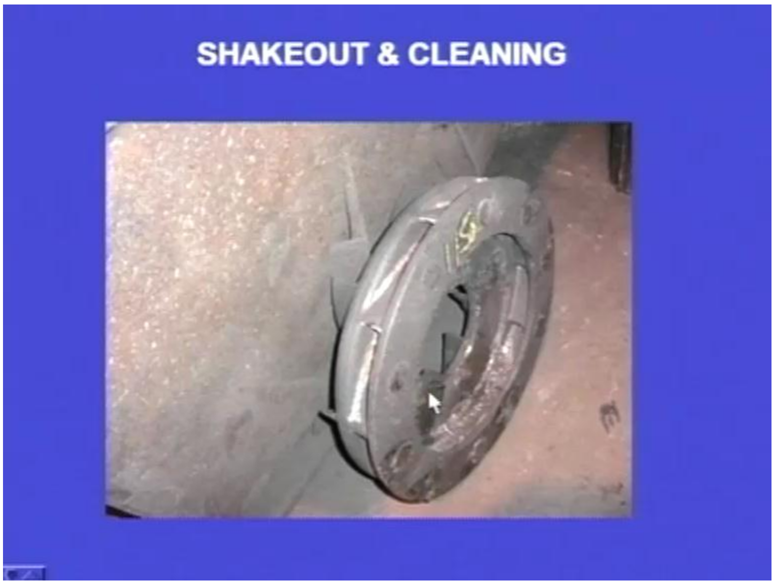

So, this is the final casting that we have obtained after solidification and after shakeout.

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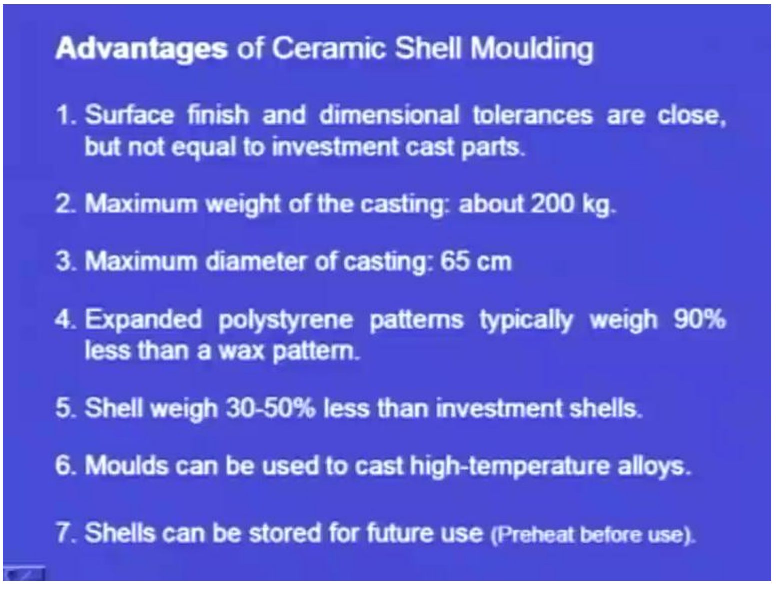

Now, let us see the advantages of ceramic shell moulding. Surface finish and dimensional tolerances are very high, but the extent of dimensional tolerances and the surface finish is not equal to that of the invest casting process. In the investment casting process, we get extreme surface finish, extreme dimensional tolerance, but here also we get good dimensional tolerance, good surface finish, but not as much we get in investment casting process. The maximum weight of the casting that can be made through this process is about 200 kg. In the investment casting process generally small castings are made, but here we can make up to 200 kg. The maximum diameter that can be obtained is about 65 centimeters.

Expanded polystyrene patterns typically weigh 90 percent less than a wax pattern. So, this is another advantage. The weight of the pattern will be 90 percent less than a wax pattern and shell weighs 30 to 50 percent less than the investment shells. That is another advantage.

Moulds can be used to cast high temperature alloys. Next one - shells can be stored for future use. May be we can expect some orders after few months. So, when we receive the orders, that time if we have to make all the shells, sometimes it may be difficult. Anticipating order, now itself we can prepare the shells and they can be stored for few months. And when we get the orders, just we can prepare the, what say, shells. Only thing is we have to preheat them before pouring and the casting can be obtained in a very shorter time. So, this is another advantage.

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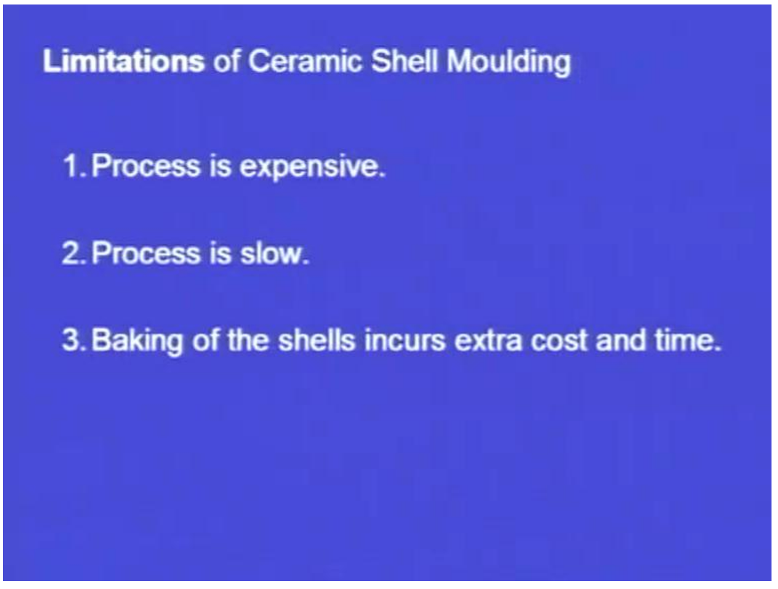

Limitations of this ceramic shell moulding: The process is expensive. The pattern material that is the EPS, the expanded polystyrene, is expensive. We have to give slurry coating. We have to give stucco coating. These are expensive. We have to keep them in ovens for baking; that makes the process expensive.

Second one is the process is slow. Yes, we have to bake the shells for few hours; that takes time. We have to give, repeatedly we have to give coating; slurry coating and stucco coating repeatedly; that takes time. So, that way the process is slow and baking of the shells incurs extra cost and extra time. So, these are the limitations of the ceramic shell moulding.

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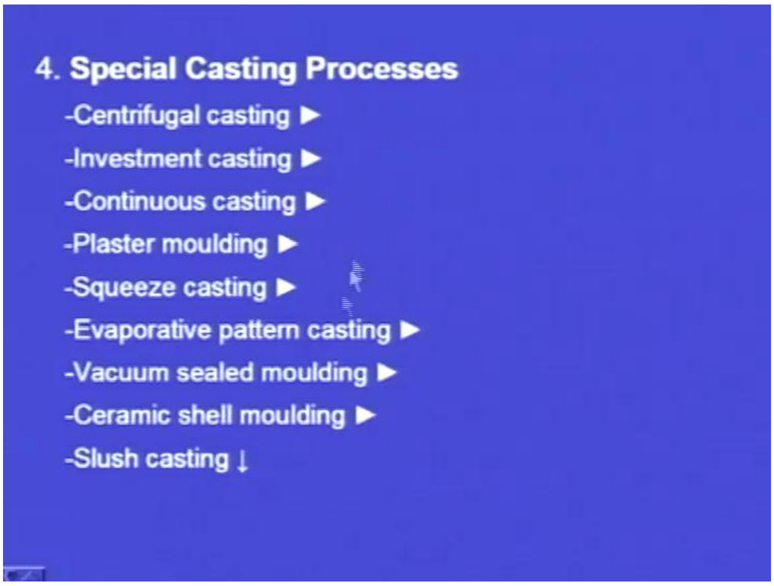

So, among the special casting process, in this episode we have seen vacuum sealed moulding. We have also seen ceramic shell moulding.

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Now, let us see the last one that is the slush casting.

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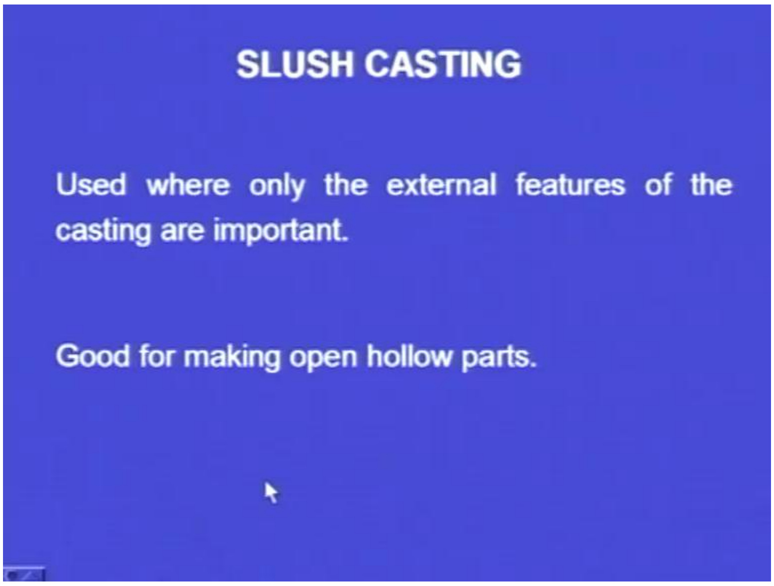

Slush casting: This is used where only the external features of the casting are important and this is good for making hollow parts.

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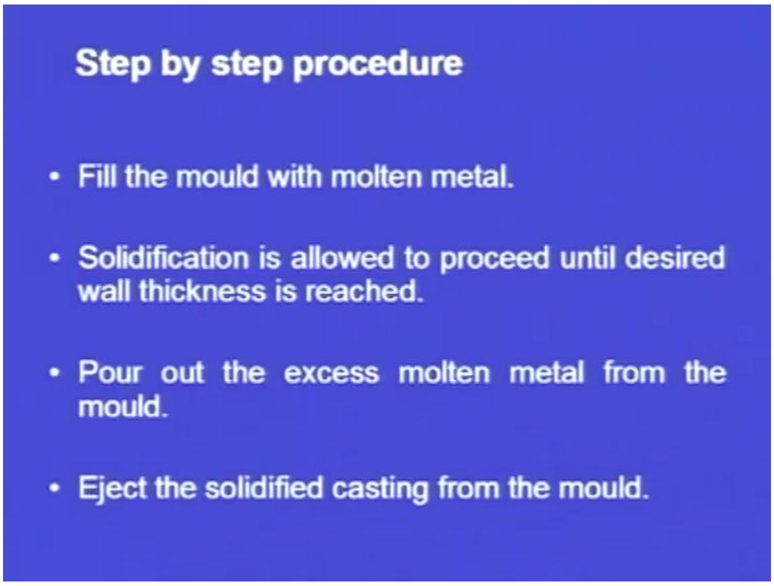

Step by step procedure. First one: We have to make the mould and fill the mould with the molten metal. In all other casting process, until the solidification is completed, until the molten metal completely solidifies, we would not touch it; we would not disturb the system. But here, before the complete solidification is over, we have to pour out the liquid metal. After the molten metal has solidified partially, after the outer shell has solidified, when the inside metal is in liquid state, that time we have to pour out the liquid metal form the metallic, that is from the mould. Pour out the excess molten metal from mould before it completely solidifies. Then eject the solidified casting from the mould.

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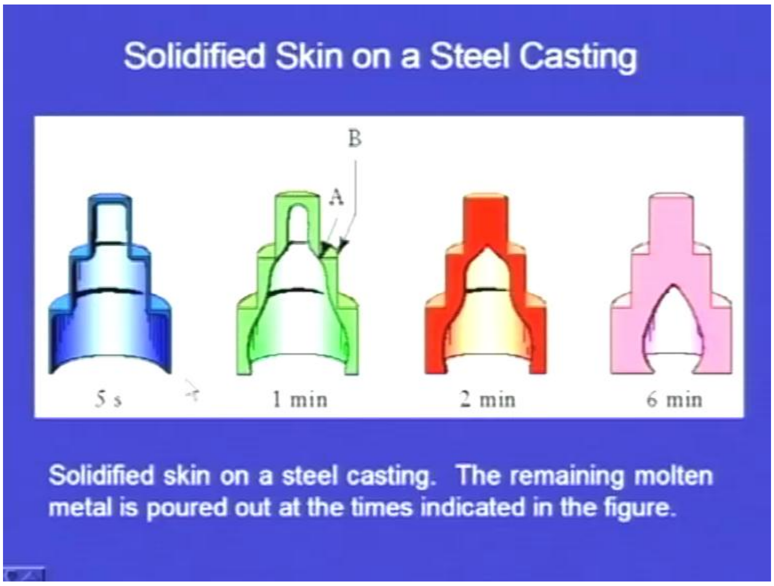

So, here we can see this is the casting to be obtained and the thickness of the shell gradually increases with respect to time. May be at five seconds, after five seconds, this will be the thickness; after one minute this will be the thickness; after two minutes this will be the thickness; after six minutes this will be the thickness. But here, only the external feature, external appearance is important; inside we are not bothered. Inside thickness of the shell is not that much important. So, the solidified skin on a casting at a different time we can see.

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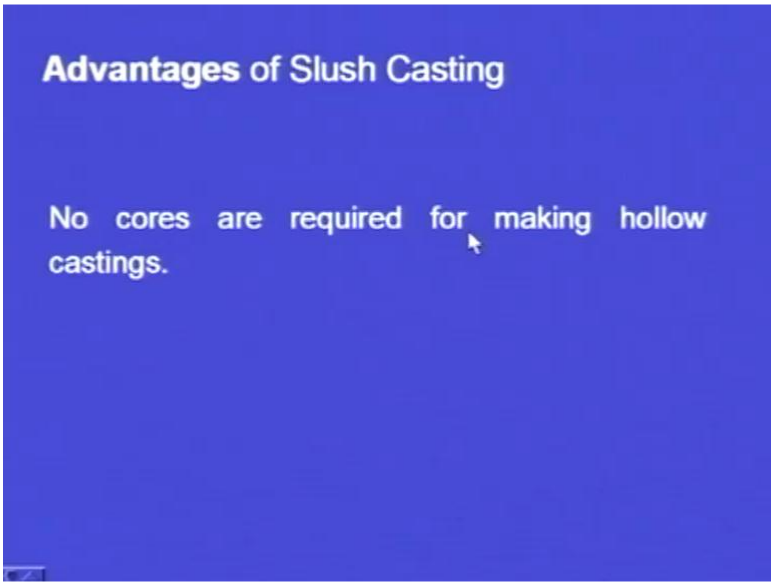

So, what are the advantages of the slush casting?

No cores are required for making hallow castings. We can make hallow castings without cores because as the outer shell is solidified, when the central liquid metal is there in the liquid state, when the metal is there in the liquid state, we pour it out. So, we are making hollow cavity in the castings.

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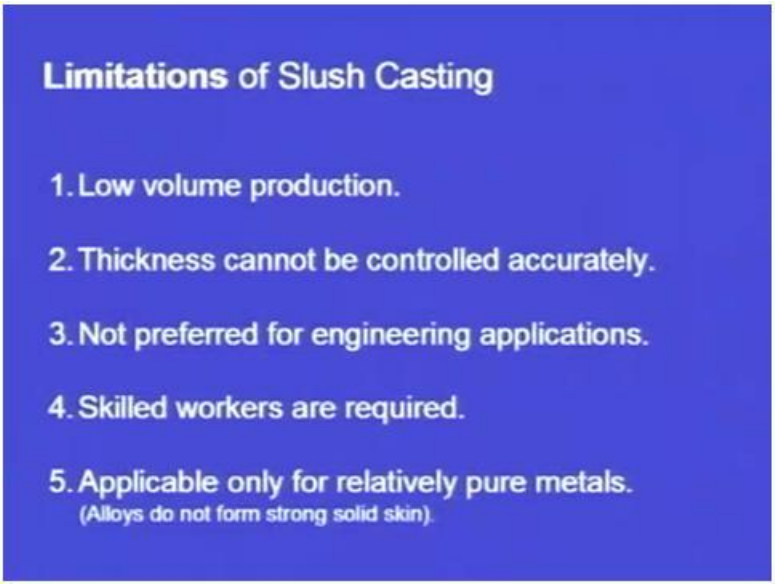

These are the limitations. Low volume production and thickness cannot be controlled accurately. Thickness can be control arbitrarily and this is not preferred for engineering applications. Only this is applicable for art items and for this skilled workers are required because we pour the molten metal and when the outer shell solidifies, when the inner part is in still liquid state, that time we have to pour out the liquid metal and for that skilled worker is required.

If the skilled worker is not there, he may pour it before time in which case the whole metal will be drained out. If it is little delayed, the entire metal may be solidified and we may not get a hollow casting. The purpose is lost. So, for this purpose, skilled workers are required and this process is applicable only for relatively pure metals; relatively for pure metals because alloys do not form strong solid skin. When the outer skin is solidified, when the inner metal is in liquid state, we pour out the liquid metal. We drain out the liquid metal which is inside, which is at the inner part and this outer skin solidifies fastly only in the case of the pure metals. For the alloys, this strong solid skin is very difficult. So, this cannot be applicable for alloys; only for pure metals or relatively pure metals.

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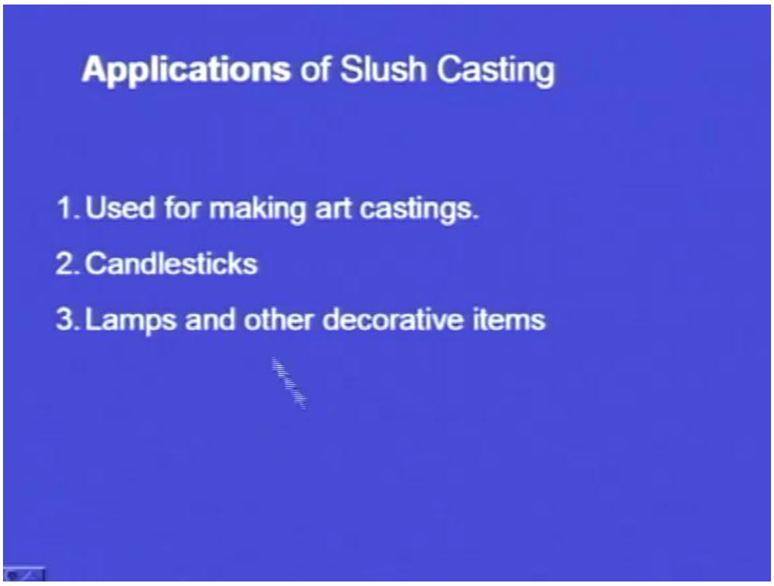

Applications: Used for making Art castings; not for engineering applications; for example, candlesticks. These are made by slush casting lamps and other decorative items. These are made by slush casting.

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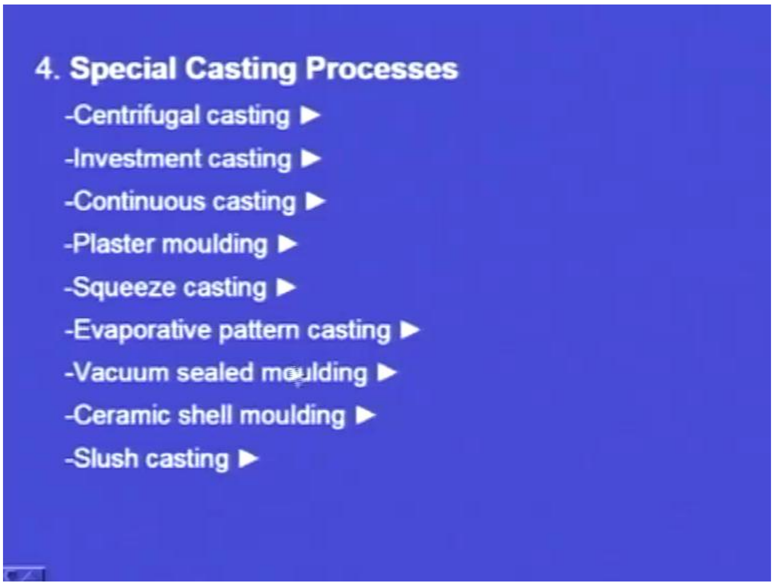

So, among the special casting process, in this episode we have seen vacuum sealed moulding, we have seen ceramic shell moulding, and we have also seen slush casting.

So, with this, we are concluding or we have completed the special casting process.

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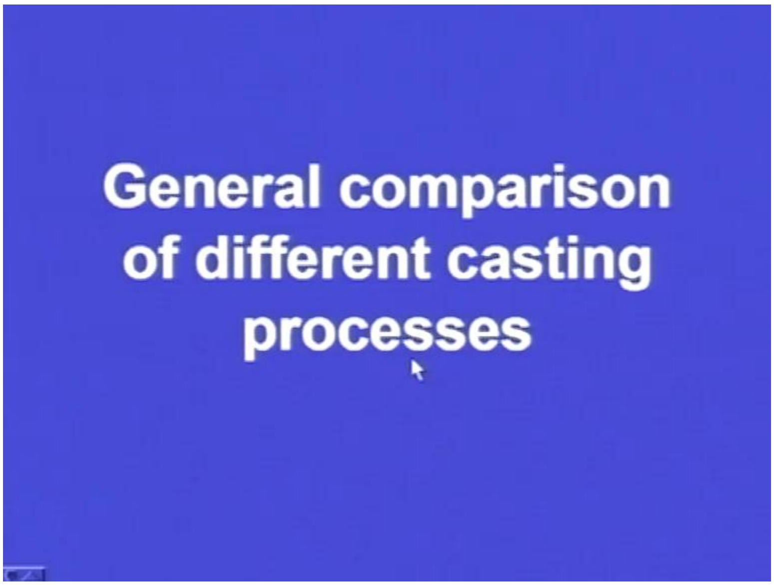

General comparison of different casting process: Let us see the advantages or the limitations of the different casting process that we have learnt.

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PROCESS	ADVANTAGES	LIMITATIONS
Sand casting	Almost any metal can be cast. No limit to part size, shape or weight. No tooling cost.	Poor surface finish. Wide tolerances. Some machining required.
Shell moulding	Good dimensional accuracy and surface finish. High production rate.	Part size limited. Expensive patterns. Cost of production is high.
Permanent / Die casting	Good dimensional accuracy and surface finish. High production rate.	High die cost. Generally limited to nonferrous metals.
Centrifugal casting	Large cylindrical or tubular parts with good quality. High production rate.	Expensive equipments. Limited part shape.
Investment casting	Excellent surface finish and tolerance. Intricate shapes. Almost all metals.	Part size limited. Expensive patterns and moulds. More labour.
Continuous casting	High casting yield. Better surface finish.	Initial investment is high. Limited part shape.

So, these are the different process and these are the advantages and these are the limitations, and all are tabulated.

Let us see. In the case of the sand casting, almost any metal can be cast; no limit on part size; very big size can be cast very small size can be cast; shape or weight, no problem; any shape can be cast and the tooling cost is very less. And it has got some limitations; poor surface finish and wide tolerances. We have to give more tolerances and some machining is required. So, this is about the sand casting.

And in the case of the shell moulding, we get good dimensional accuracy and surface finish, high production rate; these are the advantages of the shell moulding. It has got some limitations; part size is limited; big castings we cannot make and expensive patterns. We have to use metallic patterns in which there will be heating system will be there. Cost of production is high. These are the limitations of shell moulding.

Permanent moulding or die casting: We get dimensional accuracy, good dimensional accuracy, and production rate is very high. These are the advantages of permanent moulding or die casting. It has limitations; high die cost generally limited to non ferrous metals.

Next one, centrifugal casting: Large cylindrical or tubular parts with good quality we can make; high production rate, high casting yield; these are the advantages; advantages of the centrifugal casting. And its limitations are expensive equipments, limited part shapes.

Investment casting: In this, the advantage is excellent surface finish we get and excellent dimensional tolerances. Intricate shapes, very complex shapes we can obtain. Almost this can be used for all the metals and the limitations are part size; only small castings we can make. Expensive patterns, every time we have to make investment wax patterns and that wax pattern is only for one time; only for making one casting; so, the patterns are expensive. More labour is required and the process is also slow. Continuous casting: Here, the advantage is high casting yield, better surface finish, high production rate. Initial investment is high because the process is mechanized. And limited part shapes; all shapes cannot be produced.

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PROCESS	ADVANTAGES	LIMITATIONS
Plaster moulding	Intricate part shapes. Good dimensional accuracy and surface finish.	Limited to nonferrous metals. Limited part size. Long mould making time.
Squeeze casting	Fine details on the parts. High production rates. Improved mechanical properties.	Limited to aluminum and magnesium alloys.
Evaporative pattern casting	Intricate shapes can be cast. Almost any metal can be cast. Process is simple.	Expensive patterns.
Vacuum sealed moulding	Simplified sand control. Better general environment. Better surface finish.	Requires vacuum.
Ceramic shell moulding	Intricate part shapes. Good surface finish and tolerances.	Expensive patterns. Limited part size.
Slush casting	No cores are required for making cavities.	Only for art and decorative castings.

Next one, plaster moulding: Intricate part shapes can be obtained; complex shapes can be obtained. We get good surface finish, good dimensional accuracy, and it has limitations. It is limited only for non ferrous metals. Only non ferrous metals can be cast using plaster mould and the mould making time is long.

Next one squeeze casting which is the combination of casting and forming technologies. Fine details can be obtained; high production rates; improved mechanical properties. This is the main advantage; improved mechanical properties. It has limitations. It is limited to Aluminum and Magnesium alloys. Evaporative pattern casting: Intricate shapes can be cast. Almost any metal can be cast. process is simple, but here the pattern is expensive; that is the limitation.

Next one vacuum sealed moulding. Simplified sand control; we are not mixing the sand; we are not mixing moisture; we are not mixing clay; simplified sand control; better general environment; better surface finish. This requires vacuum. So, this is a limitation and this vacuum has to be controlled carefully. Skilled workers are required.

Next one, ceramic shell moulding. Intricate shapes can be made. We can obtain good surface finish and tolerances. It has got limitations. The pattern is very expensive.

Slush casting: Here we can make hollow castings without cores. That is the advantage. It has got some limitation. Only for art and decorative castings we can use this process, not for engineering applications. So, these are the advantages and limitations of different casting process that we have studied. So, depending upon the shape which we have to make, we have to choose the casting process.

Depending upon the size, we have to choose the casting process. If the size is very big, we have to go for the conventional sand casting process and depending upon the surface finish, we have to choose the casting process. If the surface finish required is very high, then we have to go for investment casting process, and if the dimensional tolerance required is very high, then we have to go for investment casting process. And depending upon the application we have to choose the process. So far we have learnt the principle of casting process; we have learnt the types of casting process.

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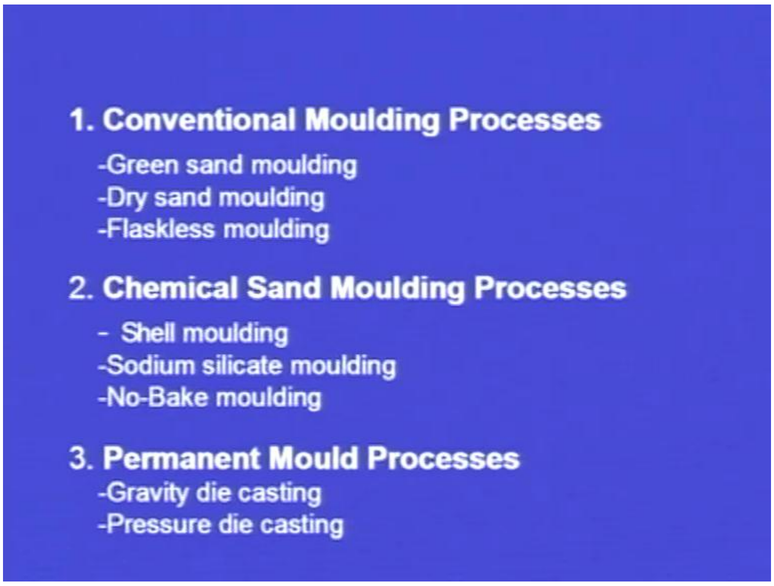

We have seen the green sand moulding, we have learnt dry sand moulding, and we have learnt flaskless moulding. These constitute conventional moulding process.

We have learnt shell moulding, we have learn Sodium silicate moulding, we have learnt no bake moulding. These constitute chemical sand moulding process.

We have learnt gravity die casting, we have learnt pressure die casting. These constitute permanent moulding process.

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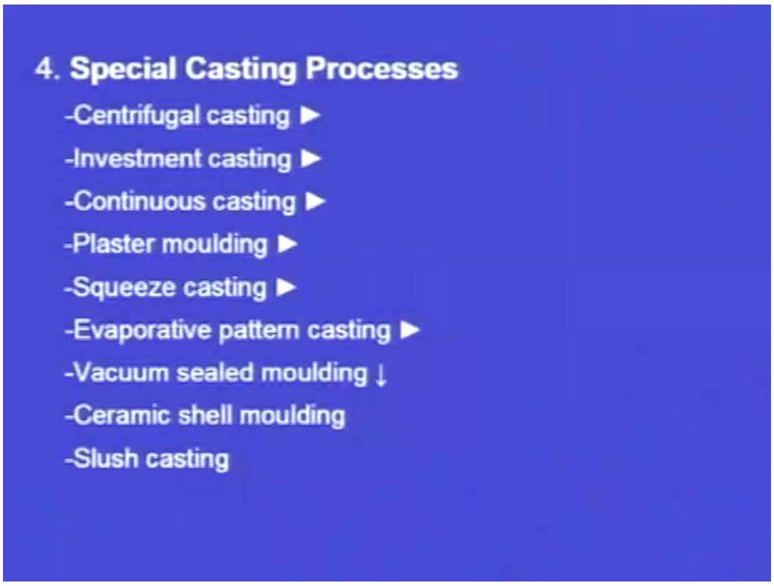

Among the special casting process we have seen, Centrifugal casting process in which the molten metal occupies the cavity by virtue of the centrifugal force falling on it. The casting yield is very high. We have seen the investment casting process in which we get extreme surface finish, extreme tolerance, and we have seen continuous casting process in which the casting yield is 100 percent. We have seen plaster moulding in which we get better surface finish. We have seen squeeze casting which is the combination of casting and forming technology. The mechanical properties are improved in the squeeze casting process.

Now, we have seen evaporative pattern casting in which we get better surface finish, but the pattern is expensive. We have seen vacuum sealed moulding which is also known as the V process in which we are holding the moulding sand by means of vacuum. We are not using any clay or moisture to bind the sand; only vacuum we are using. We are using fine and unbounded fresh sand.

We have seen ceramic shell moulding which is similar to investment casting. The surface finish is almost as good as investment casting; little inferior to investment casting, but the size of the casting can be bigger; up to 200 kgs we can make using ceramic shell moulding.

And we have learnt the slush casting in which we can cast the objects with hollow cavities, without cores. And applications we have seen only for art and decorative items.

The castings that are made by slush casting cannot be used for engineering applications.

So, we have seen all the special casting process. And in the next episodes, we will be learning about the gating system and solidification.

Thank you.