Manufacturing Processes – Casting and Joining
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Lecture – 03

Hello and welcome back to the casting section of the course, Manufacturing Processes - Casting and Joining. Now, so far what we have discussed in details and through the video clips, is the sand casting process. And, we have seen in great details how the sand casting process is performed, how the mould is prepared, how the cavity is prepared overall and, then the molten metal is poured, after it is solidified, the mould is broken and the casting is taken out.

After the casting is taken out, one thing that you should understand is that along with the casting, there will be some other parts joined in the casting. Those parts we have not discussed yet; those are the gating system overall. You may be knowing that the gating system is the part of the casting, particularly the sand mould casting. So, we will be discussing them.

Now, those parts are taken out, they are cut off from the main casting and they are re-melted, because they can be used again as the molten metal.

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This we have seen in the video clips. Particularly, in the last video clip where the wheels are made for the BMW car as I said.

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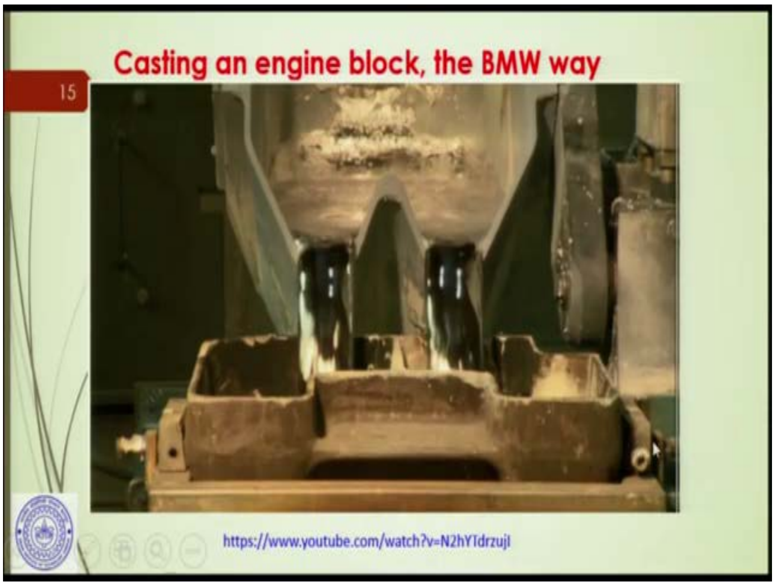

Here in this slide you can see that this is the casting of an engine block. This is also the engine block used in the BMW car and you know that these are very precise and very costly parts. I am not going to show you once again, because the process is very similar. You can use this link and watch the video at your convenience.

Here you can also see in great details how the engine block can be fabricated using the casting process. That is how the cavity is made, how the molten metal is poured and how finally, the final product can be obtained. Now, here what is important is and you can see the video afterwards, that internal shapes are very intricate, very complicated.

Because, it is an engine block, so, to get the intricate shapes you have to use different kind of cores. Those things are shown in this video that you can see using this link.

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Another casting foundry technique is shown here and you can again use this link to see this video. This is the casting process used in one of the Indian foundries. You can see the video using this link.

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Now, this I would like to show you, because this is something that is very unique, in the sense, that here the automation is used, i.e. automatic process is used. I will show you this video clip. Of course, there are two links given. So, you can also watch this video using these two links and these two links are of two different video clips. So, let us see this video, how the automation can be introduced.

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Here this mechanized core shop is shown.

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Where the mould is made and you can see that these molds are huge in shape.

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That is very big. So, this is a mechanized core shop where the cores are made. And, cores are introduced, you can see that these are the carousels.

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Here is the round table where the parts are being transferred from one place to another. This is baked here in the oven.

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And then, after this, you can see that, here it is painted.

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Different kind of paints are used.

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so that it can withstand the temperature.

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This is for the pouring of the sand in the mould. So, this is the sand mixer and you can see this is all automated.

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This is the first loop molding line; and this is the sand mixer.

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Here the cores and the pattern are placed; sand is poured on top and this is rammed.

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After ramming, the extra sand is removed and you can see that everything is done automatically. The human being is not involved here except to observe that it is going on fine.

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And, you can see that very large castings are made; then it will be rotated and it has to turn.

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Here, you can see the turning; see now it is getting rolled over. And, you have seen in the first video that this is done manually, but here it is the automated first loop molding line. This is the rolling over of the mould.

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So, these moulds are coming one by one.

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And they are getting into the automatic line here. Mould are going to the infrared oven for baking.

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so that the proper strength can be given to the mould.

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There will be a coating and that is a flood coating which is used here.

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This is the temperature resistant coating.

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This goes to the oven. This is gas fired oven.

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So, now the mould is made for the pouring of the molten metal, and placing of the cores and so on,

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depending on what kind of internal cavities will be required.

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This is the core setting area.

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This is the closing of the mould. So, this is called the mould closing area. Here it is turned around.

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Here the molten metal is prepared.

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The temperature is tested.

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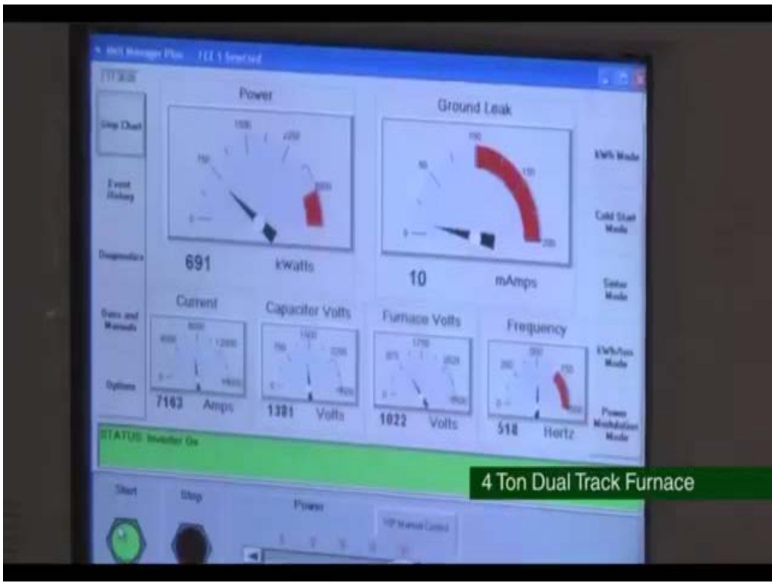

I mean, what is the temperature?

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This is a four ton dual track furnace.

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Now, here this is the pouring and the cooling lines.

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So, the pouring of the molten metal is done; you have seen earlier that the cavity has been made.

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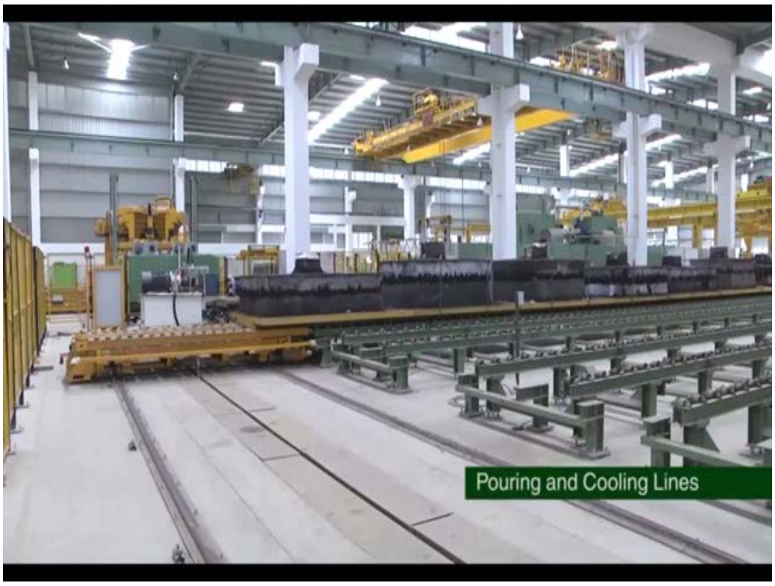

So, in those cavities the molten metal is poured and then it is cooling down. So, the solidification takes place.

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Appropriate time is given for the solidification, so that the molten metal can be solidified.

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And, here with the help of vibration it is being shaken and the mould is broken.

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Because, it is a sand mould, so, the final product or the casting will be taken out.

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Here is that, so, you can see the final casting.

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After taking the castings out, they go through the sand blasting with automatic and the manual chambers. With the help of the sand blasting the appropriate surface finish is obtained.

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And, the gas fired stress relieving furnace, because after casting there could be some internal stresses remaining.

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This is the entire process.

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Well, why I wanted to show you is that, this is the automated casting process, which is used in one of the Indian foundry shops.

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Here this is a casting of a propeller. And, this propeller is a really big one; you can see this video, I am not going to show you here. The link is given, this is the YouTube link and the YouTube link shows, the entire process how this huge propeller can be made out of casting.

These video clips will give you a fairly good idea about the casting process, namely what kind of parts that can be produced through the casting process and, how these parts are produced. So, watch these videos using the links.

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Here, again there is a link given and you can use this link to see this video in the YouTube, this is very important and very interesting video; this is casting of a mirror. How the casting of a mirror is made. And, just imagine that this is also made by the casting process. You can see the entire process; there is a good video, here is the link.

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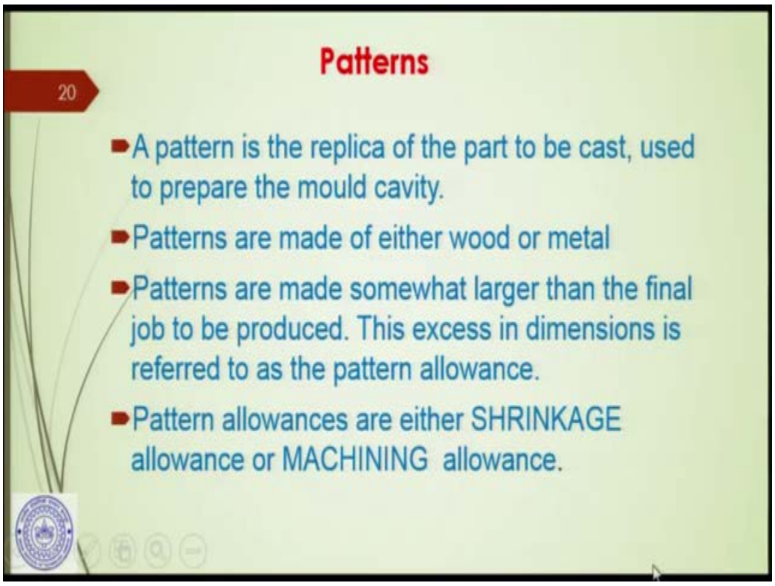

Next thing that we are going to discuss is the pattern. And, you have realized that this is a very important factor, important part of the casting, because depending on the pattern you will get the appropriate internal cavities. And, the particular part that you want to get by the casting.

Pattern is actually the replica of the part to be cast, used to prepare the mould cavity. We have seen in those videos how the patterns are placed inside the mould and around that pattern the sand is poured, so that the cavity is made.

So, the pattern is the same, I mean, it is a replica of the part. Patterns are made of either wood or metal. Now, wooden patterns, of course, will have less life than the metal pattern. However, both of these kind of patterns are used.

Now, the advantage of the wooden pattern is that it is easier to make. But, more intricate shapes can be given to the metal and accurate shape can be given to the metal pattern. Patterns are made somewhat larger than the final job to be produced. This excess in dimensions is referred to as a pattern allowance.

I already told you earlier that there are lot of important things that have to be taken care of during the casting process. Now, like I told you that when the molten metal is solidified, it shrinks. So, the dimensions are decreased. Dimensions are decreased linearly as well as in the tapering. So, there could be a different angle.

Those aspects are to be taken care of while designing the pattern. Another thing is that particularly in the sand molding, after the internal cavity is made, the pattern has to be removed. And, you have seen how carefully the patterns are removed so not to damage the cavity which has been made.

So, if the pattern does not have some kind of a tapering to facilitate its removal from the mould, then the cavity will be damaged. So, we say that when you are designing the pattern, you have to take care of those things. That, those allowances are to be given to the pattern, so, that the final casting can be produced in a proper way.

Pattern allowances are either shrinkage allowances or the machining allowance. There could be two different kind of allowances. One can be of shrinkage allowance, because of the shrinking in the molten metal; metal is solidifying, because of that or it can be machining allowance.

Because, after casting I will remind you, I told you that, we need to have the machining for better dimensional accuracy. So, you have to have some kind of an allowance. So, those are called the machining allowance.

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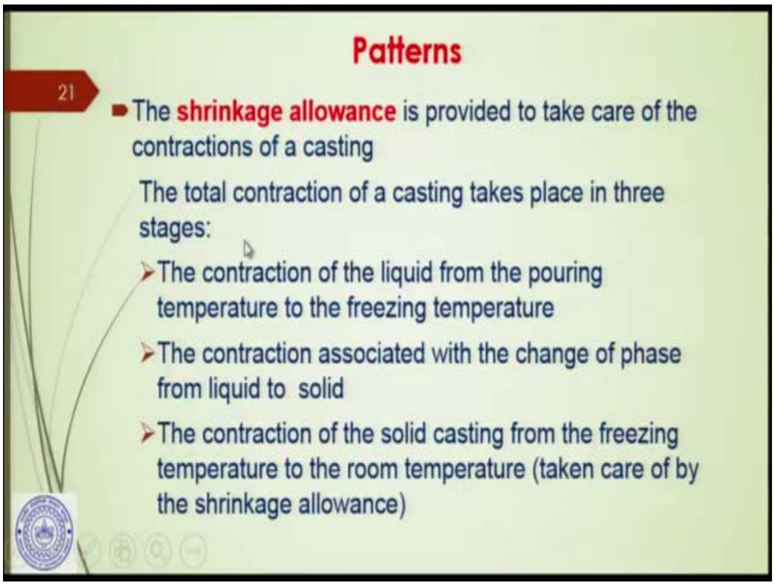

Now, the shrinkage allowance is provided to take care of the contractions of casting, I already told you. During the solidification it contracts. The total contraction of a casting takes place in three stages during its solidification. The contraction of the liquid from the pouring temperature to the freezing temperature. As soon as it is poured, from the pouring temperature up to the freezing temperature there is a contraction.

Next contraction is associated with the change of phase from liquid to solid. As the time elapses after the molten metal is poured, with time the liquid phase changes to the solid phase. At that time the shrinkage takes place again. And, the third stage is the contraction of the solid casting from the freezing temperature to the room temperature, taken care of by the shrinkage allowance.

So, all these three contractions, three contractions in three different stages of the solidification have to be taken care of by the allowances given to the pattern, which are called the shrinkage allowance.

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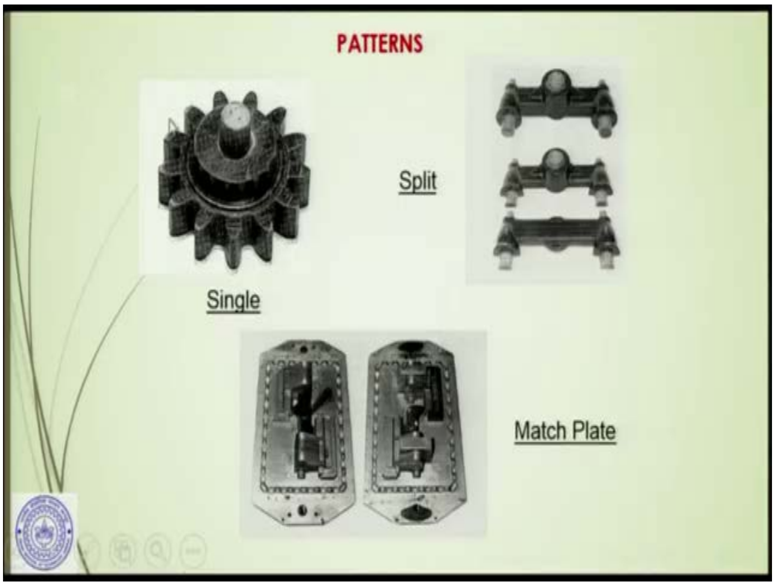

Here are different kind of patterns which are shown for example, this is a single pattern. Now, in the single pattern, this is one pattern which will make a cavity of this shape, where we have the shape of a gear or it can be split more than 1.

So, when they are together, they will actually represent a complete part, or it can be in the form of a match plate. So, these are in the two hubs and again when they are connected together, they will be actually representing a complete part. This is called the match plate. So, patterns can be single, split, or the match plate.

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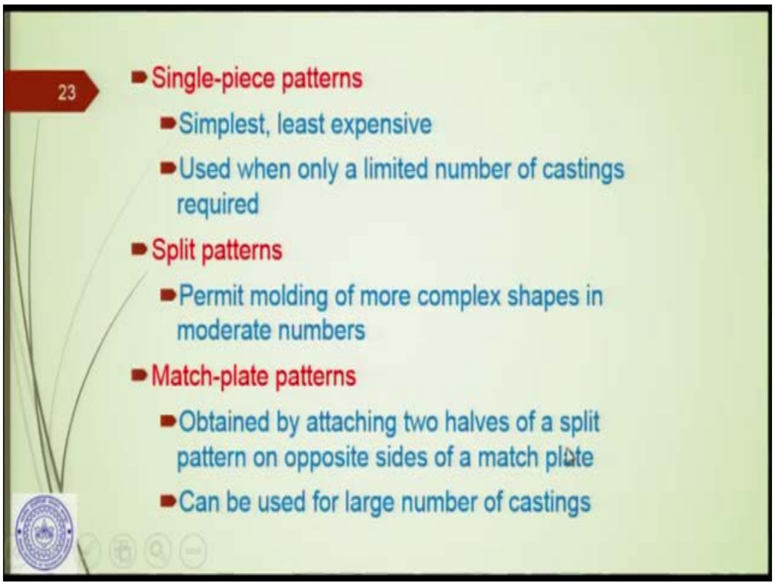

Single piece patterns like this, are the simplest, least expensive of course, because it is easy to machine, and it is simple. Used when only a limited number of castings required. So, they are not very complicated. One single pattern will actually make the cavity and they are used for the limited number of castings not in large number.

Split patterns permit molding of more complex shapes, because they are split. What happens is that when the shape of the cavity is very complicated then, if you are using a single pattern it will be difficult to take out, because there are intricate shapes; if you take out the pattern the mould may be destroyed. Therefore, it has to be split pattern, because the mould cavity itself is very complicated.

And, they are produced in moderate numbers, not very large quantity, not very small quantity. Match plate patterns, are obtained by attaching two halves of a split pattern on opposite sides of a match plate. So, I already told you once again I will show it to you, this is the match plate in two halves, can be used for the large number of castings. Normally they are made of metal. And, therefore, they can be used for large number of castings.

And, when the large number of castings required, of the same kind of casting, it is better to use a kind of a pattern that can be used multiple times, otherwise it will be very costly, each time for each casting, if you have to make a pattern.

Now here it is possible because you are making the limited number of castings. Therefore, a single piece pattern can be used, although, the single piece pattern does not mean that it has to be used only once, mind it. But these single piece patterns are simplest and when the simple castings are made, then these kind of patterns are used.

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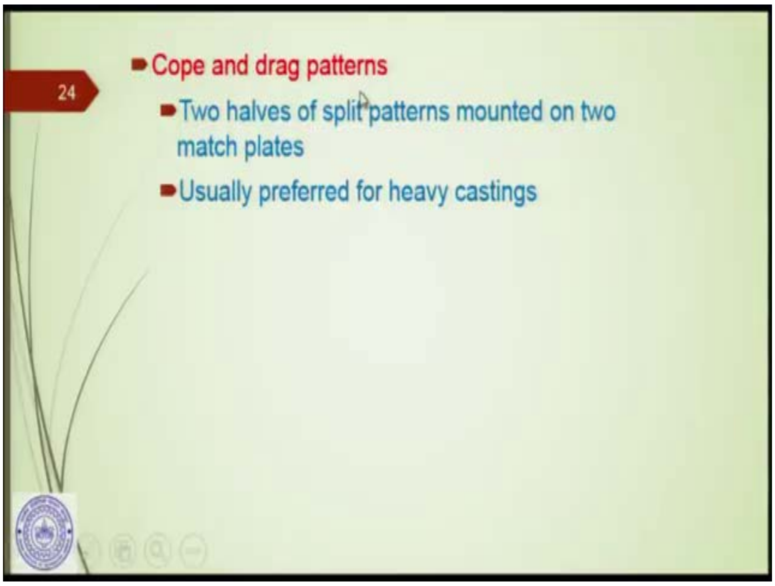

Cope and drag patterns: these are two halves of split patterns mounted on two match plates. So, this is the kind of the match plate, that I have shown to you earlier; usually preferred for heavy casting. So, when the casting is very heavy along with the match plate, there are two halves of the split pattern mounted on the two match plates additionally.

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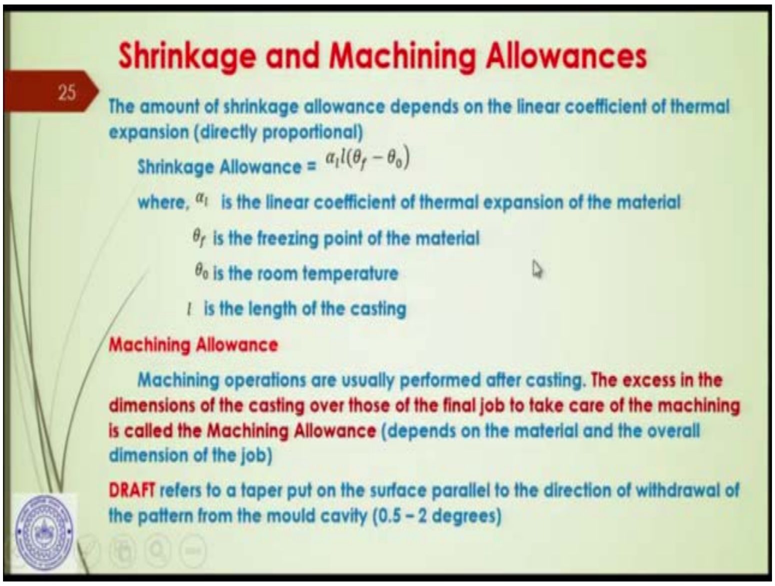

Now, let us see the shrinkage and machining allowances, how they can be estimated, and which factors should be taken into consideration while calculating, while giving the shrinkage and the machining allowance. Because, as you understand that depending on the amount of shrinkage and the machining allowance that you are giving, your accuracy of the final product or the casting depends.

If the allowance is not adequate, allowance is not accurate, in that case the accuracy will be hampered; so, this is how it is calculated. The amount of shrinkage allowance, depends on the linear coefficient of thermal expansion is a direct proportional ok. This is given by $\alpha_l l(\theta_f - \theta_0)$.

In this equation, by which you can find out the shrinkage allowance, the α_l is the linear coefficient of thermal expansion of the material. And, this coefficient will be given in the handbook for the material that you are using for the casting. So, you can find out the value of the α_l ; this is the standard value given in the handbook.

θ_f is the freezing point of the material; again the freezing point of the material can be obtained from the handbook as well. θ_0 is the room temperature that depends on where the casting process is performed. So, that has to be deducted from the freezing point of the material and l is the length of the casting.

So, as you can understand and it is very logical, that depending on the length of the casting the shrinkage allowance will depend. It is directly proportional to the length of the casting as well as to the linear coefficient of thermal expansion of the material.

So, these three factors or rather four factors should be very well and very accurately taken into consideration, otherwise the shrinkage allowance may not be appropriately given. Machining allowance is given when machining operations are usually performed after casting. I told you this already, the excess in the dimensions of the casting over those of the final job to take care of the machining is called the machining allowance.

That depends on the material and the overall dimension of the job. Like, for example, there could be different allowances along the length or along the diameter. They could be different. Suppose you are making a shaft. In that shaft there could be an allowance along the length or along the diameter and, they are different.

Draft refers to a taper put on the surface parallel to the direction of withdrawal of the pattern from the mould cavity. This I already told you that, and you have also seen that in one of the video clips, that when the pattern is taken out from the cavity, you have to be very careful so that the cavity is not destroyed.

And, that has to be taken care of by giving a draft. And, that draft is along the direction of the withdrawal, if you are taking that pattern in this way. So, the draft has to be given along this. So, it is a kind of a tapering that has to be given to facilitate the removal of the pattern from the mould cavity so that the cavity is not hampered. This is called the draft. Normally, this is about 0.5^0 to 2^0, not more than that.

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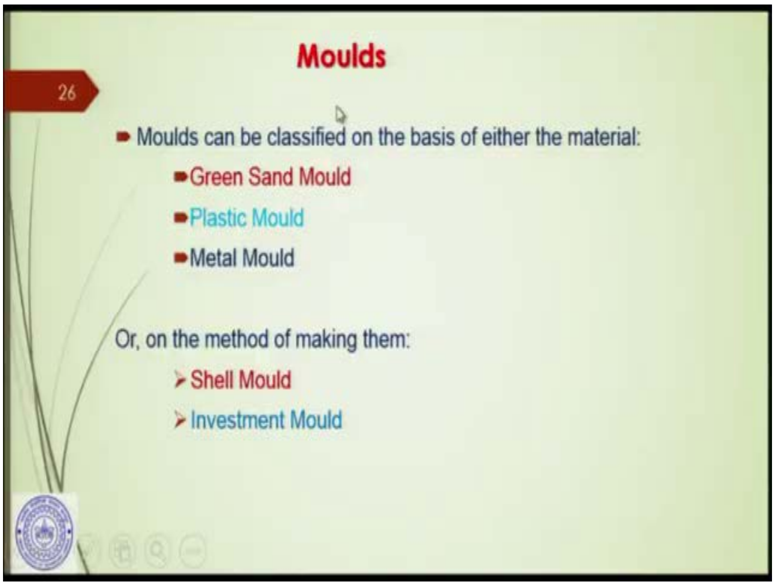

Moulds can be classified on the basis of green sand mould, plastic mould, and the metal mould. Depending on what kind of parts that you are getting, what kind of castings that you will be getting.

Green sand mould is very popularly used and the mould has to be destroyed, it is once used. Plastic moulds are used for small parts , not very heavy castings.

And, the metal moulds are used when the mould can be used multiple times and large number of parts are fabricated. Or the moulds can be classified on the method of making them. For example, we have the investment casting, I have not discussed that yet, but we will discuss it, that you can use a shell. And, inside the shell you can pour the molten metal.

So, that shell is like a cavity, shell is like the sand mould cavity we have discussed. So, either it is the shell mould or it can be that investment mould like in investment casting and so on. So, those things we have not yet discussed, and I will show it to you and discuss later.

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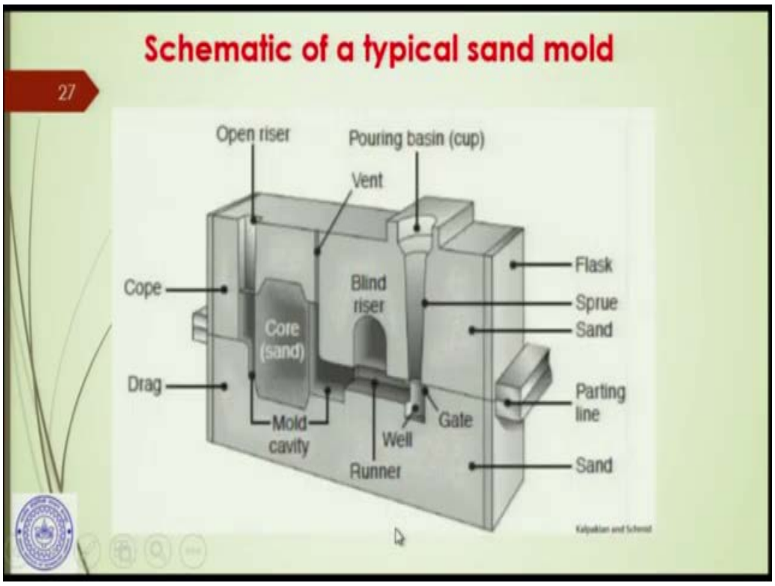

This is the typical sand mold schematic diagram. Here let us see what are the details. Of course, you have seen that how they are being made. Here, this is the mold cavity. So, in this the molten metal will be filled in and the molten metal will come from the pouring basin through the sprue; this is the pouring basin. So, basically this has two halves; the mold is called the flask.

Upper part is called the cope, and the lower part is called the drag. So, this is the flask which is the box inside that there are two, I mean there are two halves of the box. Here we have the cavity, which is the mold cavity that has been made with the help of the pattern.

And, here we have the core; core is to get the internal hole, or internal cavity, or internal shape, different kind of shapes, depending on the internal shape that you want, you can have different kind of cores. Separate sand is used for making the core and that we will see little later.

So, this is the core which is used to get the internal cavity in the casting. Now, the pouring of the molten metal is done from here as I said; this is called the pouring basin or the pouring cup. Molten metal comes through the sprue. And, it gets through the pouring gate to a well, pouring well. And, when it is filled up it will flow through the runner and fill the mold cavity.

All these things we will be discussing in more details; like why this sprue is tapered? How to design this sprue? What happens if that is, for example, a cylindrical shape? Why it is a taper shape? This we will discuss later. Now, this is the well. The molten metal will be poured and it will get into this well first before it fills the mould cavity through the runner. Now, this well is given so that there is no splash.

If the molten metal is allowed to fall freely without the well, it will splash. And, that will be a negative factor for the casting. Therefore, to prevent the splashing the molten metal first gets into the well and then, when the well is filled up, it flows through the runner to the mold cavity.

Now, another thing that you can find out is that there is a riser. So, there are two types of risers, here it is shown - one is the blind riser, and another is the open riser. The difference is that the open riser is open to air atmospheric air and the blind riser is closed.

Now, the risers are given so that the shrinkages can be compensated, meaning that when the molten metal solidifies, it shrinks. So, those shrinkages have to be compensated for. There are other shrinkages that I will show you, which need to be taken care of. For the riser we have to make sure that the riser design is such, that the molten metal which gets into the riser, solidifies later than the molten metal inside the mold cavity.

Otherwise, it will not be able to compensate for the shrinkages in the mold cavity, if it solidifies before the molten metal in the mold. We will have a detailed discussion about that.

We will discuss how to design the riser in such a way, that the solidification of the molten metal in the riser takes place after the solidification of the mold cavity. This is important, because otherwise the idea of the riser will not be satisfied.

So, riser should be a reservoir of the molten metalto compensate for the the shrinkages in the mold cavity. And, here it is an open riser. It is open to the atmosphere and I will explain all those things in more details in our next discussion class.

Thank you for your attention.