Theory of Production Processes

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Lecture – 07
Patternmaking: Types of Pattern & Allowances

Welcome to the lecture on pattern making. So, in this lecture, we will discuss about the types of patterns and the types of pattern allowances which are given on the pattern for getting the accurate size of the casting after the process of solidification. So, in the last class we discussed about the pattern, its materials, what a pattern is.

Now we know that normally we mean by pattern that it has to be used for making the cavity. So, that in the cavity you can pour the liquid metal which after solidification gives you the cast product. So, normally when you have the simple shapes of the pattern, you go for the single piece pattern; otherwise you have the design aspects to be considered, because ultimately the problem is that how to withdraw the pattern, once you are ramming the sand around it. So, if it is a simple shape pattern, like this is a single piece pattern you can say, we can see that this is the before this type of shape. You can put the hole of the casting that is pattern in the drag and you can ram the sand around it.

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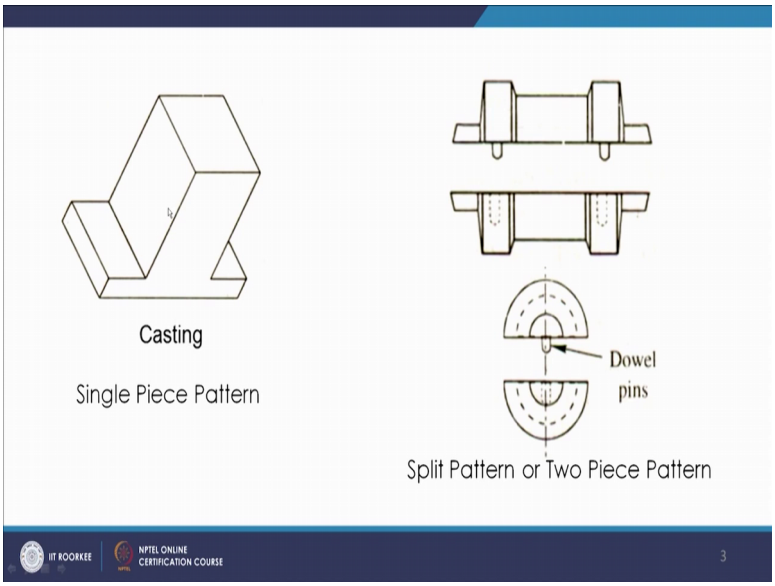

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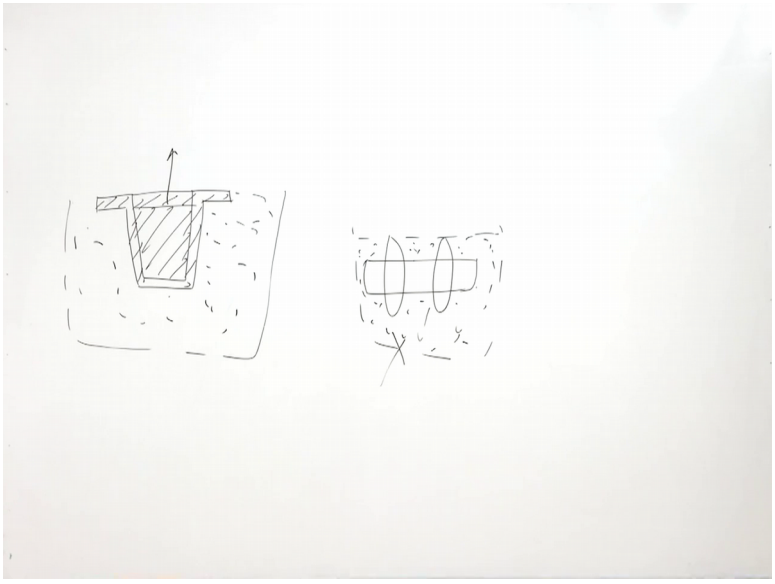

So, you have this way, you have the pattern, and anyway this is basically solid. So, whatever it be. This way you have the, suppose you have the pattern of this type. So, you can have the sand all around. And once you remove this from here, then you will have a cavity of this sit, and in that you can directly pour the liquid metal from the top. So, you will have a cavity of this type when you are taking out. So, it is all packed from all the sides by basically the sand. And once the liquid metal is poured, then this liquid metal after getting solidification it will give you similar ty type of shape of the casting.

So, such simple shapes and when we get the pattern for that, they are known as single piece pattern, they are simple in shape. You do not need to carry any other other specialized type of design of the pattern, and you do not need to make the runners or in gates. So, in that case it is simply the pouring of the liquid metal from the top. So, that way it is single piece pattern. Coming to more little bit more complex type of patterned, where it is difficult where you get the difficulty in drawing it. So, if you look at such type of the pattern. Suppose you have this kind of casting, where you have shaft, and suppose on this shaft you have mounted here, you have two wheels.

Suppose you have this kind of cast component for which you have making the pattern. Now in this case if you try to ram, basically the sand. In that case you will not be able to get it, you will not be able to take it out once you are ramming the sand. Suppose you are ramming the sand in this, may be even and the drag portion, if you are keeping it then it will be difficult to take it out, because there will be many places where you will have that damages. So, it is not possible to basically make the cavity for such shaped patterns. So, what we do is, as you see that you split the pattern into two halves and every half is made, and then they are basically joined together.

So, you will have the two part, then you join them. Once you get the cavity then you have the two boxes, then these boxes are joined, and then in that case you are making the gates or you are cutting it through hands, because still it is simple shape. So, we are cutting the channel for the entry of the molten metal into it using hand, and then you are making it. So, that after making the cavity, when you are pouring the liquid metal it will go through that channel, and enter into the cavity. So, this is the example of split pattern or two piece pattern.

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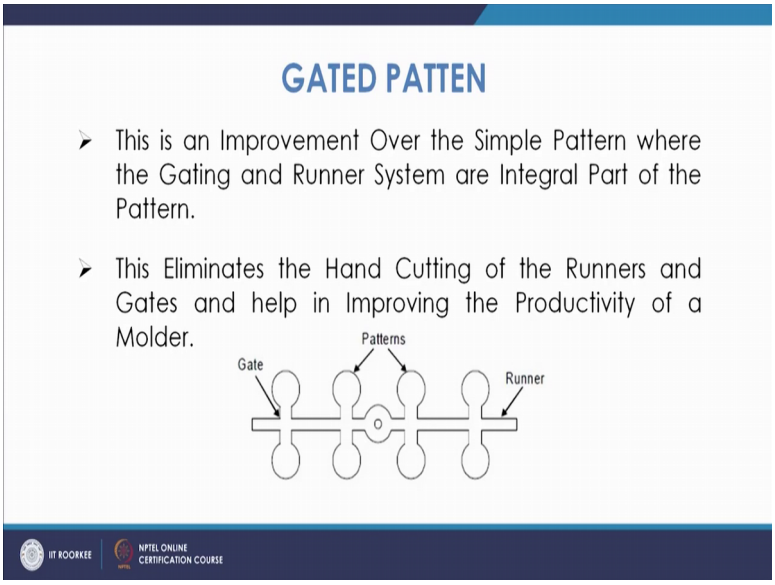

Next is the gated pattern. So, this is improvement over the simple pattern, where the gating and runner system, they are integral part of the pattern. So, as you see in this figure. In this figure you see that you have these are the patterns and you have a common runner and through this runner you have again gates. So, they are the part of the pattern, when you are making the pattern you keep that provision in mind so that when you are pouring the liquid metal, this liquid metal will go through the runner. And from there it will be fed to the cavity through the different gates, these are known as the in gates, and they will go into the different cavities and give you the casting.

So, basically the pattern itself is which you are making, it has, its integral part as runners and gates. So, basically you are making the gates and runners which are part of the pattern, and the liquid metal will pass through these gates and runners and enter the cavity and it will give you the finished cast product. So, this eliminates the hand cutting of the runners and gates. So, hand cutting certainly will take time and it will also have certain problems, because many a times, because of the hand cutting, maybe that the sand part which is removed that may go into the cavity. So, that will be a source of defect itself in the casting, if it goes inside the cavity when you are cutting through hand in the case of the two piece pattern. We are cutting these in the form of you know, we are cutting by hand itself. So, that we basically we have to we are avoiding and that increases the productivity of the process. So, this is the gated pattern; then coming to the cope and drag pattern and the match plate pattern.

Now in this case when you are; so far we are discussing about some kind of pattern where normally we do the hand moulding, hand ramming we do, but many a times we have to go for

the mechanized process. Sometimes we are going on the machine and with the machine itself you are making the mould. So, for that in that case for increasing the productivity for mass productions or so, these kinds of patterns are used. So, here you have the small components, and you can make large number of components, and then they can be put on the by use of machine you can make the basically mould for such castings.

So, what is there in cope and drag pattern you have two parts; one is for the cope you have a pattern plate, on the pattern plate you have the projection for the cope portion, and may be another pattern plate is there that is scope pattern as well as for the drag pattern, you have different pattern plates, and in one go you go for the cope portion, you keep that at the machine, where again with the machine the sand will be kept on that and then there will be ramming and then it will be taken out. So, in that case when the pattern is taken out you will have the cope portion of the mould ready. Similarly in the second go, you will have the drag part so on the drag part. So, as you see, you have the, this is the for the cope part.

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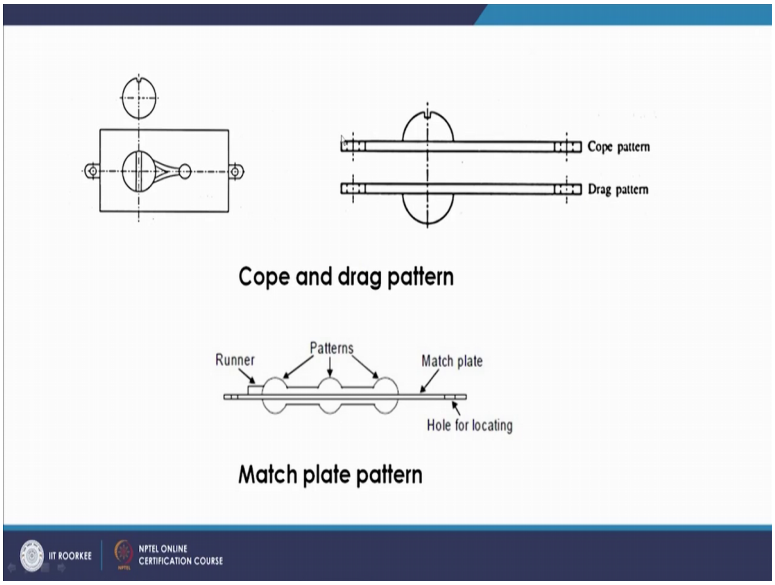

So, this will be there as a pattern plate on that you have this is the projection. So, for the casting suppose, and this basically will be taken out. And then once again you have the another pattern plate, which you are using for the drag part, and then you are joining these two you are combining these two and you are getting such kind of the cavity, and the cavity you can further pour the liquid metal.

The thing is, that here we are using the cope pattern and the drag pattern by using the pattern plates individually, because in this case you can, you have the flexibility to go for a little higher mass or little higher weight. So, that way you have the two different patterns, but on the other hand you have this match plate pattern. So, rather than taking the cope pattern portion out, then further putting another match plate, and again making the pattern, you know my plate are, you can have to make the pattern for the drag portion further if the component is smaller in size. In that case you have this pattern type known as match plate pattern where, you just invert on the other side and other side you have this pattern for the drag part. So, its normally suitable for the smaller components where just you can invert it and then use it for the drag part, and then further you can combine them and have the cavity prepared.

So, it is basically the similar to that kind of cope and drag, but here it is the only one match plate is there, and on the both sides you have the drag part as well as on the as well as the cope part. So, this is known as match plate pattern. Then further you have the loose piece pattern. Now loose piece patterns are used when you see that, it's very difficult, its in a inaccessible position. So, it is very difficult to you know make the pattern in such a way that you take it out, it is becoming difficult in some certain sense, as you see that you have the parting line.

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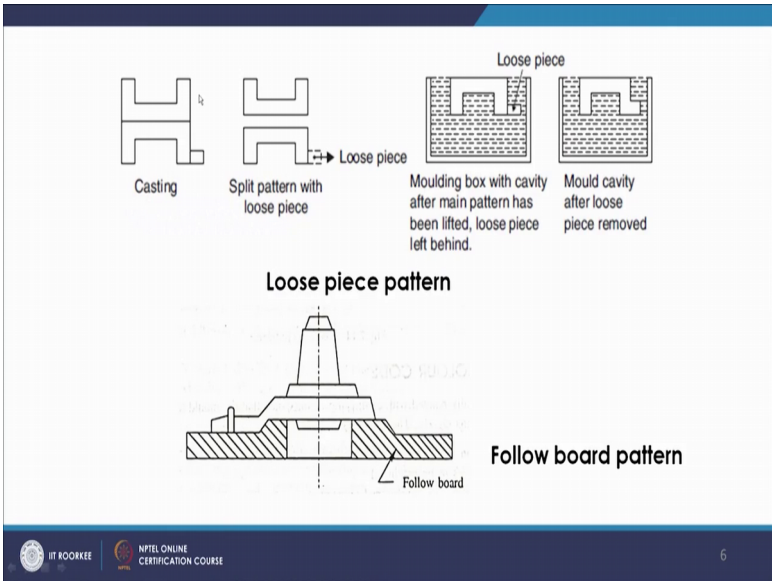

So, you make these kind of parting lines, in that you have to make the parting line, but if you have such projection on this side. Now it is very difficult to have it. So, what we do is, for

that you have a loose piece in those cases so that these loose pieces can be taken out. So, there is no other way out. So, in that case we are using this loose piece as a patterns as known as loose piece pattern.

Then you have the follow board pattern. Now follow board patterns are used when certain part of the pattern is fragile, and in that case you use a follow board. So, that the contour is matching with that fragile portion. So, these portions suppose it is there, it is configured like this. In that case if you have a normal board, and if you are putting the sand and ramming, the this portion delicate portion, the fragile portion, they may break or they may deform that may lead into the deform type of cast product. So, in that case what you do is, you make a follow board, you have a board on which you keep. So, this is basically modified. So, that when you ram, there is no problem of the dimensional deformity, while you are ramming and then further you can do a casting. So, this is known as follow board pattern.

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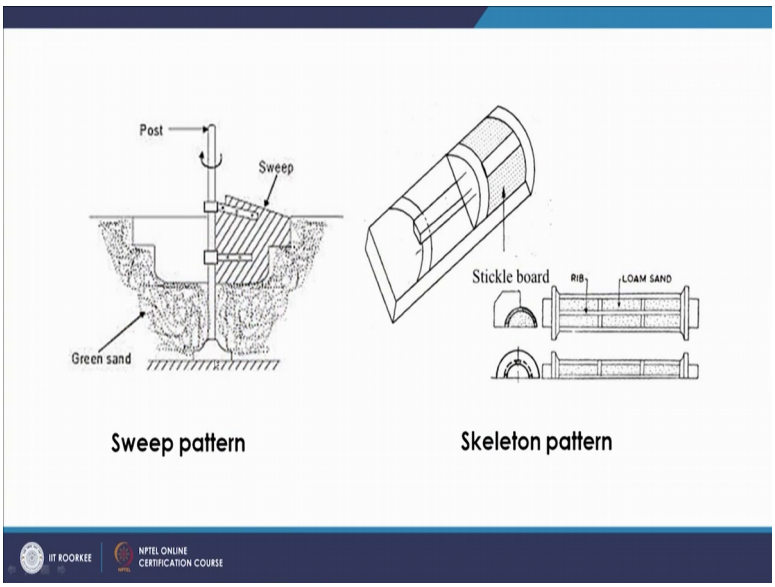

Next is the sweep pattern. So, sweep pattern is used normally for axis symmetric type of bell shaped castings which are larger in size. So, otherwise you have to make, it's very difficult to make them. So, in that case you have the sweep which is basically removing. So, it will be rotated in the circular fashion. So, you have the sweep of particular shape. Suppose you have such kind of shape which is to be made. So, we have a sweep of a particular shape which will be rotated around this axis, and this way it will remove all the material and it will make the

cavity ready. So, this kind of pattern which is used, which is using this sweep for making such axis symmetric type of bell shaped castings, they are known as sweep pattern.

Next is the skeleton pattern. So, skeleton pattern, here again its for very large type of castings, you use the stickle board you have. So, for very large castings, depending upon the size, it is very uneconomical to take, such a large pattern in such cases and then if you have to make only very small quantity of material. In those cases this skeleton pattern is used, where the skeleton of different type, different shape is used depending upon the casting shape, you use the skeleton, you also back these skeletons with the sand and this way you make the pattern. So, this way we use these skeleton patterns. So, we discussed about the different kinds of patterns, and as we know that depending upon the application, depending upon the size or complexity of the material to be cast or the cast product you make the pattern, and then this pattern basically is to be used for making the cavity. Then we are coming to pattern allowances.

Now, in the pattern allowances as we had discussed earlier; the allowances means you are giving certain you know liveries so that you get the accurate dimension. As you know that when you use the pattern, in that case we are using the some of the moulding material where the metal is cast, and because of the properties of the material, the material will shrink somewhat. You have also to take the pattern out of the cavity. So, while taking out, you will have to have some mechanism or you will have to have certain dimensional considerations. I mean that is to be kept in mind. So, that you take the pattern out of the mould.

So, again depending upon the kind of moulding process used or the kind of accuracy required for the surface finish or so, you have to remove the surfaces at least at the top surface of the material and you have to get a desired surface finish. So, for that you cannot make the pattern exactly of the same dimension or shape even, when you are making the pattern by. I mean pattern and when you are casting the material. So, basically you are making certain modifications. This modification is. So, whatever modification you are putting in, it is known as the pattern allowances. So, pattern allowances are of different types, and that one is shrinkage allowance, draft allowance, shake allowance, machining allowance and distortion allowance.

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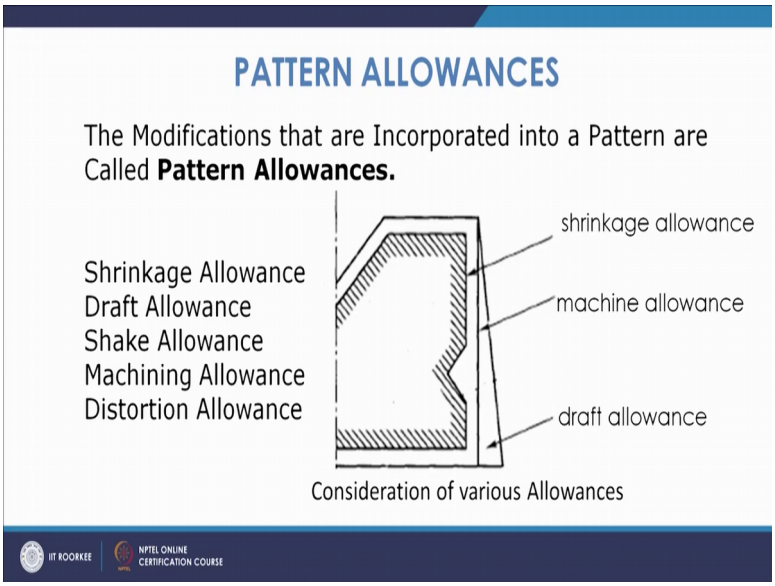

Now, if you look at this figure what we see is, that if suppose you have. So, we know that once the material gets solidified it will shrink, and this amount by which it will shrink it is the characteristic of certain material, some may shrink as 3 percent or 4 percent or so. So like that you are. So, based on that is the volumetric shrinkage, but we are giving the shrinkage in linear terms here for any linear dimension. Now in accordingly we are basically doing the changes in the dimension, because ultimately the metal will shrink. So, you will have to make the metal over size. So, that once it shrinks, then it comes to the original shape. So, for that you do the shrinkage allowance.

So, suppose this is the dimension of the material after giving consideration to the shrinkage allowance. In that case, if you look at this, this will be the machine allowance, this one which we give, this dimension extra that basically is the machine allowance, because once you are taking the product out, you will have to remove the extra material out of it. So, that is basically known as the machine allowance. So, machine allowance will again be somewhat additive in nature, you will have to give extra material, you will have to enlarge the dimension by certain amount depending upon the section size or so. And then that part is to be removed, so that is your machine allowance.

Then this is allowance known as draft allowance. So, this draft allowance basically we will discuss later. The draft allowances are basically about the easy with draw of the pattern from the mould. So, they are given on the vertical surfaces. So, because when you have the pattern

and when you are putting inside the box and ramming it from all the sides with the help of sand, then while taking out you will have to have the some taper, so that you can take it out without actually damaging it. So, then you have the draft allowance.

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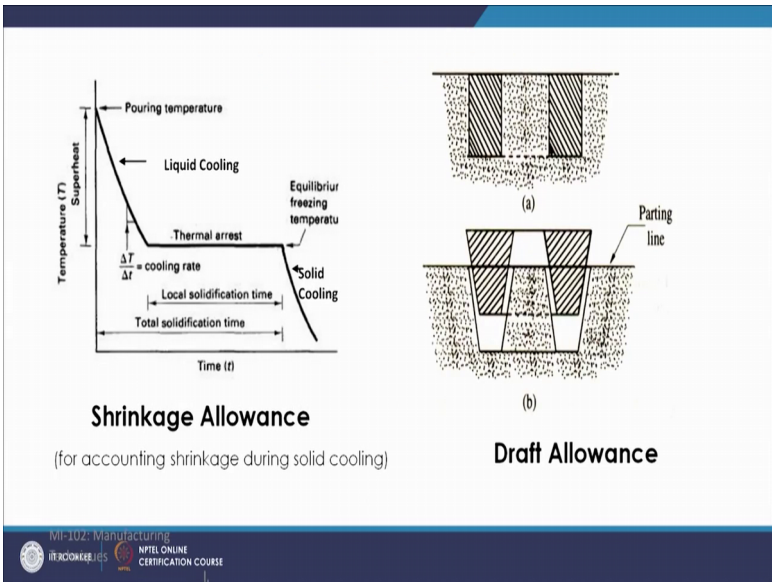

So, let us go to one by one the different kinds of allowances. The first is shrinkage allowance. So, this graph tells about the shrinkage allowance. Shrinkage allowance is given in this portion, whatever shrinkage takes place during this stage, this is a third stage. As you know that in solidification you have three stage of cooling; the first stage is liquid cooling, second stage is the solidification cooling, cooling during solidification and then you have the solid cooling.

So, not solidification cooling basically, the solidification takes place in case of alloys when during solidification there is temperature drop, but in the case of this solidification in pure metals which is the case here. In the case of pure metal there is conversion from liquid to solid state, and here again the shrinkage takes place, because the liquid is converting to solid. So, that is solidification shrinkage. And similarly you will have the liquid shrinkage during the liquid cooling. So, liquid cooling means, cooling from superheat temperature to the equilibrium temperature of melting. So, that is your liquid cooling. So, the liquid cooling in that superheat is arrested during that cooling stage, and during this solidification cooling, solidification stays, you will have the conversion of the liquid to the solid state. So, in that the shrinkage takes place.

Shrinkage again takes place when it has, the material has completely solidified and the temperature is coming down to room temperature. Now the two stage; this first and second stage liquid cooling as well as in during the solidification period, this is taken care of by the riser, because see this is only liquid metal which is basically to be supplied. So, that is supplied by the riser, you are providing a riser, and depending upon the shrinkage which occurs in that stage you will have to have adequate volume of the riser, which can supply the liquid metal, if the desired by the casting during that stage.

Then you have solid cooling. So, in solid cooling you have, the cooling from equilibrium temperature to the room temperature. So, that cooling is occurring during the solid state, and this is a compensated by giving the pattern allowance; that is shrinkage allowance. So, this shrinkage allowance will be certain percentage and certain dimension will be taken depending upon the section size, and that will be added to the dimension of, actual dimension of the cast product.

So, you will have some extra additive dimension which is added. Similarly you have, next is your draft allowance. So, as you see, the draft allowances is, here once you have to take it out. In that case on the vertical surfaces you have to give a taper. So, that you are able to take it outside without basically damaging on the sides. So, you are. As you see that this is the actual size actual shape, you are making of this shape. So, there are some angle is basically. It may be given in terms of angle or dimensions at the top and bottom part. So, that taper is they are created and then you can take it out in a comfortable manner, without actually damaging the mould. So, this is known as draft allowance.

Next is the shake allowance. Now what happens many a times that this is basically depending upon the experience of the foundry man, foundry personal. So, in many process before withdrawing the pattern from the mould, the pattern needs to be little bit shaked or wrapped. So, this is also known as wrapping allowance. So that, the places where the pattern is in touch with the mould, especially on the vertical surfaces; so wherever in the pattern that, because you will have the addition between the sand grains and the pattern material. So, this addition, because of this addition, there will be difficulty in taking the pattern out, because of this addition.

So, what we do is, we little bit shake laterally and then once we ensure that there is no proper addition at least on the surfaces, and the sand grain is expected that it is not you know gluing

or it is not, in such a way that it will come out of out of the mould cavity with the by sticking to the pattern itself. So, just we shake it little bit in the lateral direction, and then we take it out. So, what is done is in that case once you shake it laterally, then basically the size becomes little larger. So, what we do? In this case you give a negative allowance. You normally make the size cavity little smaller. So, that because you know that you are going to shake it, you are going to wrap it and in that case it becomes little bit oversize.

So, that is why this is a negative kind of allowance, and which is up to be applied only to those dimension which are parallel to the parting plane that is width or thickness, and not the height. Because ultimately it is only the over sizing applying only to the lateral dimensions not the height one. So, this is the only casting allowance. I mean pattern allowance which is negative. You will have to keep the dimension little smaller, because you know that ultimately it's going to be oversized. So, the original pattern dimension has to be reduced to account for the increase in dimension, because of the wrapping or shaping, I mean shaking.

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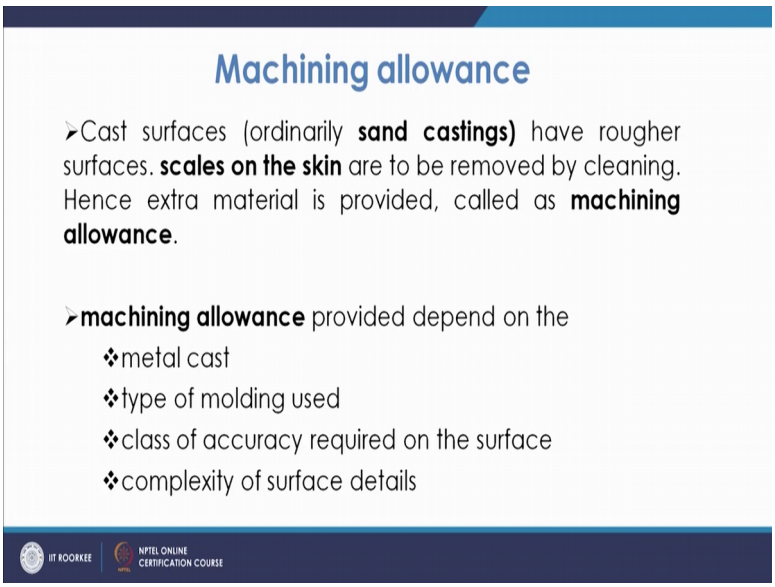

The next type of allowance is machining allowance. So, as you know that you will have to machine the surface to basically get the actual surface finish of the casting, which you desire. So, normally when you cast the material, you have the formation of scales on the surface, the last surface. Basically what happens the hot metal goes into the cavity and this reacts even with the sand sometimes little bit, you have the fusion of the sand, they stick to the surface. So, you will have gloss many a times glossy appearance maybe, because of improper

moulding materials, you have certain surface reactions, you have sand metal reaction may be in extreme cases.

So, normally on the surface it will not be very smooth; so what happens when the criteria is stringent. In that case what we do is? You have to remove the top surface, you have to further polish it or machine it, and you have to bring that particular level of surface finish. So, this is done for getting the proper finish of the material, and the allowance which you provide that is known as machining allowance. So, it depends upon the type of metal which you are casting, and the type of moulding method which you are using, class of accuracy required on the surface, and complexity of surface details. So, many a times many metals give good finish, and many metals do not. Like different depending on the type of moulding method used, like you have some sand moulding you may have, you may use other moulding methods, you may go for hand moulding, you may go for machine moulding; so moulding.

So, that way the machining allowance will vary. What type of accuracy you require, what is the complexity based on that you require to give certain kind of machining allowances.

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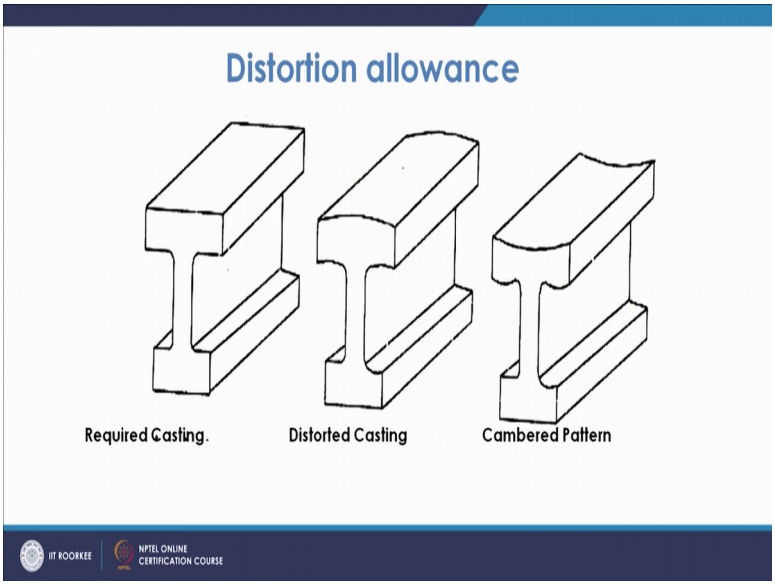

The next allowance is distortion allowance or camber allowance. So, it happens in certain kind of pattern which are flat surfaces bulky portions. And what happens that in such cases if you have the pattern of this shape. If suppose you have need a casting of this shape, and if you are making the pattern of this shape then what will happen, because of its weight it will sag. So, ultimately after distortion you will make the, you will have the casting in distorted in

such shape. So, for that what we do is, we normally give certain camber to the pattern. So, that you are giving some angle is given.

So, that once it is sagging little bit, because of its weight, because of its also shape. Then in that case it comes as a flat product. So, for that we give certain allowance; that is known as camber allowance or distortion allowance. So, these are the different kinds of allowances, which would provide on the pattern, and as we know that these allowances will give you that liberty. So, that even if suppose in case of machining allowance, even if you have certain burrs or some on surface you have some imper imperfections or you have discontinuities you can remove, and then you can be sure that you are getting the final product, final casting of the requisite dimension. So, this is about the different kinds of allowances, which are used in the practice of pattern making.