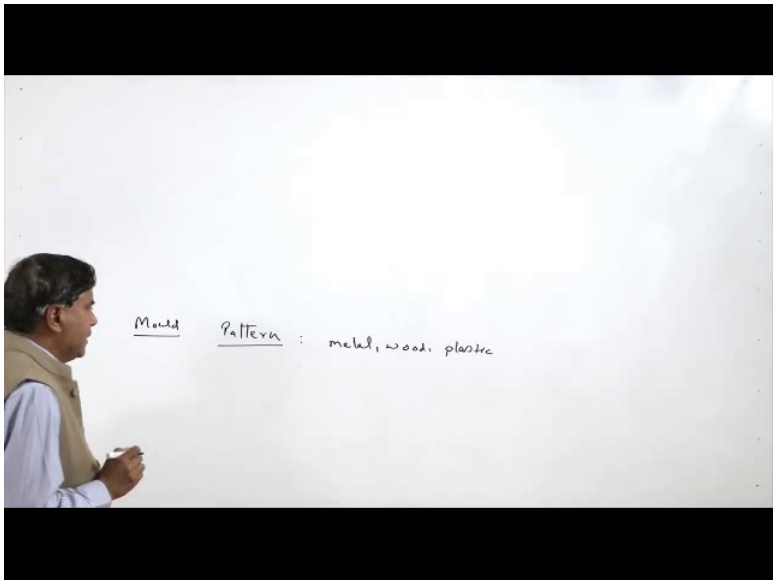
Fundamentals of Manufacturing Processes
Dr. D. K. Dwivedi
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 13
The Pattern Allowances

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes. And this presentation is particularly based on the chapter related with the casting; wherein we are trying to talk about that how the cavity that is mould is prepared using the pattern so that the suitable casting can be made with the required dimensions. So, you know that for preparing the mould; we need in case of the sand moulding mould casting process we need a pattern.

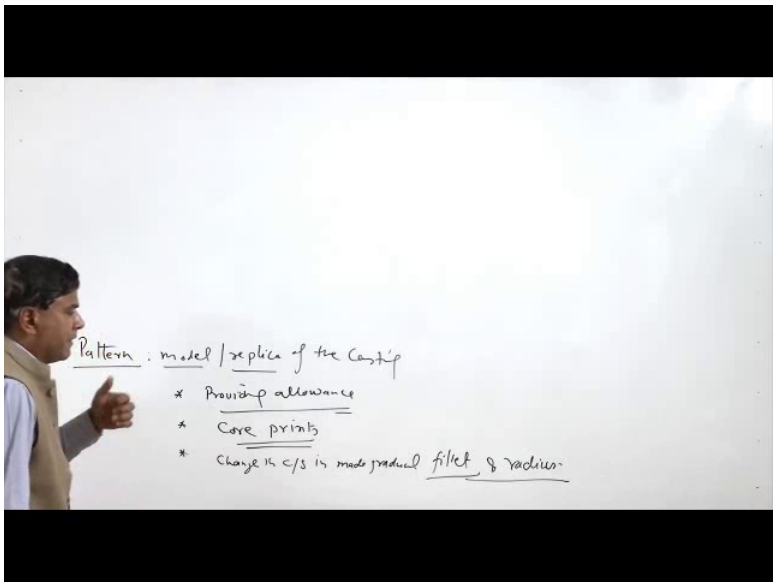
(Refer Slide Time: 00:49)



So, pattern is prepared first and which will be used for making the mould. This pattern as I have talked earlier, that can be made of the metals, can be made of wood or it can be also be prepared of the plastics.

For low volume production and for cost effective processes are the wood is commonly used for making the pattern, but the metallic patterns can also be prepared for when the large volume is to be produced and also the good surface place and the good dimensional control is needed. So, the patterns are basically as I have said these are basically models or replica of the casting to be prepared.

(Refer Slide Time: 01:45)



So, it is a model or a replica which defers from the final casting which is desired, a due to the certain regions. And these regions basically are related with the three there are three factors which lead to the development of the pattern which is different from the castings. One is like providing the allowances patterns are provided with the certain allowances.

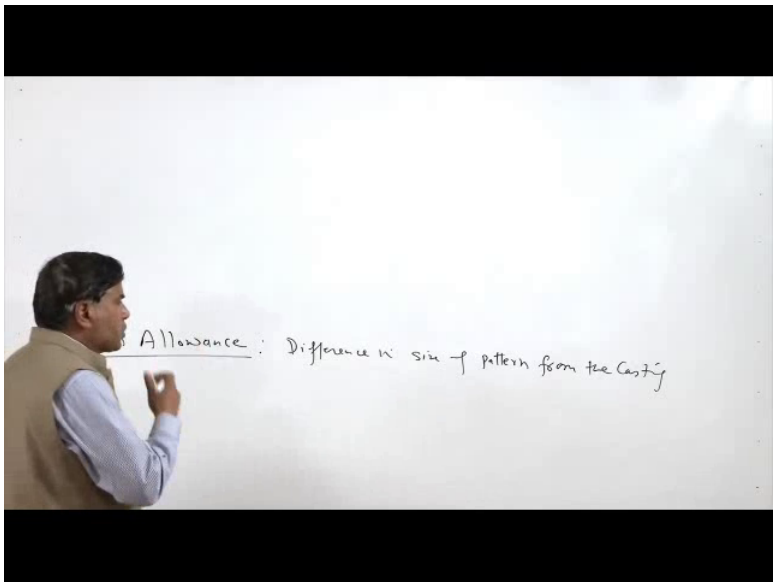
So, that after development of the casting after machining and to take care of certain other aspects, we get the desired casting. Second is it is provided with the, if the internal details need to be made, then we you have to use core and core is to be placed in the mould cavity. So, for that purpose normally, core prints are made in the patterns. So, these are the additional features which will be used to make the core a seat for the core where we can place the core in the mould cavity. So, that is basically incorporated into the pattern. And another is where ever the change in cross section is a made gradual.

So, normally this is done by providing the suitable filets or and the radius of the required size. So, that that does abrupt change in cross section is avoided, because which cannot be very effectively replicated or otherwise; it will lead to the presence of the defects in the locations where sudden change in cross section is taking place.

So, because of these three regions, we need to provide some of the filets in the locations where such change in cross section is taking place. We need to provide the print. So, that the seat for the core can be prepared in the mould cavity and we need to provide the

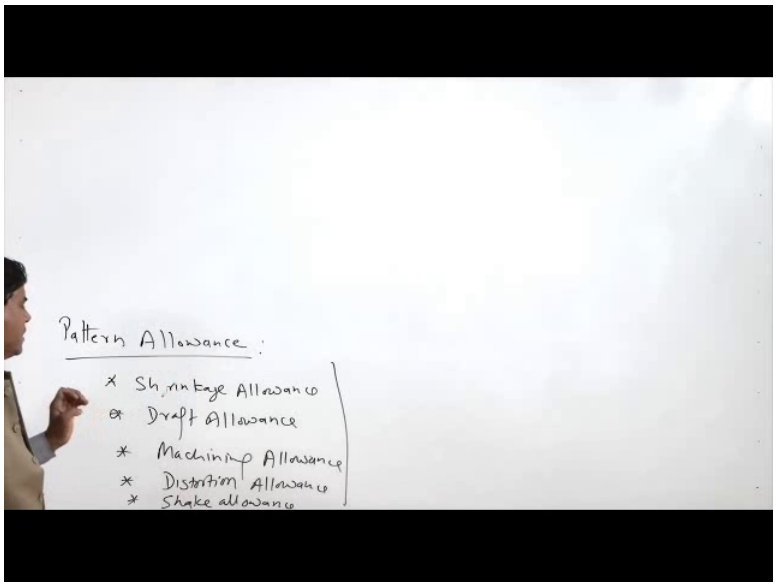
allowances. So, that it takes care of many aspects related with the casting. So, one by one we will be going through these aspects related with the allowances. This are these play very important role in a development of the castings with the required size, shape, free from the defects etcetera.

(Refer Slide Time: 04:31)



So, basically; now topic is pattern allowances. Pattern allowances will be leading to the difference in the, when these are provided it leads these lead to the difference in the size or dimensions of pattern from the casting. So, how much difference in the size, we will come that will depend upon the number of factors which will come up gradually.

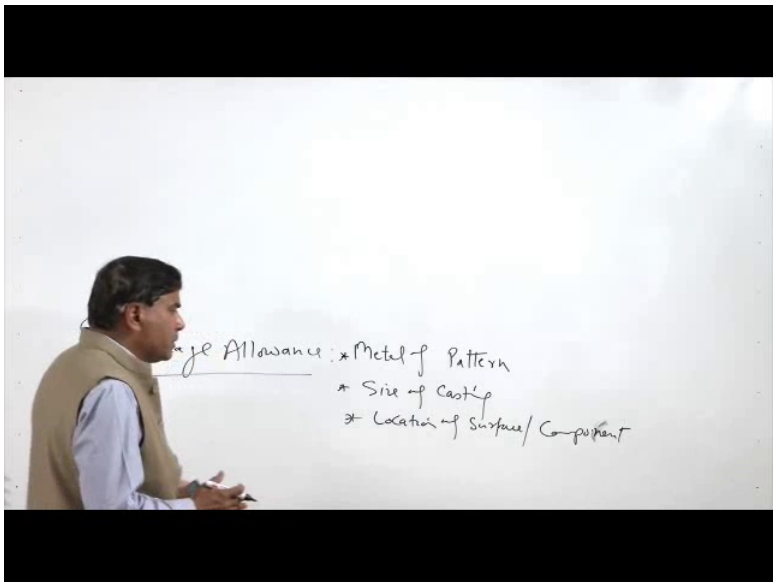
(Refer Slide Time: 05:19)



When, we will talk out about the different factors. So, the difference in size comes from the different comes due to the different regions. So, one is like say; we need to provide the shrinkage allowance. We when the vertical surfaces are there with the component or with the pattern, then we need to provide draft allowance its common to provide the machining allowance. And then there is a distortion allowance

And one is shake allowance. So, which type of the means rationally for providing these allowances, why we need to provide these allowances? And how these allowances are provided in the pattern that is; what we will be talking one by one.

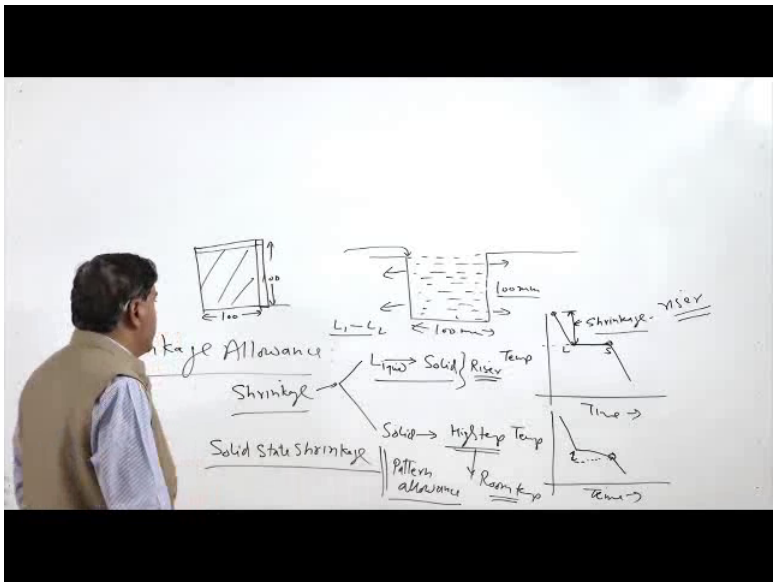
(Refer Slide Time: 06:42)



So, starting with the shrinkage allowance; which is a given to the pattern. Although; it depends upon the magnitude total magnitude of the shrinkage allowance will depend finally, on the material of the pattern. Is what material is to be used? Whether it will be made of wood or it will be made of the metal. And another is the factors that affect the allowances which is provided is the size of the casting or its component or the section.

And the third is the location of the surface or of the component; like external surfaces are given different type of the shrinkage allowance then the internal surface like hole allowance for the holes are or internal features are given in different way than those for the external features and external suffices. So, these are the factors that we will come up gradually. So, if you know that to understand the shrinkage allowance clearly.

(Refer Slide Time: 08:06)



We need to see how to castings are made; say we need to prepare first the pattern and then the mould cavity. So, the mould cavity if it has been prepared and after pouring the molten metal in the mould cavity it will be shrinking. So, let us see that the molten metal when the it is filled in the mould cavity say it is of the dimensions 100 mm in the height and the 100 mm in say this width like this.

So, gradually there will be loss of heat from the molten metal to the mould walls. And this heat loss will be leading to the reduction in temperature and which will be causing that drop in temperature of the molten metal. So, if the molten metal is pure, then solidification will be occurring at a constant temperature, and then again drop in temperature will be taking place.

But if a so, this is basically cooling curve. This is temperature and here we have time. So, this is where solidification will be the starting. On the other hand if it is an alloy, then the solidification will be occurring over a range of temperature there will be continuous drop in temperature. So, there is this is this range is called solidification temperature range. So, this there is a continuous drop in temperature of the molten metal during the solidification.

So, again the y axis we have temperature and in x axis we have time. So, due to the reduction in temperature of the molten metal, the liquid metal first shrinks. And there after once; so this shrinkage which is occurring due to the drop in temperature in the

liquid state of the molten metal this shrinkage is one type of the shrinkage and to take care of this shrinkage we have the riser. So, the shrinkage of the liquid metal is taken care of by the riser because riser is capable to feed the liquid metal to the mould cavity wherever this kind of shrinkage is occurring and this is where so this the there is another thing this is the drop in temperature of the liquid metal and then there is a change in a state of the liquid from the liquid to the solid.

So, this also be carrying out with the, this also will be occurring with a significant reduction in the volume of the metal. So, basically the two types of the shrinkages are involved here: one shrinkage is due to the transformation of the molten metal from the liquid to the solid state, liquid to the solid state. And this type of the shrinkage is taken care of apart from the shrinkage which is taking place in the liquid metal due to the reduction in temperature, this reduction temperature as well as the shrinkage which is occurring due to the change in state of the metal from the liquid to the solid this shrinkage is also taken care of by the riser. So, liquid to solid state transformation is taken care of by the riser.

On the other hand, once the solidification is over the heat is lost and the solidification is the over means we have reached to this stage and this stage. So, further in the solid state of the casting the if reduction in temperature will be leading to the a contraction. So, like say after the solidification, the drop in temperature from means reduction in temperature from the high temperature to the room temperature due to this drop in temperature also the shrinkage will be occurring. So, these are the two types of the shrinkage. So, here basically we have clubbed actually the two types of shrinkages where one shrinkage in the liquid metal occurring from the high temperature to the low temperature of the liquid metal just before the solidification commencement of solidification. An another shrinkage which again occurs in case of liquid to the solid state transformation and both these are taken care of by the riser.

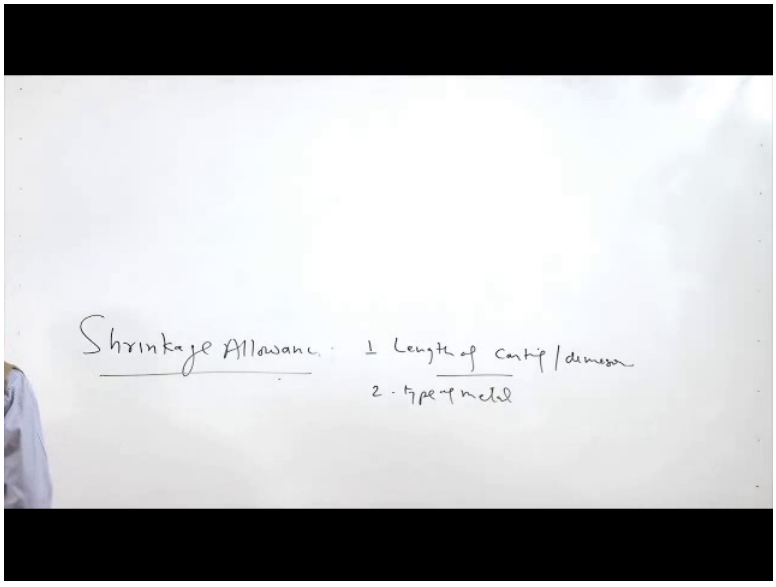
On the other hand, once the solidification is over; then the there is a reduction in temperature of the casting and that reduction in temperature of the casting up to the room temperature causes shrinkage in the solid states. So, there are basically if you precisely see there are three types of shrinkages; one which is occurring in the liquid state only, another which is occurring from the due to the transformation from the liquid to the solid state and third is which is occurring in the solid state of the casting due to the reduction

in temperature from the high temperature to the room temperature. So, this third type of the shrinkage, which is occurring in the solid state. So, basically solid states shrinkage this needs to be taken care of by the pattern allowance and say.

This 100 into 100 mm size casting, which has solidified and when after the solidification heat cools down to the room temperature this dimension which was there of the 100 by 100 just after the casting, this these dimensions will reduce. So, the extent of reduction is the need to be taken care of. And accordingly we need to make the pattern of the larger size then this one. So, that it can finally, it can be made of the after the shrinkage it is of the 100 mm.

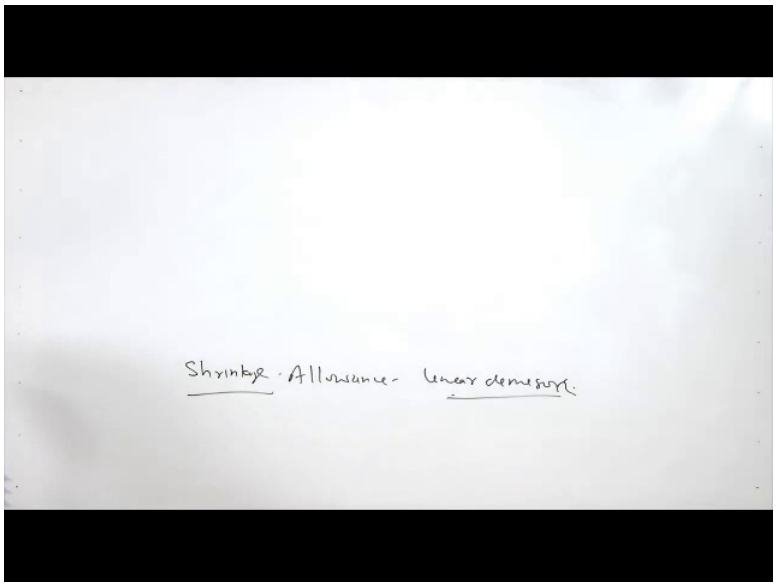
So, depending upon the dimensions and the metal type of the metal extent of the shrinkage will be determined. So, the final amount of the shrinkage which is occurring after reduction in temperature from the solidification to the room temperature, that shrinkage will depend upon certain factors.

(Refer Slide Time: 15:10)



So, one is like the length of the length or the size of the casting that particular dimensions which is being considered and the second is the type of the metal. So, for this we need to consider one example. We will talk about the kind of the factors which will be affecting the shrinkage. Shrinkage is always given shrinkage allowance is given to the linear dimensions.

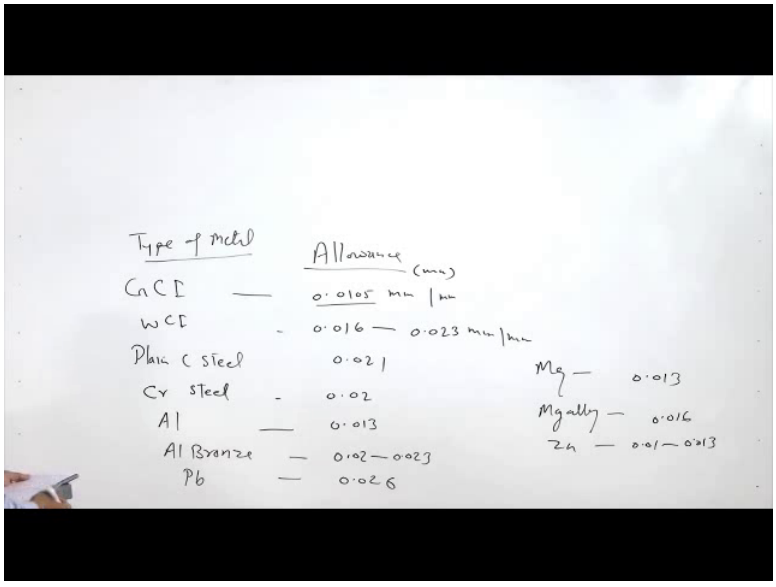
(Refer Slide Time: 15:51)



So, shrinkage allowance is given for the linear dimensions of the pattern, that is; what we will try to understand through certain examples as well as numerical values.

So, here if we see most of the metals shrink on the reduction in the temperature and the extent of reduction in dimensions extent of reduction in dimensions due to the solid state shrinkage depends upon the type of metal.

(Refer Slide Time: 16:38)



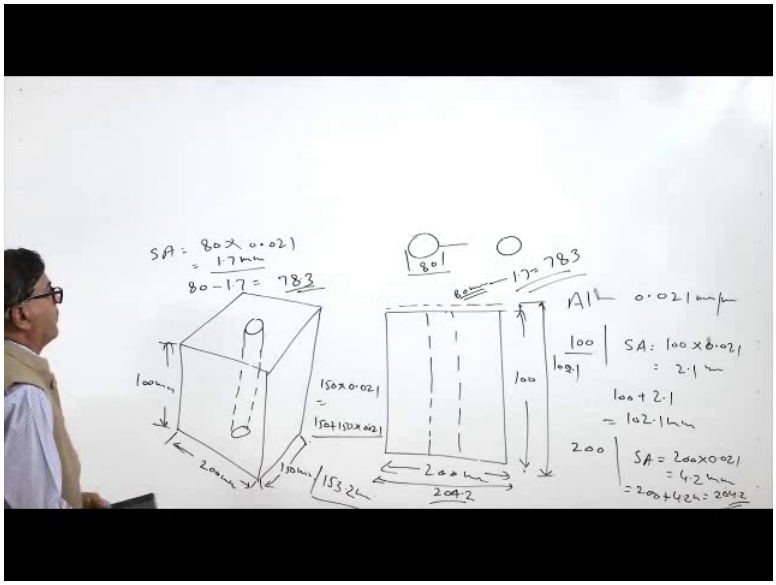
So, the most of the commonly used cast metals; metals which are used for the casting like grey cast iron. So, we will be writing about the allowances type of metal and the

extent of the allowance shrinkage allowance which is given. So, here it is like this is say in mm. So, shrinkage allowance mm per so this is on the linear dimensions. So, say for grey cast iron, it is of 0.0105 mm per mm.

Then, white cast iron it is given in the range of 0.016 to the 0.023 mm per mm. Plane carbon steel this is given of the 0.021 mm. So, for chromium steel it is of a 0.02 mm per mm for aluminium it is 0.013 for aluminium bronze it is 0.02 to 0.023 and led and for the lad it is a 0.026.

Similarly, for the magnesium it is a 0.013 for magnesium alloys it is 0.016 and for the zinc it is 0.012 – 0.013. So these are this is the extent of the shrinkage which occurs in the solid state for linear dimensions and that is why it is expressed that this is the extent of reduction per mm. So, if we take some example to consider the shrinkage allowance how it is given that is what will try to see.

(Refer Slide Time: 19:49)



So, considering an, is an example where in these dimensions. So, here this the height is say 100 mm and this width is 150 mm and this dimension is 200 mm.

So, these are the three dimensions height, width or we can say thickness, width and the length like that. Now, if it is having one central hole like this, then we can show this the spanner in the front view, where in this dimension are 100 mm and this hole is of 80 mm. So, how to give and this dimension is say 200 mm. So, if you have to provide the

shrinkage allowance considering that the pattern is made of the aluminium. So, for which is shrinkage allowance is 0.021 mm per mm. So, considering this if you have to give the allowance to the linear dimensions. So, it will be simply like say for this height for that this height 100 mm.

So, shrinkage allowance will be 100 multiplied by 0.021. So, the net dimension is 2.1. So, the total this height will be of the will be added with the extra 100 plus 2.1. So, net height which will be given to the pattern will be of 100 2.1 mm. Similarly, for the width we can say this 200 mm dimension 200 dimension shrinkage allowances will be 200 into 0.021. So, it will be 4.2 mm and the total final dimensions will be like 200 plus 4.2 mm. So, this is mm, so 204.2 mm.

So, this dimension will be further revise. So, and it is this width will be 204.2 after the after giving shrinkage allowance and this dimension will be like 102.1. Now we similarly we can give it for this the dimensions 150. So, 150 multiplied by 0.021 this will give us the shrinkage allowance and that is to be added with 150 plus 150 into 0.021. So, this will be the modified dimension and it comes out to be after modification means after adding the shrinkage allowance it will be 153.2 mm.

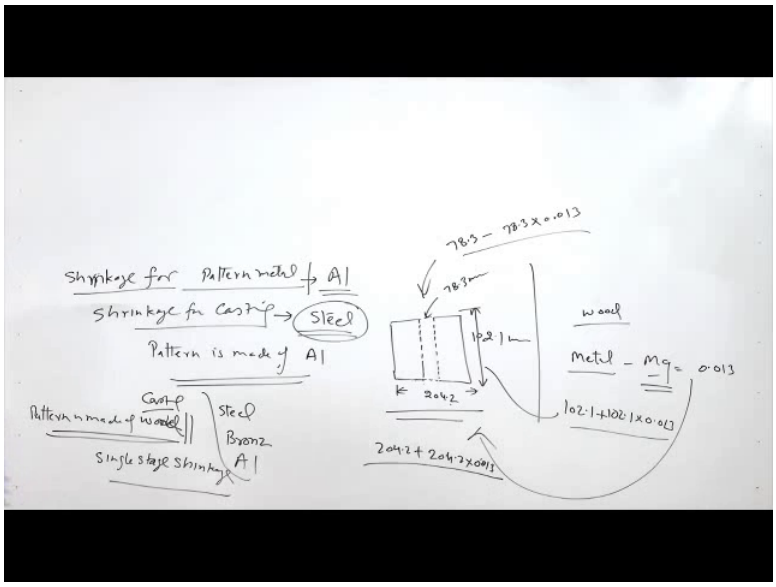
So, this is how the dimension shrinkage allowance is given to the external dimensions. Now, if you have to see we know that; if the initially the size of the hole is diameter of the hole is 80 mm. So, we know that when the molten metal shrinks, then the there will increase in size of the hole. So, it is given negatively and so if the dimension of the 80 mm is to be achieved, then it will be added to the linear dimensions and the hole size is to be reduced. So, for that purpose basically, the shrinkage allowance will come out to be 80 multiplied by 0.02 so this will give us the value of 1.7 mm. So, 1.7 mm and this is to be reduced.

So, we need to may actually make the pattern of the smaller n diameter y. So, the after adding the shrinkage allowance the 80 minus 1.7 this will give us 78.3. So, basically the pattern which is to be made pattern which is to be made means this hole dimension will be of after adding this shrinkage allowance this will be alike say 1.7 equal to the 78.3. So, this is added negatively for the internal dimensions internal like holes and for external dimensions it is added positively. So, that the dimension it will beginning the

dimensions extra while in case of the internal features like holes, if they are to be incorporated, then it will be leading to the reduction in the size of the hole which is to.

So, this will basically the pattern dimension is sorry the core dimension. The core dimension is to be reduced by 1.7 mm. So, that after the shrinkage of the molten metal in large size the hole is achieved to get the desired dimensions of the hole. Now coming to another; now one more thing that if the pattern is made of.

(Refer Slide Time: 26:28)



For in case of the wood we can use these the modified dimensions after adding this shrinkage allowance directly, but if the pattern is made of the aluminium or any other metal, then in that case we have to add the another allowance and for that purpose say we have made this we have made this pattern of wood in the first stage and final a pattern is to be made of the if the final pattern is to be made of the aluminium. Then again another allowance is to be given. So, say modified dimensions are like this where like this dimension is a 204.2 and this dimension is 10 this dimension is 102.1 mm and this is the reduced size of the hole and it is of the 78.3 mm say these are the three dimensions in different view we have taken of the earlier one. So, these are the which we have got after applying the shrinkage allowance if the pattern is to be made of the wood.

But if the pattern is to be made of the aluminium, then again the aluminium pattern is to be made by the casting process and that is why the double shrinkage allowance need to be provided. And the double shrinkage allowance will be used as per the case like what;

So, here we have considered initially the shrinkage allowance for the metal of the casting for making pattern of the wood, but if the pattern itself pattern itself is to be made of the metal sorry; metal we can use for making the pattern of the different size it can be of their steel it can be of the bronze it can be aluminium. So, any metal can be used.

So, depending upon the type of metal to be used for making the pattern, so that is what we will be considered for calculating the shrinkage allowance. So, according to the type of the metal the shrinkage allowance will be calculated. So, instead of say aluminium if we consider the any other metal like say the magnesium if is this is the pattern of the wood which was consider that this pattern was made of the wood. Now we have to make the pattern of the metal made of magnesium using. So, again we have to make the shrinkage allowance we have to provide shrinkage allowance for the magnesium for these dimensions.

So, basically the double shrinkage allowance is given for metallic patterns, because in that case first of all we have to make the pattern of wood and thereafter after the casting will be obtaining the metallic pattern. So, a metallic pattern will be the will be given the again the shrinkage allowance for the casting. So, double shrinkage allowances given. So, if we have to make the pattern of the metal in that case these allowances say the shrinkage allowance for the magnesium is 0.013. So, then this one will be calculated again like say 204.2 plus 204.2 multiplied by 0.01 0.013. So, this is how this dimension will be revised. And then again these dimension need to be revised using 102.1 plus 102.1 multiplied by 0.013 and this hole is to be reduced further, so 78.3 minus 78.3 into 0.013.

So, this is how all three dimensions will be reduced in case of this. So, this will be used when first the pattern is made of wood in this case single stage shrinkage is given, but if the pattern is to be made of metal then. So, this in case of the wood will be considering the metal of the casting to be used, but if the pattern is to be made of metal in that case; first of all shrinkage will be calculated shrinkage will be calculated for the pattern material. And once the pattern is ready; then that the second allowance is given for the shrinkage for the casting. So, basically two stage shrinkage is need to be given. If and according to the type of metal the shrinkage is considered if the pattern is to be made of the aluminium.

Then, first allowances will be considered for the aluminium when the casting is the of the different metal like say is it a steel, then the allowances to the aluminium pattern will be given based on the metal of the casting which is to be made. So, this is what is there double shrinkage allowance.

So, here now I will conclude the presentation. In this presentation I have talked about basically the shrinkage allowance and we have seen that if the pattern is to be made of the woods then we need to provide the one stage shrinkage allowance considering the metal of the casting. And if the pattern is to be made of the metal then two stage shrinkage is provided where in first of all we consider the shrinkage of the metal of the pattern and once the dimensions are identified thereafter; we consider the shrinkage of the metal of the castings which is to be made. So, accordingly we have to modify the design of the pattern and the dimensions of the pattern considering the shrinkage aspect for the casting.

Thank you for your attention.