Fundamentals of Manufacturing Processes
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Lecture - 19
Casting: Yield and Riser Design

Hello, I welcome you all in this presentation. This presentation is related with the subject fundamentals of the manufacturing process. And as we are talking about the casting processes. So, related with this we will be talking about, first of all the yield or the casting yield.

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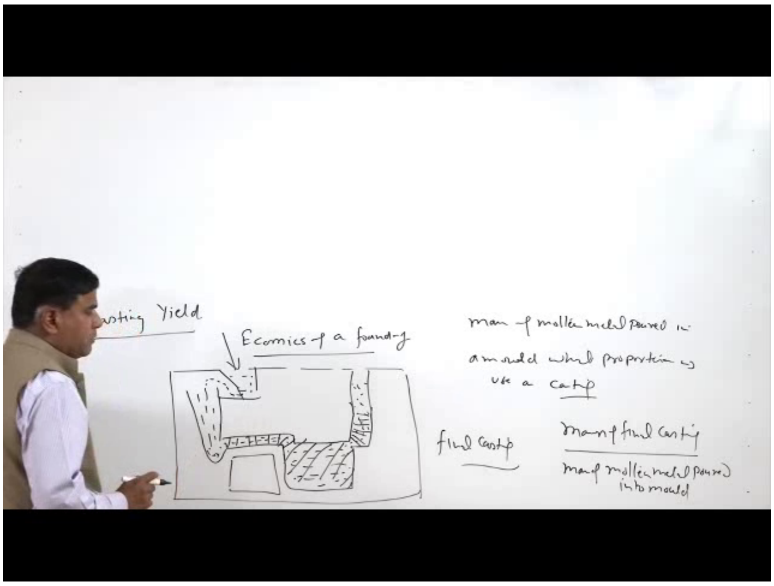

So, the casting yield actually suggests or it shows the economics of a foundry. Means how effectively the resources are being used. So, what it is basically the yield casting yield means for a given mass of molten metal poured in a mould, in a mould what proportion is used as casting.

So, because we know that in a mould like this where in pouring basin, and then from the pouring basin metal is going in to the sprue a sprue base runner then in gate and then mould cavity and then we can say riser. So, this is the riser. So, these are the different elements of a gating system, and this is a the entire the mould and the packed in flask. So, this riser may be opened or it may closed also. So, here when the molten metal is poured from the laddle into the pouring basin, it flows from the pouring basin through the sprue into the sprue base, then into the runner and thereafter it will be flowing into the mould cavity and once the mould cavity is filled in then it fills the riser.

So, here so the mass which is the amount of the molten metal which is fed into the mould that is determined. And out of that amount what portion of that molten metal is being converted into the final casting. So, if you see here, the final casting is just of this zone. So, mass of this casting is actually used. So, mass of the final casting divided by mass of the molten metal poured into mould.

So, if we see here the molten metal left some of the molten metal left in the riser that way also we will solidified molten metal left in the in gate will also be solidified, and then molten metal in the riser will also be solidified. So, whatever is the amount of the molten metal left in the gating system, that will be solidified that will also be solidifying apart from the casting. So, all these metal which is solidified in the runner in gate and the riser. This is not actually used in making the casting, but this needs to be removed from the casting. And it is remelted as a raw material. So, we need to process that those runners the metal solidified in the runner gating system and the riser.

If we see this ratio this ratio, this ratio actually reflects the yield. So, yield casting yield is basically the mass of final casting divided by the mass of the molten metal poured in to the mould. And this ratio is usually less than 1. So, what are the factors which will be governing the yield. Basically there are 2 factors. So, if you see here if the mass of the final casting is closed to the mass of the molten metal poured, then our casting yield will be good and the economics of the foundry will be much better. So, we need to see what are the factors that will be affecting the casting yield.

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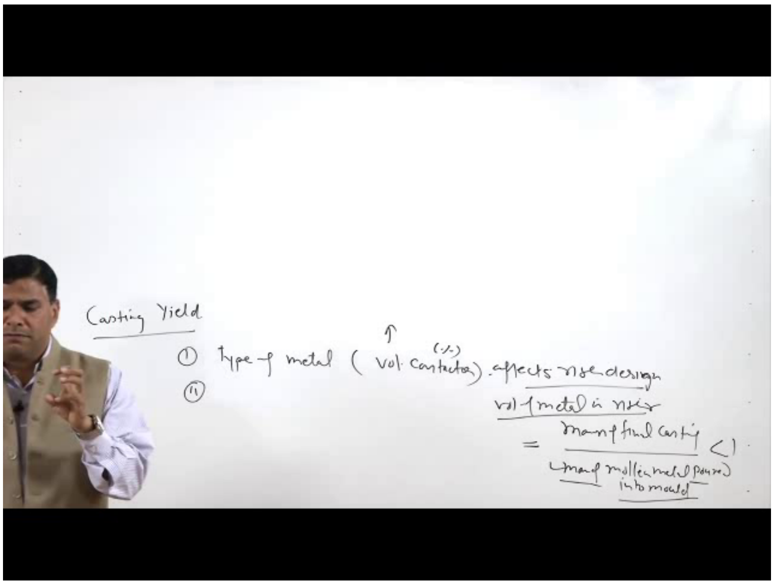

There are 2 factors, one is the type of metal and more precisely the volumetric contraction, which will be taking pace in the metal being processed and the 2 because this affects the riser design or the oh or we can say the volume of the metal in the riser, that is needed. So, in general higher is the contraction higher is the volumetric contraction which is expressed as a percentage. So, greater will be the volume of the metal required in the riser, and if the greater is the volume of the metal is a needs to be fed into the riser, then greater will be the amount of the molten metal which will be solidifying into the riser.

Which interned will be reducing the yield of the casting. So, mass of the molten metal which is to be supplied in to the mould in case of the high volume contraction metals that will be more. So, which intern will be reducing the yield of the casting. Another factor is the complexity of the complexity of the casting. So, like the simple shape simple shape castings the simple shape castings do not require extensive risering, but in case of the complex castings we may require more than one number of risers so that it can feed the molten metal wherever a it is required, since the volume of the molten metal or the amount mass of the molten metal to be fed into the number of risers that will be increasing. In case of the completive castings and which intern will be reducing the yield of the casing because increasing any factor.

Like either the volumetric contraction or the coming increasing the requirement of the risering for the complex geometric casings, both these will be increasing the mass of the molten metal to be poured into the mould because we need to feed that molten metal into the riser so that it can compensate the shrinkages related with, but whenever this amount is increased even for the given size or given mass of the final casting our casting yield basically decreases. So, efforts are always made to design the gating systems in such a way that the requirement of the molten metal requirement, if the extra molten metal to be fed into the gating system. That is that is not much above beyond the requirement of the final casting.

So, basically focus is on the gating system design.

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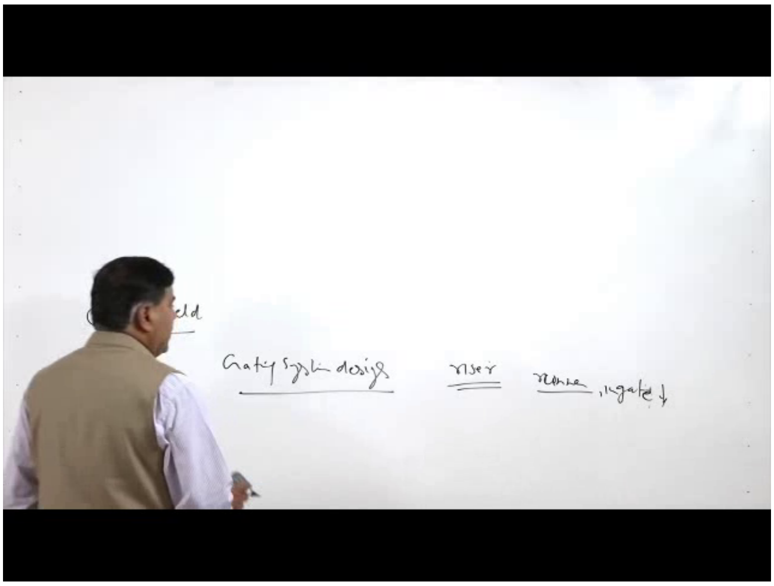

So, that unnecessary risering unnecessary amount of the molten metal being fed into the riser that can be reduced and unnecessary the molten metal being fed, or being solidified in the runner and the gating system can in gates can also be reduced. So, so if the gating system is desired in such a way that the mass of the molten metal required, actually for making a casting of a given size then the risering must be mass of the molten metal to be fed into the riser runner and the gating syst in gates. If it is less then this intern will be increasing the casting yield for a given mass of the casting.

So Focus is on the proper gating system so that it can be casting yield can be increased. Now we will see that how the how the shape size and the metal affects the casting yield. So, we will be talking about the some typical casting.

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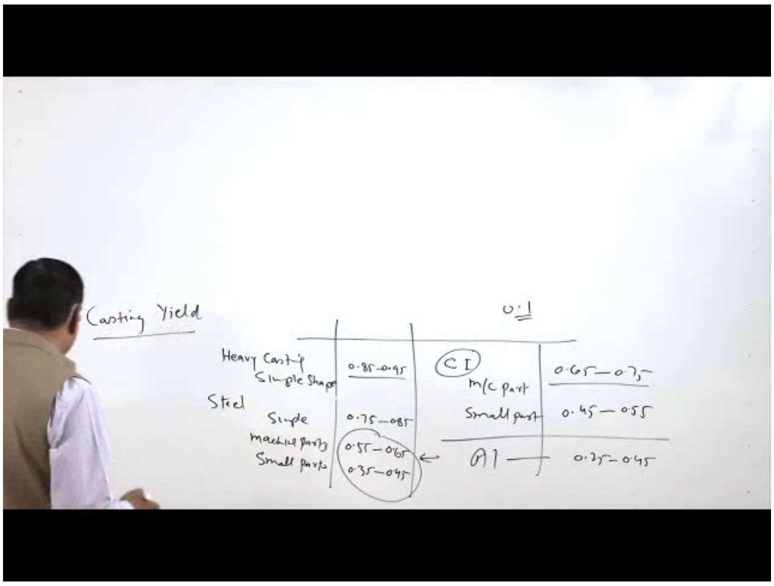

Yield values for the different metal systems like say for heavy castings of simple shapes. So, for such kind of castings the casting yield may be to the tune of 0.85 to the 0.95. So, this too high yield because the losses are very less or We can say the mass of the molten metal being solidified in the riser design is in the range of 0.505 to the 0.15.

Like in case of the steels for the casting of the simple shapes the yield is quite high it is 0.75 to 0.85, for the machine parts heavy machine parts made of the steel the yield is in the range of 0.55 to the 0.65, while in case of the small parts the yield is found to be in the range of a 0.35 to 0.45.

If we consider the cast iron So, the same way cast iron for the machine parts heavy machine parts the yield is found in the range of a 0.65 to 0.75, while for the small parts yield is found in the range of a 0.45 to the 0.55. While in case of the aluminium the yield is found quite low 0.25 to 0.45 depending upon the size and the complexity of the casting.

So, if we try to compare these 2 in case of the steels and cast iron. So, in case of the steel for machine parts the 0.5 to 0.55 to 0.65 and here for machine parts it is 0.65 to 0.75.

And so, this little bit higher yield in case of the cast iron as compared to the steels that difference is of point one. So, this difference is attributed to the better castability of the cast iron as compared to the steel.

Now, we will be talking about the riser Design.

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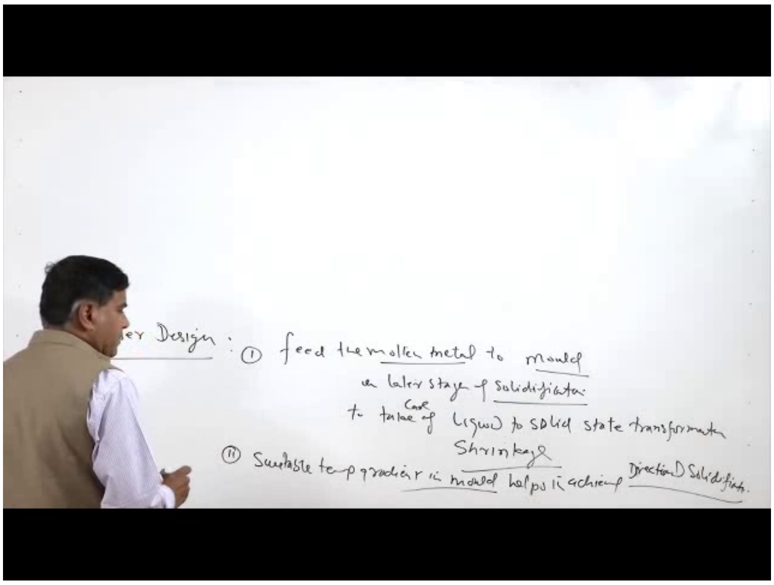

We know that the role of the riser is to role is primary there to feed the molten metal through the mould, in the later stages of solidification. The primary goal is to take care of to take care of the liquid to solid a state transformation shrinkages. So, shrinkages occurring due to this liquid to solid state shrinkage that is taken care of by feeding the molten metal to the mould in the very later stages of the casting so that the sound casting can be made. This is the one purpose additionally it also helps to maintain the suitable temperature gradient in the mould.

So, this suitable temperature gradient actually helps in helps in achieving directional solidification. So, basically our goal is to achieve the directional solidification through the proper temperature gradient n the mould so that it the sound and at the defect free casting can be produced. So, this is these are the basically 2 roles which will be performed by the riser. So, if you see the role the cast to act effectively the molten in the riser should solidify after the solidification of the casting main casting.

So, for that purpose we need to see. So, we need it is required that riser is designed in such a way that the solidification in the riser takes place after the solidification of the casting. So, in which case the riser is crucial and in which case riser is not crucial.

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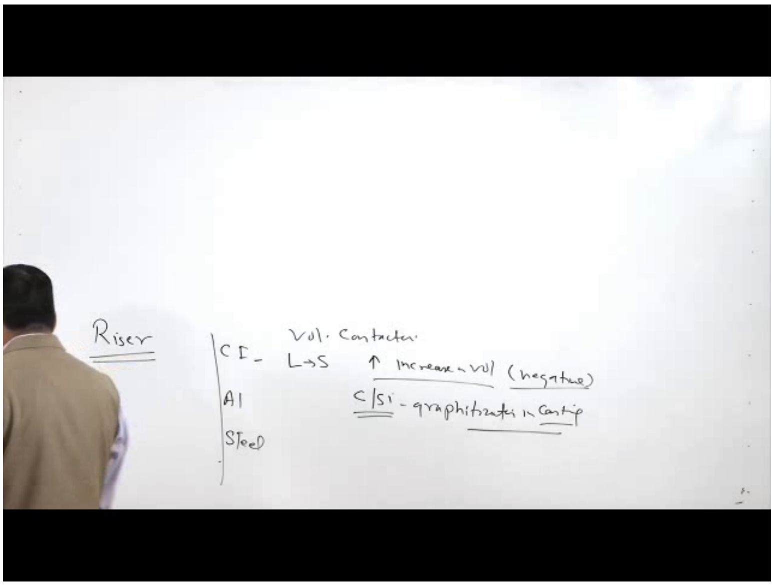

So, for that purpose we need to see the certain metal systems like cast iron aluminium and a steel. So, if you see the volumetric contraction in these 3 metals sometimes the cast irons on liquid to solid state transformation are subjected to increase in volume. And if this happens then the shrinkage actually does not take place.

But there is a negative shrinkage means which appears in form of increase in volume. So, in this situation risering is not a crucial and this happens primarily because of the carbon and the silicon presence when they are present in the appropriate proportion the graphitization in the casting, graphitization in the casting of the cast iron takes place. And which happens with the increase in the volume of the casting, which leads to the increase in volume of the casting. And under such conditions the role of the risering becomes not that crucial because the casting on the liquid metal on transformation to the solid state occurs with the increase in the volume.

That is why in case of the cast irons grey cast iron where graphitization is predominant increase in a increase in volume of the casting during the solidification will lead to the negative shrinkage and which will reduce the requirement of the risering. So, the risering not that crucial while in both these cases where the contraction Volumetric contraction is in the range of 5 to 6 percent.

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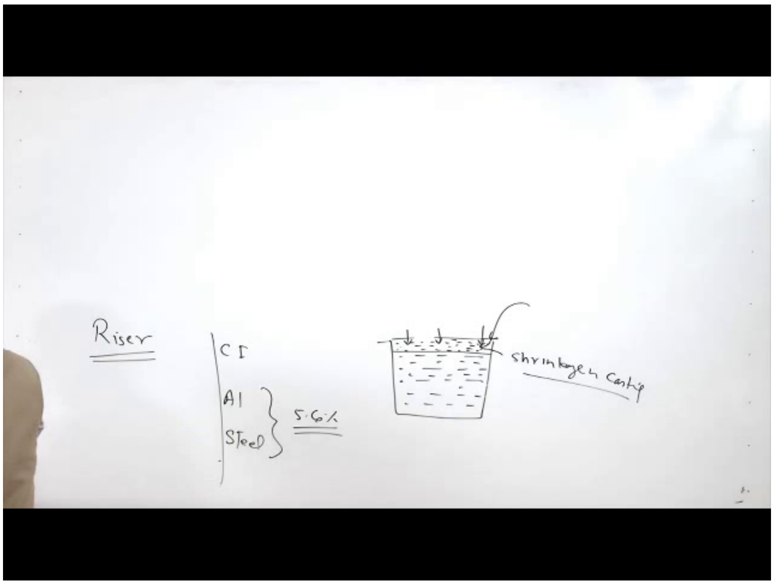

So, significant reduction in the volume of the casting like say in this case this is a one typical mould and if here, the solidification of the molten metal takes place.

So, there can be different situations and different conditions related to the solidification, but if the 5 to 6 percent shrinkage is taking place. Then it will be ending up with the lot of a reduction in the volume and we will find that at the top, some of the spaces still left to be filled in because as the molten metal which will be solidifying that will be occurring with the reduction in the volume significantly through the volumetric contraction. And this will lead to the shrinkage in the shrinkage defect in the casting. So, this can be avoided by feeding the molten metal at this stage when the solidification in the casting has been over.

So, in this case the molten metal from the riser will be fed in and that will be filling. This gap whatever is being created due to the volumetric shrinkage on account of the liquid to solid state transformation. This is the case when the solidification is progressing in one direction; that means, let us consider The case and that the factors which will be governing the solidification.

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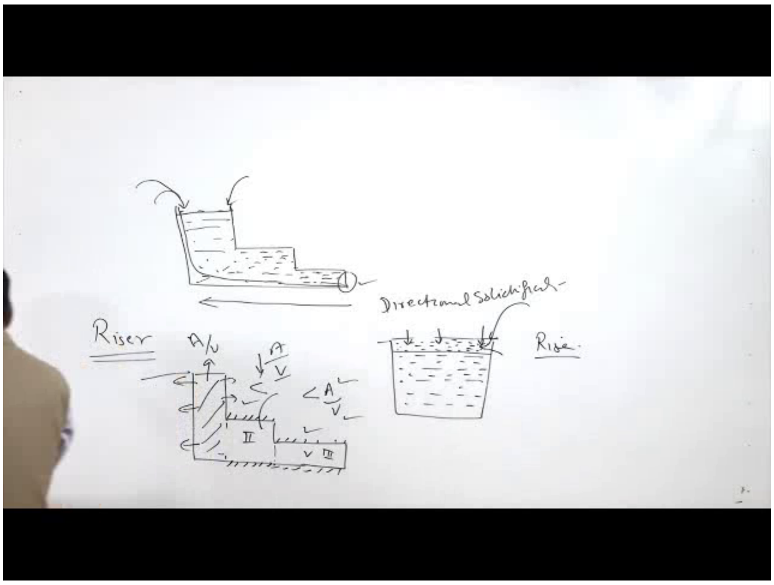

If we see here the surface area of this zone of the casting is much larger as compared to the volume while in this case there zone 3 while in case of the zone 2 consider this zone 2 the surface area surface area to the volume ratio volume surface area to the volume ratio is lesser for the 2 and Here much more area to the volume ratio is much more somewhat lesser and further lesser is for this zone.

So, area to volume ratio is a deferring with the here much greater thickness somewhat lesser thickness and further lesser thickness. So, it is the area which will be governing the heat transfer from the molten metal. So, if the area is more heat transfer will be faster. So, in this case if we are feeding the molten metal in this mould the mould is of the. So, we are as a as a molten metal is being fed say from the top. So, the molten metal will be of reaching to this zone this is the remotest zone from the feeder. So, this zone is expected to solidify first because of the higher volume to the surface area to the volume ratio.

So, here solidification will start here and then it will be progressing to, So it will be starting from this zone 3 then it will be progressing towards the zone 2 and then zone one. So, in this case since the solidification is starts from the remotest possible place the remotest point from the feeder and then it will be approaching towards the feeder. So, this in this case the solidification is starts from the remotest place and then it approaches towards the feeder.

This kind of solidification is called the directional solidification, and in this case if any shrinkages will be occurring then that will be leading the that will be occurring near the feeder which can be effectively fed by the molten metal either coming from the feeder or from the in gate or from the riser. So, any such kind of the shrinkages can easily we taken care of by the riser if the proper temperature gradient is maintained, but in those case is where temp proper temperature gradient is not maintained. Means that the solidification does not remain directional, in those cases the some other kind of the issues are encountered.

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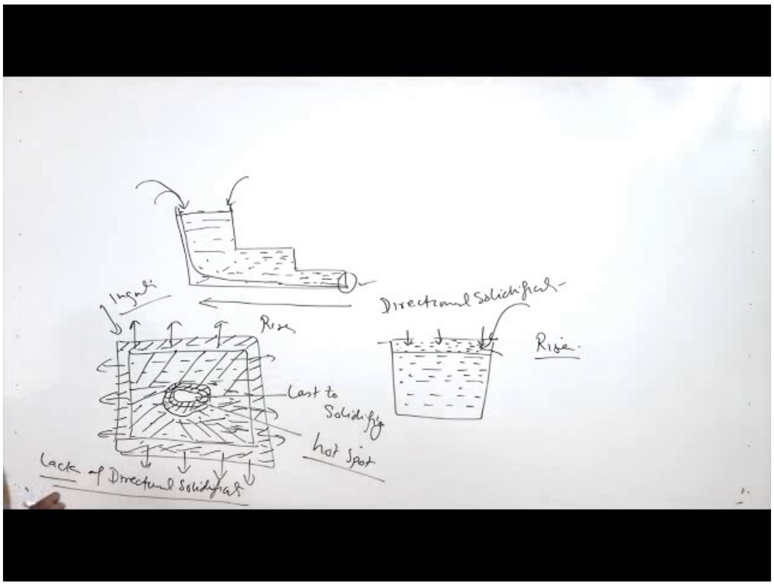

Say for a an example this is the mould and it is full of the molten metal like this.

So, if the transfer of the heat is taken place from all the sides all these 4 sides of the mould. So obviously, the solidification will be starting from the mould and then it will be progressing towards the center. So, like this So, this is the one zone which will be found next to the mould wall, and the remaining will be the liquid metal. So, as the solidification progresses again the solidification with the progress of the solidification from all the sides what will be seeing, that the molten will be pushed towards the center. So, finally, what will be seeing that due to the shrinkage of the liquid metal due to the shrinkage on account of the transformation from the liquid to the solid state.

This is said the zone which is left for the liquid metal and all these are the areas which have been solidified. So, here in this case solidification is taking place from progressing from all the sides and the liquid metal will be left at the center. So, is still when this starts solidifying gradually at the end we will find that one this is the space which is left to be filled in, but this could not be filled due to the presence of the solid metal from all the sides, and this is the reason which is last 2 solidify. So, solidify this is also this is region you can say the hot spot region which will be solidifying at the end. So, since this in this case the liquid metal solidifying at the end is in the inside. So, molten metal cannot be fed from the outside either from the riser or from the in gates.

So, this kind of the cavity cannot be corrected using either the riser or using the in by feeding the molten metal from the either in gates or in the or from the riser. So, this is the issue related with the lack of due to the lack of directional solidification. So, in order to correct this kind of the issues the casting is designed in such a way and the cooling characteristics of the mould is designed in such a way, that the hottest spots are exposed to the surface so that they can be taken care of by feeding the molten metal from the in gates or from the riser. So, this is the need this establishes the need of the directional solidification, and I will give one more example related with this like if the mass of the Casting is like this.

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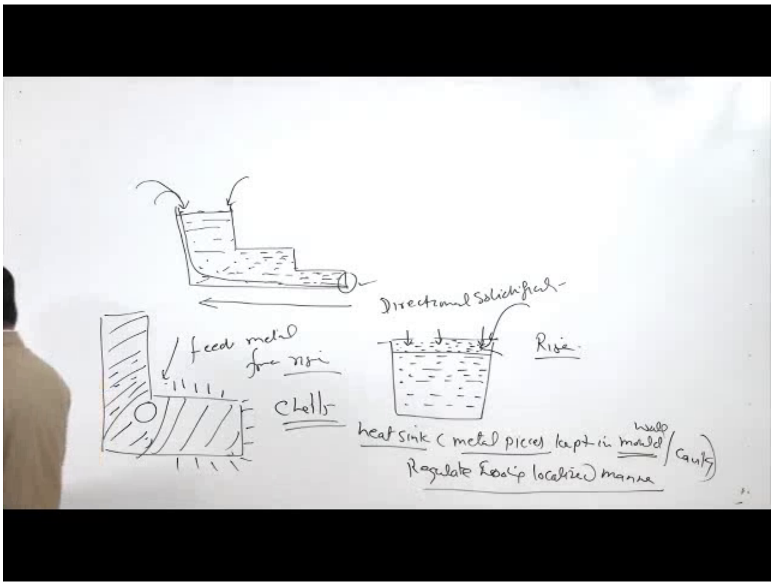

So, here in this case the mass of the molten metal in this zone is much more and in other areas the heat transfer will be causing the solidification. And the solidification will of course, we progressing and at the end here may find that some porosity is left us and the shrinkage cavity is left in this area of the casting. So, to take care of these issues where due to the lack of the directional solidification or unfa the hotspots are being formed unfavourably at such locations, which cannot be corrected by feeding the molten metal feeding metal from riser.

So, in those locations where hotspots are being formed which cannot be taken care of by the riser, then these kind of the issues are corrected by using chills. So, we basically try to provide the chills. What these are the chills? Chills are basically heat shrink means these are the metal pieces which can pieces kept in either the mould or they are kept in the mould cavity itself. So, in the mould means there is a mould wall or in the cavity itself. So, so these will be actually the since the chills are the metallic pieces they absorb heat much faster rate.

So, basically they regulate chills regulate the cooling rate locally or in the localized manner. So, the localized in higher actually locally we using the chills we try to provide the localized higher cooling rates so that the hotspot zones can be solidified earlier at a much faster rate. So, the shrinkage cavity formation in those areas can be reduced. So, in this case say if the if the hotspot is being found at this location.

So, what will be ensuring that since this is the area, which is solidifying at the end. So, what we will try to have that this area solidifies at much faster ate so that hotspot is not formed here or this region does not form the last region to solidify. So, for this purpose we add the metallic piece at this location this metallic piece in these areas can help to extract the heat at much faster ate. So, these pieces will be will be kept in the mould wall. So, heat will be extracted by these metallic pieces at much faster rate. And ensuring that the heat transfer from this region is taking place at much faster rate cooling rate is much faster.

So, this region will be solidifying earlier as compared to the case earlier when there was there were no chills. So, this situation will avoid. So, this at like the forced use of forced cooling using chills, help to solidify help to achieve the solidification in the area where hotspots are being formed so that the cavities due to the shrinkage of the molten metal can be avoided. So, develop application of the chills is one of the methods which can be used to regulate the position of the hotspots, and another method is to locate or the position locate or the position of rise rr position the riser suitably so that the favourable temperature gradient in the mould can be established.

So, basically chills are providing the localized cooling in the areas of the hotspots so that those a zones can be solidified at much faster ate and the location of the hotspots from those areas can be avoided or those hotspots can be eliminated through the use of chills by applying the increased cooling rate so that the shrinkage cavities can be avoided.

So now here I will summarise this presentation. In this presentation I have talked about the casting yield which shows the economics of the fund industry. And also I have talked that how the solidification takes place in the castings. And how we can regulate the solidification pattern in the castings in order to avoid the hotspot formation in the interior zone of the castings which will eventually be leading and to the shrinkage cavities. In the next presentation I will talking about the riser design.

Thank you for your attention.