Metal Casting
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Module - 02
Sand Casting Process
Lecture - 13
Design Of Risering System-V

Welcome friends, in the previous class we have been learning about the multiple risering and in this a multiple risering we have seen the concept of what say end effect and the risering effect and we have seen the need for adopting multiple risers; if the feeding length right is the less than the casting length. Now let us continue this, now we will come across three more terms called feeding distance, feeding length and shri centreline shrinkage. Of course, this feeding distance we have already seen now, let us learn feeding length and the centreline shrinkage.

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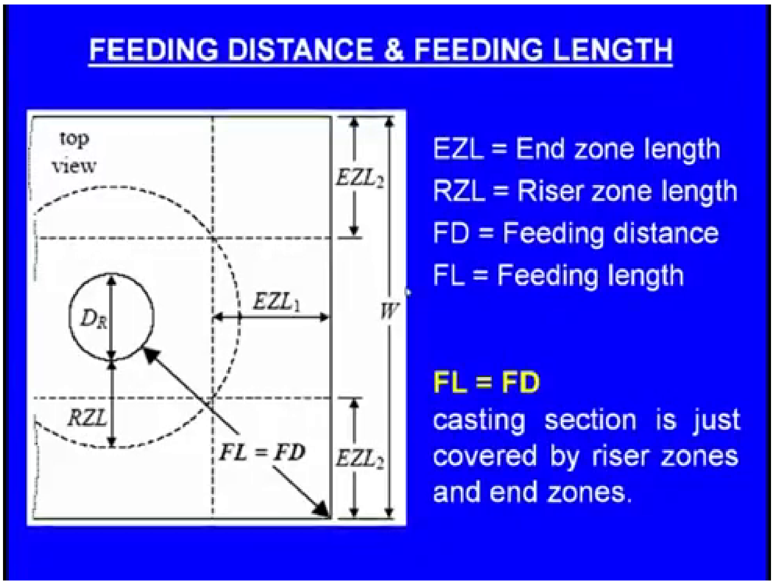

Now, there is a difference between feeding distance and feeding length. For example, say this is the casting, this whole thing is the casting and this is the riser,. Now, around the riser there is a riser zone is there means in this zone in this circle there is no shrinkage because the riser is present.

Now, outside this riser zone you can see here EZL right means end effect zone, end zone or simply. So, that we can see here this much say starting from the end. So, this is the end of the casting right starting from here up to here this dotted portion is the end zone, means in this portion there is no shrinkage cavity because it is covered by the end effect and this much is covered by the risering effect. Now, here we can see EZL means end zone length. So, this is the EZL you can see this is the end zone length. Next one RZL that is the length covered by the riser effect. So, this is that one RZL, next one feeding distance feeding distance means it is the sum of riser effect and end affect here we can see.

So, here this much is the or what say riser effect RZL which is the feeding distance, which is covered in the what say riser zone, his is the riser effect. Now, the from here to here, so you from this end to this end you see this is the end zone up to this point this is the end effect. So, the sum of end effect and riser effect is known as the feeding distance. Now, what is the feeding length? Now in this case feeding distance is equal to feeding length means the length of the casting is equal to means the this portion the length diagonally is equal to feeding distance. That is why feeding length is equal to feeding distance in this section means casting section is just covered by the riser zones and the end zones.

Now, we will see the difference between the what say feeding distance and feeding length more clearly.

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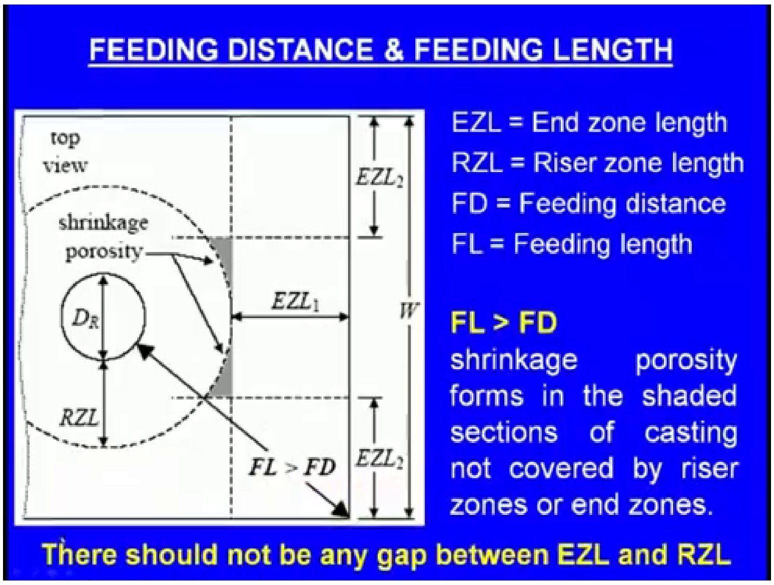

Now, let us see here, now the length of the casting is little more than the previous one. Now, the length is such that this is the end zone; the end zone length is this much. This much is the riser zone length from here, but if we start from here and measure like this from here to here this much portion is the RZL means start from here and you end here. So, this is the riser effect, now where is the end effect? End effect starts from here to here. So, that is the end effect.

So, this some of end effect and riser effect is the feeding distance. Now, you can see there is a gap right means that including that to; that means, sum of this riser effect some of this end effect and sum of that gap, sum of these three components is known as the feeding length. Means that is the actual length in the casting measured diagonally in this case right. So, here what we can conclude? Feeding length is greater than the feeding distance, shrinkage porosity forms in the shaded sections of the casting not covered by the riser zone or the end zones. For example, you see up to this much portion the casting it is covered by the riser zone. So, there is no possibility of formation of the shrinkage cavity up to here.

Now, this much portion right this much portion is the end zone. So, in this there is no chance of formation of the shrinkage cavity because of the end effect. Now, what about this portion starting from here say this shaded portion this is not covered by the riser effect, this is not covered by the end effect. So, there will be shrinkage cavity will be there, why a shrinkage cavity is there? Because in this case the feeding length is greater than the feeding distance. So, there should not be any gap between EZL and RZL, where EZL is the end zone length and RZL is the riser zone length, but unfortunately in this case the this is the EZ what say EZL and this is the RZL, there is a gap. So, that is how a shrinkage can take place in this case.

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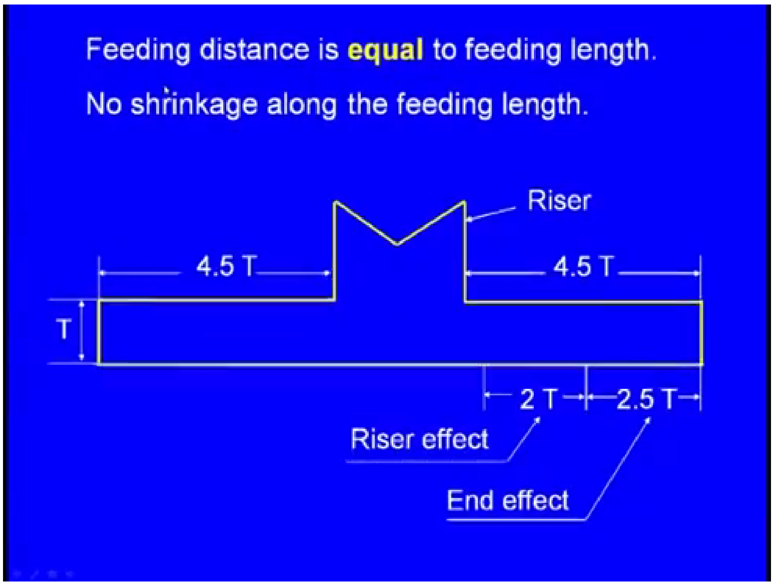

Now, let us see some cases feeding distance is equal to the feeding length means the length of the casting is such that the what say that section to be fed by the riser is equal to the feeding distance. Then what will happen? No shrinkage along the feeding length say if. So, for example, this is the casting this is the casting and this is the riser. Now, there will be riser effect will be there the riser effect will be 2 T means the what say distance covered by the riser to prevent shrinkage that is 2 T, here we can see. Now, this is end effect. What is that end effect? Distance covered by the edges of the casting to prevent the shrinkage cavity. So, this is 2.5 T. So, some of these components is known as the feeding distance and that is equal to 4.5. One side it is 4.5 T and the other side is also it is 4.5 T, where T is the thickness of the what say slab or thickness of the section of the casting to be fed by the concerned riser.

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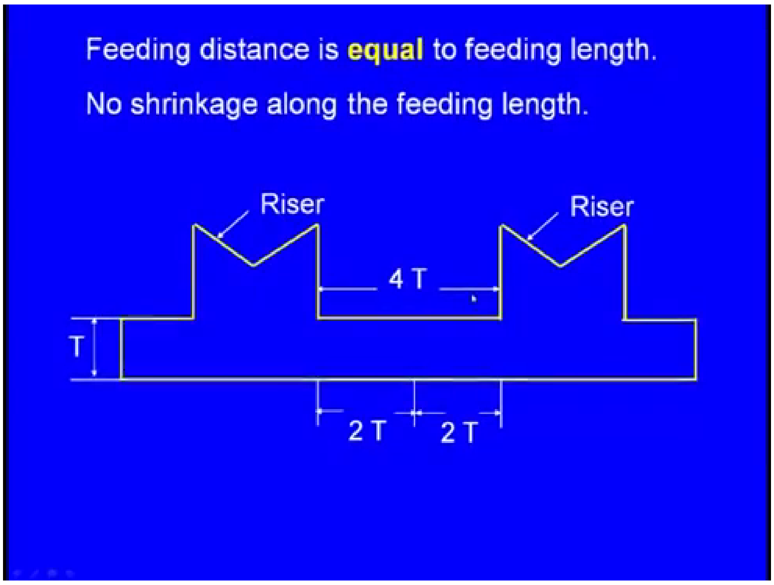

Now, let us see another case where two risers are used right in this case also the feeding distance is equal to feeding length. Here we can see from here right this is one riser one side there is 2 T, that is the riser effect and the other side there is 2 T that is the riser effect and the distance total distance or the total feeding distance between these two risers is 2 T plus 2 T that is 4 T and we have arranged the risers such that the distance between these two risers is exactly equal to 2 T. So, there is no question of formation of the shrinkage cavity.

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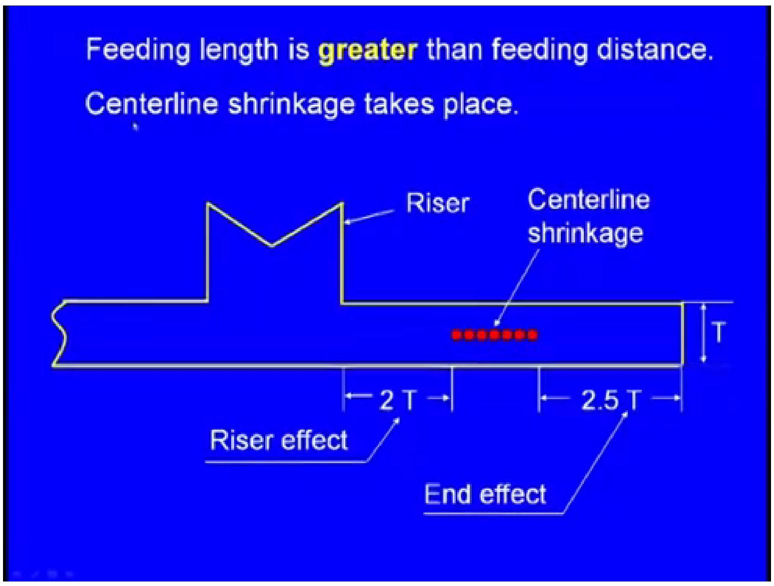

Now, let us see another case feeding length is greater than the feeding distance, you see here this is the casting and there is single riser is there, this is the riser. Now, this is the length of that section to be fed by this casting, this riser. Now, here we can see riser effect is there means distance covered by the riser to prevent the shrinkage cavity, that is 2 t and this is the end effect 2.5 t, that is the distance covered by the adjust casting to prevent the shrinkage cavity. So, this is 2.5 t. So, in this portion there is no shrinkage cavity because of the end effect.

In this portion there is no shrinkage cavity because of the riser effect, now what about this portion. This portion is not covered by the riser or it is not covered by the riser effect and it is not covered by the end effect, then what will happen. There will be shrinkage will be there you can see this is known as the centreline shrinkage right. So, centreline shrinkage can takes place when feeding length is greater than the feeding distance. Feeding length means the actual length falling under the load of the riser. So, this whole length is the feeding length whereas, feeding distance is the sum of the end effect and the riser effect. So, in this case that feeding length is greater than the feeding distance.

So, that is how a centreline shrinkage cavity what say defect is arising here and we can see another case, where there are two risers and for this one riser one side there is 2 t that is the riser effect.

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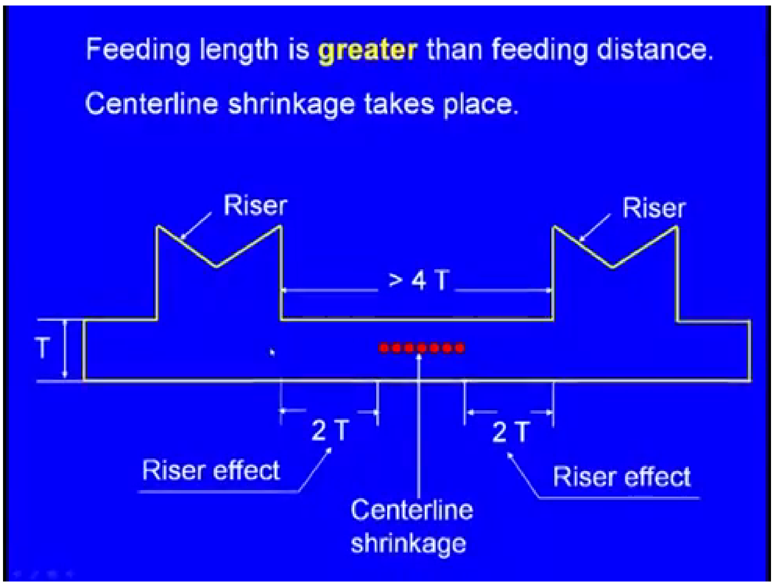

So, there is no question of shrinkage cavity in this region and this is another riser and here there is riser effect 2 t, where t is the thickness of the section. Now, in this region also there is no shrinkage cavity because of the riser effect. Now, what about this portion this is not covered by the this riser the left side riser this is not covered by the right side riser. Then what will happen of course, there is no question of the end effect because there is a no edge only two risers are there on both sides. Then what will happen the centre portion which is not covered by either of the risers there, there will be shrinkage cavity. Here also feeding length is greater than the feeding distance.

Now, here what is the feeding distance the feeding distance is here it is 2 t and here it is 2 t the total feeding distance between these two risers is 4 t. Whereas, the feeding length the actual distance falling under the two risers is greater than the feeding distance that is how a shrinkage what say cavity will take place. So, we will call it as the centreline shrinkage here also. So, this is the centreline shrinkage. Ways to increase the feeding distance oh. So, now, just now we have seen that when the feeding length is greater than the feeding distance a what say centreline shrinkage defect will arise. Now, at any cost we have to see that the feeding distance we have to increase or to improve.

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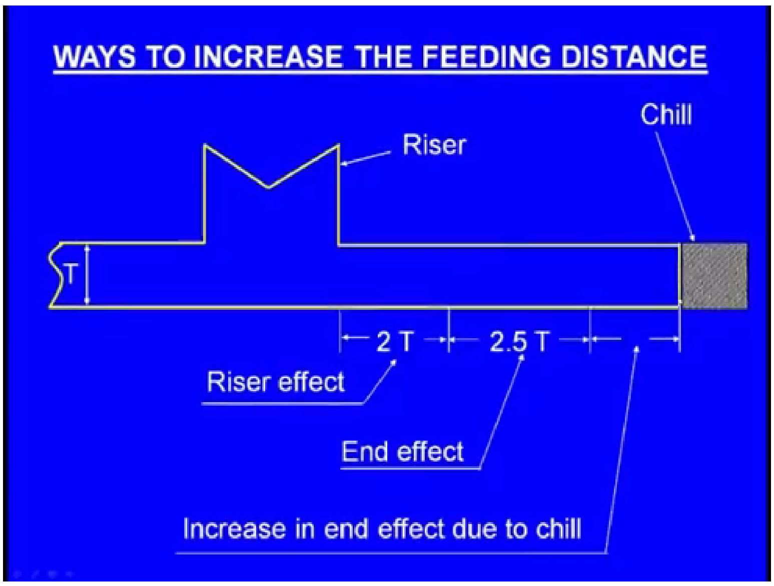

How to improve? We can place a chill here. For example, this is the casting and this is the riser and again here you can see there is 2 t, that is the riser effect and right here there will be 2.5 t, that is the end effect and we can increase the end effect by placing a chill here. So, chill is a steel block which is placed on the side of the mould wall. Right, then what will happen it will rapidly increases the heat because of that more what say part of the casting will be solidifying in lesser time that is how the end effect will be more compared to the case where there where is there is no chill.

So, by placing a chill on the oh in inside the mould we can increase the feeding distance. Thus, we can also increase the efficiency of the riser.

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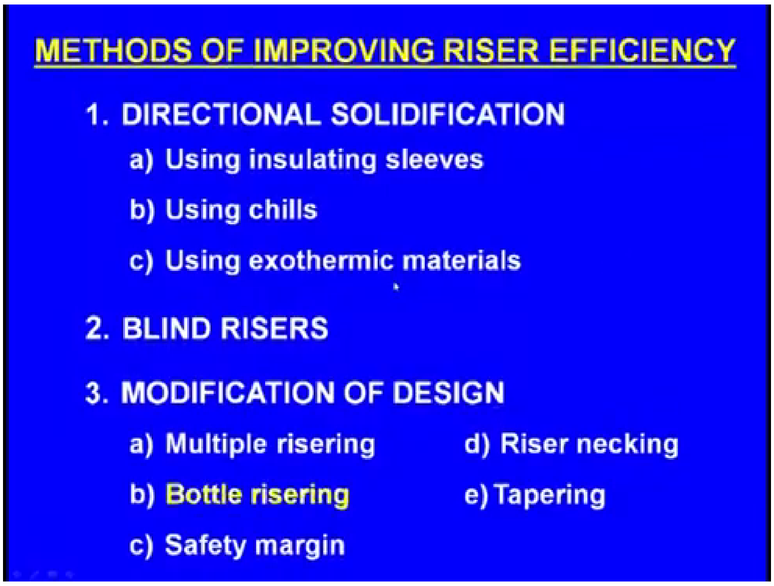

Next one let us see where what say learning about the modification of the design. So, instead of going for a single riser, if we go for multiple risers we can have a better efficiency. That is what we have seen under the multiple risering. Now, we will see another what say topic called bottle risering.

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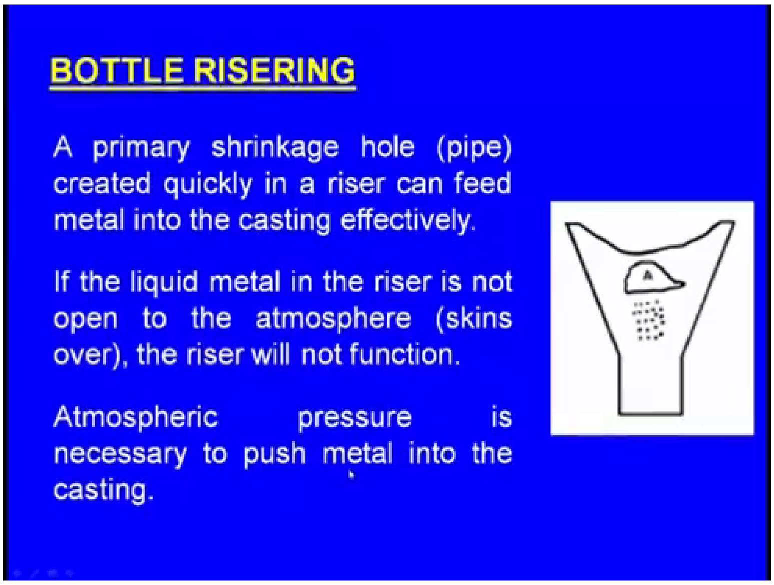

By incorporating bottle risering we can improve the riser efficiency. What is this bottle risering or what is a bottle riser bottle risering. A primary shrinkage hole right a pipe is created quickly in a riser right.

So, this what say pipe because of this pipe the metal will be forced inside the mould cavity, a pipe is created on the sides of the riser because of that the molten metal which is present in the riser will be pushed inside because of the atmospheric pressure. Right, if the liquid metal in the riser is not open to the atmosphere then the riser will not function. So, because of the atmospheric pressure once a pipe is created on the both the sides around the what say what say surface right the molten metal will be pushed inside the cavity, atmospheric pressure is necessary to push the metal into the casting. A bottle riser it is also known as Heine riser has such a small area at the top diameter that will begin to pipe very quickly. What is the specialty of a bottle riser? It is top diameter will be very small right.

So, because of that the what say piping takes place very quickly, means a pipe will be created at the top, means the what say molten metal near the mould wall will be solidifying quickly. A circular pipe is created and inside there will be liquid metal that will be pushed into the molten what say cavity.

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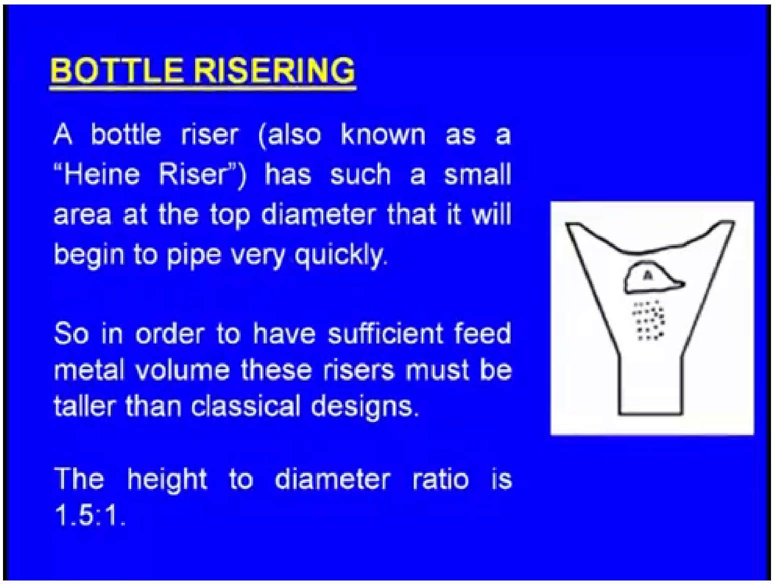

So, in order to have sufficient feed metal volume these risers must be taller than the classical design. So, usually we have seen that especially in the NRL method. What is the H by D ratio? It will be between 0.5 to 1 the H by D ratio should not be greater than 1.

But here the length of the what say risers will be more than the conventional risers. The height to diameter ratio is 1.5 to 1. So, this is the typical height to diameter ratio for a bottle riser.

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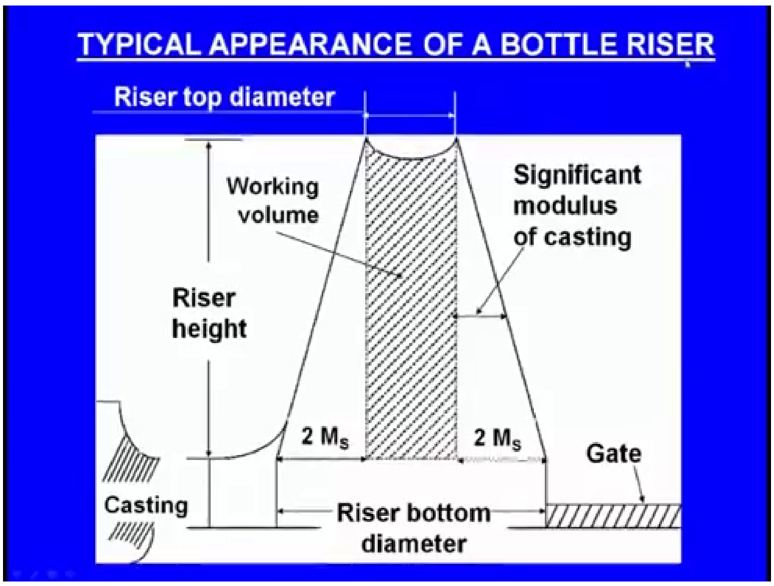

Now, this is the typical appearance of a bottle riser you can see this whole thing is a bottle riser. See it is slanting right at the bottom this is the bottom diameter you can see riser bottom diameter is this much starting from here to here whereas, this is the top diameter you see top diameter is very small whereas, bottom diameter is very large and here we can see this is the gate right through this gate right molten metal enters and this is the this side is the casting and this is the height of the riser you can see this is the height of the riser.

Now, we come across a an another interesting term called significant modulus of the casting. What is this significant modulus? This significant modulus we can see say there is a difference in the diameters of the riser at the top it is very small at the bottom it is very large. Now, there is a difference between the what say diameters both at the top and the bottom. Now, half of this difference in the diameter is known as the significant modulus, right half of that difference. That is indicated by M s, now at the bottom it will be 2 M s and this side there will be 2 M s. Formula for bottle riser, how to design the bottle riser, right riser bottom diameter is equal to 4 into M s plus riser top diameter.

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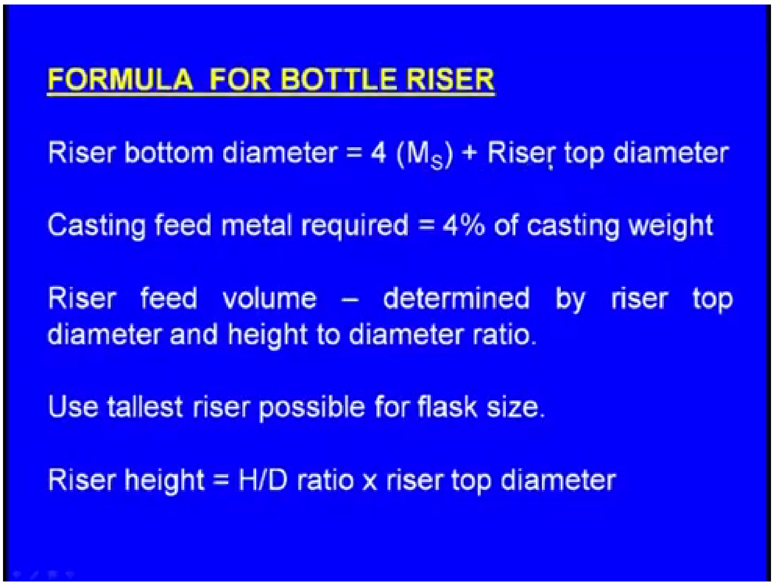

The cast casting feed metal required is equal to 4 percent of the casting weight. Riser feed volume determined by the riser top diameter and height to diameter ratio, use tallest riser possible for the flask size and riser height is equal to H by D ratio into riser top diameter. Now, this is the what say feed metal table for bottle riser in different cases means when the H by D ratio is changing in different cases.

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FEED METAL TABLE FOR BOTTLE RISER

H:D = 8:1		H:D = 6:1		H:D = 5:1	
Top Dia. (mm)	Feed Wt. (g)	Top Dia. (mm)	Feed Wt. (g)	Top Dia. (mm)	Feed Wt. (g)
10	44	10	32	10	28
20	352	20	264	20	219
30	1186	30	890	30	741
40	2813	40	2110	40	1758
50	5495	50	4121	50	3434

So, these are the what say feed metal what say diameters in different cases. Here we can see H by D ratio is equal to 8 is to 1. Now, when the top diameter is ten what say mm the feed weight is equal to 44 grams. When the top diameter 20 mm, the feed weight is equal to 352 grams, when the top diameter is 30 mm, it is 1186 grams, when the top diameter is 40 mm.

The feed weight is 2813 grams and when the top diameter is 50 mm, the feed weight is 5495 grams. So, these are the cases when H by D ratio is equal to 8 is to 1. Now, H by D ratio is 6 is to 1, that be the case when the top diameter is 10 mm, the feed weight is 32 grams. When the top diameter is 20 mm, the feed weight is 264 grams. When the top diameter is 30 mm, the feed weight is 890 grams. When the top diameter is 40 mm, the feed weight is 2110 grams.

When the top diameter is 50 mm, the feed weight is 4121 grams. So, these are the cases when H by D ratio is equal to 6 is to 1. Now, let us see another case where H by D ratio is equal to 5 is to 1. When the top diameter is 10 mm, the feed weight is 28 grams. When the top diameter is 20 mm, the feed weight is 219 grams. When the top weight is 30 top diameter is 30 mm, the feed weight is 741 grams. When the top diameter is 40 mm, the feed weight is 1758 grams. When the top diameter is 50 mm, the feed weight is 3434 grams.

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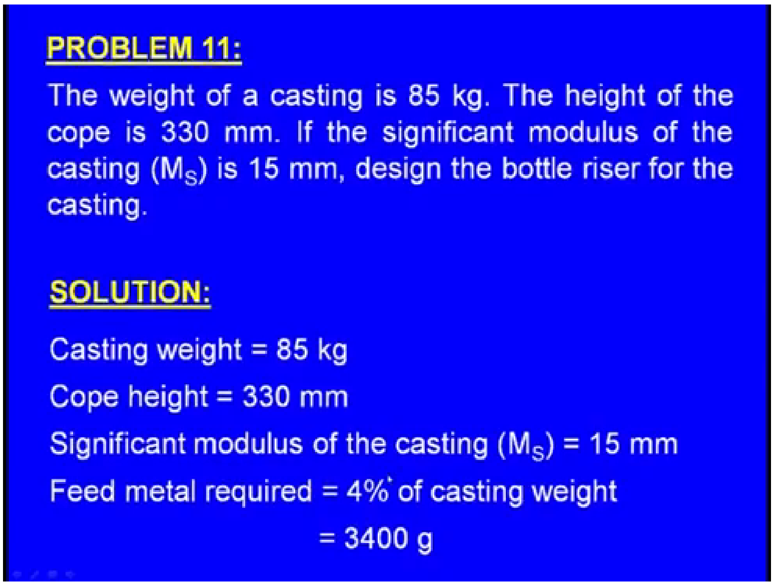

So, this is the case when the H by D ratio is equal to 5 is to 1. Now, let us solve a problem. The weight of a casting is 85 kilograms. The height of the cope is 330 mm. If the significant modulus of the casting M s is 15 mm, design the bottle riser for the casting. Now, we have to design the bottle riser. Casting weight is equal to 85 grams given. Cope height is equal to 330 mm. Significant modulus of the casting M s is equal to 15 mm. Feed metal required formula we have already seen 4 percent of the casting weight that is equal to 3400 grams. So, this is the feed metal.

Now, we need to for this feed metal we need to find out the dimensions of the bottle riser.

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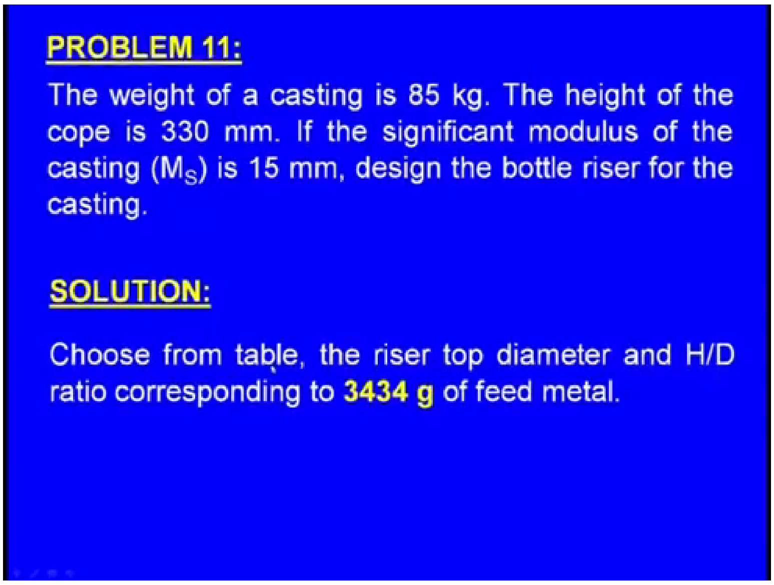

Choose from the table, the riser top diameter and H by D ratio corresponding to 3434 grams of the feed metal right. So, this is the what say standard table for the bottle riser and here we can see that much what say feed metal we can see here in this case 3434 grams. So, means so this is the diameter top diameter of the bottle riser and say this is the H by D ratio 5 is to 1. Accordingly, we can design the bottle riser.

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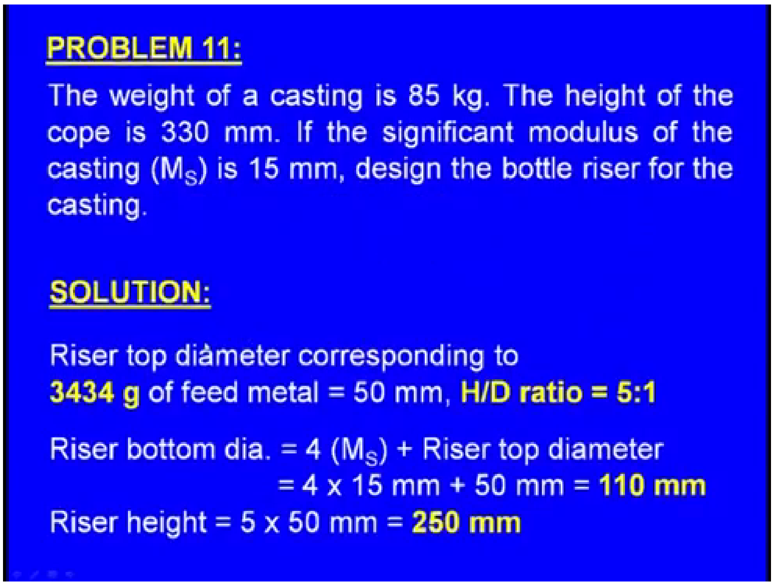

That be the case, then what will happen riser top diameter corresponding to 3434 grams of feed metal is equal to 50 mm, H by D ratio is equal to 5 is to 1. Now, riser bott bottom diameter is equal to 4 into M s plus riser top diameter, where M s is the significant modulus.

Now, that is equal to 4 into 15 mm plus 50 that is equal to 110 mm. So, the riser height is equal to H by D ratio is 5 is to 1. So, a riser height is equal to 5 into 50 that is equal to 250 mm. So, this is the riser height and what about the bottom diameter bottom diameter is 110 mm what about the top diameter 50 mm. So, this is the design for the bottle riser in this case. Now, we are seen learning about the case how to modify the design of the riser to improve the risers efficiency. Under that we have seen we can go for the multiple risers and also we can go for the bottle riser. Now, this is a term called another topic called safety margin.

By what say incorporating the safety margin by what say carefully designing the safety margin we can improve the risers efficiency.

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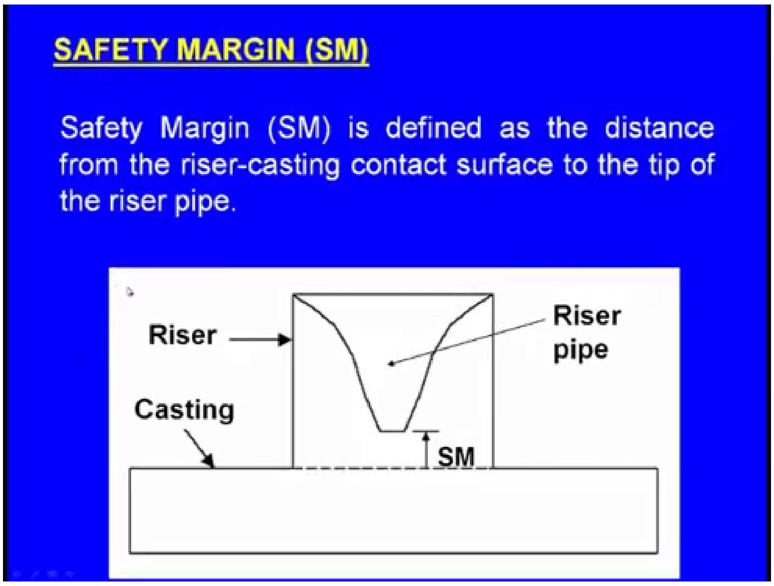

Now, let us see what is this safety margin, you can see this one this is the casting and this is the riser. Now, once we what say pour the molten metal immediately this much portion right a pipe is created here on this sides. Now, insert the liquid metal and it flows this liquid metal here and it will be feeding the casting. Thus, there is a what say cavity will be created here a cavity will be create. So, this much portion there is a cavity and this is the solidified portion. Now, this cavity is like a right pipe and it comes and it is stopping here. Now, what is this? This is the safety margin.

Safety margin SM is defined as the distance from the riser casting contact surface to the tip of the riser pipe. So, this is the safety margin. Now, what does this indicate now when the if this safety margin is just touching the what say a casting no problem. Suppose if this is safety margin is going below the casting surface means what does it mean there is shrinkage cavity is there. On the other hand if the safety margin is too much what does it mean means from this region you see only this much length of the riser is utilized for the feeding of the casting. What about this much length of the casting starting from the surface of the casting to here. That much portion of the riser is not involved in the feeding of the casting.

Now, if the safety margin is more and more what will happen that extra portion of that extra length of the riser is not involved in feeding of the casting means that is a wastage only. So, the safety margin should be minimum, it should not be too much, on the other hand it should not be zero right zero means it will be just touching and it should not be negative.

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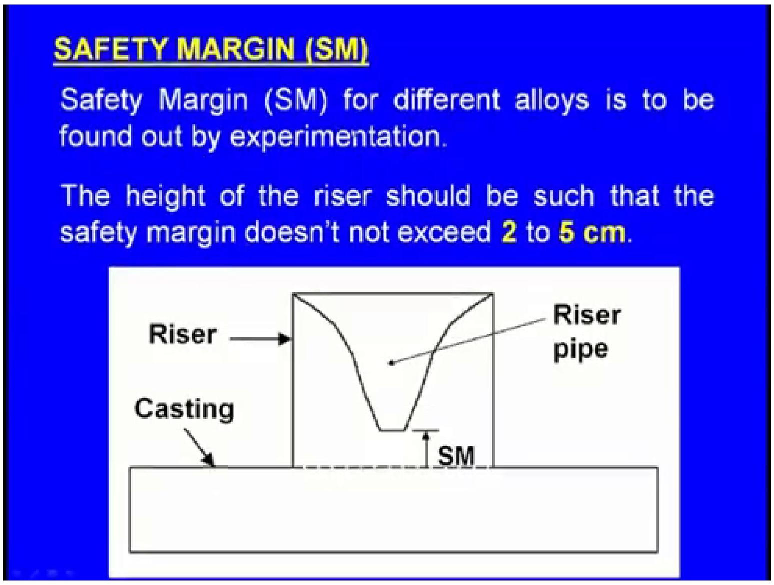

Safety margin for different alloys is to be found out by experimentation. The height of the riser should be such that the safety margin does not exceed 2 to 5 centimetres right. If they are safety margin is more than 5 centimetres certainly there won't be any shrinkage cavity, but that is a wastage of the riser material.

Whatever what say, length of the riser covered in that safety margin is waste and on the other hand it should not be too less right. The in such a case there may be a shrinkage cavity and it should not be negative. So, the height of the what say the length of the safety margin should be between 2 to 5 centimetres. So, this safety margin by properly designing the safety margin by conducting the exhalants and we have to find out the safety margin for different cast alloys. Accordingly, we have to fix up the what say height of the riser. Then the efficiency of the riser will be improved.

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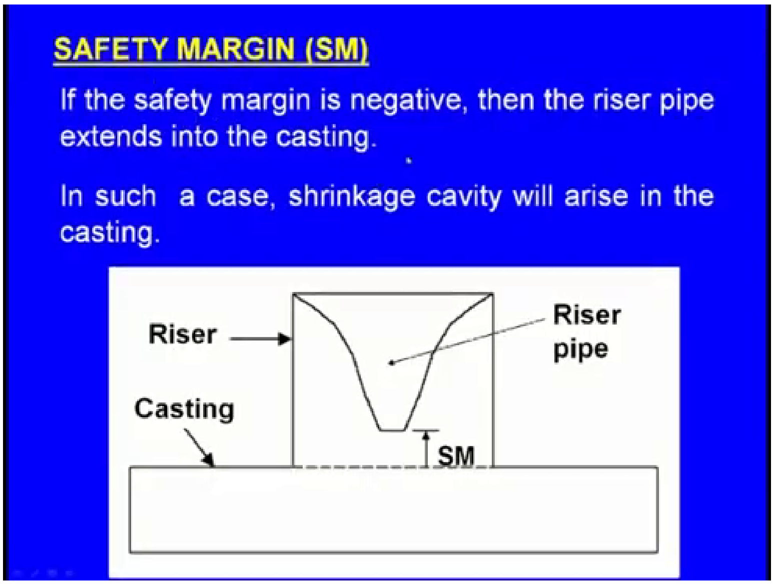

If the safety margin is negative then the riser pipe extends into the casting in such a case shrinkage cavity will arise in the casting.

Next one ah there is another topic called riser necking. So, this is also a modification to the riser design with this also with this riser necking also we can improve the efficiency of the riser. What is this riser necking?

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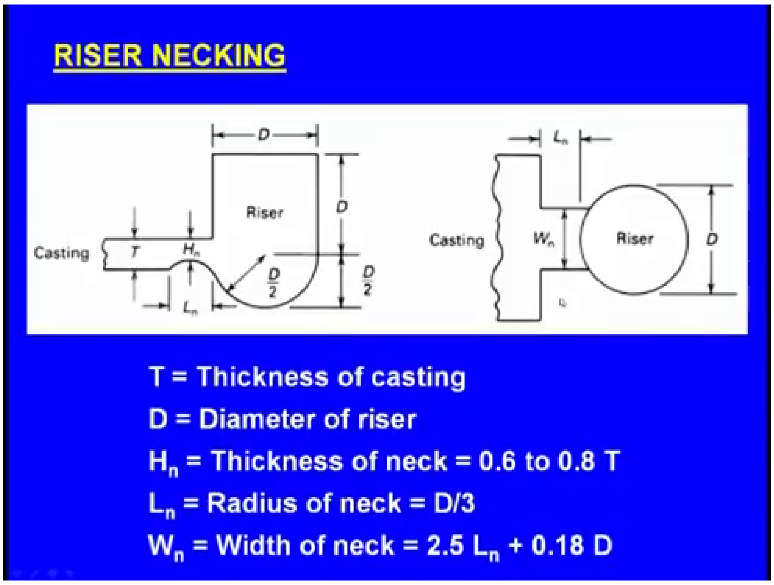

Now, you can see here. So, this is the riser and casting is this side. Now, the riser is given a necking here. So, this will improve the efficiency of the riser now here we can see T is the thickness of the casting, of the section to be fed by the riser and D is the diameter of the riser, H n is the thickness of the neck. This much portion is the H n is the thickness of the neck. That is equal to 0.6 to 0.8 times the thickness of the casting or the thickness of the section to be fed.

Next one L n is the radius of the neck. This is the L n that is equal to D by 3 where D is the diameter of the riser. Next one W n is equal width of the neck that is equal to 2.5 times L n plus 0.18 D. So, by incorporating riser necking we can improve the efficiency of the riser. Finally, tapering is there. By tapering means by giving a taper to the casting we can improve the risers efficiency. Here we can see this is the casting, this is the casting this is the casting and this is the riser.

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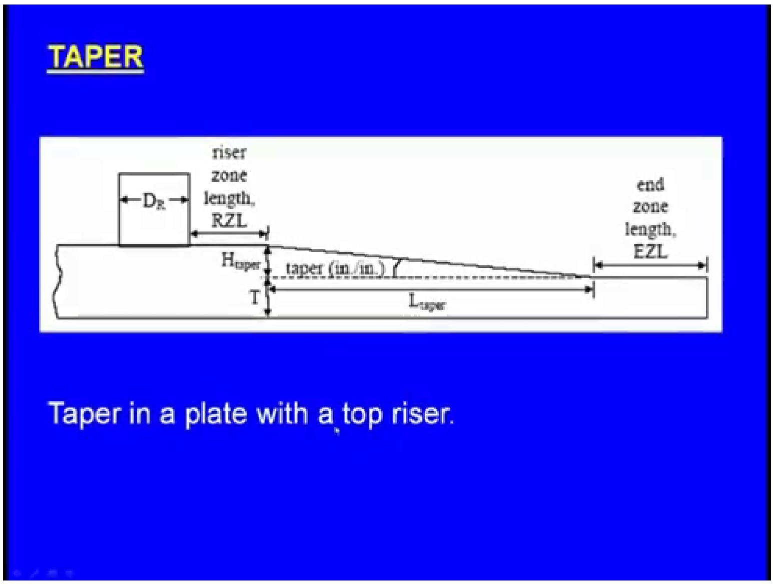

Now, taper is provided you can see here. Here the thickness is more and slowly the thickness is reduced. This will definitely improve the performance of the riser.

Now, here we can see this is the end zone length end effect and here we can see this is the riser zone length right and here a taper is given. So, because of this taper the what say efficiency of the riser will be certainly improving.

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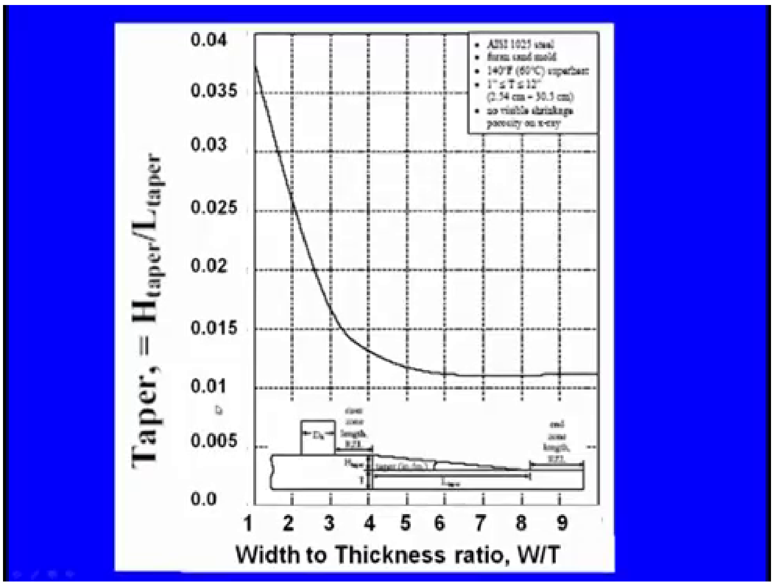

Now, how to choose this taper and this is the what say graph available to us and here we can see on the x axis width to width to thickness ratio W by T on the x axis. On the y axis we can see taper that is equal to height by length height of the taper divided by length of the taper and here we can see the width to thickness ratio 1 2 3 up to 9 and here we can see the taper H divided by L. So, it is this much right. So, by what say considering this graph.

We can successfully what say design the taper for the casting, which will definitely improve the efficiency of the riser. Now, computers in design in riser design. So, far we have been learning about the different methods of the riser design. We have seen the caines method which was very tedious and time consuming. Next we have seen the modulus method. The modulus method right it requires that we need to find out the surface area of the casting. Of course, in the in these lectures we have what say considered some simple shaped castings. So, that is how we were able to find out the what say surface area of the castings very easily, but in practice the surface area would be very complex. In such a case calculating the surface area would be very tough.

That is how even the modulus method has got certain practical difficulties and finally, we have seen the NRL method. The naval research laboratory method, where the what say time what say required would be very less. Within no time we can design the riser right also this surface area does not come into picture, but still we need to check the what say our design using the feed volume concept, whether what we have designed is proper or not. That way that also takes time, but fortunately the computers have what say come into in to picture in the riser design. Using the computer software’s we can also design the risers. So, we will see certain important or what say computer software’s that have been developed around the world to for the riser design.

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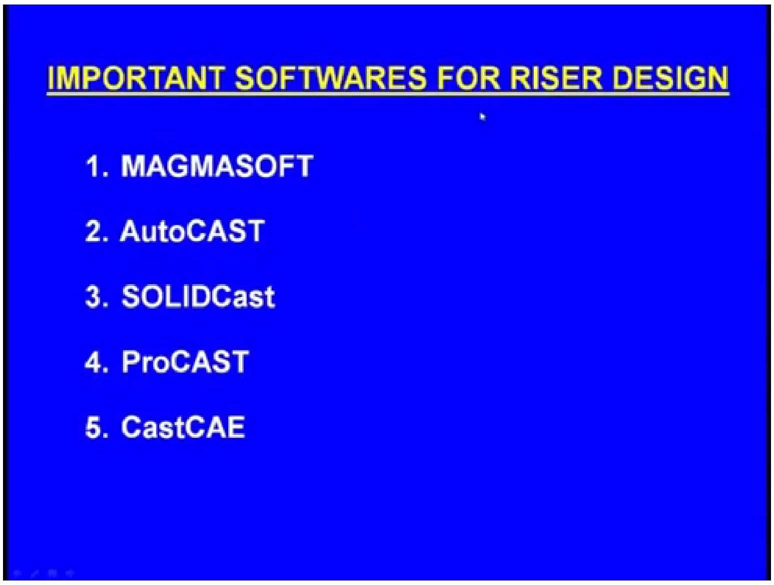

Important software's for the riser design. One is the MAGMASOFT another one is the autoCAST another one is the SOLIDcast another one is the proCAST and another one is the castCAE and there are more software's which are available for the riser design. Let us quickly review what these software's are.

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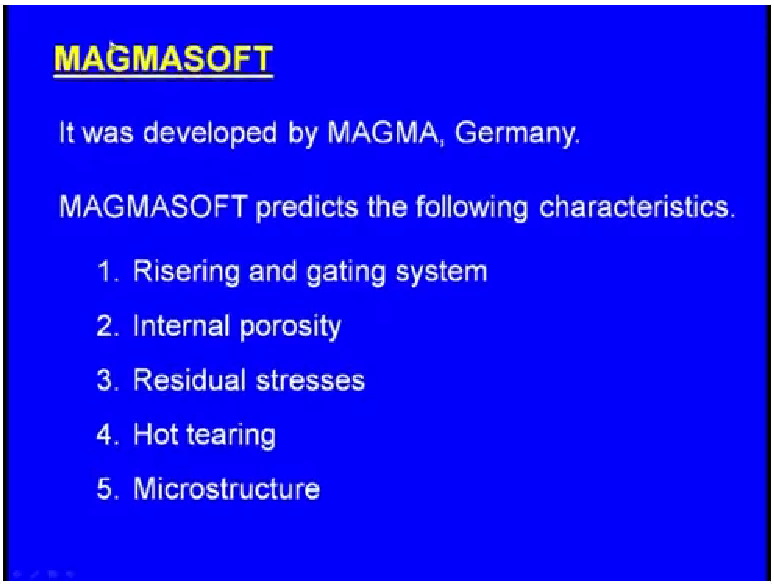

MAGMASOFT right, It was developed by MAGMA Germany. MAGMASOFT predicts the following characteristics, right it predicts the Risering and gating system. We can design Risering and gating system, internal porosity is predicted by this software

MAGMASOFT, residual stresses are predicted by this software, hot tearing that is a defect which is a what say cracking of the casting during solidification.

So, this hot tearing is also predicted by magmasoft. Finally, the microstructure which is very important as far as the properties are concerned that is also predicted by magmasoft, but though it has got several components one component is the what say design of the risering and gating. So, we can using this magmasoft we can design the risering and getting this is an a what say an example using the magmasoft method right.

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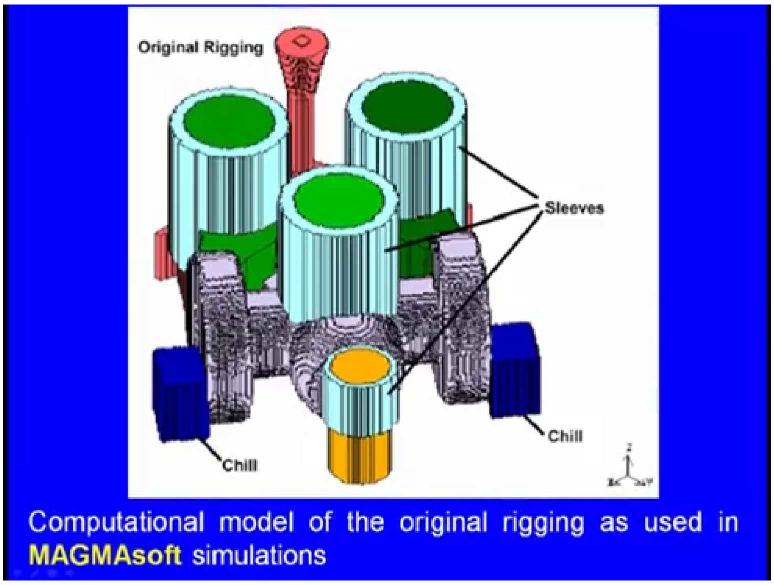

So, this is the computational model of the original rigging as used in the magma soft simulation you can see. Yes, these are all the sleeves where sleeves are used and here we are placing the chills and this is the pouring cup and this is the sprue and it will successfully predict the what say design of the riser

In different cases when sleeves are used, when sleeves are not used, when chills are there, when chills are not there likewise in different cases what should be the dimension or the design of the riser it will be successfully predicting.

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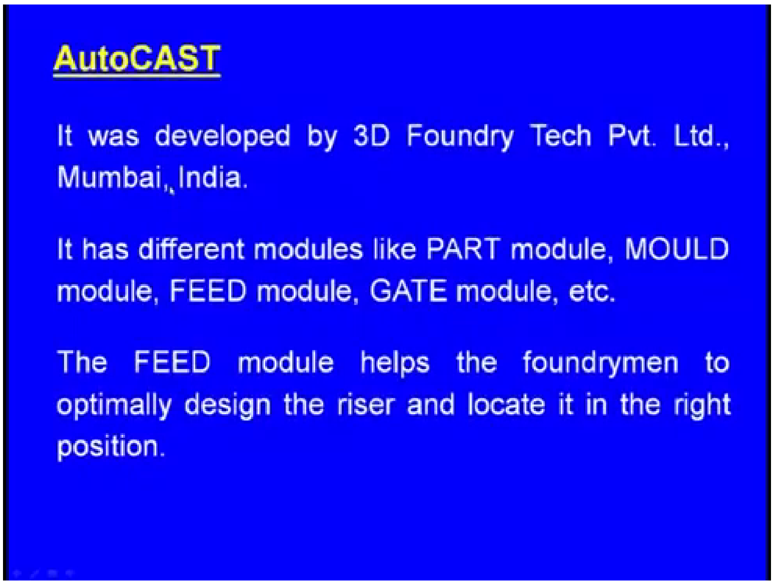

Next one there is another software called autoCAST. So, this was developed by 3D Foundry Tech private limited. Mumbai in India right it has got three modules one is PART module second one is the MOULD module next one FEED module and GATE module and so on. Now, the FEED module helps the foundry men to optimally design the riser and to optimally locate it in the right position right. So, this software we can use and this feed module will help us to design the riser not only to design the riser to locate the riser in the right position.

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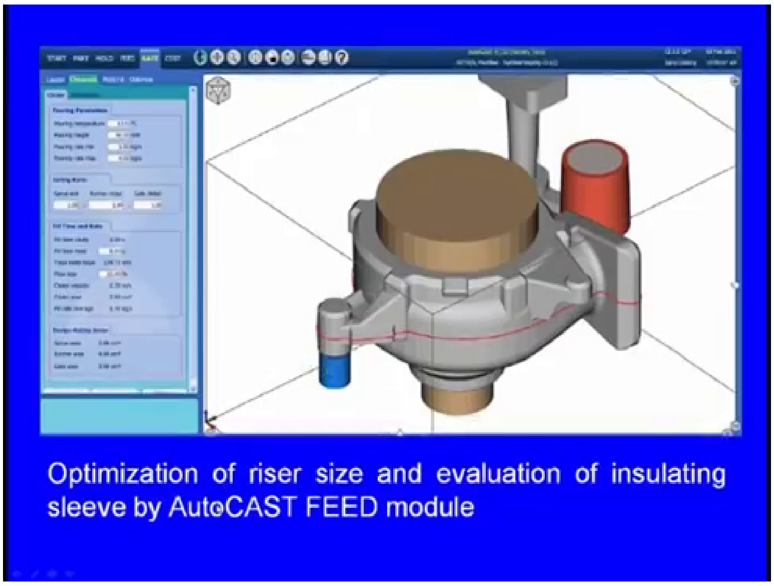

So, this software can be used. So, this is a an important software produced in India and this is the optimization of the riser size and evaluation of the insulating sleeve by auto cast feed module, here we can see right. So, here the size of the riser is optimized and where in insulating sleeve is used. Next one next software solid cast it contains the riser design wizard and gating wizard design wizard. It can be used to simulate castings poured in grey cast iron, ductile cast iron, steel, aluminium, copper based alloys, nickel based alloys and almost any other alloy.

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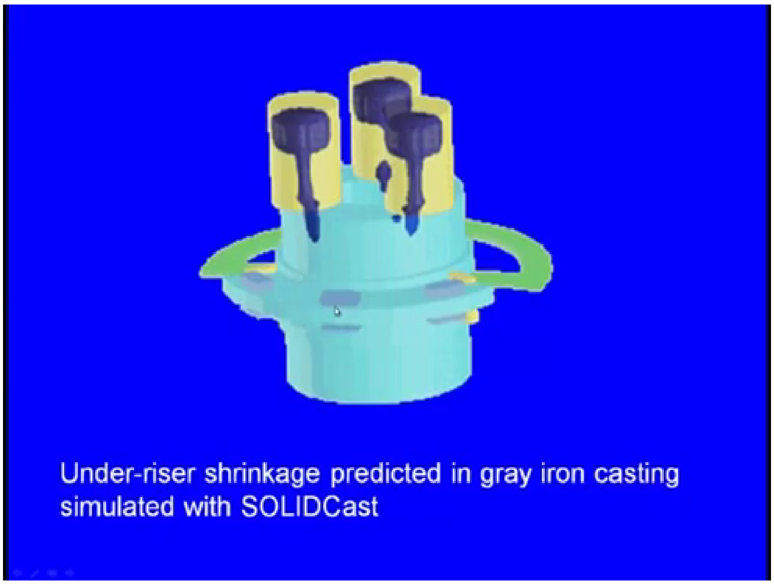

And here we can see the what say simulation using this software. Under what say riser shrinkage predicted in grey iron casting simulated with solid cast.

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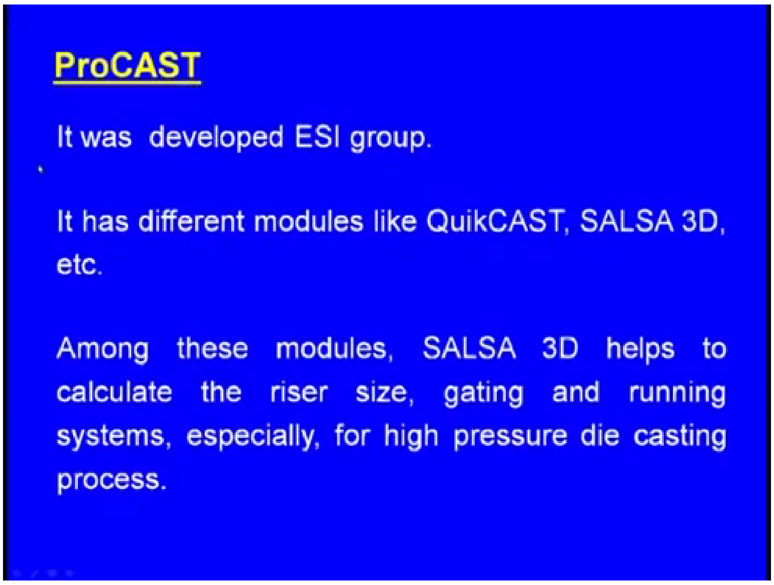

Next one we have the proCAST software. It was developed by ESI group. It has different modules like quikCAST right, SALSA 3D, etcetera right. Among these modules, SALSA 3D helps to calculate the riser size, gating and running systems, especially, for high pressure die casting process.

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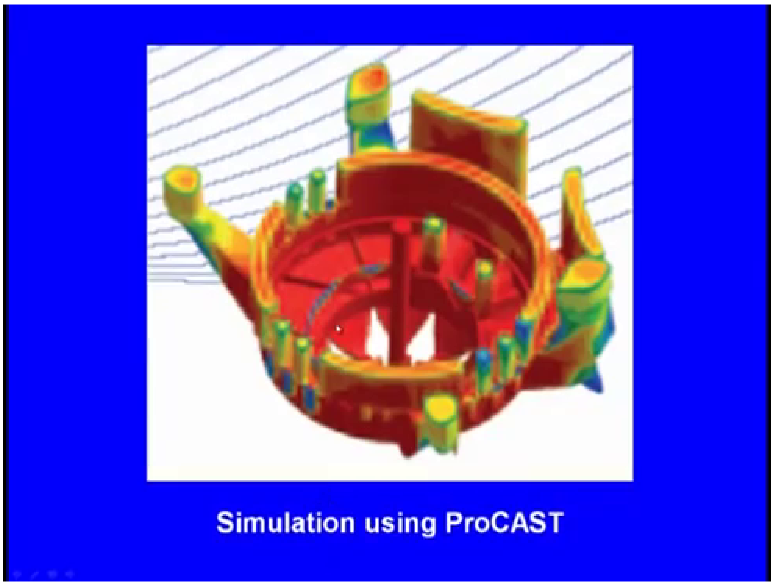

Here we can see simulation using procast. Next one castCAE. So, this is another software developed by a Finland company.

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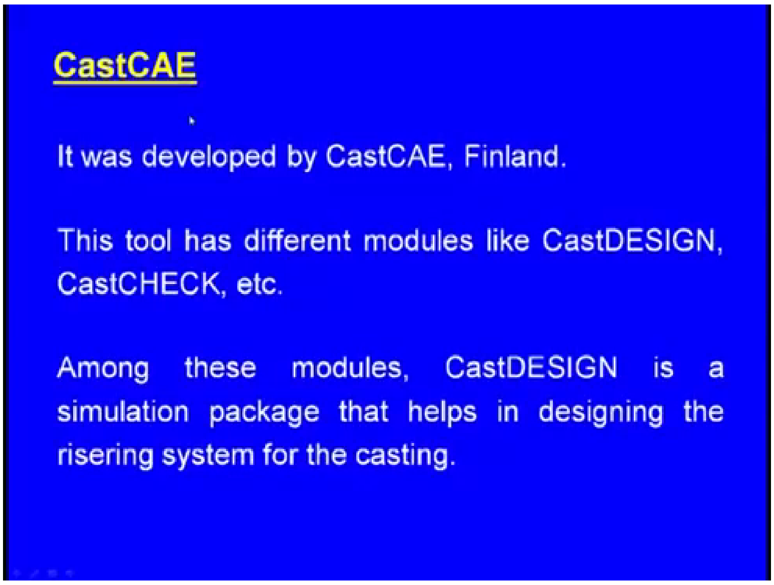

This tool has different modules, castDESIGN, castCHECK and so on. Among these modules cast design is a simulation package that helps in designing the risering system for the casting.

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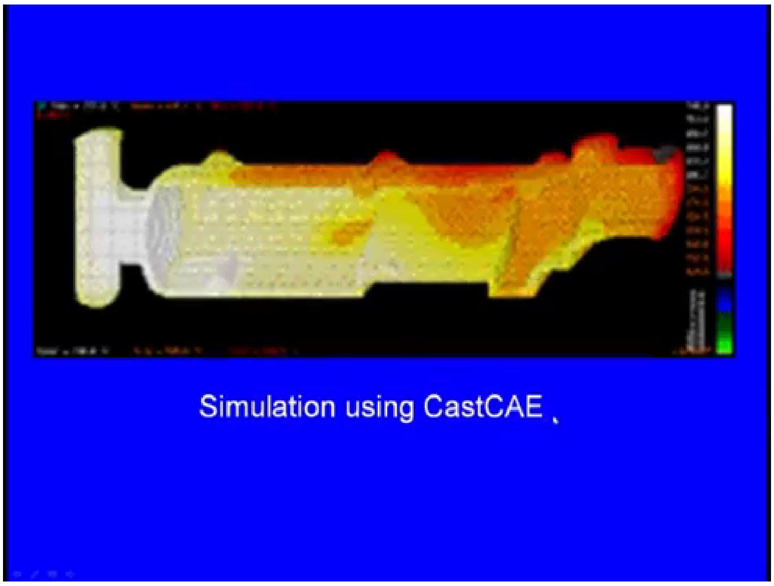

And here we can see simulation using castCAE.

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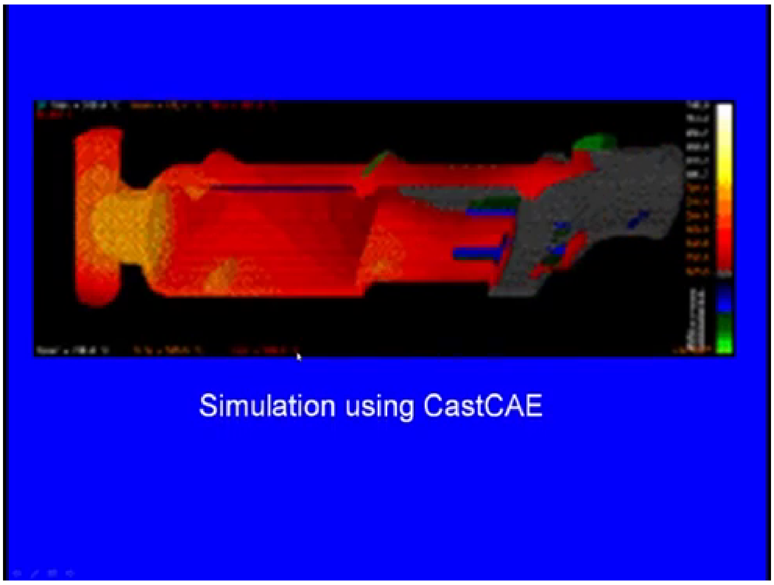

Friends till now, what we have learned. We have seen in this two lectures we have seen the feed volume concept right.

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FEED METAL VOLUME

$$\alpha\,(V_C + V_R) = \eta_f\, V_R$$

Where, V_C is the volume of the casting.

V_R is the volume of the riser.

α is the percentage volumetric shrinkage of the cast metal. (Values of α for different metals/alloys are shown in the next slide).

η_f is the riser efficiency (ratio of feed metal available to the total volume of riser).

So, alpha into V c plus V R is equal to eta f into V R where, V c is the volume of the casting and V R is the volume of the riser and alpha is the percentage volumetric shrinkage of the cast metal and this is different for different cast alloys and eta f is the riser efficiency. What is riser efficiency? It is the ratio of freed metal available to the total volume of the riser.

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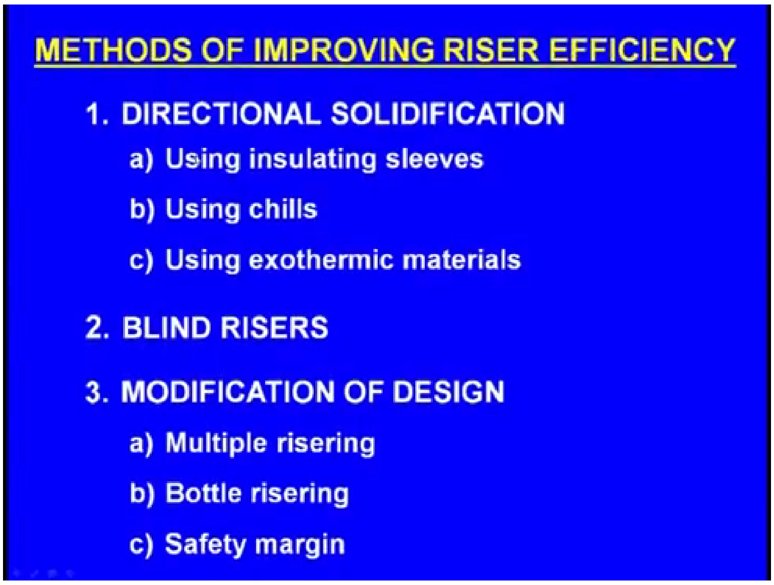

We have also seen the methods to improve the riser efficiency. The riser efficiency can be improved by direct achieving directional solidification. Again directional solidification can be achieved using insulating sleeves. Directional solidification can be achieved using chills. Directional solidification can also be achieved using exothermic materials.

Next one the riser efficiency can be improved by adopting blind risers. So, this is what we have learnt. Finally, we have learnt that modification of the risers design also helps us to improve the efficiency of the riser. How to modify the riser design one is the multiple right multiple risering, second one bottle risering, safety margin and we have seen the other factors which will be helping us to improve the modify the design and this is the fifth lecture I am delivering on the design of the risering system. In this five lectures what we have learnt, we have seen the caines method and in the caines method.

We have to find out the freezing ratio and also we have to find out the what say surface sorry we have to find out the freezing ratio and accordingly we have to find out the design of the riser and we have seen that caines method is tedious and time consuming and we have seen the modulus method where the what say freezing ratio does not come into picture, but we have to what say calculate the modulus of the casting and the modulus of the riser. Where, modulus is the volume to surface area ratio of the volume to surface area and surface area we need to calculate and finally, we have seen the naval research laboratory method.

So, this was developed by the U.S. navy and here the what say modulus does not come into picture .The surface area of the casting does not to come into picture. Only shape factor comes into picture and using the shape factor we can directly find out the what say design of the riser using the riser curve and also the riser what say height selection charts. That is what we have learnt in these five lectures. Finally, we have seen how to what say improve the risers efficiency. So, with this we are closing the design of the risering system and in the next class I will be delivering the lecture on the design of the gating system.

Thank you.