Metal Casting
Dr. D. B. Karunakar
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 02
Sand Casting Process
Lecture - 11
Design Of Risering System- III

Welcome friends. In the previous class we have learnt about the naval research laboratory method for the design of the riser, these also known as the NRL method. So, this became very popular. In this NRL method a new term called shape factor was defined by the team, NRL team.

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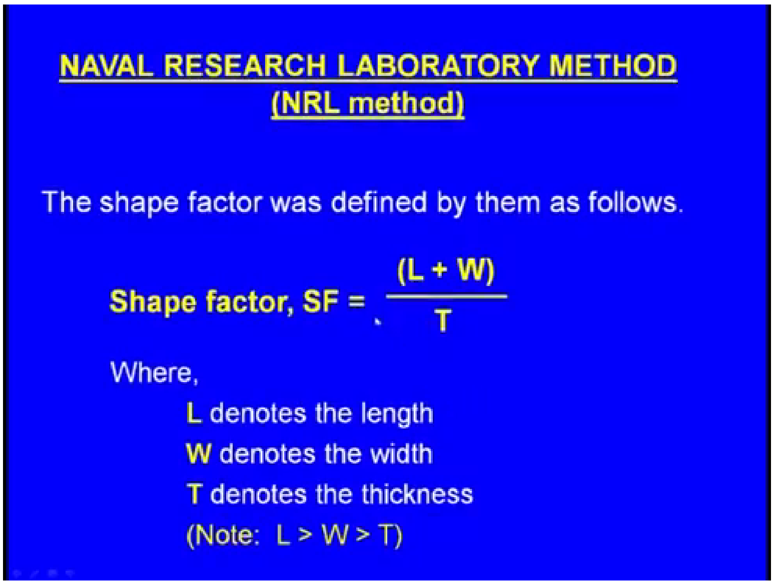

The shape factor which is abbreviated as SF is equal to L plus W divided by T. Where, L is the length of the section to be fed by the casting raiser, W is the width of the section, T is the thickness. And there is a condition that L is greater than W, W is greater than T. So, this way a new term was defined in the NRL method.

After finding out shape factor we can find out the riser size or the riser volume from a graph given.

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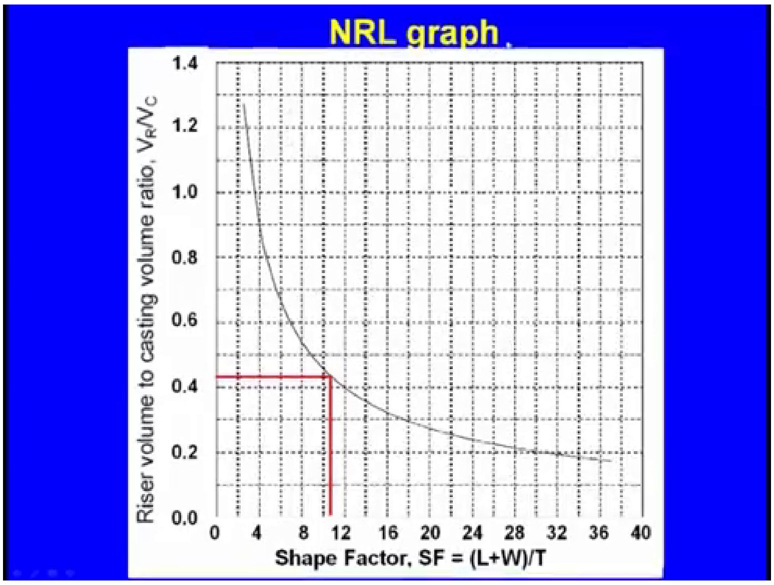

That graph is given by the steam, so this is that graph. In this graph the shape factor is plotted on the x axis and the riser volume to casting volume ratio V R by V C is plotted on the y axis. Once we could calculate the shape vector, from this shape factor we will draw a line then we will find out the corresponding V R by V R ratio. Then, we know the V C the volume of the casting. Then ultimately, we can know the volume of the riser required for the feeding of the required what say section.

And after we find out the volume of the riser, we can also find out the dimensions of the riser.

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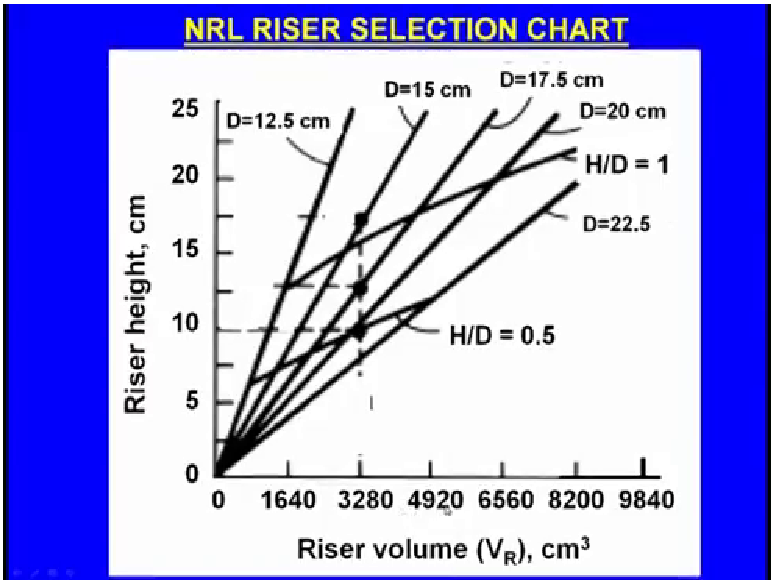

Maybe We can find the different it we can arrive at a in any different volume right we can plot your line perpendicular to the x axis, then it will be what say intersecting with all these lines. Now what are all these lines? All these lines will be representing different diameters. For example, this line represents 12.5 centimeters diameter of the riser, this line represents the risers diameter as 15 centimeter, this line represents risers diameter as the 17.5 centimeters and this line represents risers diameter as 20 centimeters, and finally this line represents risers diameter as 22.5 centimeters.

Now, when we are what say draw plotting a line perpendicular to the x axis and it may intersect with more than two lines or even more lines, then what happens. At each line again we will be drawing a line right parallel to the x axis and such that it comes to the perpendicular to the y axis, then what happens. The value the ordinate that we obtain represents the riser height. So, this line represents the riser diameter and this portion represents the riser height.

So, that way we can find out different combinations of the riser diameters and the heights for the same volume of the riser. So, depending upon our requirement and depending upon our convenience we can finally select any combination of the diameter and height of the riser. That way the NRL method offers certain advantages over the previous methods; the modulus method and the Caine's method. So, we have seen few examples in the a NRL method in the previous class, now we will see one more example in the NRL method.

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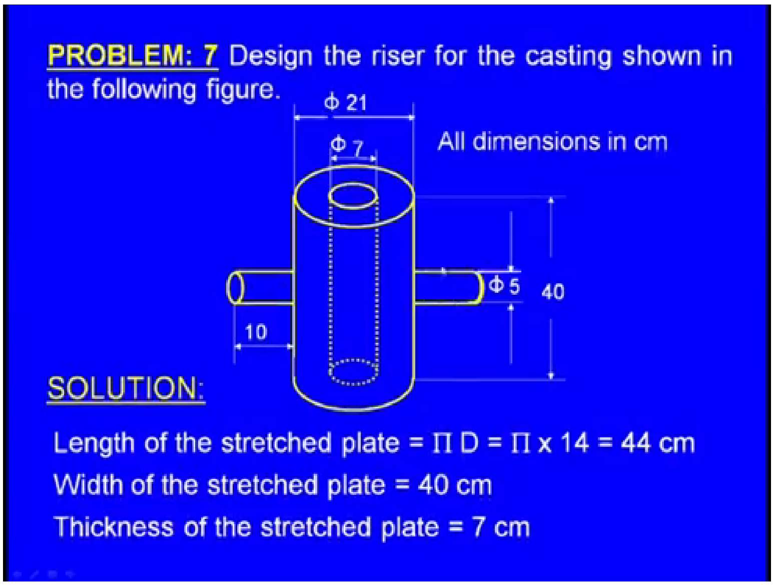

Now, we have another problem design the riser for the casting shown in the following figure. Now, what is this figure, what is this casting? This casting is a cylindrical casting and with an annular hole inside means, an axial hole is there parallel to the axis of the cylinder and the axis of the hole and the axis of the cylinder are coinciding. So, that is geometry of the casting.

In addition to that, the casting has to what say what say additional elements are there on both sides here is 1 additional element is there a cylindrical element the same element is there on the other side also. These are known as the parasitic volumes. Now under such conditions, we have to find out the what say riser dimensions for this casting. Now how we will proceed? Solution length of the now initially we have to assume that these additional elements are not there. For the time being, let us assume now what we are going to further assume means we are cutting at this casting on one side like this we are just cutting parallel to the axis of the casting like this.

From here to here vertically we are cutting it. Then we will stretch it. Then what will happen it will become a plate like casting, but of course, on one side the diameter what say length will be more on the other side it will be less. Maybe on one side, what happens the diameter will be right more than what say it is 21 centimeters on the other side the diameter is what say 7 centimeters, but if we construct the average diameter the average diameter will be 14 centimeters.

So, let us assume that they what say casting is cut and it is stretched finally, what is its length? Length will be pi D. What is the average diameter? Average diameter, the outward diameter is 21 centimeter. The inward diameter is 7 centimeters. So, the average diameter is 14 centimeters. So, the length of the stretched plate is pi D. That is, pi into 14 that is equal to 44 centimeters. If we stretch it like a plate like casting, then what about the width of this stretched plate? Width will be the height of the cylinder that is the 40 centimeters. Then, what is the thickness of this stretched plate? Let us see what is this outside diameter? That is, the 21 centimeters; what is involved inside diameter? That is 7 centimeters. So, inside it is 7 outside it is 21. So, this much is 7 centimeters and this much is 7 centimeters that is how the external diameter will become 21 centimeters.

So, the thickness of the casting will be 7 centimeters. So, that way we have assumes that the casting is cut and it is stretched. So, that it would become a plate like casting.

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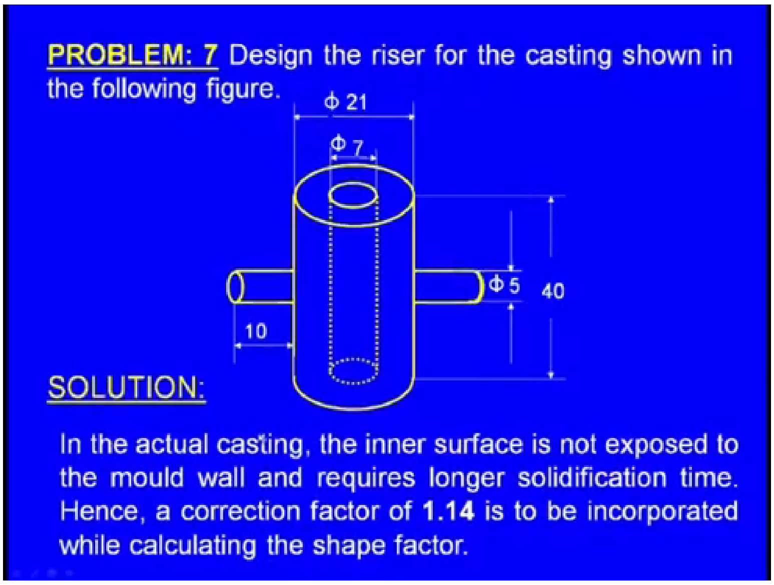

Now, in the actual casting the inner surface is not exposed to the mould wall and requires longer time for solidification naturally right. So, if we take a what say actually if the casting is actually a plate like casting, all the 6 sides it is exposed to the what say a mould wall. So, it requires a particular what say time for the complete solidification, but now, this is actually a cylindrical casting and with a hole inside now we are assume.

Assuming that it is cut and it is stretched. So, that it would become a plate like casting. So, this kind of what say assumed plate like casting would require more time than a actual plate like casting. If the casting is a actual what say plate like casting.

So, this requires both time. Then what happens? We have seen in the previous case a correction factor is required a correction factor of 1.14 is to be incorporated while calculating the shape factor.

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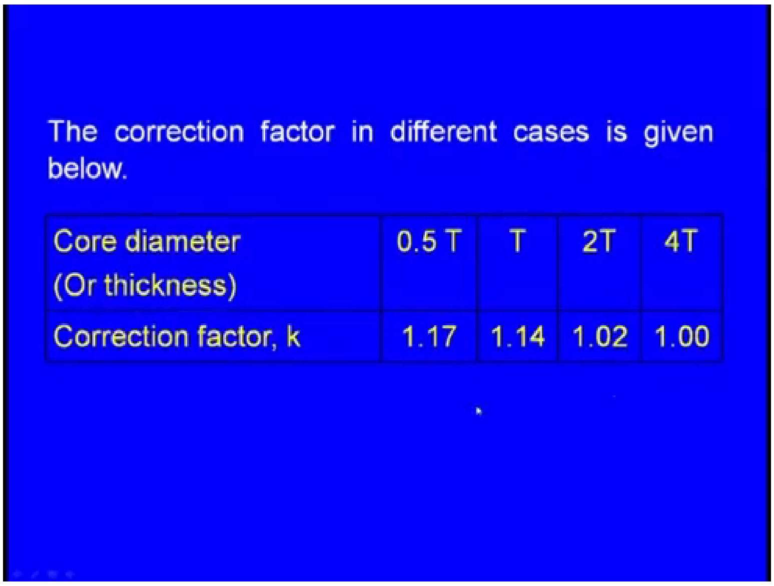
The correction factor in different cases is given below.

Core diameter (Or thickness)	0.5 T	T	2T	4T
Correction factor, k	1.17	1.14	1.02	1.00

You see this is information we have. In fact, this information was furnished by the NRL team Bishop and the team right when the core diameter on the thickness is 0.5 times the thickness of the casting the correction factor is 1.17 and when the core diameter or the thickness is equal to the thickness of the section then the correction factor is 1.14.

Now, what is the thickness of the casting? The thickness of the casting is you see 7 centimeters. You here we can see the 7 centimeters now what is the thickness of the core that is also equal to 7 centimeters. So, here this is our case the thickness of the core is equal to thickness of the section. So, the correction factor to be taken is 1.14 now the shape factor is equal to L plus W divided by k T where k is the correction factor and L is the length of the section, W is the width of the section and T is the thickness of the section.

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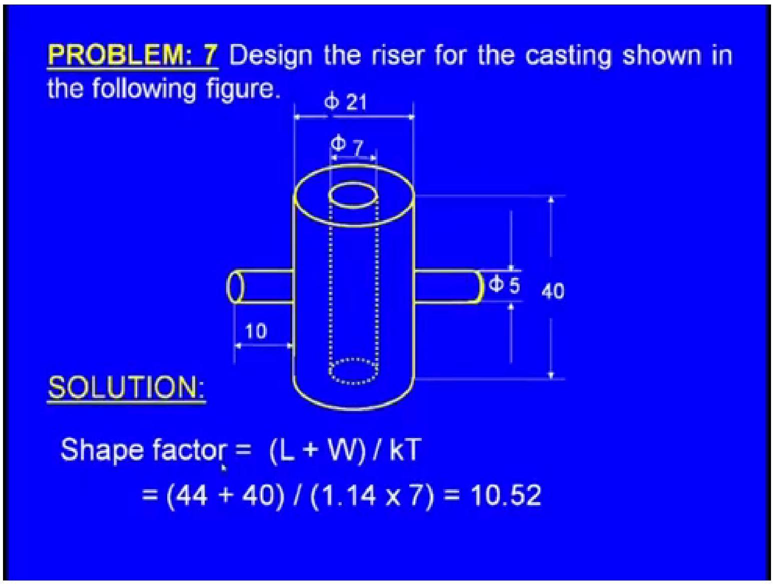

So, we have already seen length of that stretched plate. Imaginary stretched plate is 44 centimeters and the width is the same thing this much that is the 40 centimeters. All right and k is 1.14 and T is the 7 centimeters finally, we get your shape factor of 10.52.

So, this is the shape factor when we assume that this cylindrical casting is cut on one side and stretched into a plate like casting. Now after we obtain the shape factor we have to what say find out the volume of the riser for feeding this plate like casting and this is the what say graph which gives us the volume of the riser. Here we can see on the x axis, there is the shape factor and the y axis we have riser to casting volume ratio that is the V R by V C. So, V C we can always find out V C means volume of the casting. So, once we know the volume of the casting we can very well find out the volume of the riser.

Now, for this problem we have the shape factor as 10.52. You can see here this is 10.52. So, this is a 10.52 this red line. Red line represents 10.52 is let us plot this line we have plotted actually now this line is coming and this is the curve. This is the curve and this line at 10.52 is coming and it is just touching the curve here and from here we have to go parallel to the x axis. So that it would touch the y axis. Here now this point gives us the V R by V C ratio means volume of the riser to the volume of the casting ratio.

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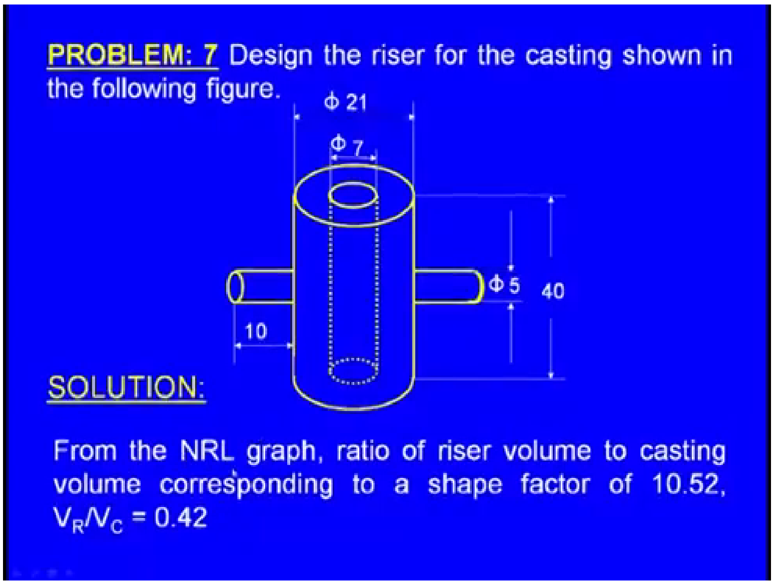

From the NRL graph ratio of riser volume to the casting volume corresponding to a shape factor of 10.52 that is V R by V C is equal to 0.42 that is what we have obtained from the graph.

Now, in this ratio right V R by V C is equal to 0.42. We are used to be found out volume of the riser and V C we can find out.

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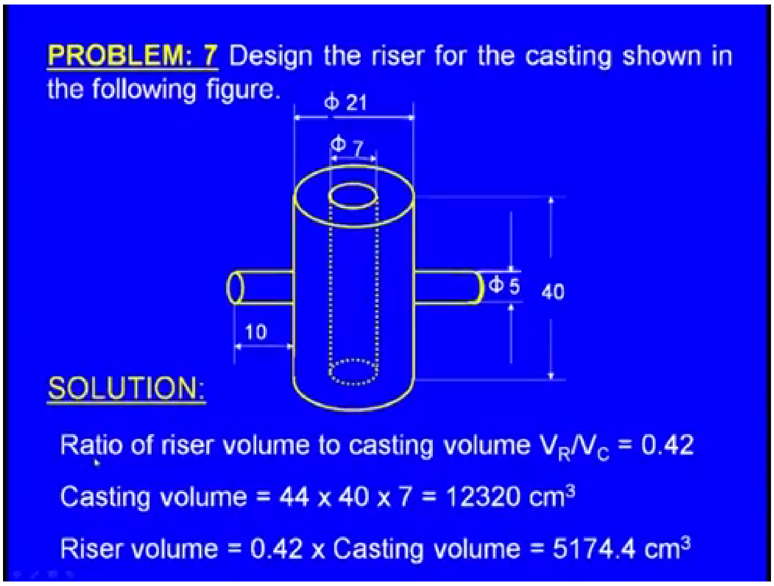

Now, ratio of the riser volume to casting volume V R by V C is equal to 0.42 casting volume. Say we have assumed that the casting is like a plate like a casting where the length of the casting is 44 centimeters, width of the casting is 40 centimeters and the thickness is 7 centimeters. So, just multiplication right, it is when we multiply it becomes 12320 cubic centimeters.

So, this is the volume of the casting ,now riser volume is equal to how see riser volume is equal to V C into 0.42 now 0.42 into V C. What is V C casting volume? Then we get 51000 sorry 5174.4 cubic centimeters. So, this is the riser volume right right we got the riser volume, but what is for the diameter what about the height. So, the again we have the what say another chart is there and. So, based on the chart we have to find out the diameter and riser, but prior to before that.

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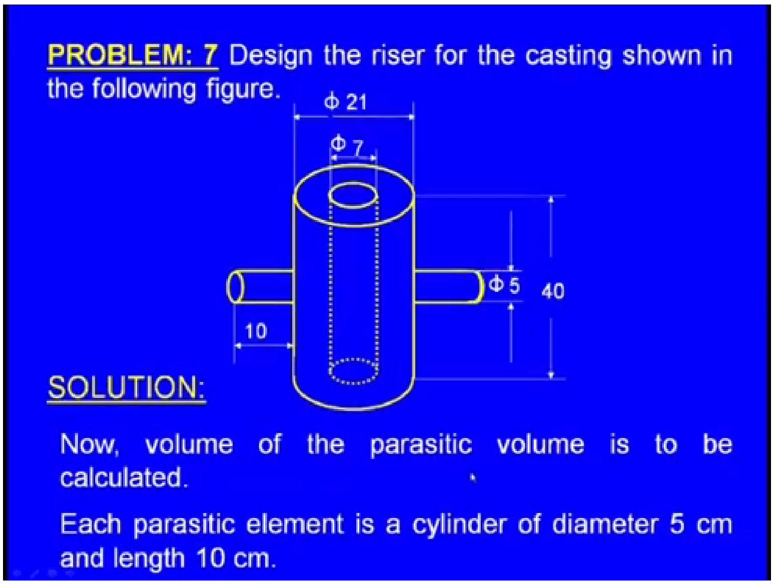

And we have to consider these parasitic elements until now we have assumed that these parasitic volumes are not there according we have assumed that the casting is cut and it is stretched.

Now, let us consider the parasitic elements now volume of the parasitic volume is to be calculated. Each parasitic element is a cylinder of diameter 5 centimeters and length. Length is 10 centimeters. Now we have to find out volume of the parasitic element volume of each parasitic element is equal to 196.4 cubic centimeters.

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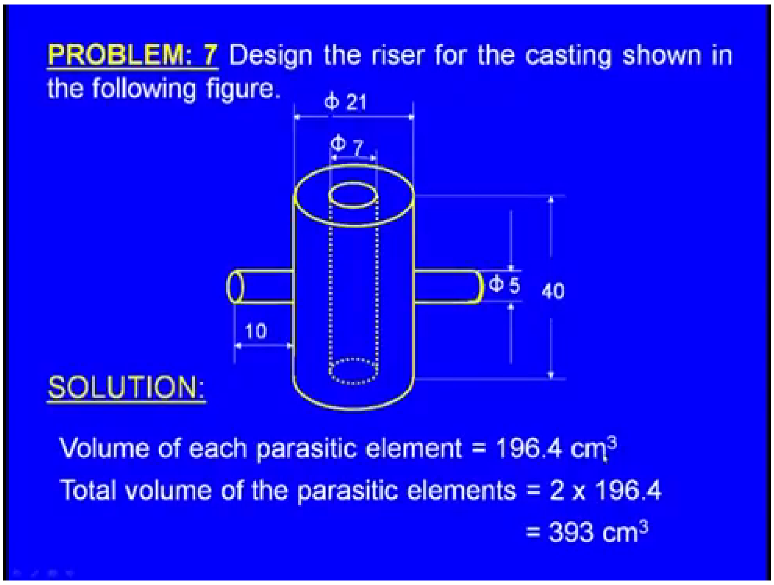

Total volume of the parasitic elements is just double 2 into 196 for that is equal to 393 cubic centimeters.

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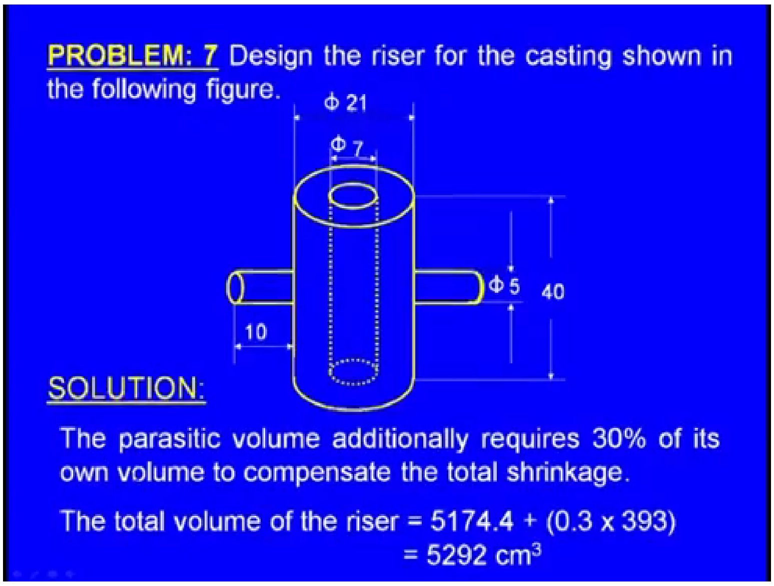

Now, the parasitic volume additionally requires 30 percent of its 1 volume to compensate the total shrinkage previously we have found out the riser volume that riser volume is enough provided these parasitic elements are not present, but once the parasitic elements are considered the volume of the riser must be more and what is the that excess volume in the riser that is the 30 percent of the volume of the parasitic elements.

Now, the total volume of the riser is equal to. So, if this is 5174.4 cubic centimeters. So, this is the volume we have obtained right without considering the parasitic elements plus 0.3 into 393 right cubic centimeters. So, this 393 is the total volume of the 2 parasitic elements. Now the total volume of the riser is equal to 5292 cubic centimeters. So, this is the total volume of the riser to be what say considered.

Now, we obtain the total volume of the riser then what about the dimensions. What is its ray height what is its diameter we need to find out. Now again we have another chart furnished by the Bishop and the team let us see the chart. Yes, this is the chart.

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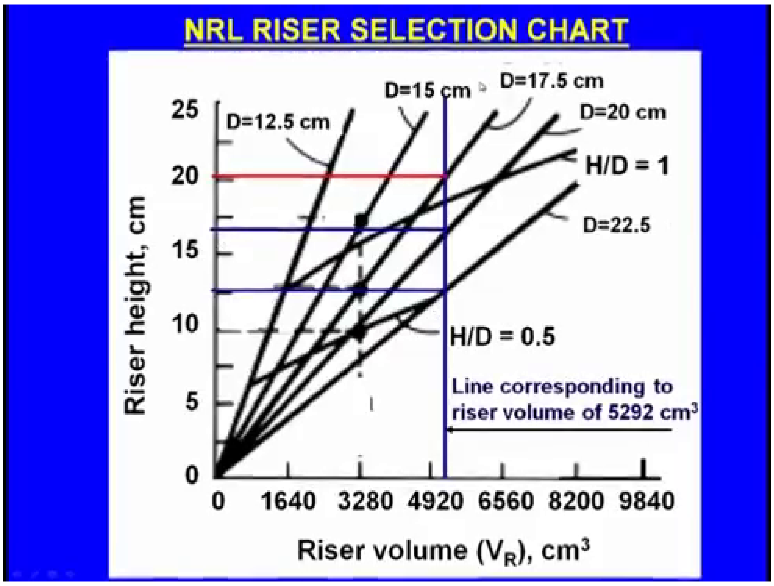

Now, in this chart again there are different lines are there this line represents 12.5 centimeters diameter of the riser and this line represents risers diameter as 15 centimeters and this line represents 17.5 centimeters diameter of the riser this line represents diameter of the riser as 20 centimeters and finally, this line represents diameter of the riser as 22.5 centimeters.

Now, we have obtained that the total volume of the riser, after considering the parasitic elements is equal to 5292 cubic centimeters now we need to what say identify that point on the x axis. Now in this graph, the x axis indicates the riser volume. Now let us identify 5292 cubic centimeters here. So, this point indicates the riser volume corresponding to 5292 cubic centimeters. So, from here you draw a line upwards like this. Like this and like this now this what say vertical line from at a at the riser volume of

5292 cubic centimeters has cut you can see 3 riser lines see the riser line of diameter 17.5 centimeters the riser line of diameter 20 centimeters the riser line of diameter 22.5 centimeters are cut by the line representing 5292 cubic centimeters riser volume.

Now, from here you can draw a line horizontally. Now this is one possible height of the riser and the diameter is 17.5 centimeters. Now again our line has cut the line riser. Line of diameter 20 to 20 centimeters here and from here you draw a line horizontally, and yes, this is another height possible height and the diameter is 20 centimeters and again our line has cut the riser line of diameter 22.5 centimeters here now you draw a line horizontally. So, this is the another possible height and the diameter is 22.5 centimeters. So, we got the 3 combinations, but there is a another class that the H by D ratio should not be greater than 1 the H by D ratio again should not be less than 0.5.

Now, these are the limits. So, this line represents the line where the H by D ratio is 0.5 this line. This line and this line you see this line this line represents H by D ratio is equal to 1. Now, this line and this line they are within the ranges they are within the ranges of say H by D ratio as 0.5 to and up to 1. What about this one this one? So, may where the diameter is 17.5 centimeters. So, here it has crossed the upper limit. So, this we have to exclude. So, this we are excluding only this one and this one we are considering. Means we are considering the riser diameter of 22.5 centimeters and the riser diameter of 20 centimeters only these 2 are, we are considering and their corresponding heights we will be what say calculating. So, one we are excluding in. So, after excluding that one which has crossed the upper limit of the H by D ratio we have two possibilities.

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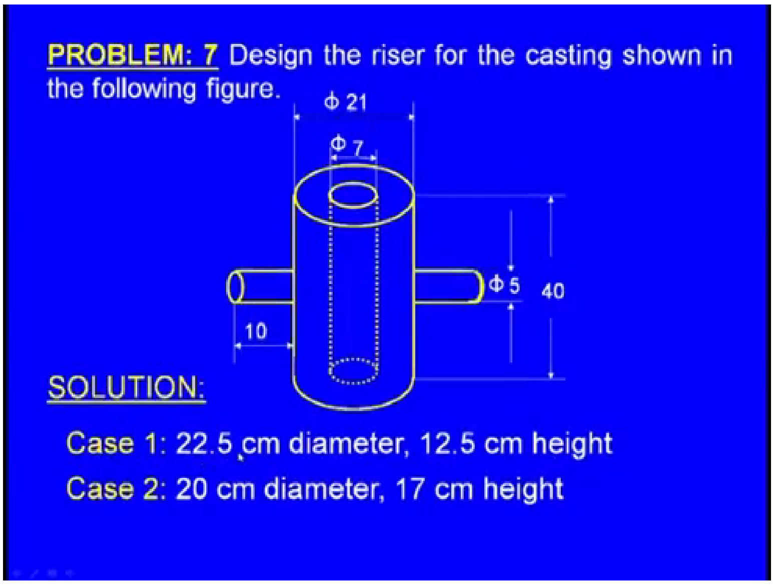

And in the one possibilities are in the first case the diameter of the riser is 22.5 centimeters and the height is 12.5 centimeters and in the second case or the second possibility the diameter of the riser is 20 centimeters and the height is 17 centimeters.

So, based on our convenience we can take any of this these combinations. It is up to us or it is up to the found remain. So, this is how we need to what say design the riser using the NRL method.

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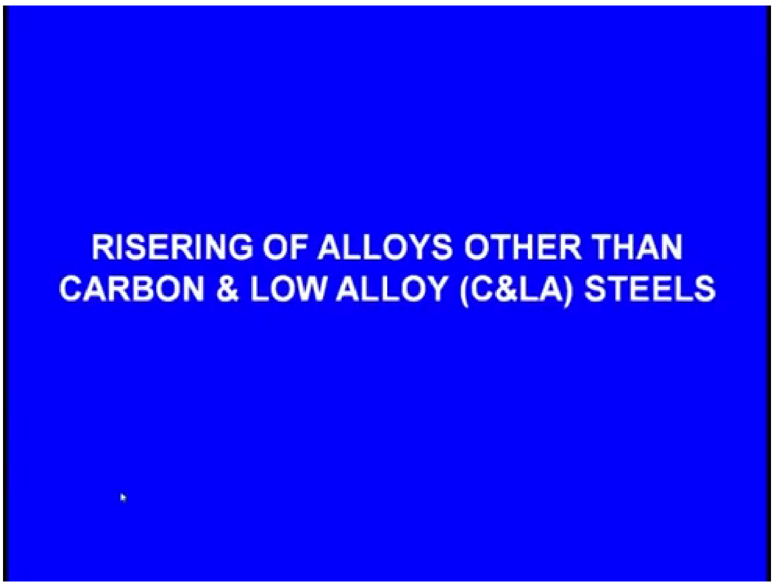

Now, risering of alloys other than carbon and low alloy steels in the beginning, I have told you that the NRL method or the naval research laboratory method which was a developed by HF Bishop and the team was applicable only for carbon and low alloy steels this cannot be applied for the other alloys.

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Now, what about risering of alloys other than carbon and low alloy steels? Again, there were subsequent investigations of Bishop and team, right. So, during 1958 J Varga and his team from the Battelle memorial institute USA continued the work carried out by HF Bishop and his team Bishop and the team they have done this work sometime during 1955 after 3 years Varga and the team from the Battelle memorial institute they have done. In fact, they have continued the similar work of the naval research laboratory method.

Now, J Varga and team carried out investigations on the risering of alloys other than carbon and low alloy steels. So, this carbon and low alloy steels are known as C and LA steels right. So, means Varga and team they have carried out investigations on the high alloy steels and they began their investigations with the shape factor concept proposed by the Bishop and team. So, these people have also what say used a factor called shape factor the same shape factor which was used by the Bishop and team.

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High Alloy Steels investigated by J. Varga and team

Alloy	Chemical composition by weight percent								
	C	Mn	Si	P	S	Mo	Cr	Ni	Fe
HF	0.20 - 0.40	2.0	2.0	0.04	0.04	0.5	18-23	8-12	Bal
HH	0.20 - 0.50	2.0	2.0	0.04	0.04	0.5	24-28	11-14	Bal
HT	0.35 - 0.75	2.0	2.5	0.04	0.04	0.5	15-19	33-37	Bal
CF-8	0.07 - 0.09	1.5	2.0	0.04	0.04	-	19	9	Bal
CA-15	0.12 - 0.18	1.0	1.5	-	-	-	12.5	1.0	Bal

Now, so these are high alloy steels investigated by J Varga and the team right. So, they have chosen say 5 high alloy steels 1 alloy name is HF alloy second alloy is the HH alloy third alloy is the HT alloy fourth alloy CF-8 alloy 6 fifth alloy ci 15 alloy.

Now, these are the compositions of these alloys HF alloys composition is carbon 0.2 to 0.4 percent, manganese 2 percent, silicon 2 percent, phosphorus 0.04 percent, sulfur 0.04 percent, molybdenum 0.5 percent, chromium 18 to 23 percent, nickel 8 to 12 percent and iron is the balance now in the HH steel carbon is 0.2 to 0.5 percent manganese 2 percent, silicon 2 percent, phosphorus 0.04 percent, sulfur 0.04 percent, molybdenum 0.5 percent, chromium 24 to 28 percent, nickel 11 to 14 percent, and iron is the balance and in the HT steel the carbon content is 0.25 to 0.75 percent, manganese 2 percent, silicon 2.5 percent, phosphorus 0.04 percent, sulfur 0.04 percent, manganese 0.5 percent, chromium 15 to 19 percent, nickel 33 to 37 percent and iron is the balance and in the CF-8 alloy the carbon content is 0.07 to 0.09 percent, manganese is 1.5 percent and silicon is 2 percent and phosphorus is 0.04 percent sulfur 0.04 percent and no molybdenum here and chromium is 19 percent, nickel is 9 percent and the iron is the balance and lastly in the c a 15 alloy carbon content is 0.21 to 20.18 percent and manganese. Manganese is 1 percent, silicon is 1.5 percent and no phosphorous, no sulfur, no molybdenum.

Chromium content is 15. 12.55 percent, nickel is 1 percent and the balance is the iron. So, these are the details of the 5 high alloy steels investigated by Varga and team. So, these are the high alloy steels which were not covered by what say Bishop and the team in the original NRL method.

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Now, Varga and team could develop 3 empirical charts similar to the one developed by HF Bishop and team. Now, in the Bishop and team, what they have done initially they have given as a graph. In that graph on the x axis we can see the shape vector and on the y axis we can see volume of the cast into volume of the riser to volume of the casting ratio V R by V C ratio we can see. So, from that graph we can find out the v r by V C ratio then there is the riser selection chart is there. So, these people also have done say 3 similar what say empirical charts they have prepared right.

So, these charts could be used to design top blind risers for the high alloy steels that are mentioned above. So, in the same way these people also have may what say develop the three charts right. So, using these three charts we can find out the V R by V C ratio.

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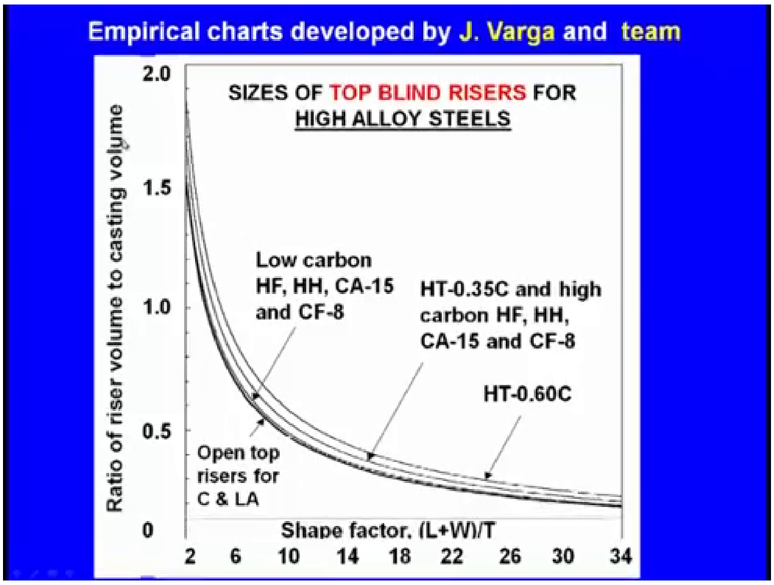

Now, this is the empirical chart developed by Varga and team here we can see you see there are four curves are there totally right the extreme on left curve is the curve which was developed by the Bishop and team. So, they have shown here for the comparison. Now, what let us see three more curves? We can see this is one curve and this is the second curve and this is the third curve. So, these people Varga and team they have developed three additional curves apart from the one which was developed by Bishop and team.

Now, what does this first curve represent it represents the what say it gives us this what say are ratio of riser volume to casting volume for low carbon HF HH , C A-15 and CF-8 high alloy steels. So, this first curve indicates these alloys now let us come to the second curve. So, this is the second curve what does this second curve what say furnishes it gives us the ratio of riser volume to casting volume for HT 0.35 carbon and high carbon HF, HH, C A-15 and CF-8 high alloy steels. Now, what about the third curve? This third curve gives us the ratio of riser volume to casting volume for HT 0.60 carbon high alloy steels.

So, these are the what say empirical charts developed by Varga and the team and you can see here the shape factor is the same shape factor which was defined by Bishop and the team l plus W divided by T were length is the L is the length of the section to be fed W is the width of the section to be fed and T is the thickness of the section to be fed the concept is same only thing is they have what say furnished three more graphs which represents what they different what say high alloy steels that were we have mentioned before.

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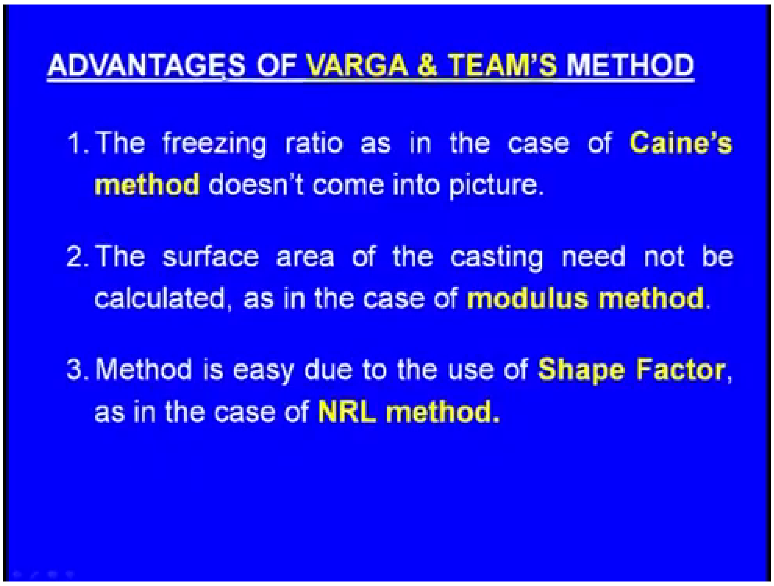

Now, these are the advantages of Varga and teams method. What are the advantages of the Varga and teams method the freezing ratio as in the case of the Caine's method does not come into picture freezing ratio is very complicated as far as the calculation is concerned. Surface area is to be found out volume means to be found out most of the times the surface area of the casting may not be simple maybe in our a what say example solved examples we are taking simple castings for the purpose of the what say solving, but in practice in the real world castings the surface of the casting would be very complex in such a case calculation of the surface area would be a tough task.

So, that is the what say drawback of the Caine's method we need to find out the freezing ratio. So, that problem will not arise in the case of the Varga and teams method the surface area of the casting need not be calculated as in the case of the modulus method [not only in the canes method even the modulus method. Also, we need to find out the surface area of the casting. So, that way a even here also we need not find out the surface area next one the method is easy due to the use of shape factor as in the case of the NRL method in the NRL method or the naval research laboratory method. What is the simplicity known need to find out the what say freezing ratio? No need to find out the modulus, no need to find out the surface area of the casting, just to find out the shape factor. Where shape factor is the L plus W divided by T where, L is the length of the section W is the width of the section and T is the thickness of the section very simple. In the same way, similar to the NRL method here also, one can use the shape factor the definition of the shape factor in the Varga method is exactly same as that of the what say original NRL method developed by the Bishop and team.

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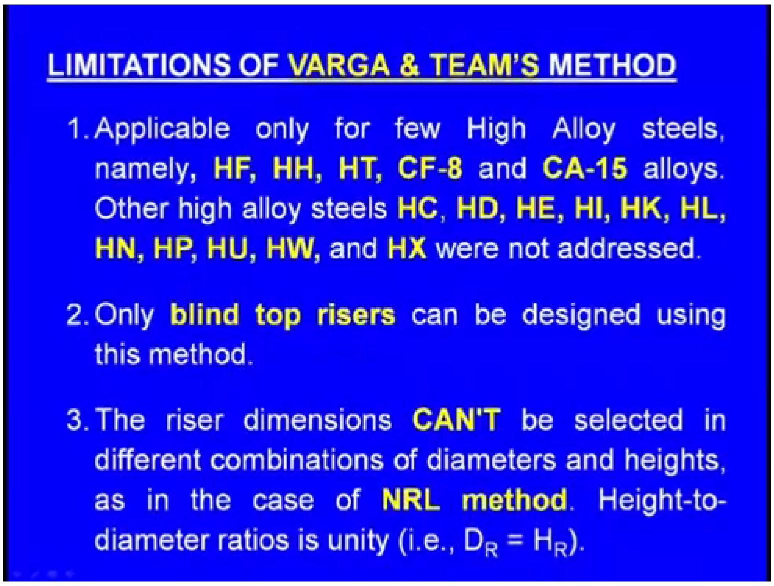

Now, let us see the limitations of Varga and teams method now Varga and team they have developed for five types of i alloy steels. What are they? One is the HF steel second one is the HH steel, third one is the HT steel, fourth one is the CF-8 steel high alloy steel and fifth one the C A-15 high alloy steels. Only for these five high alloy steels they have what say developed their method. What about there are more high alloy steels like HC steel, HD steel, HE steel, HI steel, HK, HL, HN, HP, HU, HW and HX steel. So, these were not addressed. So, these are also very important in the industry.

So, that is the first limitation of Varga and team. There is second limitation, second limitation is, only blind top risers can be designed using this method whereas, Bishop and their team in their virginal NRL method have what say given us a way to design the top risers open top risers whereas, these people have given us a way to design only the blind top risers then how to design the open risers for these alloys. No, that issue was not addressed. So, that is the second limitation of this method.

There is the third limitation that riser dimensions cannot be selected in different combinations of diameters and heights as in the case of the NRL method. In the NRL method, Bishop and the team they have given us a riser selection chart. So, in this riser selection chart we can what say make different combinations of the riser heights and diameters within the range. So, there is a range the H by D ratio should not be more than 1 again the H by D ratio should not be less than 0.5. So, with in this range, we can choose any combination of the riser diameter and height as per our convenience. So, that was the greatest advantage of the greatest advantage and flexibility of the NRL method compared to any other methods.

.So, here that flexibility is not there always the height to diameter ratio is unity means diameter of the riser is always equal to height of the riser. So, different combinations are not possible in the case of the Varga and team method. So, that way there are three limitations for the Varga and team method. Now, let us see the details of the high alloy steels investigated by J Varga and team right. The Varga and the team, they have developed this system for HF steel, HH steel, HT, CF-8 and C A-15 alloys.

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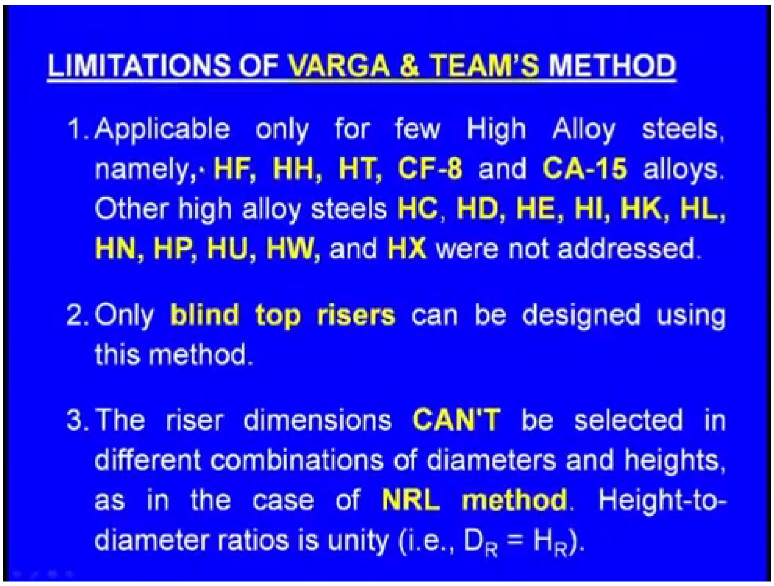

Now, we need to know little more about these high alloy steels before using them right. So, let us learn something about these steels what are they what say applications and so on details of the high alloy steels investigated by Varga and team.

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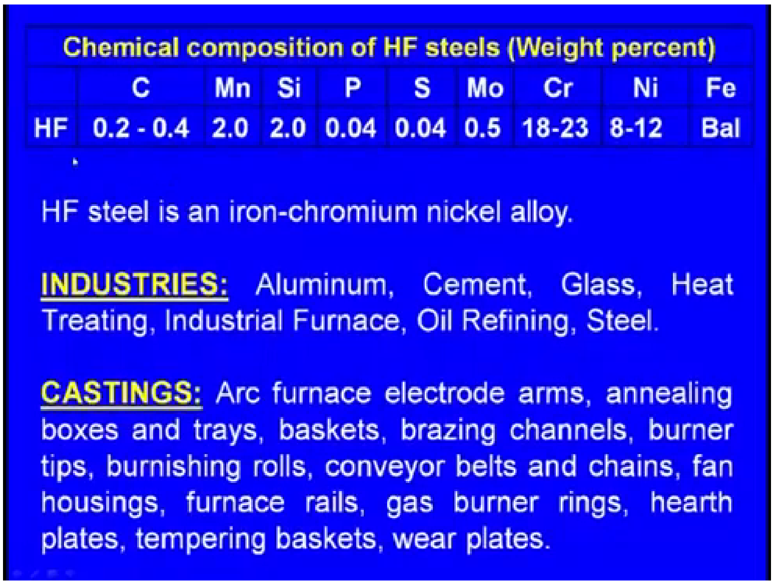

First alloy is the HF steel investigated by Varga and team. So, this is the chemical composition of HF steel this is by a weight percent carbon is 0.02, 0.4 percent, manganese is 2 percent, silicon is 2 percent, phosphorus 0.04 percent, sulfur 0.04 percent, molybdenum 0.5 percent, chromium 18 to 23 percent. Next nickel 8 to 12 percent and iron is the balanced HF steel is an iron. Chromium, Nickel alloy and what are the industries where this steam is used aluminum cement glass heat treating industrial furnace oil refining and so on.

Now, these are the actual what say castings made by this steel arc furnace electrode arms annealing boxes and trays basket braising channels burner tips burnishing rolls conveyor belts and chains fan housings furnace rails gas burner rings hearth plates tempering baskets and wear plates.

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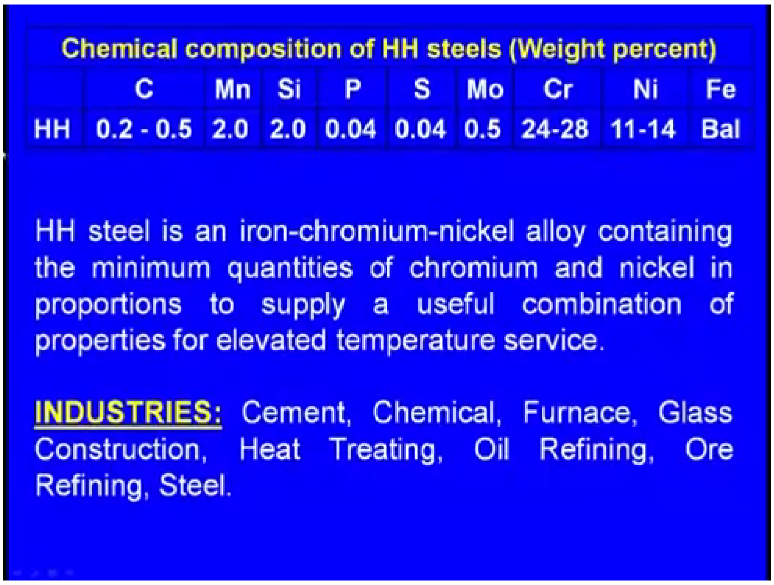

So, these are the important applications of the HF steel next one let us see the HH steel that was used by the Varga and the team. This is the chemical composition by 8 percent, carbon is 0.2 to 0.5 percent, manganese 2 percent, silicon 2 percent, phosphorus 0.04 percent, sulfur 0.04 percent, manganese 0.5 percent, chromium 24 to 28 percent, nickel 11 to 14 percent and iron is the balance right HH steel is an iron chromium nickel alloy containing the minimum quantities of chromium and nickel in proportions to supply a useful combination of properties for elevated temperature service and these are the industries which use the HH steel cement chemical furnace glass construction heat treating oil refining ore refining steel and. So, on and these are the actual applications means the castings right.

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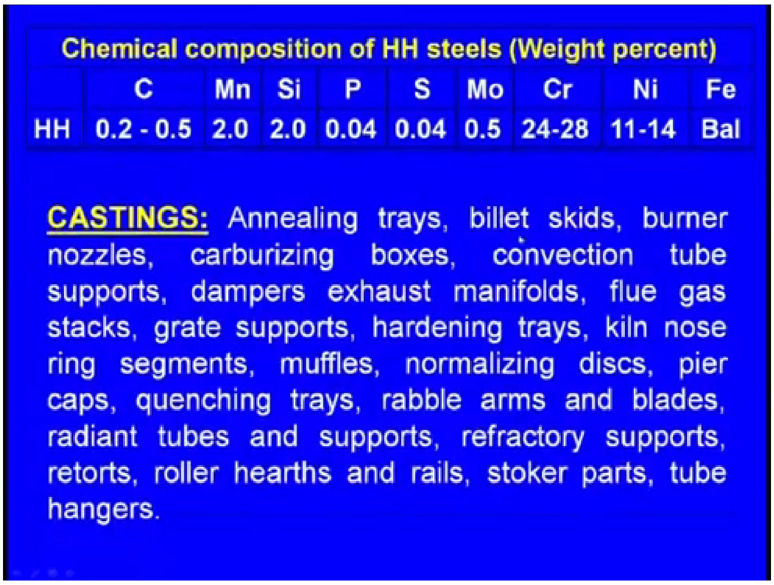

Annealing trays billet skids right burner nozzles carburizing boxes convection tube supports dampers exhaust manifolds flue gas stacks grate supports hardening trays kiln nose ring segments muffles normalizing discs right a pier caps quenching trays rabble arms and blades radiant tubes and supports refractory supports retorts roller hearths and rails stoker parts tube hangers.

So, these are the important applications of the HH steel.

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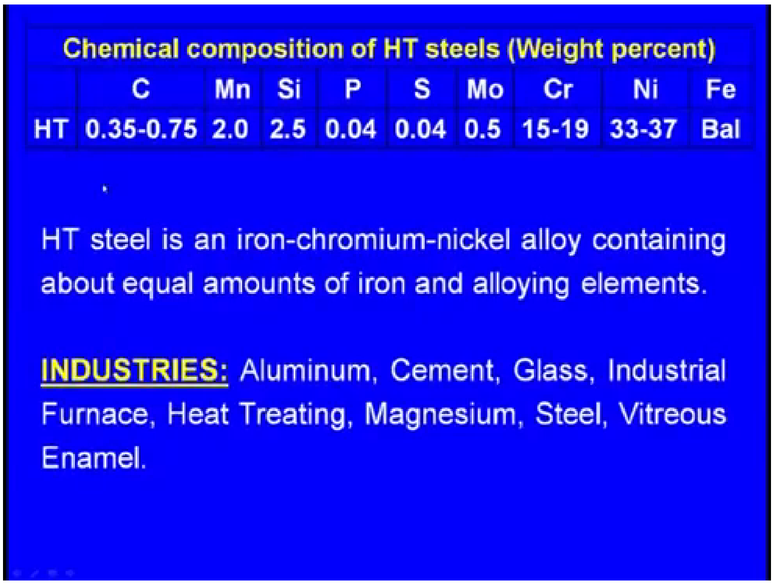

Next one let us see the HT steel the chemical composition by weight percent is carbon 0.35 to 0.5 percent, manganese 2 percent, silicon 2.5 percent, phosphorus 0.04 percent, sulfur 0.04 percent, molybdenum 0.5 percent, chromium 15 to 19 percent, nickel 33 to 37 percent and the balance is the iron HT steel is an iron chromium nickel alloy containing about equal amounts of iron and alloying elements. Here, you can see the alloying elements are too much. The proportion of the alloying elements is too much.

Now, these are the industries which use the HT steel aluminum cement glass industrial furnace heat treating magnesium steel and vitreous enamel.

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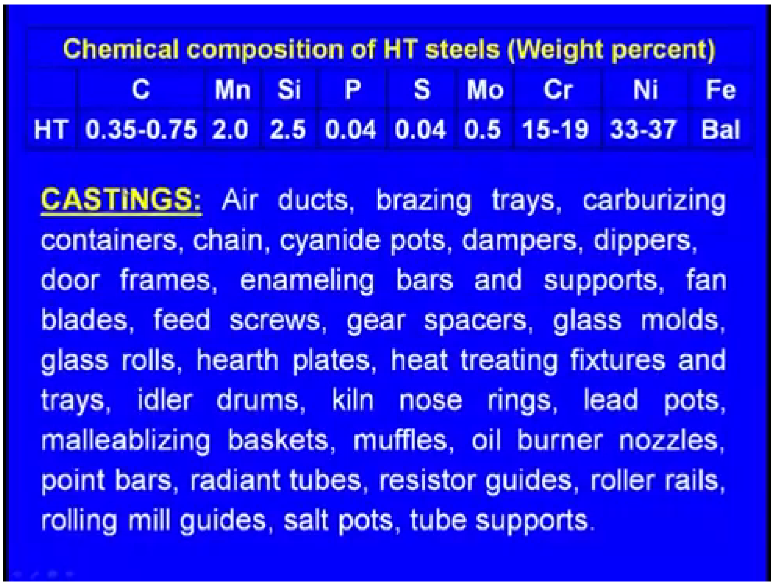

Now, these are the actual castings with which HT steel is used right. Air ducts, brazing trays, carburizing containers, chains cyanide pots, dampers, dippers, door frames, enameling bars and supports, fan blades, feed screws, gear spacers, glass molds, glass rolls, hearth plates, heat treating fixtures and trays, idler drums, kiln nose rings, lead pots, malleablizing baskets, muffles, oil burner nozzles, point bars, radiant tubes, resistor guides, roller rails, rolling mill guides, salt pots and tube supports.

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So, these are the important applications of the HC steel now HF Bishop and team developed empirical charts for carbon and low alloy steels. So, this we have already learnt in the beginning. See the original NRL method are the naval research laboratory method was developed by Bishop and the team and they were working in the United States navy and they have develop the NRL method only for carbon and low alloy steels and they were from the naval research laboratory of the US navy.

So, this is the what say graph they have given us to determine the V R by V C ratio on the x axis we can have the shape factor and on the y axis there is V R by V C ratio and with once we find out the shape factor.

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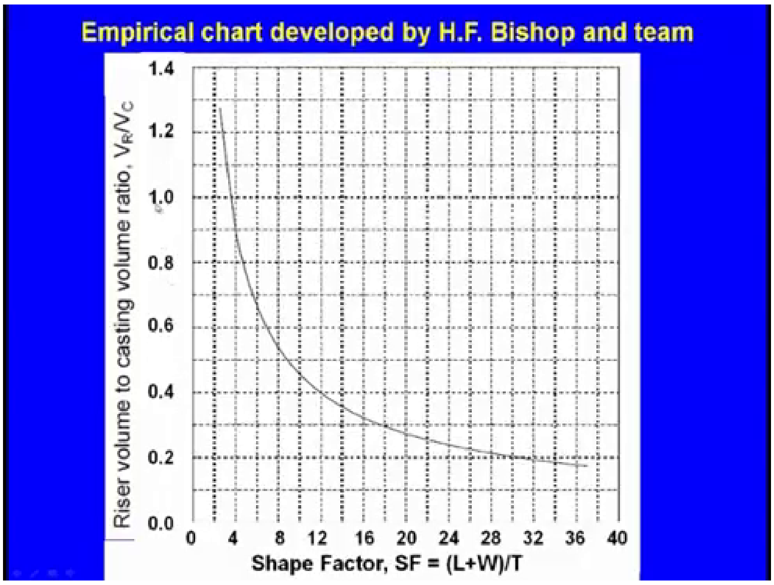

We can also find out the V R by V C ratio after that yes, there is a what say riser selection chart is there we can also find out the riser diameter and the riser height in different combinations.

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After Bishop and the team Varga and team furnished three empirical charts for high alloy steels other than the carbon and low alloy steels along with the one developed by the HF Bishop and team HF Bishop and team have developed the graph for the carbon and low alloy steels and they have plotted a graph against the shape factor and the V R by V C ratio. Now, these people Varga and people have furnished to 3 graphs for the high alloy steels along with those three graphs they have also included the graph which was developed by the Bishop and team right these people Varga and team were from Battelle memorial institute USA.

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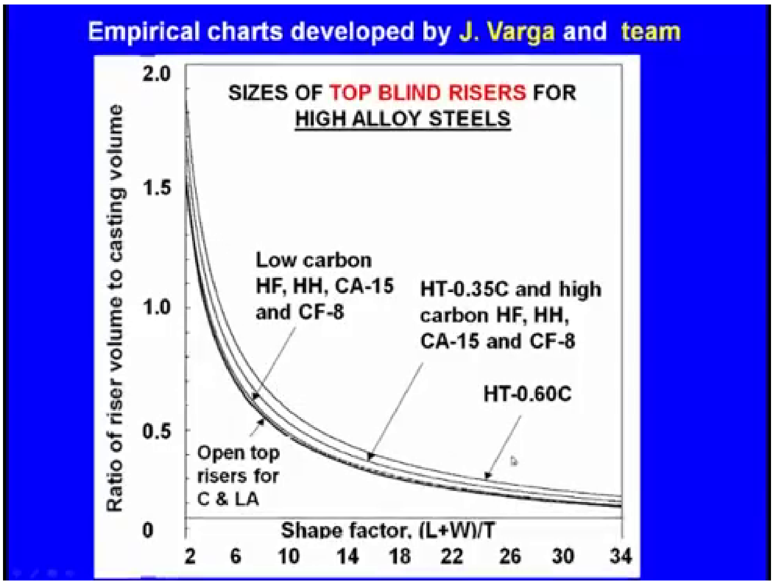

Now, this is the graph developed by the Varga and team. We can see here and only top blind risers for high alloy steels can be what say designed using these graphs and same shape factor is there on the x axis and what say V R by V C ratio is there on the y axis.

Now, the first graph you see this is the open top raisers for the carbon and low alloy steels. So, this graph was developed by the Bishop and team the original what say NRL method whereas, the second curve, third curve and fourth curve were developed by the Varga and team both the teams have used the shape factor for designing the riser.

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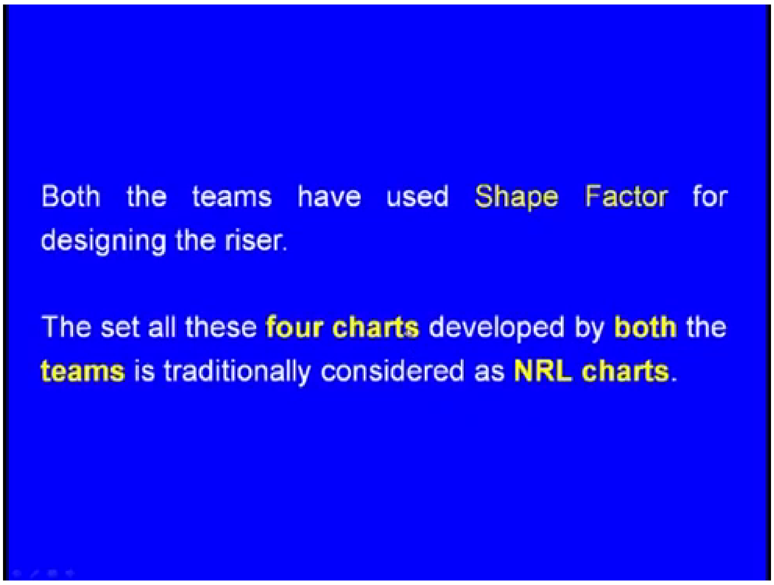

So, that say what say in interesting thing, but the set of all these four charts developed by both these teams is traditionally considered as the NRL charts.

Now, what happens people say consider this whole thing as the NRL method because the original graph developed by the Bishop and their team in the original NRL method is already here in addition to this three more graphs are there which are meant for the design of the riser for the high alloy steels. So, this whole set of these four curves is known as the NRL graphs. This is the traditional NRL charts. Friends, in this lecture we have seen the design of the risering system for the carbon and low alloy steels and this method was developed by the Bishop and their team then. They were from the US navy that is why it is known as the naval research laboratory method and after that another team Varga and team they have developed the risering curves for the high alloy steels.

So, totally there are four curves are there. So, this is known as the naval research laboratory method what say graphs right and we have seen how to what say design the riser first initially we need to find out the shape factor and from the shape factor we need to find out the V R by V C ratio means volume of the riser to the volume of the casting ratio then, once we find out the what say volume of the riser using the riser selection chart we can also find out the diameter of the riser and height of the riser. So, that is what we have learnt in the NRL method.

So, with this, we are completing the NRL method. In the next class we will be learning more topics on the risering system.

Thank you.