Theory of Production Processes
Dr. Pradeep Kumar Jha
Department of Mechanical Engineering
Indian Institute of Technology, Roorkee

Lecture – 14
Risering methods

Welcome to the lecture on risering methods. So, in this lecture, we will talk about different methods for the riser volume calculation. So, we have discussed in the earlier lecture that you require the sufficient amount of volume of liquid metal in the riser. So, that it can feed to the casting in case of shrinkage. Now, the thing is, that we know by using the Chvorinov’s rule that t is proportional to V by SA square.

Now, what does it mean? It means that solidification time will be proportional to volume by surface area square.

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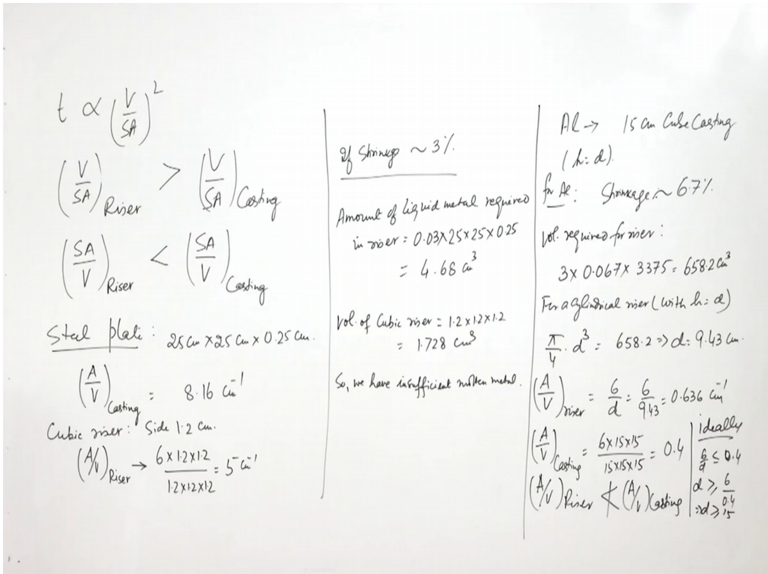

So, suppose, so there also we discussed that for riser this t should be higher, means the V by SA for riser should be higher than the casting. So, V by SA for the riser has to be more than V by SA of casting because riser must solidify later than the casting. Then only the riser will be able to feed the liquid metal to the casting, conversely if you take the surface area by volume of riser, then this has to be less than surface area by volume of casting.

So, this is basically time of solidification, so this will be basically proportional to the time of solidification, so V by SA and this will be the inverse of that. So, if this is more for riser, this has to be lesser for the riser because if this value is higher it will take less time to solidify. So, this has to be of the lower values.

So, then again what should be the quantity of the riser amount that is also important. So, as you know that rising requirement is because of the contraction or shrinkage which take place during the solidification and we know that what is the typical amount of contraction values or shrinkage values that is normally is in certain percentage of the volume and that varies from 3 to about 7 percent.

So, if you know these percentages and if you know the casting volume I mean you can say that at least this much of amount of liquid metal is required for the riser. So, both the things are important you must have sufficient volume of the liquid metal in the riser. So, that it can be fed whenever there is shrinkage in the casting, also this freezing characteristic conditions should be satisfied, surface area by volume of riser should be basically you know satisfied I mean it is this should be less than surface area by volume of the castings. So, these are the conditions which should be satisfied.

Now, let us take an example, suppose you are taking a steel plate of dimension 25 by 25 by 0.25 centimeter. So, suppose you take steel plate of dimension 25 by 25 centimeter by 0.25 centimeter. Now, if you look at this plate for this if you find the A by V. So, A by V of casting, so A by V you can find it.

Now, you can find it by A by V like 2 into 25 into 25 plus 25 into 0.25 plus 25 into 0.25. So, if that is calculated that comes out to be 8.16 per centimeter. So, A by V of casting comes out to be 8.16 because V we know, V will be 25 into 25 into 0.25 and A we can find it. Now, if we take suppose a cubic riser of dimension 1.2 centimeter, side 1.2 centimeter. So, if we try to find it is A by V, so A by V of riser. So, this A by V of riser that will be basically again we can calculate 6 into 1.2 into 1.2, divided by 1.2 into 1.2 into 1.2. So, it will be 5, so again that is what we get in case of cubic riser.

Now, the thing is what we see here is A by V of the casting is 8.16 per centimeter and A by V of riser is again 5 per centimeter. So, what you see is A by V of riser is less than A by V of casting. The thing is that, this condition is satisfied, but let us see whether it satisfies that what is I mean on the aspect of quantity of the metal which is required. So, suppose if the 3 percent is the shrinkage amount, if shrinkage amount is 3 percent; shrinkage is 3 percent, volumetric shrinkage is 3 percent let us say, in that case the amount of liquid metal required in riser that will be basically 0.03, 3 percent of the volume, volume of the casting.

So, casting is 25 into 25 into 0.25. So, basically that comes out to be, so if we to take that, so that comes out to be about 4.68 centimeter cube. So, this is the amount of liquid metal which is required for the riser. Now, what we see, we have the riser suppose you have selected the riser of cubic shape of side 1.2 centimeter. So, what is it is volume, now volume of the cubic riser that is coming out to be only 1.2 into 1.2 into 1.2. So, it will be 1.728 centimeter cube.

Now, this is basically less than this, although it is satisfying the condition for the freezing characteristic, but the amount of liquid metal which is required that is not sufficient. So, you have, so we have insufficient riser volume, I mean molten metal. So, this sufficiency condition is not met. In fact, even you will have to have the volume more than this because riser is also a casting and that will also solidify. So, this much for, this much of volume required you need even a larger dimension larger configuration. So that, this it can release at least this much of liquid metal if required.

So, this is very important because that is how we see, that why the rising is required? Why a certain volume is required? So, we do not know what will be the volume of metal required. We can have another example, let us say you have a cube of 15 centimeter each side.

So, let us say that you have the aluminum of, so you have aluminum as the liquid material and it is a 15 centimeter cube casting and if you take the riser of cylindrical shape and for the you can find this V by A to be minimum or as A by V to be I mean V by A to be maximum or A by V to be minimum, you can have the condition that for which you know condition this for cylindrical riser for what ratio of h and d the A by V will be minimum or V by A will be maximum, that condition can be found out and it can be calculated and it can be found that for h equal to d you get suppose that optimum condition.

So, you need to design a riser for which suppose the h equal to d and you want to find that for this casting of aluminum which is 15 centimeter a cube, in that case let us see how it finds. So, suppose you, it has a again it is 6.5 percent of contraction is there. So, suppose for aluminum shrinkage is 6.7 percent. Now, if we assume that you take 3 times the volume required, as you would know that this is the volume which is required of for metal to be fed.

Now, you assume, sometimes empirically or sometimes just roughly they assume that you take 3 times the volume. So, if you take that in assumption, so the volume of this material for the riser that will be required as, so volume required for the riser it will be 3 times 6.7 percent of the volume of the casting. So, this can be found out and this is computed out to be suppose, 658.2 centimeter cube.

Now, this is suppose you have taken based on the assumption that you take 3 times the volume of the shrinkage amount for just for being the safe side and let us see if you design the riser based on that for a compact case for h equal to d what will happen. So, for h equal to d, now if this is the volume of the riser, so for a cylindrical riser with h equal to d. So, it will be pi by 4 h cube or d cube and that will be 658.2. So, you can have d value you can compute it and this is computed out to be about 9.43 centimeter.

Now, this is the diameter of the cylindrical riser which is basically there corresponding to if you have taken the liquid metal to be 3 times the shrinkage which you feel and which will be basically will a that is 6.7 percent of the volume. Now, we can find the A by V of the riser and A by V of the casting. So, suppose A by V of the riser if you take it, A by V of riser. So, A by V of riser will be 6 by d, whereas equal to d and when both the surfaces top and bottom as well as the curved surfaces are you basically taking part in the heat extraction in that case that will be A by V will be 6 by d.

Now, A by V will be 6 by d, so that will be 6 by 9.43. So, 6 by 9.43 that will be 0.636, so this is A by V for the riser, we can also find A by V of the casting and if we find a by v of the casting, so A by V of the casting will be a will be 6 times area. So, that is area of 1 face divided by the volume of the casting. So, it will be 0.4.

Now, what you see is A by V of the riser is 0.636 and A by V of the casting is 0.4 and for meeting this condition that A by V of riser should be less than as A by V of the casting, we see that this condition is not met. So, even if you have sufficient amount of this volume of liquid metal in the riser, it does not ensure that this will, so it is in fact, what you see is A by V of riser is, so A by V of riser is not less than A by V of casting.

What does it mean? It means that, riser will solidify early than the casting. So, even if you have sufficient amount of liquid metal, the volume sufficiency condition is met this is seen that the riser is going to solidify early. So, that is not going to serve the purpose and that is why this will not work. So, basically it has to see your riser this one, this cannot be more than 0.4. So, once you give this A by V riser 0.4 from there, you have to get the diameter of the riser. So, what you see is you can get the riser diameter by putting this value to, the A by V, so that you can further find the value of the dimension of the riser.

So, 6 by d has to be basically, so ideally 6 by d has to be less than equal to 4. So, that is what the condition tells that is 0.4. So, d has to be more than equal to 6 by 0.4. So, that is d has to be more than equal to 15. So, at least you need a riser of diameter, 15 centimeter for having the condition that it will solidify later.

So, what we see, is that it is very important to have these conditions meet and also it is important to know that there are 2 requirements, 1 is the freezing characteristic of the material which is important for calculating the dimension of the riser, whereas the sufficiency of the volume, the volume must be sufficient. So, that the riser is can basically see that it will be able to feed the liquid metal required in that case.

So, what we see, have seen that these conditions are to be kept in mind and then the riser volume is quite required to be computed. So, we will discuss the different methods which have been given by the researchers by doing certain experiments and there are certain principles based on these characteristics that how to calculate the riser volume required for feeding a casting, so that you ensure that there is no shrinkage in those cases.

So, let us move to the different methods. So, 1 of the method which has been suggested, the first method is by Caine. So, that method is known as Caine's method. So, Caine's have given this condition 1 given by 1 expression that is x equal to a by y minus b plus c.

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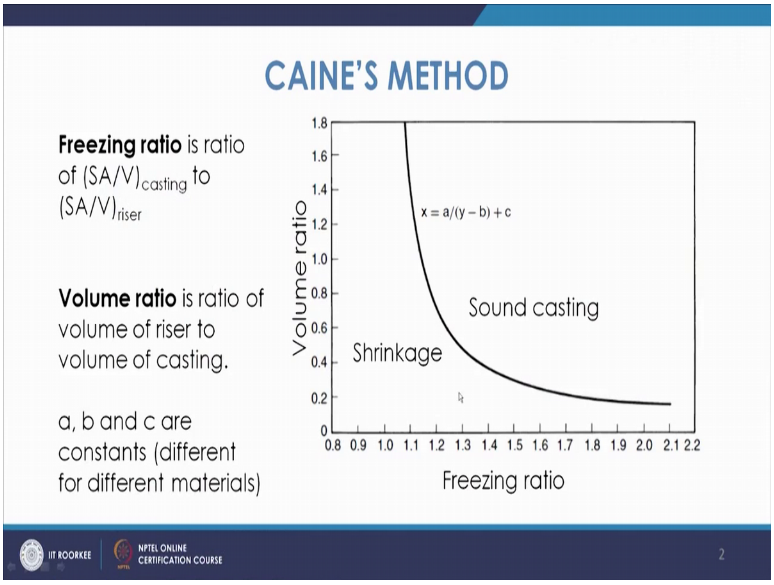

So, this is the, we see here this is the line which talks about the condition of the casting. If the, if you have the volume ratio volume ratio is nothing but, so in the x direction let us have, the x direction is freezing ratio. So, basically it is representative of the freezing characteristics we have seen that V by A or A by V talks about the freezing characteristic of the casting.

So, V by A basically is proportional to you can have that in mind that it is somewhat proportional to because t is anyway proportional to V by SA square. So, that way keeping in mind, so that it is inverse is SA by V. So, let us say if the SA by V is taken, then this freezing ratio; it is ratio of SA by V of casting to SA by V of riser or you can say V by SA of the riser to V by SA of casting. So, that way it is the x dimension is that and the y axis this is basically volume ratio that is ratio of the volume of riser to volume of casting.

So, once you have any casting, if you have the casting, now for that you have to calculate these freezing characteristic values and this is basically SA by V casting you know. So, you can have the surface area of the casting, you can have the surface volume of the casting, so that is known. So, once you know that, you will have SA by V of casting. Now, find to find SA by V of the riser. So, for riser, you have to have though condition known to you that what kind of riser you want to have. So, suppose you are taking the cylindrical riser with all it is faces you know taking part in extracting the heat.

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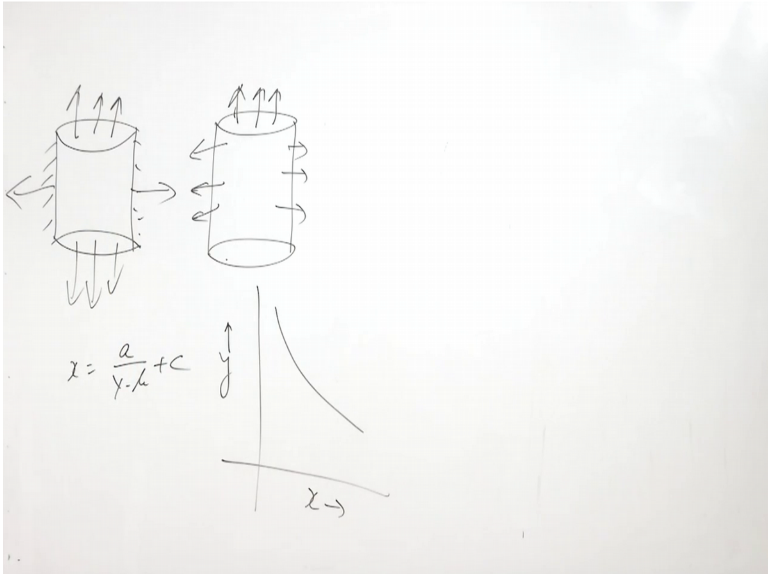

So, if you take the cylindrical riser suppose, you are taking a cylindrical riser. Now, you can have the condition whether you can allow all the portions to extract heat or sometimes, many times you what you do is, so you with all the surfaces; the heat is extracted, but not from here because we assume that the bottom part is in touch with the casting sometimes either be the top riser or even the side riser, if it is in very much proximity to the casting then this portion does not get involved directly I mean it does not aid in the transfer of heat from this face.

So, you can have 2 key cases, 1 in 1 case you will have V by h d by 5, in another case it will be v by h d by 6. So, depending upon the situation you will have d by 6 or d by 5. Now, based on that once you have that condition, you know this SA by V of riser also in terms of the diameter of the casting and that whether h u and d of what ratio you are taking that is up to you. So, that also again is on your choice you are taking a cylindrical riser of h equal to 2 d or h equal to d.

So, once you know that in the term of h or d you know SA by V of riser. So, now, you put in this equation x equal to, so you will have x equal to a by y minus b plus c, so that is what the equation is. Now, in this equation you will have this equation this is x and this is y. So, once you know this, this x you can compute that will be in term of d and then for that this equation is solved. So, you will put here in that equation and then you find. Now, if the thing is what we see here, is that you will have to see.

Now, this volume ratio of riser also can be found out they that will again be in the term of d. So, it will have that because you know the volume of casting and you know the dimension of the riser that you have assumed with 1 variable that is d or h. so that also known. So, that is becomes an equation and once you give that in equation you are you can solve it, now here, this, a b and c are constant.

So, for different materials you have different constant values. So, this becomes basically an equation the polynomial equation it comes out and that needs to be solved for that value of d. So, that basically is solved normally you will have to solve it and that is solved by iteration methods. So, it will take time, but you can get the values. Now, this graph tells that this, if this for any freezing ratio value. If the value comes out in this region then your casting a sound, otherwise if it falls in this region then your casting is likely to have the shrinkage.

So, this graph is given by Caine's method, I mean Caine and that is why this method is known as Caine's method. So, in this the advantage is that you have to solve an equation, but that is also a disadvantage, that this equation is a complex equation that needs to be solved by a iteration method and you can solve it. You will be given the value of a b and c in the problem, so that you can solve it.

We can solve these questions maybe in the next lecture, when we solve certain questions. Next method is the NRL method or naval research laboratory method or shape factor method.

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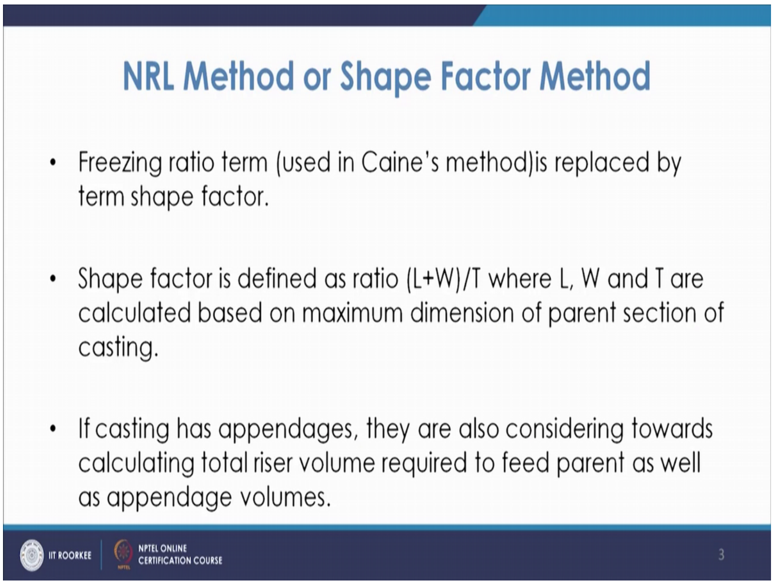

So, that is in an improvement over this Caine's method in the sense, that there you have to solve a complex equation. So, basically that is replaced this freezing ratio term which is there on the x axis, this term this freezing ratio term, so that is basically replaced with the shape factor and shape factor is nothing but L plus W by T, so length plus width by thickness.

So, once you know the length and width and the thickness of the casting, you find the value and then you have a graph that graph you can use.

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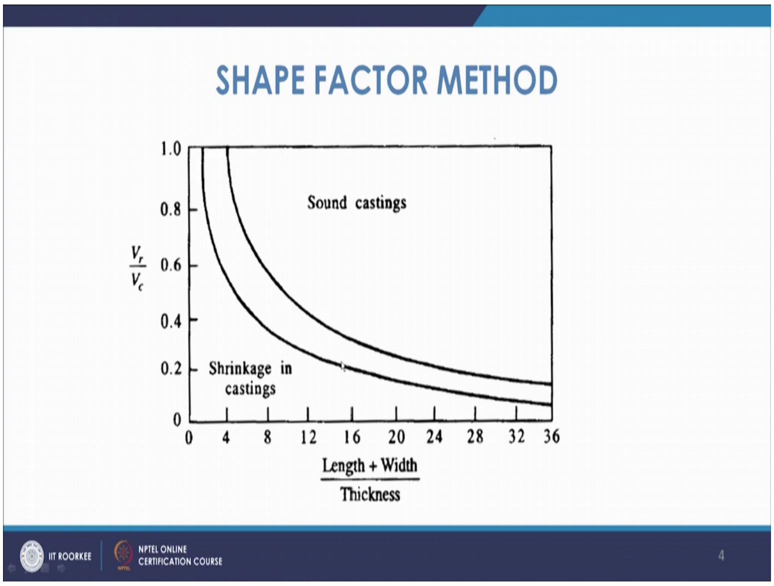

So, this is the graph which is proposed by the NRL, naval research laboratory and that is why it is known as NRL method. So, once you know the length plus width by thickness, then for suppose here if you come in between this you can have satisfactory results and if you come here in this region it is sound casting, but if you fall below that then this v r by v c for this, you will have the chances of porosity.

So, that is why, it is an easier method because simply you have to calculate the length plus width by thickness. So, from there you will get v r by v c point, you can just refer this point, you may have a single line also. So, you may have a single line from there you go there and you can have the satisfactory results. So, if you get that v r by v c, once you know v c you can find v r that is riser of riser volume.

So, this is a method which is used for calculation of the riser volume. Now, in this case even the appendage volumes are also taken into account. Now, in this case if the casting has appendages they are also considered, considering towards calculating the total riser volume. So, in this case what is meant is because you have length, width and the thickness is of the dimension, this, these dimensions are taken into consideration.

So, you know the casting is taken as either a plate or a bar that cross section. So, once you have that consideration in mind, then you have to have the consideration like what kind of appendage is there, whether main casting is plate and it is feeding that appendix volume that is bar or main casting is bar feeding to a plate like that.

So, in that case that contribution has to be added to total riser volume. So, if you look at this.

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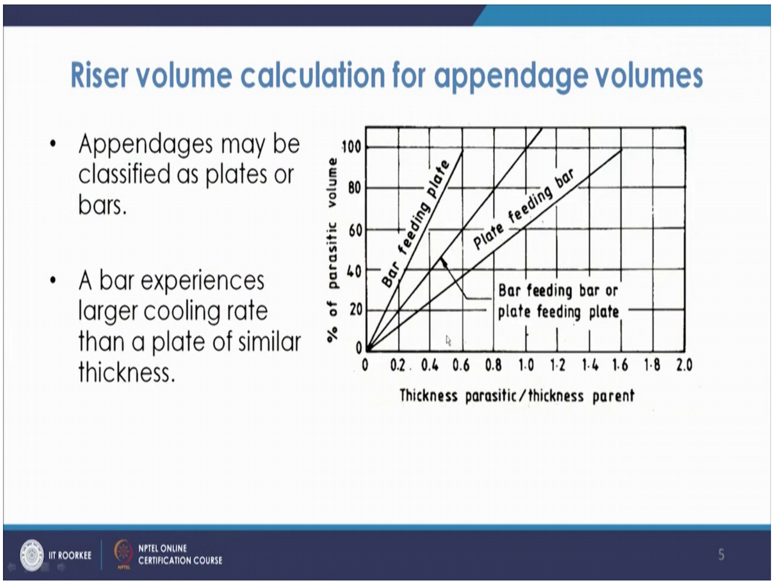

Suppose the main casting is bar and it is feeding a plate, in that case by this curve if the thickness parasites, so this appendage volume, suppose what happens many a times you have a casting like this and this, suppose you have a casting like this. Now, this is basically the main casting which is feeding these 2.

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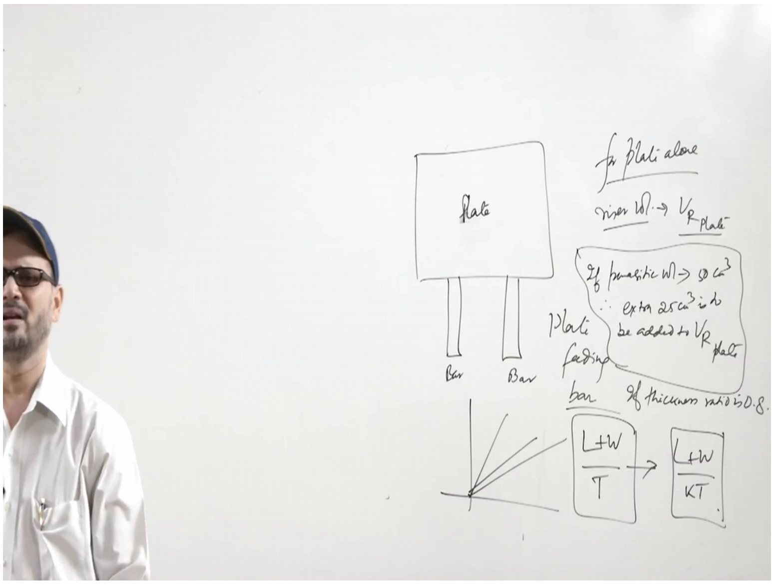

So, this is a case of, suppose this is a bar and this is a plate or this is a plate and this is bar. So, this is a case of plate feeding bar, plate is feeding bar. So, you can, what you can do is first of all you will have to find the requirement of riser volume for this plate.

Suppose for plate alone, riser volume comes out to be V R, V R plate, then you need some extra material for the bar also because this plate is feeding the to the bar also. So, what you will do? You will use this, you know graph and what you will do is, you will find the thickness of this bar to thickness of this plate ratio. So, that is thickness parasite by thickness parent, parasite means the appendage, which is taking the liquid metal from this main casting.

So, you will have the thickness ratio, once you have the thickness ratio then you go to typical curves, you have the typical curves as you see. So, this is the case of plate feeding bar. So, suppose if the thickness has ratio of 0.8, then for 0.8 you will see that, you will have this point suppose 50 percent of the, 50 percent will be the percentage of parasitic volume means if the parasitic volume is, so if parasitic volume is suppose 50 centimeter cube.

So, extra 25 centimeter cube is to be added to VR plate. If thickness ratio is 0.8, what you see is that if the thickness ratio for the bar and plate is 0.8, in that case for this plate feeding bar condition 0.8 it is 50 percent. So, that is why if the, if it is whole volume is 50 centimeter cube in this you will have to add the 50 percent of this 50, that is 25 centimeter cube and then the total riser volume will be required.

So, this method has that advantage also that this is used for calculating the riser volume even in the case of appendices. Next method is, so even in that case sometimes for hollow cylindrical shapes sometimes, the shape factor when you have the hollow projections in those cases the shape factor is altered.

So, suppose you have a core in between and the depending upon the diameter of the core this correction factor. So, this L plus W by T, so shape factor L plus W by T, this is changed to L plus W by K T and this value K comes from this table because when you have a core in that some effective surfaces they are not basically can be seen, that they cannot be considered as the surfaces which are extracting the heat.

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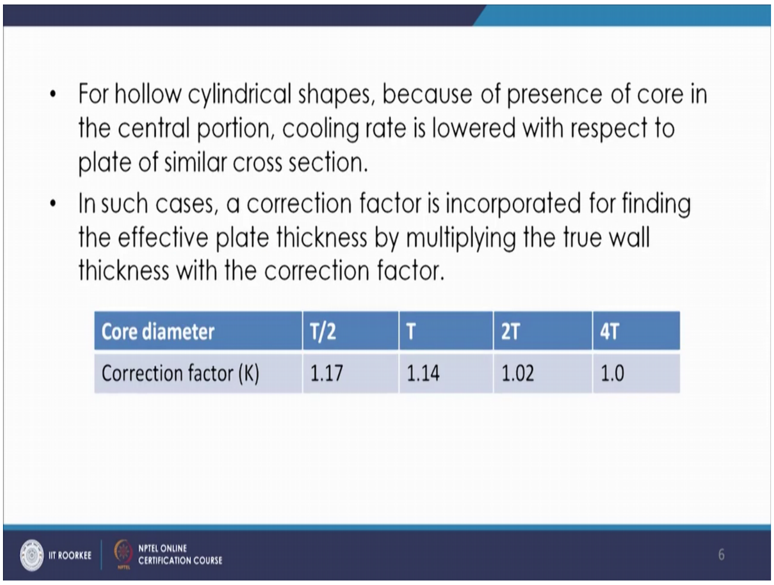

So, depending upon the diameter of the core this correction is to be incorporated and the value of K you can have, so in those cases, when you have that the core dimension is given, the external diameter and internal diameter is given, so you know the thickness. So, that basically if the core diameter is T by 2, thickness by 2 in that case correction factor is 1.17, if it is T 1.14 or so. So, that is 1 correction which has to be put, correction factor is to be put in this method.

The next method is modulus method.

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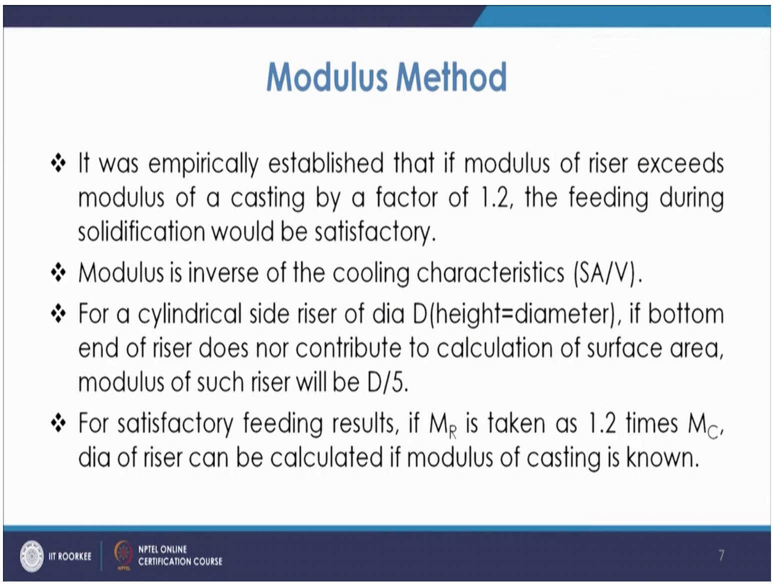

So, what has been seen is that, as we know that T is proportional to V by A square. So, suppose V by A term, volume by cooling surface area this is known as modulus of the casting.

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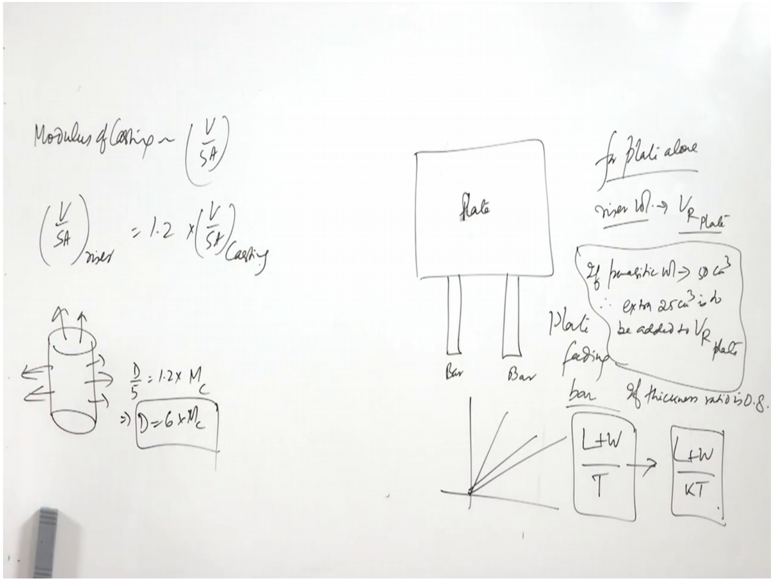

So, modulus of casting, it is defined as V by SA, will be by cooling surface area; volume by cooling surface area. Now, the thing is that volume this term we discussed that for riser it must be more than that of the casting. So, it was seen that the V by surface area, that is modulus of riser, if it is 1.2 times A by SA of casting, in that case it is seen that the casting is satisfactory.

So, what we see is that if you get this, so if you know the casting, if you have the casting with and you know the volume and surface area of that casting. So, based on that you can directly get the dimension of the riser and if, so as you know, that m c is the suppose d by 5 is so far suppose cylindrical side riser where you take height and diameter and you we discussed that you are taking a cylindrical side riser and you assume that this part is not contributing bottom part only top part is contributing. So, for that the volume by surface area will be d by 5.

So, d by 5 will be there, so this will be riser and this will be 1.2 times volume and by surface area of the casting, that is modulus of the casting. So, in that case you directly get d equal to 6 times modulus of the casting. So, you can directly get the diameter of the riser, if you know, if you have the, these volume and surface area of the casting known. So, that this is another method which is there for calculating the riser volume.

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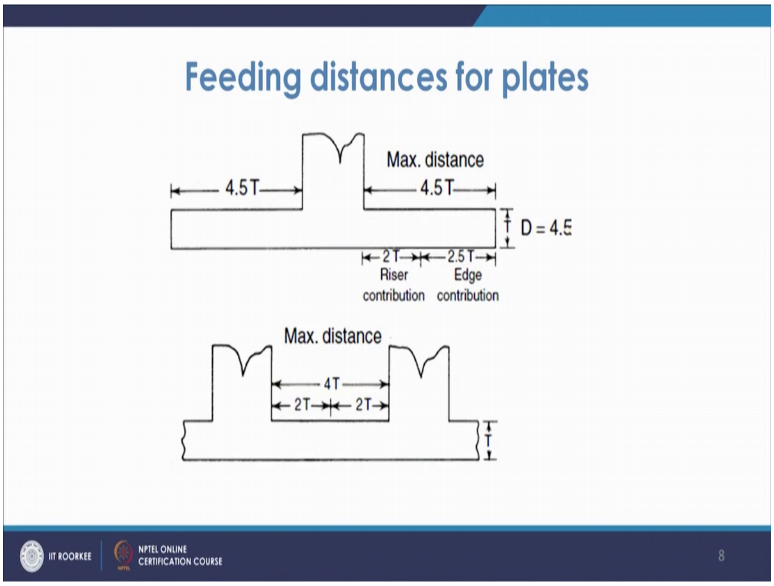

Then you must know also, the feeding distances for plates and bars. So, that is very much clear, that once you have the riser, how much up to what distance it will be able to feed the liquid metal. So that, for suppose if the plate casting as you see that you have the maximum distance in 1 side is 4.5 T. So, that is riser contribution is 2 T and the edge contribution is 2.5 T. So, this way you can say that, you have this amount that is riser contribution as well as edge contribution for a plate dimension.

So, if you keep 2 risers, in between as you see riser contribution is 2 T and 2 T from both the sides, so it will be 4 T here and then this side you will have the edge contributions.

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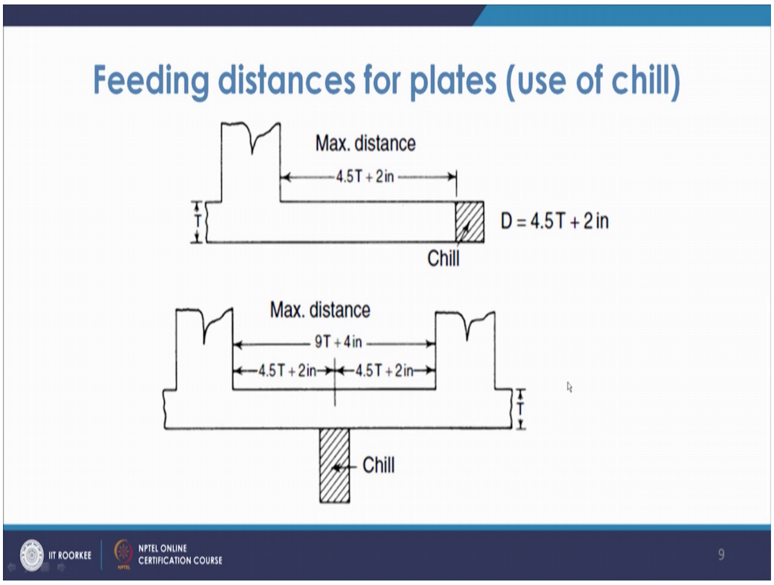

Similarly, you will have the, for plates when you use the chill, in the case of chill you will have the extra contribution by the chill. So, extra contribution (Refer Time: 36:20) by the chill is given as 2 inch. So, 4.5 T was earlier and you have the chill 2 inch.

So, and if you replace the 2 risers, you see that 4.5 T this side and this side and 2 inch both because of the chill. So, this way, depending upon where to place the riser, so that your casting is a is completely fed and it does not have any kind of thirst, it does not have any kind of shrinkage defects that has to be seen by looking at the dimension of the riser, the how much distance because if there is small distance is left you can use the chill, but if the large distance is left you will have to increase the number of risers.

So, number of risers also can be decided based on that. This is for bars, for bar it comes out to be 6 root T on 1 side and then if you use the chill in the bar also it will be plus T. So, this is how 6 root T, on both the side if you have the 2 risers, so you get maximum you can feed 12 root T and if you use a chill 12 root T plus 2 T. So, this is how the feeding distance is defined for bars and plates and you can see that you can ensure that how many of the risers are required to be used for these.

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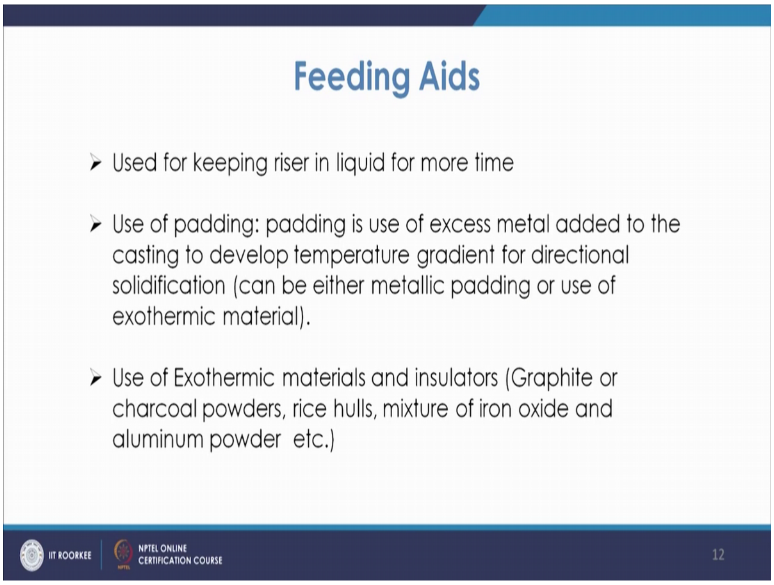

You can use the feeding aids for increasing the efficiency of the risers. Feeding aids means those medium by which the riser can be seen that it can be used for longer time, so where the liquid is for larger time. So, you can use the padding method in padding, you use excess of the metal.

So, that the solidification time increases and that is used normally in case of wheels, you know casting for crane wheel casting, where you use the metallic padding or you can use the exothermic materials also anti piping compounds in the riser. So, that in the riser the liquid metal is there for longer time. So, that we buy these using these feeders, the size of the riser when can be minimized or decreased. So, that the riser effectiveness is not decreased or if it is higher.

Thank you very much.