Fundamentals of Manufacturing Processes

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

Lecture - 20
Casting: Riser Design

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing process. And in this presentation I will be talking about the design of risers or riser design.

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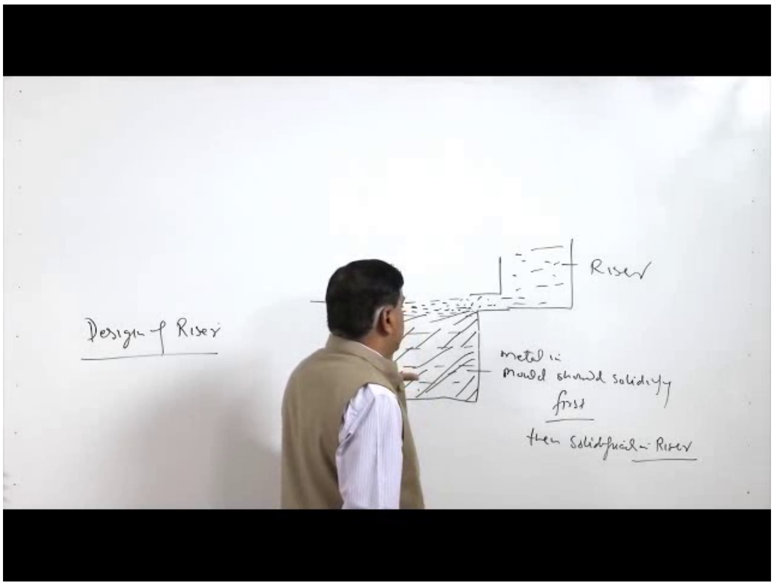

We know that the role of the riser is to feed the molten metal to the mould so that the shrinkage related with the liquid to solid state transformation can be compensated, but to perform this role; say this is the mould and here we have riser. So, if any shrinkage is taking place due to this transformation from the liquid to the solid state, that needs to be compensated by feeding the molten metal present in the riser.

So, this is a riser. So, it is expected that the solidification of the molten metal will be taking place first in the mould. So, and once this solidification is over, then whatever shrinkage due to this transformation has occurred, that will be left at the top so that shrinkage that volume of the metal which is deficient due to the shrinkage is to be fed from the riser. So, the mould or you can say the metal in mould should solidify first. And then solidification in riser should occur means; till this molten metal until the molten metal solidifies; means the molten metal solid should solidify in the mould first and so that the whatever there is the shrinkage is there that can be fed in by the molten metal in the riser.

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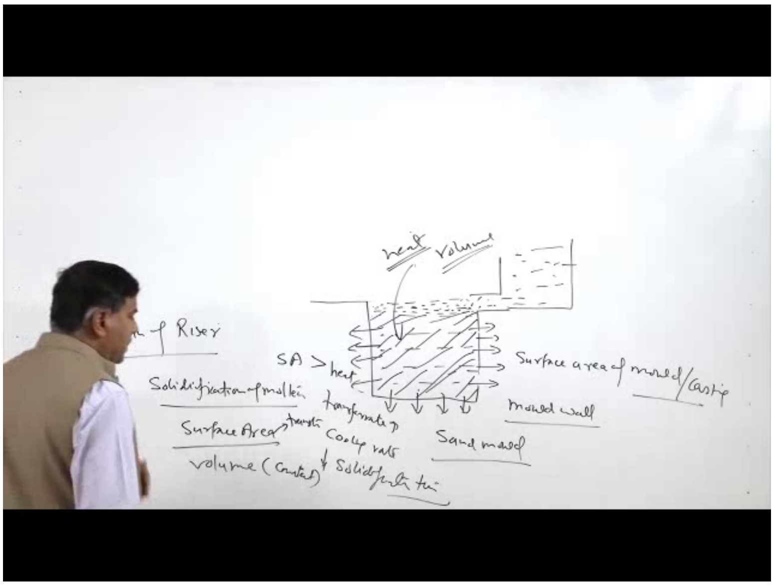

So, this solidification we know that the solidification of molten metal depends upon the fact that, how fast heat is transferred from the molten metal to the mould wall. So, all around we have mould walls. So, if these are of the metal, then they will be extracting heat at much faster rate as compared to the case when they are made of the sand mould; the walls are made of the sand or the moulding sand.

So, in addition to that material aspects say for a given; sand mould the rate at which heat will be transferred will depend upon the surface area of the mould or we can say casting through which after the solidification of the molten metal will be getting. So, greater the surface area is more than the heat transfer rate will also be high which will be leading to the high cooling rate and so less solidification time. So, what we want that to ensure the solidification of the casting first.

It is necessary that the surface area of the casting is more than the surface area of the riser, but in addition to that we have to consider one more aspect; that is about the volume. Since the heat contained by the molten metal depends upon the volume of the molten metal. So, the ratio of the surface area to the volume, this is a determining that heat transfer and this is about the heat content. So, if the surface area to the volume ratio is high, then the heat transfer rate will be much faster and the cooling will be occurring much earlier.

So, this ratio is basically used to define the cooling characteristic of the mould or of the casting. So, if the cooling characteristic of the casting is high it is higher than the cooling characteristic of the riser. So, what we can say here surface area of the casting divided by the volume of the casting. This ratio should be greater than the surface area of the riser to the surface to the volume of the riser. If this ratio is a achieved then means the riser is prepared in such a way that this ratio is obtained then this will be ensuring.

That the cool casting will be solidifying earlier as compared to the solidification of the riser means the molten metal in the riser molten metal will and the metal in the riser will remain in the liquid state for the longer period as compared to the case in the mould or for the casting. So, the cooling characteristic is one of the important characteristic related with the design of the risers. So, this efforts have been made to relate the solidification time.

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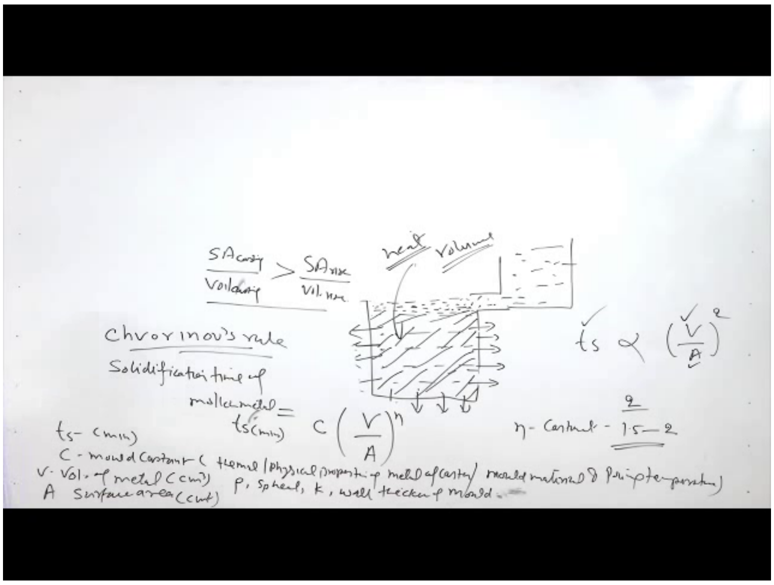

Solidification time of the molten metal it can be say in casting or in the riser this can be given with the help of like say t c in t s in minutes means the solidification time in minutes.

So, here what we mentioned like the C is the mould constant and it is the ratio of the V by A n. So, what are these parameters are the solidification time t s is given in minutes C is the mould constant, it depends on the thermal and physical properties of the metal of casting as well as; thermal and physical properties of the mould material; as well as the pouring temperature. At what temperature molten metal is being poured into the mould. So, these are the factors which will be affecting. Among these like mainly the rho density, the a specific heat, thermal conductivity of the molten metal of the metal of the casting as well as the mould and wall thickness of the mould wall or of the mould. This is what we can say the V is the volume. V is the volume of the metal whether it is casting or the riser and A is the surface area of the casting or of the riser.

So, V is the volume centimetre cube and area in the centimetre square means, the mould constant and the t s it is the time for the solidification. So, and the value of n; n is a also constant and whose value is normally it is written 2, but it is found in the range of 1.5 to the 2. So, normally it is like solidification time is given as a proportional to the square of the volume to the surface area ratio. So, here you will for the larger volume the time will be more similarly for the larger area for a given volume the time will be less.

This is how the solidification time can be given. And this is one of the very commonly known equation this is called expressed as c h v o r i n o v s rule used for expressing the solidification time and; using this basically we can determine, when the solidification in the riser and when the solidification in the mould will be taking place. To express it more clearly the one term which is called freezing ratio.

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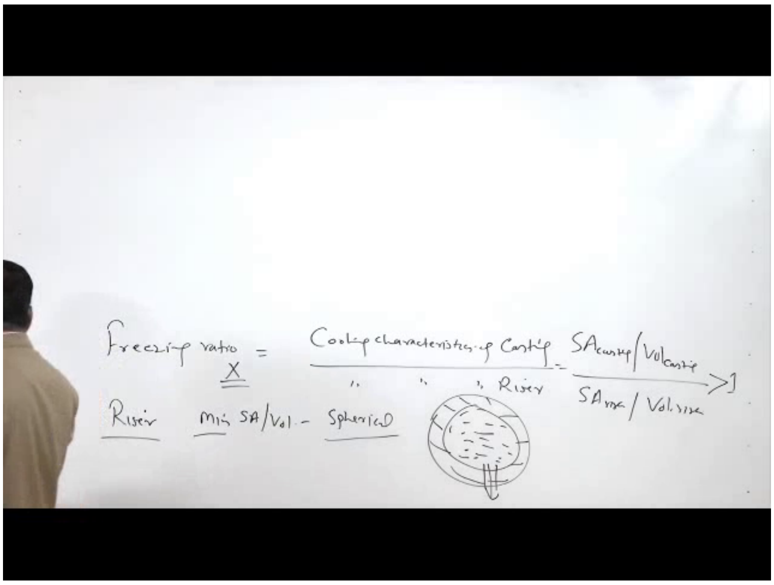

Also has been obtained or developed which is basically the ratio of the cooling characteristics of the casting to that cooling characteristics of the riser.

Which means; it is this S A the surface area of casting divided by the volume of the casting divided by the surface area of the riser divided by the volume of the riser. So, this ratio has to be is surface area divided by the so to ensure that the casting solidifies first this S A surface area to the volume ratio of the casting, this should be greater than the surface area to the volume of the riser. And this ratio that is why should be greater than one.

In order to ensure that the riser is able to feed the molten metal to the casting and this ratio is expressed as x letter x so far, so according to this one the what are the possible shapes for the riser? If we consider the riser with the minimum so, to have the higher value of this ratio it is required that surface area to the volume ratio is minimum and the minimum surface area to the volume ratio is a obtained in case of the spherical shapes,

But is in case of their spherical shapes; obviously, the solidification will be starting from the surface and the molten metal will be left in the in between so, we will not be able to feed the molten metal from the riser to the mould when it is desired. So, this is found to be difficult to implement for using as a riser shape. So, next preferred shape for the riser is the cylinder.

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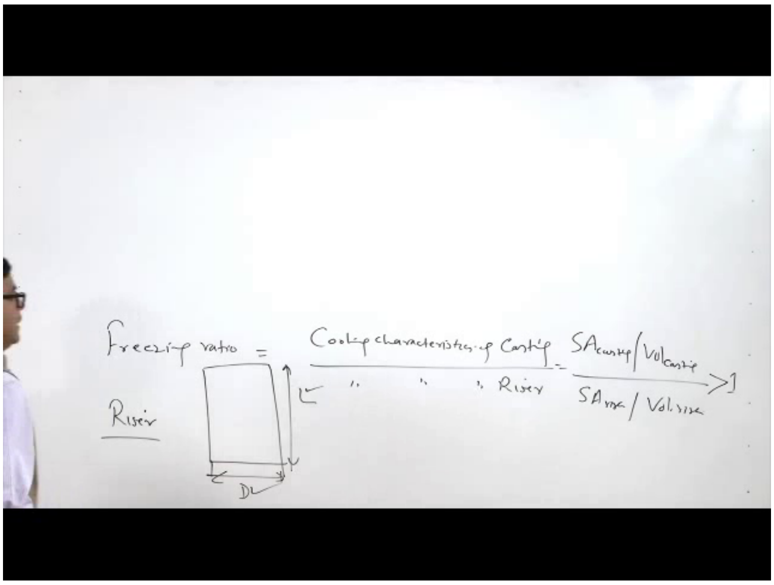

So, in case of the cylindrical shape rises basically the length and the diameter of the riser is obtained as for as the design is concerned. So, basically efforts are made to determine the diameter to the diameter and the length of the risers. So, that the desired freezing ratio can be achieved so, here some freezing ratios for the cylindrical shapes have been equations have been developed for operating.

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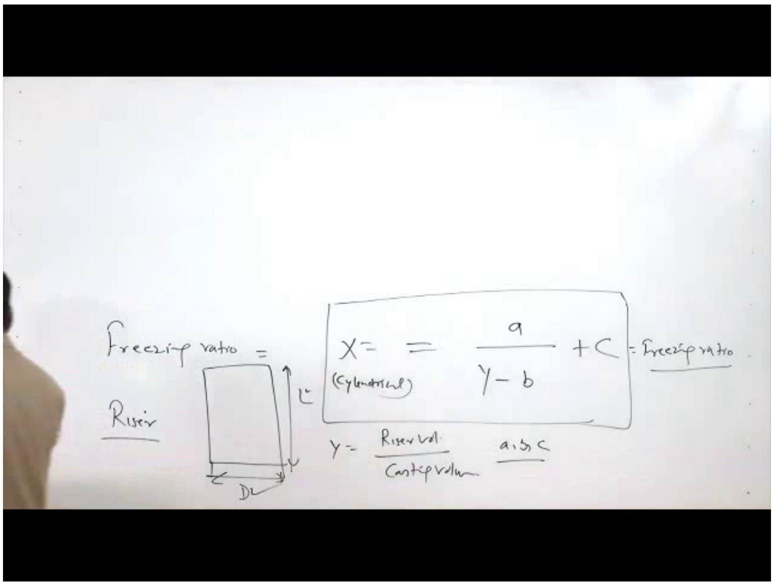

The freezing ratios for the risers of the cylindrical shapes; this is expressed as a by y minus b plus c. This is one typical freeze equation used for determining the freezing ratio for the cylindrical shape risers.

So, where this as I have already told this is basically, the freezing ratio which is the ratio of the cooling characteristics of the casting to the that of the riser. And the y is the ratio of the riser volume to the casting volume. And a, b, c are basically a, b, c are the constants. So, people have developed the identified the value of the constants through the experimentation for designing the risers. So, here I will be writing that values of the common constants which are used for designing the risers for the common foundry metals; say for aluminium is steel and cast iron the values of a, b and c.

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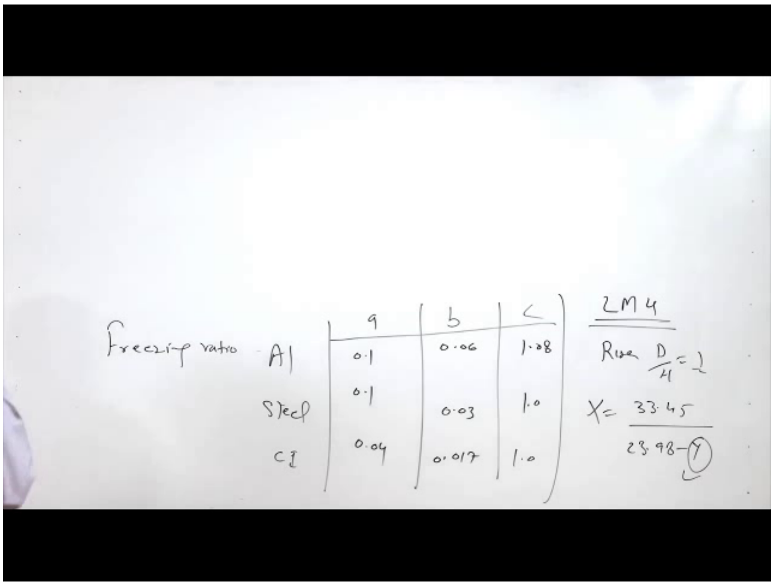

So, like a for aluminium 0.1, for a steel 0.1, and for cast iron 0.04 and b for aluminium is 0.06, 0.03 for a steel and 0.017 for cast iron. Similarly c for aluminium is 1.08, 1 and 1 for cast iron. One typical freezing ratio for one of the commonly used aluminium alloy L M 4 freezing ratio for the riser, when the diameter to the height ratio is one the freezing ratio is given by the equation 33.45 divided by 23.98 minus y.

So, this basically the y is used for; the y is used for determining the volume of the riser, while considering the this ratio d by h is equal to 1; means the diameter to the height ratio of the riser is 1. Since, it is always desired that the value of x is greater than 1 in order to ensure that the molten metal in the riser solidifies at the end. We will be now seeing one typical plot, which shows the relationship between the freezing ratio which should be greater than 1.

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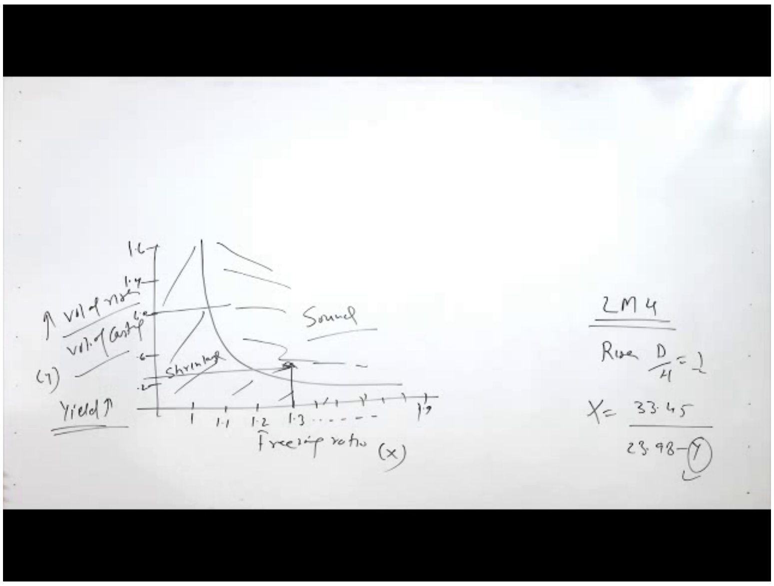

So, freezing ratios from 1 to say 1.9 the interval of say 0.1 we can say. So, 1, 1.1, 1.2, 1.3 and likewise to 1.9 and here the volume of the riser to the volume of the casting this is basically the value of the y in our equation. So, the relationship between basically the x and the y and what it shows.

That, it goes in like this here the value of the y is in the range of like say 0.2 to 1.6, 0.6, 1, 1.4 like this and, what we see here? When the this the freezing ratio is greater than 1 and this. So, the there are two jowls basically this line divides the two jowls one is the sound casting and another is with the shrinkage porosity. So, proper the values of the y and x are to be maintained in order to have the sound casting and if the two are not maintained like say, what should be the freezing ratio for the different values of the y? And what should be the value of the y for the different freezing ratios that is what can be obtained.

So, the if the freezing ratio is high then even the low riser to the volume of the casting can be used, and if this kind of ratios are used then these will be helping in increasing the yield because the ratio of the molten ratio of the riser molten metal in the riser to the ratio to the volume of the metal in the casting. So, if this ratio is high for sound casting, then definitely our yield will be much better because in the molten metal being solidified in the riser that will be less as compared to the volume of the metal which is solidifying in the casting. So, efforts are always made it. So, it is better to have them much better freezing ratios for using the high for achieving the high yield through the low riser volume to the casting volume ratio.

There is another method of the riser design and that is called a Modulus method. Modulus method this basically determines the modulus of casting and modulus of the riser. What is the modulus basically?

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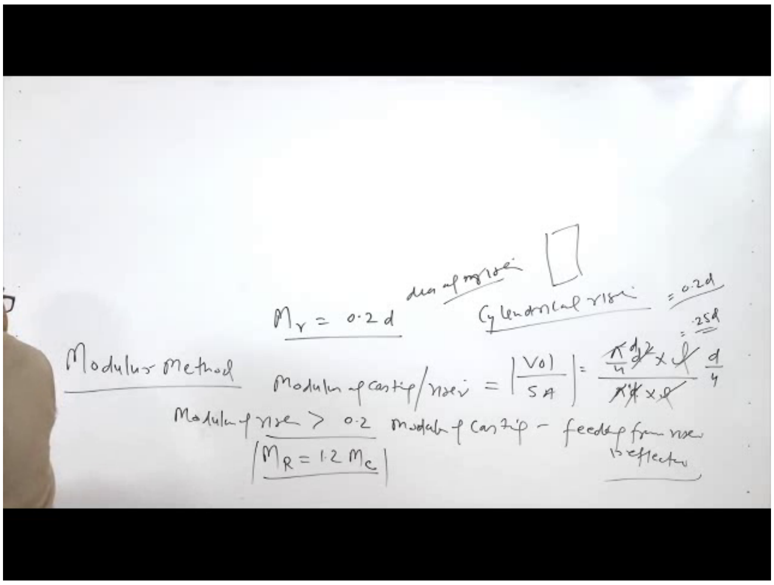

The Modulus is the inverse of the cooling characteristics means cooling characteristics we have determined cooling characteristics we have determine we have defined as a ratio of the surface area to the volume. So, the modulus is the inverse of the cooling characteristics means modulus of the casting or the modulus of the riser will be the volume to the surface area.

So, this ratio is the modulus of the casting. According to this method if the modulus of the riser is a 0.2 times greater than the modulus of the modulus of casting. Then feeding from riser is effective. So, two or the riser to be effective it is necessary that the modulus of the riser is equal to 1.5, 1.2 times of the modulus of the casting. This is what is to be maintained. So, if we go by this then it comes out to be the volume of the volume of the casting say for cylindrical riser or casting the volume is like pi by 4 d square into l. L is the length and the d is the diameter divided by surface area is pi d into l.

So, here l and l will be cancelled d and d will be cancelled. So, here one d is left pi and pi will be cancelled. So, we are left with the d by 4. So, which is precisely 0.25 d mostly it is taken as 0.2 d. So, if you have to modulus is basically; modulus of the riser is 0.2 times of the d; d is the dia of diameter of the riser. If it is the cylindrical riser so d is the diameter of the riser. So, considering this equation for a successful working of the riser, it is required that the modulus of the riser is greater than the modulus of the castings.

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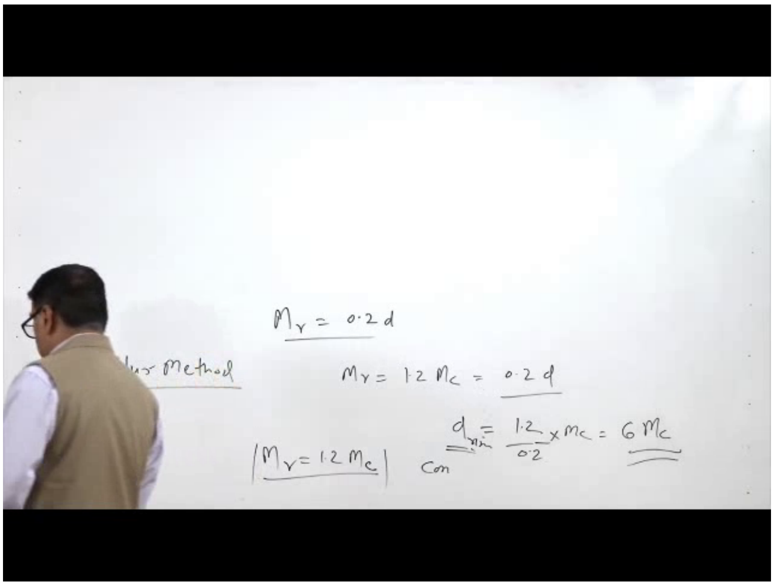

So, in that case since the M r this M r. So, M r is equal to 1.2 times of the modulus of the casting is equal to 0.2 times of the diameter of the riser. So here this is what we can say that in the diameter of the riser will be equal to 1.2 divided by 0.2 into the M c. So, it is basically the 6 times of the modulus of the casting. This is how we can determine the diameter of the riser and because assuming that the diameter.

So, this is how the diameter of the riser can be determined for the purpose of a designing the riser. Now, I will summarize this presentation. In this presentation I have talked about the two methods relative the related with the riser design. In one method is the Kanes method and another is the Modulus method. And in both the cases we have seen that the cooling characteristics of the casting and the cooling characteristics of the riser are plays an important role in ensuring that the molten metal in the riser solidifies after the solidification of the casting.

Thank you for your attention.