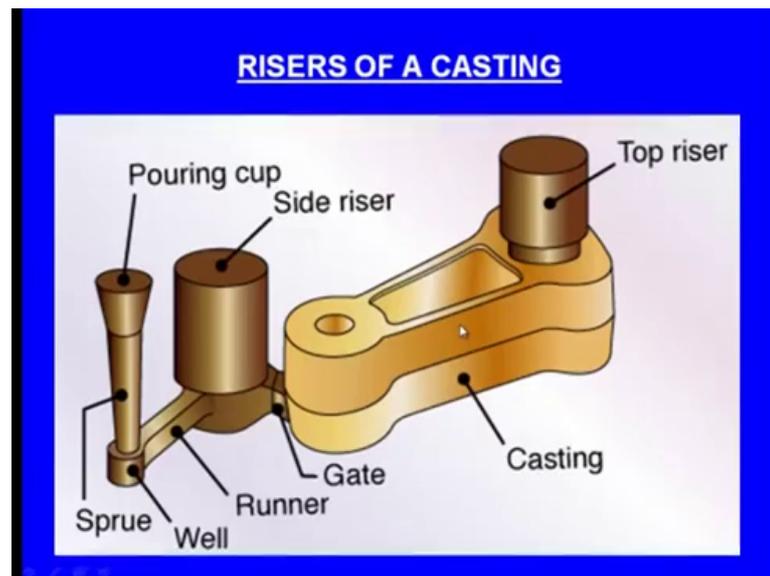


Metal Casting
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Module - 02
Sand Casting Process
Lecture - 09
Design Of Riser System-I

Good morning friends. In the previous classes we have been learning about the moulding sands, core sands, the patterns. And also in the previous lecture we have seen the different steps involved in the making of a sand casting. Now, in this lecture let us learn about a an important topic that is the Design of the Riser. So, this lecture will be on the design of the riser.

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First of all, what is a riser? Now, we can see this is the casting and this is the pouring cup, this whole thing is compacted inside the moulding right the moulding boxes. Now, this is the pouring cup, the molten metal will be coming like this and this is the sprue and it will be passing through this sprue and this is the sprue well. Then the horizontal passage is known as the runner. It passes through the runner then this is the gate it, through the gate it enters into the mould cavity.

Once the molten metal is full with the molten metal it rises like this through the riser. So, this is the riser. And here we can see another riser is there. So, here we can see a top riser and here we can see a side riser. So, through the riser the molten metal rises. So, once the molten metal rises through the riser, we stop pouring the metal right. So, that is why because it is rising it is known as the riser.

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PRIMARY FUNCTION OF A RISER

- It acts as a reservoir of molten metal in the mould to compensate for shrinkage during solidification.

SECONDARY FUNCTIONS OF A RISER

- It gives an indication that the cavity is full with the molten metal.
- It also enables escape of hot gases during pouring of molten metal.

Now, let us see what is the primary function of a riser. It acts as a reservoir of the molten metal in the mould to compensate for the shrinkage during solidification. We all know that all the metals when they solidify right in the liquid level and when they are solidifying they undergo shrinkage. This is known as the solidification shrinkage.

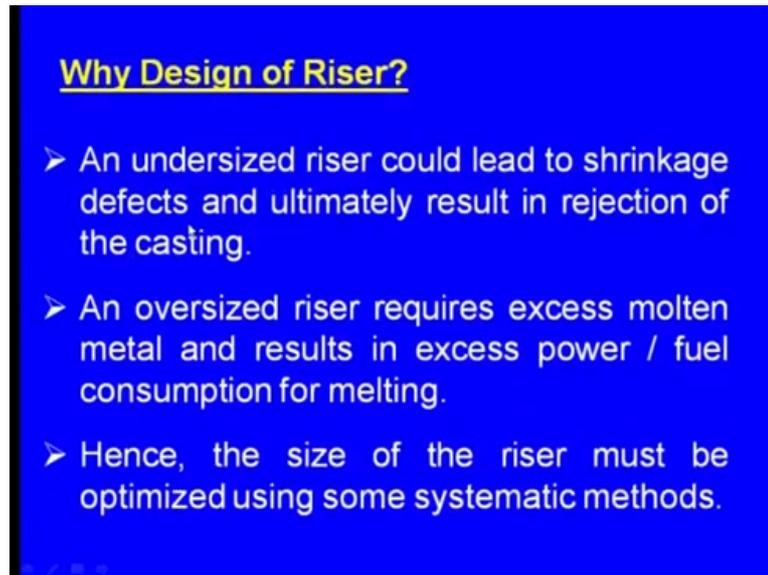
Now, that time the some molten metal will be inside the mould cavity and during the solidification because of the solidification shrinkage there will be a shrinkage cavity will be there. And the molten metal which is inside the riser comes and fills that gap and it compensates that gap. Not only during solidification, during the liquid cooling of the molten metal. For example, let us take the aluminium. Aluminium melts at about 600 and 60 degree centigrade, but we used to pour it about 750 degree centigrade. From 750 degree centigrade to 660 degree centigrade there is liquid cooling, there is no solidification. But during this liquid curing cooling also there is a reduction in the volume inside the mould cavity. But, this reduction is compensated by the liquid metal which is inside the riser.

So, the riser or the liquid metal in the riser compensates what say reduction in volume due to liquid cooling of the metal. It also compensates the molten metal due to solidification shrinkage. So, that is the primary function of the riser and it has got secondary functions also. It gives us an indication that the cavity is full with the molten metal. Yes, we keep pouring the molten metal through the sprue and through the pouring cup and through the sprue and it passes through the runner and it fills the cavity. Once the cavity is full with the molten metal, it rises up. That is why it is known as the riser. Because, it is feeding the casting it is also known as the feeder.

Next one there is another secondary function. It also enables escape of hot gases during pouring of the molten metal. Yes, as we keep pouring the molten metal, immediately the moisture in the moulding sand comes in contact with the molten metal, spontaneously this moisture turns into vapour and hot gases will be released. And as, we keep pouring the molten metal, yes through the riser hole they will be escaping. But this escaping of the hot gases is possible as long as the riser is not filled with the molten metal.

Once the riser is filled with the molten metal, hot gases cannot escape through the riser any longer. That time they will be escaping through the wind holes. They also escape due to the permeability of the moulding sand. So, these are the functions of the riser. Remember that the primary function of the casting is to feed the casting during the liquid cooling, but also during the solidification process. So, that is why it is known as the feeder. And it has got the secondary function due to rises and uses an indication that the cavity is full with the molten metal. Because it rises it is known as the riser.

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Now, the question is why design of riser, cannot we make the riser with some size under do the casting? There is a problem. If the size of the riser is not adequate what will happen? An undersized riser could lead to shrinkage defects and ultimately result in rejection of the casting. If the size of the riser or if the diameter of the riser is not adequate and the molten metal inside the riser is not adequate to feed the casting, what will happen? Ultimately during the solidification there will be shrinkage cavity inside the casting. Then what happens that casting has to be rejected.

Cannot we keep the riser size is too large so that this problem will not occur, what happens? An oversized riser requests excess molten metal and results in excess power or fuel consumption for melting. For melting the metal, what we do? We use the electricity or if we use the cupola furnace we use the coke sometimes we use the oil foiled furnaces. So, that is also a fuel. So, if we are using, if we are keeping a what say here the very big riser what happens? It requires excess of the molten metal. And to fill this excess of the molten metal what we have to do, we have to spend excess what say money and excess time for melting the metal. So, that increases the cost of the production.

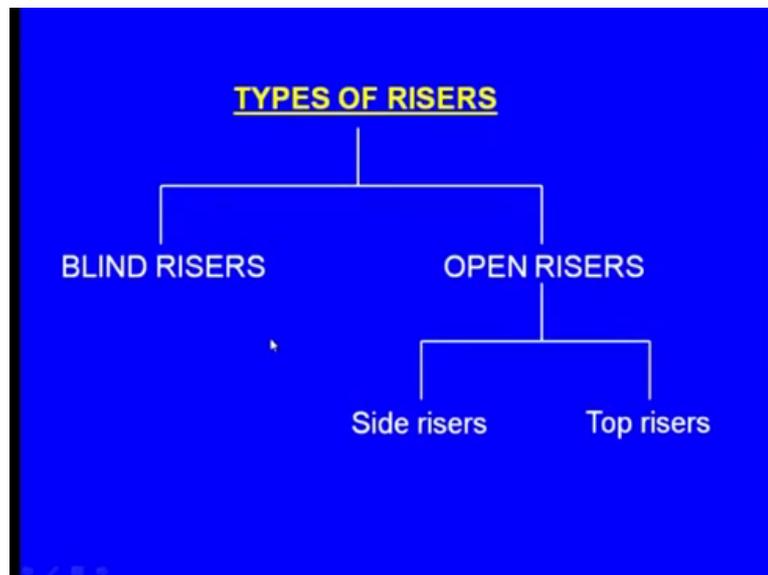
That is why hence, the size of the riser must be optimized using some systematic methods. So, that is why we are going to learn about the design of the riser in this lecture.

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Now, this is what can happen; if the size of the riser is not adequate. Right, if the liquid metal in the riser is not enough to feed the casting during this solidification process, a shrinkage cavity will be developed on the surface sometimes inside the surface also it can develop.

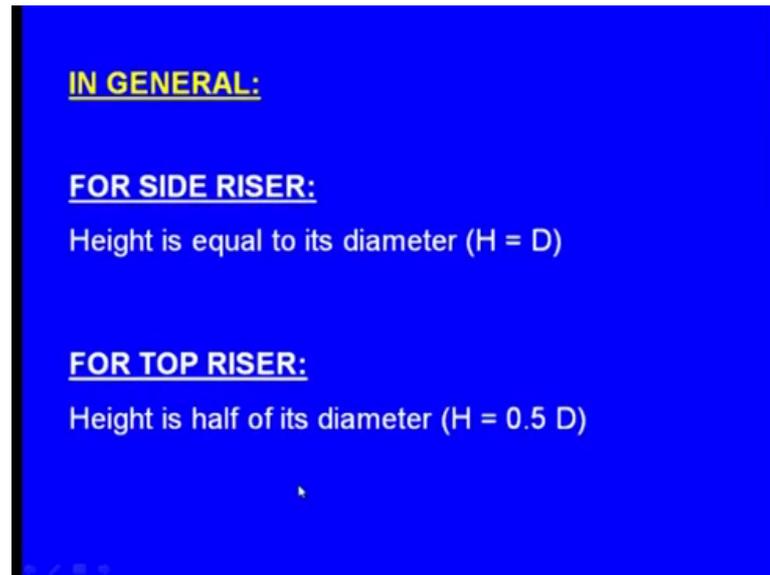
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Now, these are the types of the risers. Before we learn about the design of the riser, let us see these are the types of the riser. One is the blind riser right means. It is inside the mould cavity, it is not visible and it is not exposed to the atmosphere.

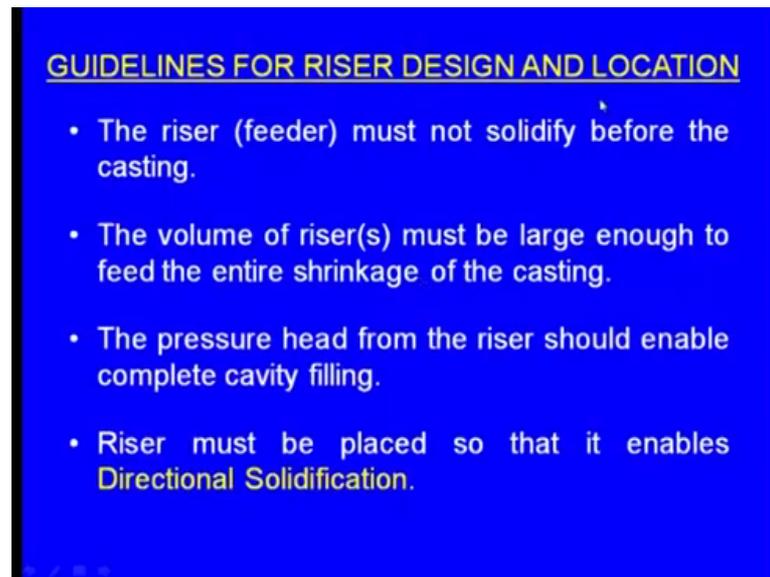
Next one, the second category is the open risers. These open risers are visible outside and they are exposed to the atmosphere. So, these are the open risers. Again in the open risers there are side risers and top risers. Side risers we have seen, it is on the side of the casting, whereas the top riser is above the kept above the casting. So, these are the types of the risers.

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In general, for a side riser, height is equal to its diameter. If the height is H and if the diameter is D : H is equal to D . And for a top riser, height is half of its diameter; if the height is H and if the D is the diameter H is equal to $0.5 D$. This is in general right.

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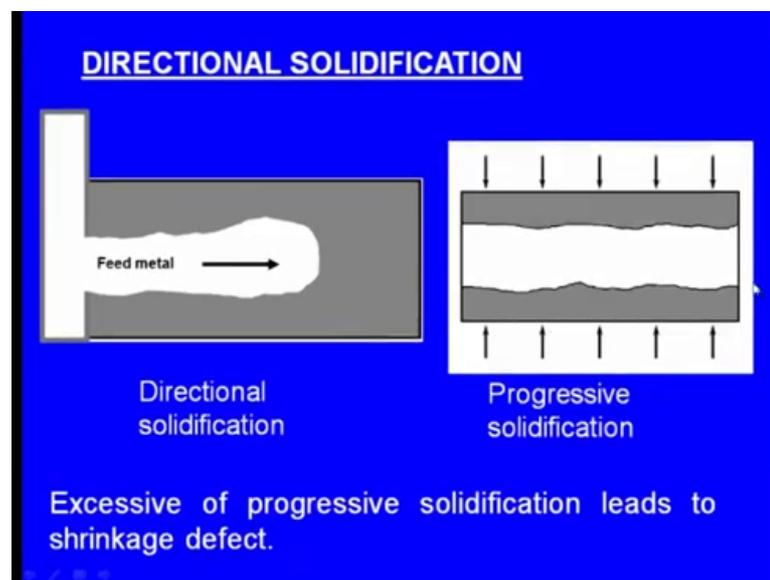
Next one, guidelines for riser design and location: how to what say designed a riser and how to locate the riser? The riser or the feeder must not solidify before the casting. If it solidifies before the casting, how can it feed be casting? So, that is why it is known as the feeder, it is like mother feeding her children. When the mother makes an important dish, a delicious dish it mother feeds the children; only after something is left outmould mother will take it. If the mother would consumes all what say delicious dish how she can feed the children? She cannot be a mother, she cannot be a feeder. Similarly, a feeder or a riser of the casting must solidify only after the casting solidifies. So, that is the fundamental rule.

Next one, the volume of the riser or risers must be large enough to feed the entire shrinkage of the casting. The first rule says that the riser must solidify after the casting solidifies, but here the riser is no doubt the riser is solidifying after the casting solidifies. But it is not large enough to feed the entire shrinkage of the casting, it is able to feed part of the shrinkage of the casting only during the initial stage of the solidification and at the final stage of the solidification there is no sufficient metal in the liquid metal in the riser; then how can it feed the casting? So, the quantity of the riser liquid metal in the riser must be large enough to feed the entire shrinkage of the casting. So, that is the second guideline.

The third guideline is the pressure head from the riser should enable complete cavity filling right. So, the pressure head from the riser it should enable complete cavity filling. No cavity or no part of the cavity of the mould should be what say, left out without the molten metal.

Next one, riser must be placed so that it enables directional solidification. The position of the riser must be such that there will be directional solidification. Now, the question is what is this directional solidification? Let us see right.

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So, here we can see there are two cases. In one case directional solidification is in what say progress. Means, it is dominating. In another case, progressive solidification is dominating. Means, what is happening here? This is the casting and this is the riser. Now, here there is liquid metal is there. So, this portion this gray portion indicates the solidified casting. Now, the solidification is gradually propagating towards the riser. As it is propagating towards the riser liquid metal in the riser is able to feed any shrinkage that is taking place during the process of the solidification. So, what is happening?

So, the direction of the solidification is in this direction right, if that solidification is progressing this way like this. Now, let us take the second case. Let us assume the riser is like this somewhere here the riser is like this. No doubt there will be directional solidification will be there, but here we can see progressive solidification. Means, what is happening here, the solidification in the previous case, the solidification is what say

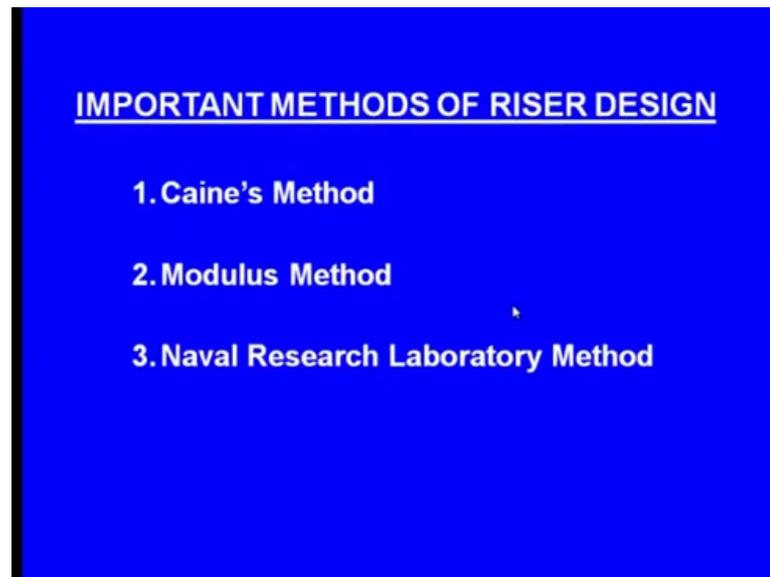
going towards the riser. Now here, the solidification is propagating perpendicular to the what say direction of the solidification. This is the direction of the solidification, even if what say a solidification is going on in this direction.

Now, the solidification is going perpendicular. Now, what happens? The riser is somewhere here. The riser is here and the solidified portion is becoming more and more and after some time, this is what say there will be a very narrow region with liquid metal. Now suppose this portion is blocked because it is solidifying perpendicular to the direction then what happens? The liquid metal may not be in a position to what say compensate the shrinkage, that is taking place of maybe here there is a liquid portion is there, but because of these progressive solidification this portion is already solidified and the riser is here and the here there is a liquid metal and there will be shrinkage cavity. How this can be compensated by the riser? It cannot be compensated.

So, here we can see directional solidification and progressive solidification. So, in a solidification of the casting both these solidifications will be there. But the thing is, if the directional solidification is dominating, that is good there will not be any shrinkage defect. But on the other hand, compared to the directional solidification, if the progress of the solidification is dominating then what happens? The there will be or say some portion with the in the liquid state and the riser cannot feed that liquid portion, because somewhere the passage is blocked.

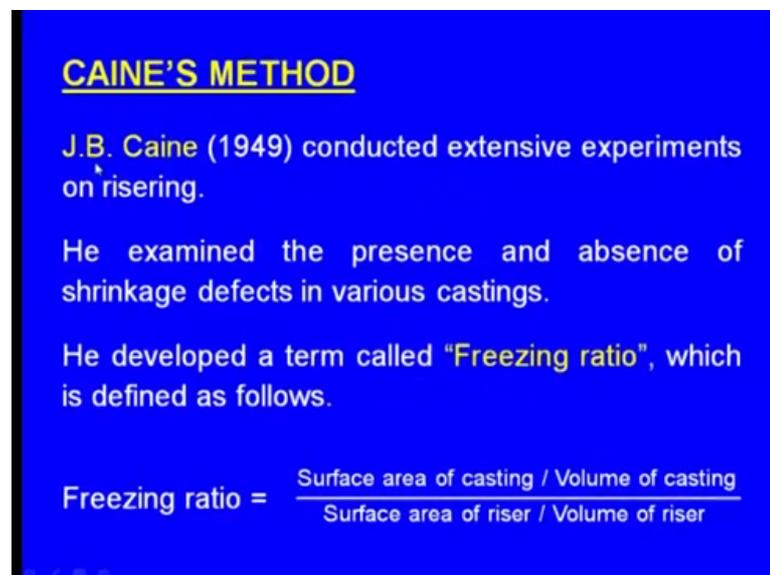
Excessive of progressive solidification leads to shrinkage defect. So, the riser must be placed in such a way that there will be more directional solidification and less progressive solidification. So, these are the important methods of the riser design.

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One is the Caine's method second one is the Modulus method third one is the Naval Research Laboratory method. Now we will see all these one by one.

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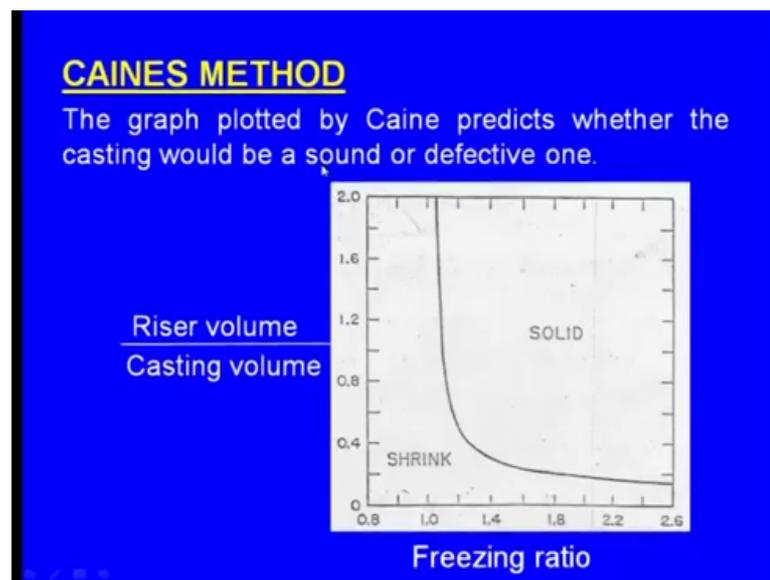


First we will see the Caine's method. Now, J.B Caine has conducted extensive experiments on risering sometime during 1949. He examined the presence and absence of shrinkage defects in various castings. Then, he developed a term called freezing ratio which is defined as follows. Freezing ratio is equal to surface area of the casting by

volume of the casting whole divided by surface area of riser divided by volume of the riser.

So, this was the definition given by Caine for the freezing ratio. Based on the freezing ratio, he has given some idea how to identify the shrinkage defects in the castings. Now let us see what is that procedure, how to identify the shrinkage defects in the castings?

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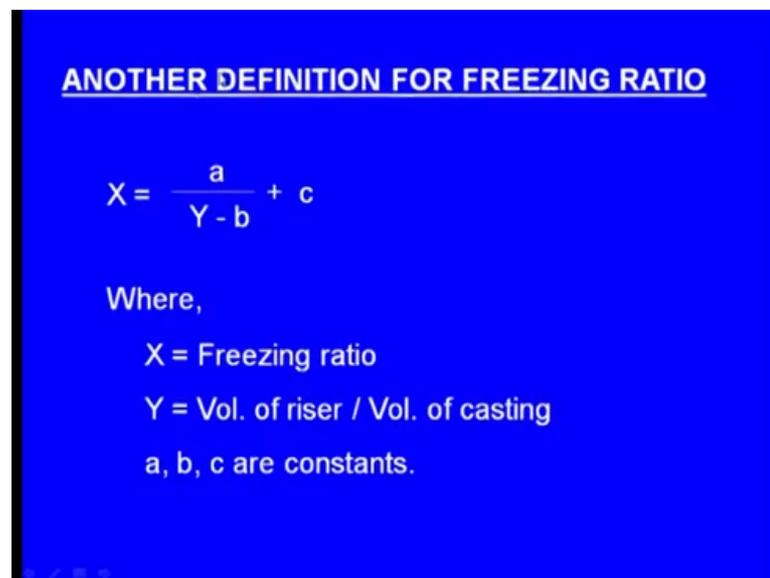
Now, here you can see; now the Caine has plotted a graph like this. Means, he has conducted extensive experiments on the castings and on several castings he got the shrinkage defects and in some castings he got the sound castings, and for all the castings he has calculated the freezing ratio. And he has also calculated the riser volume to casting volume. Now, with freezing ratio as the x axis and the riser volume to casting volume as the y axis he has plotted this graph. So, this is the graph plotted by Caine. Now, what does this graph tell us? The graph plotted by Caine predicts whether the casting would be a sound or defective one.

Now, let us see this graph here. There is a curve right, so when he has plotted taking freezing ratio on the x axis and the riser volume to casting volume on the y axis so a curve was plotted. Now, all the castings that fall on the right side of this curve will be sound castings without any shrinkage defects. Now, all the castings which are falling on the left side of this graph, right curve will be defective castings with shrinkage defects.

So, this was the finding of the Caine and he this he has plotted after conducting extensive investigations.

Now the problem is what is the limitation? Definitely this is was a very good work, but what is the limitation. What say this process says that you design some riser and I will tell you whether you will get a sound casting or a shrinkage casting. You design a riser yes this is going to give you a shrinkage defect. You design another riser, this is going to give a sound casting. Now my question is; what is the size of the riser with which I can get a sound casting and that size of the riser must be optimum, the Caine's method cannot give answer to this. So, that is the small limitation of this Caine's method.

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ANOTHER DEFINITION FOR FREEZING RATIO

$$X = \frac{a}{Y - b} + c$$

Where,

- X = Freezing ratio
- Y = Vol. of riser / Vol. of casting
- a, b, c are constants.

Now, there were this work was further extended. Now another definition was given for freezing ratio. Now here, x is the freezing ratio. Now freezing ratio x is equal to a divided by Y minus b plus c. Where, X is the freezing ratio, Y is equal to volume of the riser divided by volume of the casting, a, b, c are constants and they depend upon the material of the casting.

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Values of a, b, and c for different metals

	a	b	c
Steel	0.1	0.03	1.0
Aluminum	0.1	0.06	1.08
Cast Iron	0.04	0.017	1.0

Now, these are the values of a, b, c constants for different metals.

For steel a is equal to 0.1, for steel b is equal to 0.03 and c is equal to 1. For aluminium a is equal to 0.1, b is equal to 0.06 c is equal to 1.08. For cast iron a is equal to 0.04, b is equal to 0.017 and c is equal to 1. So, these are the values of the a, b, c for different metals. So, he has given these values for steel aluminium and cast iron.

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PROBLEM:
Calculate the size of a cylindrical riser necessary to feed a steel slab casting of size 25 x 25 x 5 cm. Height of the riser and its diameter are equal.

SOLUTION:
Volume of casting = $25 \times 25 \times 5 = 3125, \text{cm}^3$
Surface area of casting = $(2 \times 25 \times 25) + (4 \times 25 \times 5)$
 $= 1750 \text{ cm}^2$
Let the diameter of riser = D
Volume of riser = $\pi D^3/4,$
Surface area of riser = $\pi D^2 + \pi D^2/4 = 1.25 \pi D^2$

Now, let us see a problem. How to solve this problem or how to get the design of the riser using the Caine's method? Now let us take this problem, calculate the size of a

cylindrical riser necessary to feed a steel slab casting of size 25 into 25 into 5 centimetres, height of the riser is its diameter are equal means, it is a side riser. Now, how to design the riser means, how to get the dimensions of the riser.

Now this is the solution. Now, volume of the casting; this is the simple geometry 25 into 25 into 5 that is equal to 3125 cubic centimetres. Now, surface area of the casting: it has got the 6 surfaces right, 25 into 25 surfaces there are 2; so 2 into 25 into 25. Similarly 25 into 5 surfaces there are 2. So, similarly actually there are 4, so 4 into 25 into 5, So, the surface area of the casting is equal to 1750 square centimetres.

Now let the diameter of the riser is equal to D . Now, what is the volume of the riser πD^3 cube divided by 4. So, here we can see this is the volume of the riser. Now, we have to find out the surface area of the riser. So, how to find out the surface area of the riser? So, surface area of the riser means it is a cylindrical one right under if we consider the development of the surfaces if we develop right it will become a rectangle. Now, what is the length of that rectangle? That is the πD . πD multiplied by a height what is the height? Height is the diameter. So, πD into diameter that is equal to πD square right plus what about the top circle that is πD square by 4.

Means the top circle we are considering the bottom circle we are ignoring. Why we are ignoring? Because compared to the surface area of the casting the bottom circle is very small. That to it is not exposed to the atmosphere. So, that is why we are excluding the bottom circle. So, this πD space indicates the surface area of the top circle. Now the total surface area of the riser is equal to $1.25 \pi D$ square. So, we have calculated the surface area of the riser.

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PROBLEM:
Calculate the size of a cylindrical riser necessary to feed a steel slab casting of size 25 x 25 x 5 cm. Height of the riser and its diameter are equal.

SOLUTION:

$$\text{Freezing ratio, } X = \frac{SA_{\text{Casting}} / V_{\text{Casting}}}{SA_{\text{Riser}} / V_{\text{Riser}}}$$
$$= 0.112 D$$

Now, freezing ratio X is equal to; so this is how Caine has defined the freezing ratio; Surface area of the casting by volume of the casting whole divided by surface area of the riser by volume of the riser, so that comes to be 0.112 D.

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PROBLEM:
Calculate the size of a cylindrical riser necessary to feed a steel slab casting of size 25 x 25 x 5 cm. Height of the riser and its diameter are equal.

SOLUTION:

From Caine's new equation, $Y = V_{\text{Riser}} / V_{\text{Casting}}$

$$= 0.000251 D^3$$
$$X = \frac{a}{Y - b} + c = \frac{0.10}{0.000251 D^3 - 0.03} + 1.0$$

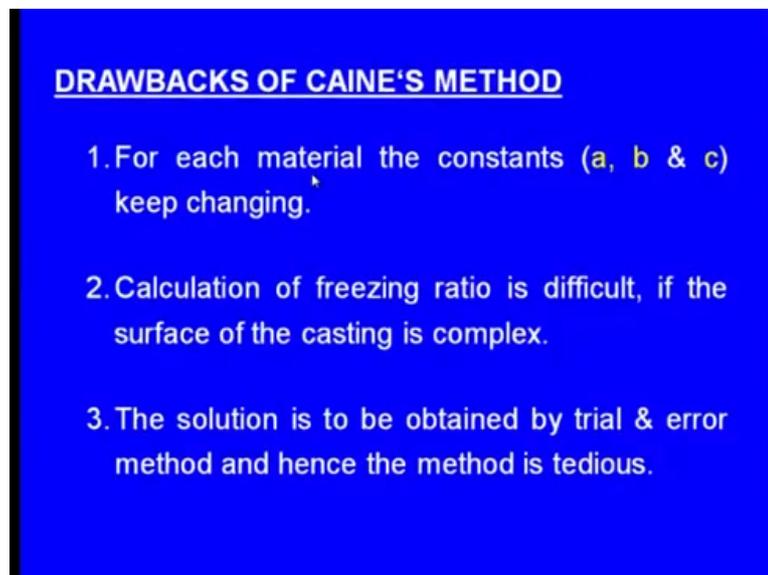
By trial & error, $D = 11.44 \text{ cm} \approx 12 \text{ cm}$

Now, this is there is a definition for Y right. What is Y? Y is equal to volume of the riser divided by volume of the casting. So, that is equal to 0.000251 D cube, it comes to be that much say it seems to be a complex value right it comes to be that much.

Now so far we have calculated to freezing ratios right. One is the using the freezing ratio this was the first definition given by Caine. So, using this definition we got the freezing ratio yes $0.2112 D$ and using another definition right. So, this is the other definition for the freezing ratio. Using this definition yes, we have substituted these are the values for the a, b and c we are substituting those values right. So, when we substitute those values it will become this much.

So, the previous this one is X the previous freezing ratio and the present freezing ratio we are equating; we are equalizing. Then by we get an expression in that expression say D is unknown. So, we cannot calculate this D directly only thing is we have to try some value put some value and try, whether it satisfies both sides. So, by trial and error method we have to substitute several values; finally, one value will be what say sat satisfying both the sides. That value is the correct value of the diameter of the riser. So, by trial and error method we get diameter of the riser is equal to 11.44 centimetres or it is almost equal to 12 centimetres. Now, we know the diameter of the riser diameter and height are equal, so when the diameter is 12 centimetres height is also equal to 12 centimetres. So, this is how we have to design the riser using Caine's method.

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DRAWBACKS OF CAINE'S METHOD

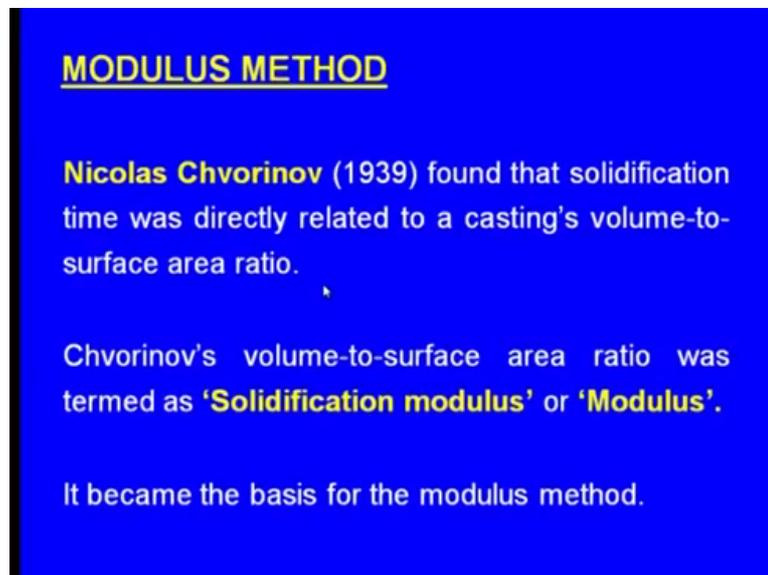
1. For each material the constants (a, b & c) keep changing.
2. Calculation of freezing ratio is difficult, if the surface of the casting is complex.
3. The solution is to be obtained by trial & error method and hence the method is tedious.

Drawbacks of the Caine's method: for each material the constants a b and c keep changing, for steel it is different, for aluminium it is different. Likewise for the he has mentioned for the three materials right, only for these three materials we can what say

design the riser using Caine's method. Now, it is reverse a every time it is difficult for us to remember these values. So, that is another drawback.

Next one calculation of freezing ratio is difficult; if the surface of the casting is complexion right. Thus, that is another drawback. Next one the solution is to be obtained by trial and error method. Directly we cannot solve, we have to substitute some value and try whether it satisfies both sides. We have to keep on what say changing till both the sides are equal. So, this takes time and this process is tedious. Next one, so we have seen the Caine's method now let us see the Modulus method.

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MODULUS METHOD

Nicolas Chvorinov (1939) found that solidification time was directly related to a casting's volume-to-surface area ratio.

Chvorinov's volume-to-surface area ratio was termed as '**Solidification modulus**' or '**Modulus**'.

It became the basis for the modulus method.

In this Modulus method was based on the Nicolas Chvorinov's work. Nicolas Chvorinov, he has conducted again investigation in the year 1939, and she found that solidification time was directly related to castings volume to surface area ratio: volume to surface area ratio right. Means, v by s a Chvorinov's volume to surface area ratio was termed as solidification Modulus or simply Modulus. Now this became the basis for the Modulus method.

So, Chvorinov has developed a term called Modulus or the solidification Modulus. Just like to Caine has developed the freezing ratio, Chvorinov has developed a term called the solidification Modulus which is equal to the ratio of the volume to surface area.

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CHVORINOV'S RULE

$$TST = C_m \left(\frac{V}{A}\right)^n$$

Where,

- TST** = total solidification time
- V** = volume of the casting
- A** = surface area of casting
- n** = exponent usually taken as 2
- C_m** is a constant which depends upon mould material

Now, this was the Chvorinov's rule, right. In the Chvorinov's rule TST is equal to C_m multiplied by V by A to the power of n. Where, TST is the total solidification time, V is the volume of the casting, A is the surface area of the casting, n is an exponent and it is usually taken as 2, C_m is a constant which depends upon the moulding materials right. So, this is the Chvorinov's rule; TST is equal to C_m multiplied by V by A to the power of n.

So, here we can see that the volume means volume of the casting, A means surface area of the casting right so it applies to the casting, this also applies to the riser. Means, if we apply this tool to the riser what these terms will become; TST means total solidification time of the riser, V means volume of the riser, A means surface area of the riser and n is the component and C_m it depends upon the moulding materials, right.

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What Does Chvorinov's Rule Tell Us ?

$$TST = C_m \left(\frac{V}{A} \right)^n$$

- A casting with a higher modulus (volume-to-surface area ratio) cools and solidifies more slowly than the one with a lower modulus.
- To feed molten metal to the casting, **TST** of the **riser** must be greater than **TST** of the **casting**.
- Since the mould constants of riser and casting will be equal, riser should be designed to have a larger modulus so that the main casting solidifies first.
- Ideal shape of a riser is a **sphere**.

What does Chvorinov rule tell us? TST is equal to C m multiplied by V by A to the power of n. What does this rule tell us? A casting with a higher Modulus, what is modulus? So, volume to surface area ratio V by s a or v by a ratio right, with a casting with a higher Modulus ratio cools and solidifies more slowly than the casting with a lower Modulus. Here, the Modulus when the Modulus is very high the casting cools down very slowly. Why means the V by A ratio; V by A ratio is high means what the A area is less because area is less V by A ratio is high. Means, when area is less it is less exposed to the mould wall. Means, less heat is dissipated to the mould wall. That is how it takes more time for solidification compared to a casting or compared to a riser with a lower Modulus.

Now, to feed the molten metal to the casting, total solidification time of the riser must be greater than the total solidification time of the casting. The total solidification time of the riser right must be greater naturally; if the riser solidifies before the casting it cannot feed the casting. So, the solidify must to solid the riser must solidify after the casting solidifies. Means, the total solidification time of the riser must be greater than the total solidification tome of the casting. So, that is the second what say information we can get from the Chvorinov's rule.

Next one, since the mould constants of riser and casting will be equal riser should be designed to have a larger modulus so that the main casting solidifies first. So, the third

rule says that, if we want the riser to have longer solidification time its Modulus should be smaller than the Modulus of the casting. When its Modulus will become smaller right its; sorry its if the Modulus should be larger right that is what the rule says the riser should be designed to have a larger Modulus then the surface area is minimum. The surface area of the riser should be minimum then only it will have a larger Modulus, then only it will take longer time for solidification.

Then that be the case, what happens? The Chvorinov rule says that the riser should have the minimum surface area, then only it will have the larger Modulus. Now, if we take particular what say must in different shapes may be in a what say square prism and a triangular prism and a sphere and a what say cylinder in all the cases the mass is same. Which one, which geometry has the least surface area? Sphere has got the least surface area. So, Chvorinov suggested that the ideal shape of is a riser is a sphere.

Bur spherical riser yes, ideal it is very good, it has the least surface area thus it will have a larger Modulus and it will take longer time for solidification, but incorporating a spherical riser inside the moulding boxes would be a tough task. That is why instead of a spherical riser a cylindrical riser would be adopted. So, these are the things which we can learned from the Chvorinov's rule.

Now Chvorinov has suggested that the modular of the riser must be larger than the Modulus of the casting, then only the riser will take longer time for solidification, then only it can feed the casting is it not. So, then that be the case, how much the Modulus of the riser should be larger than the Modulus of the casting.

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Requirement of the riser to feed the casting

$$M_R = 1.2 \times M_C$$

Where,

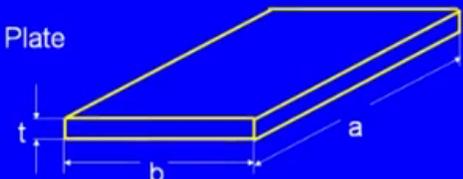
M_R = Modulus of riser
 M_C = Modulus of casting

By experiments say the further investigators found that the Modulus of the riser is equal to 1.2 times the Modulus of the casting: M_R is equal to 1.2 times M_C . Where M_R is the Modulus of the riser, M_C is the Modulus of the casting. How much time it should be larger? It is enough if the Modulus of the riser is 1.2 times the Modulus of the casting. Then, it is large enough to what say take longer time for solidification and to feed the casting perfectly. So, this is the relation right M_R is equal to 1.2 into M_C , remember this.

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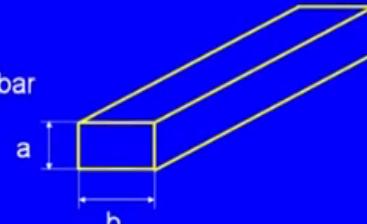
MODULI OF SIMPLE GEOMETRIC SHAPES

Plate



$M = 0.5 t$
($a < 5 t$)

Long bar

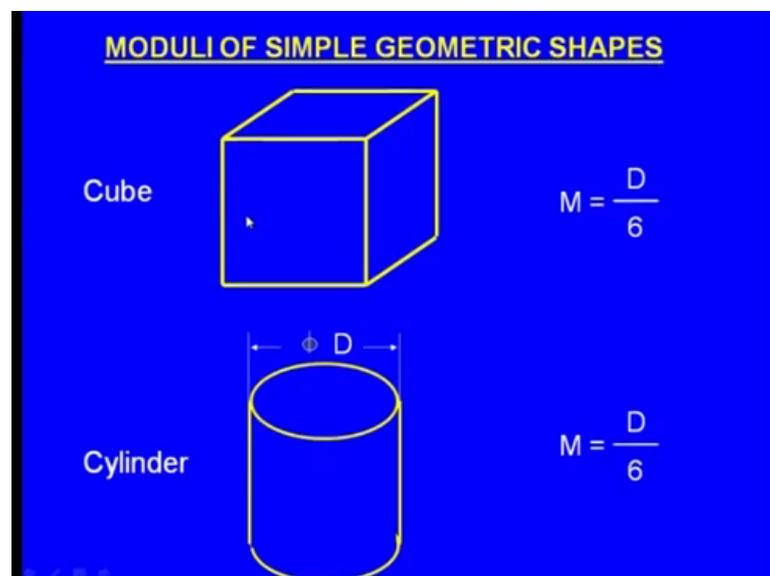


$M = \frac{a b}{2(a + b)}$

So, these are the moduli of simple geometric shapes. So, this is a plate right a long plate right, its thickness is t and its length is a and its width is b . Then the Modulus is 0.5 into t . So, you can see the Modulus, now it is no way connected with the length and the what say width it is only dependent on the thickness: Modulus is equal to $0.5 t$, where a is less than $5 t$.

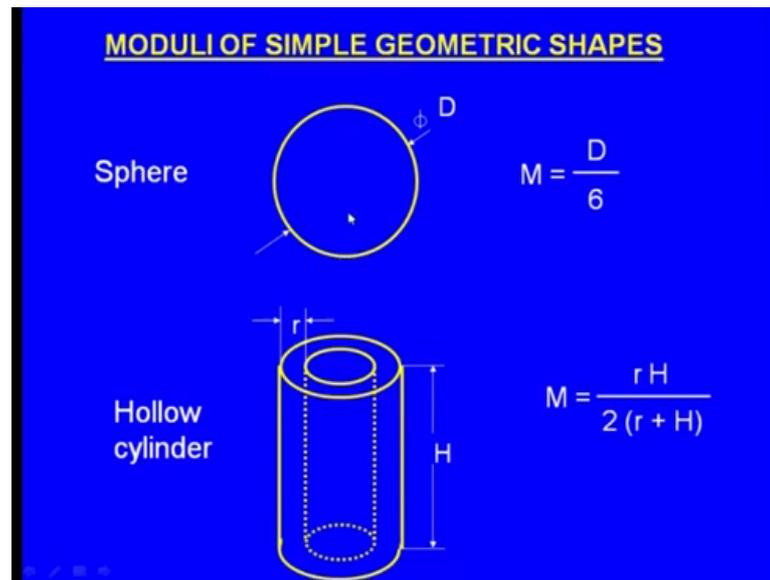
Next one, let us consider another a simple shape that is the long bar, where a is the height b is the width. Then Modulus is equal to $a b$ divided by 2 into a plus b . Next one let us take the cube another simple geometrical shape.

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This is a cube right, so where right one side is equal to D Modulus is equal to D by 6 . So, calculation I am not showing, but even if you calculate you will get the same what say figures same values. Next one, let us consider a cylinder where diameter is equal to D . And if you are try to get the Modulus, Modulus means volume by surface area; you calculate the volume and you calculate the surface area and the ratio of the volume to surface area and if you calculate it comes to be D by 6 .

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Next one a sphere and for sphere the Modulus means the ratio of the volume to surface area, again it is equal to D by 6. Next one, let us consider a hollow cylinder. And here we can see this is a cylinder right, so inside there is a hole. Actually you can see and the height of the cylinder is H and the here we can see the thickness of the solid portion is r.

Now in such a case what is the Modulus is the same expression Modulus is equal to volume divided by surface area, and if you calculate the volume and if you calculate the surface area and if you calculate the ratio of the volume to surface area you will get this thing. M means Modulus is equal to rH divided by 2 multiplied by r plus H. So, these are the moduli of some simple geometrical shapes. Now, let us take a problem.

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PROBLEM:

Determine the size of a side riser for a casting of dimensions 25 x 25 x 5 cm, using modulus method.

SOLUTION:

Volume of casting, $V_c = 25 \times 25 \times 5 = 3125 \text{ cm}^3$

Surface area of casting, $SA_c = 2(25 \times 25) + 4(25 \times 5)$
 $= 1750 \text{ cm}^2$

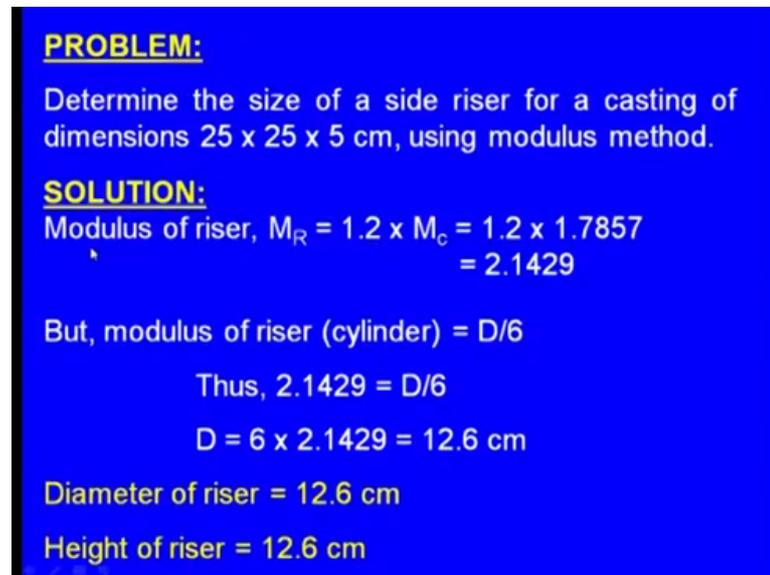
Modulus of casting, $M_c = V_c / SA_c = 3125 / 1750$
 $= 1.7857$

Determine the size of a side riser for a casting of dimensions 25 into 25 into 5 centimetres using Modulus method. Now previously we have designed the riser using Caine's method, now we are going to design the riser using Modulus method. This is the solution. Now in the Modulus method what we have to do, we have to find out the rule says that the Modulus of the riser M_R is equal to 1.2 times the Modulus of the casting. So, we have to initially find out the Modulus of the casting, then we have to find out the Modulus of the riser. Based on the Modulus of the riser, we have to find out its diameter. So, that is the procedure.

So, first we are going to find out the Modulus of the casting. So, volume of the casting V_c is equal to just to multiply this 25 into 25 into 5 that is equal to 3125 cubic centimetres. Next, we have to find out the surface area of the casting. Surface area of the casting means again, so, this 25 into 25. Surfaces there are 2 so 2 into 25 into 25. Similarly this 25 into 4 there are 4 surfaces; 4 into 25 into 25. The total surface area of the casting is equal to 1750 square centimetres. Now the Modulus: what is Modulus volume by surface area right. So, M_c is equal to V_c by SA_c . The V_c means volume of the casting, SA_c means surface area of the casting that is equal to 3125 divided by 1750 that comes to be 1.7857.

So far, we have found out the Modulus of the castings, now based on this we have to find out the Modulus of the riser. The rule says that the Modulus of the riser M_R is equal to 1.2 multiplied by Modulus of the casting.

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PROBLEM:
Determine the size of a side riser for a casting of dimensions 25 x 25 x 5 cm, using modulus method.

SOLUTION:
Modulus of riser, $M_R = 1.2 \times M_c = 1.2 \times 1.7857$
 $= 2.1429$

But, modulus of riser (cylinder) = $D/6$
Thus, $2.1429 = D/6$
 $D = 6 \times 2.1429 = 12.6 \text{ cm}$

Diameter of riser = 12.6 cm
Height of riser = 12.6 cm

So, this is the Modulus of the riser is M_R is equal to 1.2 into M_c that is equal to, right so, 1.2 into M_c what is M_c we got 1.7857; so 1.2 into 1 right, 1.7857. So, this is the Modulus of the riser. But previously, we have seen we have found out the moduli of some simple geometrical shapes. Among them cylinder was there you remember just to go back.

So, what was the Modulus of this cylinder? D by 6; so now we do not have to calculate again, we need not calculate the volume and we need not calculate the surface area again, straight away we take the Modulus of the cylinder as D by 6 now the Modulus of the riser that is a cylinder is equal to D by 6. Now, this D by 6 is equal to 2.1429, this. From this we can find out the D . D is equal to 6 into 2.1429 that comes to be 12.6 centimetres. So, the diameter of the riser is equal to 12.5 centimetres. Similarly, the height of the riser is equal to 12.6 centimetres. So, this is a side riser. So, this is the way to calculate or to design the riser using Modulus method.

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PROBLEM: 3 During the casting of a certain alloy using a sand mould, it took 155 seconds for a cube-shaped casting to solidify. The cube was 50 mm on each side. (a) Determine the value of the mould constant in Chvorinov's Rule. (b) For the same alloy and mould, determine the total solidification time for a cylindrical casting whose diameter is 30 mm and length is 50 mm.

SOLUTION (To determine the mould constant)
Volume of the cube, $V = (50)^3 = 125,000 \text{ mm}^3$
Area of the cube, $A = 6 \times (50)^2 = 15,000 \text{ mm}^2$
 $(V/A) = 125,000 / 15,000 = 8.333 \text{ mm}$
Total solidification time, $TST = 155 \text{ seconds}$
Assumed value of $n = 2$
Mould constant = ?

Now let us see one more problem. During the casting of a certain alloy using a sand mould it took 155 seconds for a cube shaped casting to solidify. The cube was 50 millimetres on each side. Now there are two questions: the first question is determine the value of the mould constant in Chvorinov's rule, and the second question is for the same alloy and maul determine the total solidification time for a cylindrical casting whose diameter is 30 millimetres and the length is 50 millimetres.

Now, let us see the solution. To determine the mould constant that is the first question. Volume of the cube V is equal to 50 cube that is equal to 1.20000 cubic millimetres. Now, area of the cube A is equal to 6 into 50 square that is equal to 15000 square millimetres. Now we have to find out V by A ratio. So, that is equal to 125000 divided by 15000 that is equal to 8.333.

Now, total solidification time TST is equal to 155 seconds that is given. Now assumed value of the n is equal to 2. Now what is the mould constant?

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CHVORINOV'S RULE

$$TST = C_m \left(\frac{V}{A} \right)^n$$

Where,

TST = total solidification time = 155 seconds

V = volume of the casting = 125,000 mm³

A = surface area of casting = 15,000 mm²

n = exponent usually taken as 2

C_m is a constant which depends upon mould material

Now, this is the Chvorinov's rule. TST is equal to C_m multiplied by V by A² the power of n; where TST is equal to total solidification time that is equal to 155 seconds, V is equal to volume of the casting that is equal to 125000 cubic millimetres, A is equal to surface area of the casting that is equal to 15000 square millimetres, n is equal to exponent usually taken as 2 and we have taken it as 2 and C_m is a constant which depends upon the mould material.

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PROBLEM: 3 During the casting of a certain alloy using a sand mould, it took 155 seconds for a cube-shaped casting to solidify. The cube was 50 mm on each side. (a) Determine the value of the mould constant in Chvorinov's Rule. (b) For the same alloy and mould, determine the total solidification time for a cylindrical casting whose diameter is 30 mm and length is 50 mm.

SOLUTION (To determine the mould constant)

From Chvorinov's rule:

$$\begin{aligned} C_m &= TST / (V/A)^2 \\ &= 155 / (8.333)^2 \\ &= 2.232 \end{aligned}$$

Mould constant = 2.232 s/mm²

Now, from Chvorinov's rule C_m is equal to TST divided by V/A^2 . So, that is equal to 155 divided by 8.333 square. And if we simplify this it will become 2.232

So, the mould constant in this problem is 2.232 seconds per square millimeters.

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PROBLEM: 3 During the casting of a certain alloy using a sand mould, it took 155 seconds for a cube-shaped casting to solidify. The cube was 50 mm on each side. (a) Determine the value of the mould constant in Chvorinov's Rule. (b) For the same alloy and mould, determine the total solidification time for a cylindrical casting whose diameter is 30 mm and length is 50 mm.

SOLUTION (To determine the total solidification time)

For cylindrical casting with dia. 30 mm & length 50 mm

Volume, $V = \pi D^2 L / 4 = \pi (30)^2 (50) / 4 = 35,343 \text{ mm}^3$

Area, $A = 2\pi D^2 / 4 + \pi DL = \pi (30)^2 / 2 + \pi (30)(50)$
 $= 6126 \text{ mm}^2$

$V/A = 35,343 / 6126 = 5.77$

Next problem is to determine the total solidification time. For cylindrical casting with diameter 30 millimeter and length 50 millimeters volume V is equal to $\pi D^2 l$ by 4 that is equal to 35343 cubic millimeters, area A is equal to $2\pi d^2$ divided by 4 plus πDL that is equal to π multiplied by 30 square divided by 2 plus $\pi 30$ into 50 and if we simplify this it becomes 6126 square millimeters. So, this is the area. Now V/A is equal to 35343 divided by 6126 that is equal to 5.77

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PROBLEM: 3 During the casting of a certain alloy using a sand mould, it took 155 seconds for a cube-shaped casting to solidify. The cube was 50 mm on each side. (a) Determine the value of the mould constant in Chvorinov's Rule. (b) For the same alloy and mould, determine the total solidification time for a cylindrical casting whose diameter is 30 mm and length is 50 mm.

SOLUTION (To determine the total solidification time)

$$TST = C_m \left(\frac{V}{A} \right)^n$$
$$= 2.232 (5.77)^2$$
$$= 74.3 \text{ seconds} = 1.24 \text{ minutes}$$

The casting solidifies in a time span of 1.24 minutes.

TST is equal to C m multiplied by V by A to the power of n that is equal to 2.232 multiplied by 5.77 to the power of 2 means that is the constant. So, if we simplify this it is 74.3 seconds or if we convert into minutes it becomes 1.24 minutes. So, the casting solidifies in a time span of 1.24 minutes.

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MERITS OF MODULUS METHOD

1. The method is independent of the material of the casting (Constants a, b & c don't come into picture).
2. Method is simple and not tedious like Caine's method.

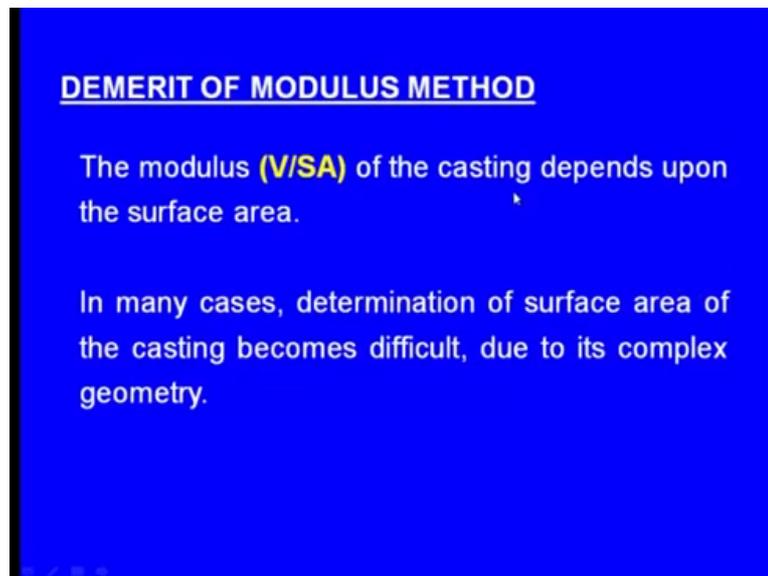
So, in this lecture we have seen the what say design of the casting, now we will see design of the riser. Now we will see the merits of the Modulus method. Now these are the merits of the Modulus method. The method is independent of the material of the

casting, whereas in the case of Caine's method for each material there were different constants a b c. So, for each material the values of these constants were different. So, there was a lot of calculation right. So, whereas, in the case of the Modulus method these constants a b c do not come into picture. So, that is the merit of the Modulus method.

Next one method is simple and not like tedious like Caine's method. In the Caine's methods right we got your what say you know higher order equation and by trial and error we had to solve it.

So, that was a tedious process. So, such a process is not this one this is a simple process. But it has got limitation too. What are its limitations?

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So, this is the demerit of the Modulus method. The Modulus means the volume to surface area ratio of the casting depends upon the surface area of the casting, is it not. We have considered in this problem just for the sake of the what say exercise we have taken simple shapes a rectangular block. But in the real world in the practical applications what would be the geometry of the casting? Most complex geometries would be there, the most of complex surfaces would be there, then how to find out the surface area of such surfaces. It is very difficult. That is why in many cases determination of surface area of the casting becomes difficult due to its complex geometry.

No problem as long as the what say geometry of the casting is simple we can very well find out the surface area and we can find out the modulus. But once the casting has a complex surfaces then the determination of the surface here would become a tough task at such times use of this method would be a difficult task.

So, friends in this lecture we have seen the purposes of the riser, the functions of the riser, types of riser and different methods that have been developed for designing the riser. They are the Caine's method, Modulus method and the Naval Research Laboratory method. In this lecture we have seen and we have learnt about the Caine's method and the Modulus method. We have seen the merits and the limitations of both these methods. And in the next lecture we will be learning about the Naval Research Laboratory method

Thank you.