Principles of Casting Technology
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Lecture - 18
Gating System Design
Pouring Time Calculation

Welcome to the lecture on Gating System Design, in this lecture we will discuss about finding the pouring time for top and bottom gating system.

So, what we have understood so far is that, you can pour the liquid matter either from the top of the box or top of the cavity, you can pour it from the bottom of the cavity, and you can also pour or you can allow the molten metal to enter into the cavity at the parting line. So, we will try to find what is the difference when we change the point of pouring either at the top of the cavity, or at the bottom of the cavity if we pour, what is the difference in pouring time? So considering the top gating first, as we know that, in case of top gating, we are simply you have a cavity. So, this cavity is to be filled.

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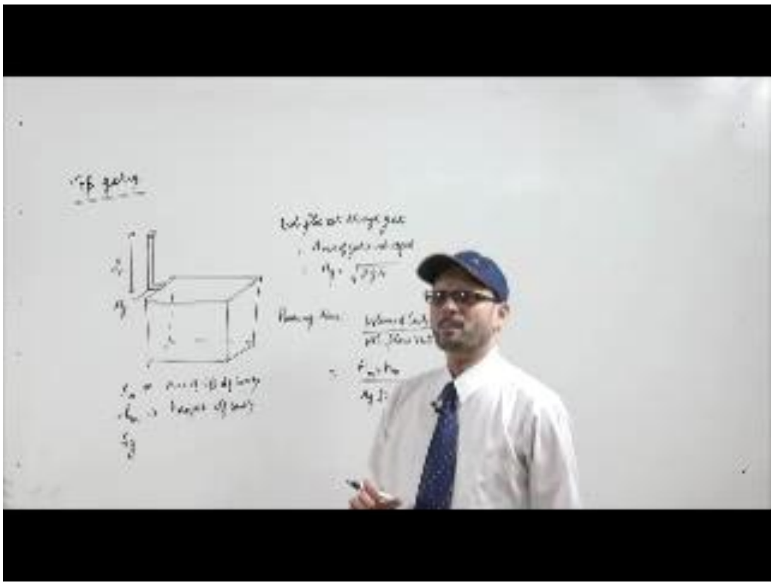

Now this cavity is to be filled, and the molten metal will enter at this point. So, it will be entering from here and you have a pouring cup here. So, basically if this is the height, if this is the height of this portion from where the metal enters into the cavity. So, this is the head of the metal, in that case, once you know the area of cross section of this casting

A m as area of cross section and of cavity or mold cavity, and then if h is the height, is the height of mold or cavity. In that case and this A g, A g is the A g here, this is A g. So, the volumetric flow rate will be area times the velocity at this point. So, volumetric flow rate will be through gate that is top gate, it will be volume. So, it will be area into velocity, it will be area of the gate into velocity at gate. So, are of the gate you can take it as A g and you can have velocity. So, velocity since it is coming from the height of h. So, using the Bernoulli's theorem, you can find this velocity will be root 2 g h.

So, if you have to find the pouring time, pouring time can be found by dividing this volume of this cavity upon volumetric flow rate. So, it will be volume of cavity or mold divided upon volumetric flow rate. So, once you know the volume of the cavity, which is to be filled in. So, this m represents for the metal basically. So, this will be A m into h m upon A g into root 2 g h. So, this is fairly simple in case of top gating. Once you know the effective metal head from where the pouring cup is placed and each point the metal is entering into the cavity, you can have the velocity. This velocity will be multiplied with the area of the gate, and that will be basically the denominator part, and the numerator part will be the volume of the metal or volume of the cavity, and then you if you divide them you get the pouring time. Now we will discuss about the bottom gating.

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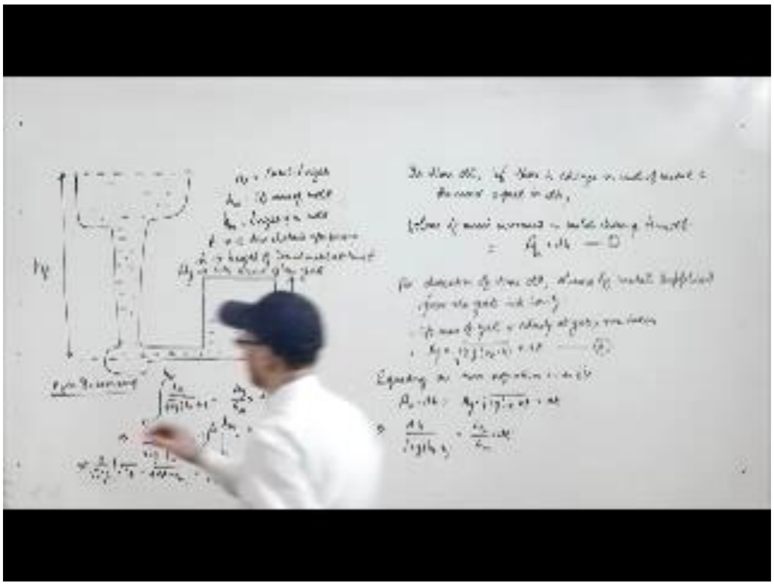

Now, in the case of bottom gating what we see is your metal will enter from the bottom. So, it goes like this, this is the schematic for a bottom gating where the pouring is done at the bottom. Now this height can be taken as total height. So, this h t is taken as the total height. So, this is the head available initially when the metal will start falling down, this is the height of the mold or the cavity, that is h m, the area of cross section. So, you have few terminologies h t is total height. So, it is total height of the spool level up to the top of the pouring machine then you have A m as cross sectional area of the mold or the cavity. So, this portion which is to be filled in, h m is height of the mold which is to be filled in, t is basically we take t a time elapsed after pouring. So, after time t

So, you in this case what happens, when metal starts getting poured into this cavity. So, as the metal starts to getting poured, the liquid metal rises into this cavity. So, initially you have a head available equal to h t. whereas; as it rises the head available will be h t minus h. So, suppose if you take this height as h, h is the height of liquid metal at time t. So, what happens after time t as the time progresses, the head which is available to you, that basically is started decreasing; so that becomes h t minus h. In that case, the velocity which was initially under root 2 g h t. If you look at the velocity at this point at the start of the time when the molten metal is just first entering into this cavity, it will be root under 2 into g into h t; however, it you go on decreasing and that will be root under 2 g into h t minus h.

A g is taken as the cross sectional area of the gate. So, the area of cross section at this point of the gate, from where the metal enters into the cavity is taken as A g. Now what happens? That in time d t, if there is change in level of metal in the mold equal to d h. So, if in the time d t the level of change is d h. So, in the d h time, the A mount of metal which is supplied in time d t will be, if that is multiplied with the time d t. So, area of this gate multiplied by velocity of the gate, multiplied by time d t, that should be equal to the volume of the metal which has rows in the time d t and so volume of metal increased in mold during time d t. So, during this time d t, the level of metal increased is d h and the area of the cross section of the mold is A m. So, it will be A m multiplied by d h.

Now, this volume is nothing, but in the time d t there has been some velocity here, multiplied by the area of the cross section multiplied by the time. So, for duration of time d t, volume of metal supplied from the gate into the cavity. So, that will be nothing, but it will be cross sectional area of the gate, multiplied by velocity at the gate and then that being multiplied further by the time taken. So, cross sectional area of the gate is written as A g.

Now velocity at the gate: so at time t, the height was h. So, at this point of time the velocity at the gate was under root 2 g h t minus h, and then it will be multiplied with time d t. So, this will be the A mount of liquid metal which will be supplied from this portion into the cavity, because that has increased the level of this height by d h. So, we have to equate this and this. So, what will happen A m into equating the. So, if you take this as 1 and this is as 2, the 2 equations, 1 and 2, if you try to equate that what you see is, A m into d h will be A g into root 2 g, h t minus h into d t.

So, you can further write as d h upon under root 2 g, h t minus h, it will be equal to A g upon A m into d t. So, we have to integrate on both the sides. So, once we integrate it, you can get, after integrating. So, how you have to integrate, this h varies from 0 to. So, 0 to d h upon root 2 g, h t minus h and time will be. So, total time of pouring and A g upon m. So, it will be A g upon m into time of pouring T p. So, what you see is, this will be one by root 2 g, and then it will be minus of h t minus h to the power half, and this will be multiplied by 2. So, 2 by root 2 g minus of h t minus h, it will be equal to A g upon A m into time of pouring, and you have to put it from 0 to h m.

So, it will be nothing but. So, once you do it, now in this case what you see is, here you have h m coming first. So, h t minus h m and then this is minus, and in the another case where it will be 0 coming, it will be only h t. So, that word term will be positive. So, it comes to be 2 by root 2 g into root h t, minus root h t minus m will be equal to A g by A m into T p. So, we can find the expression for T p.

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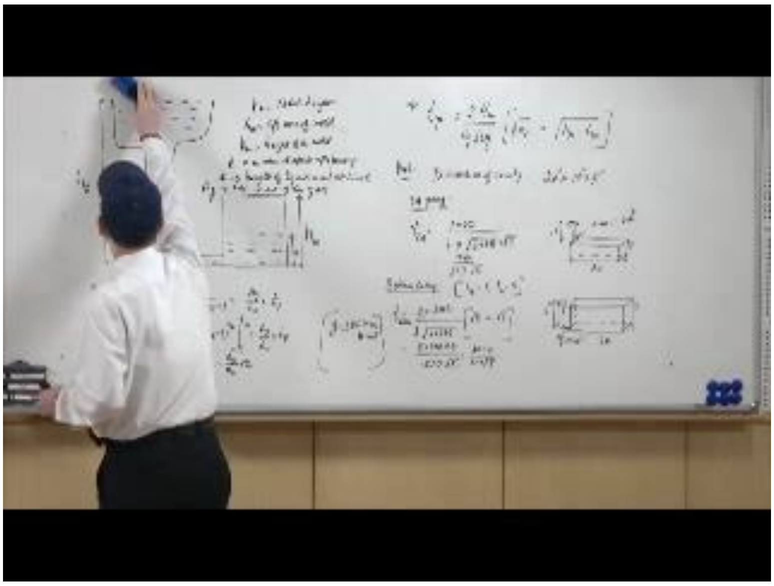

So, we can get from here the value of T p as, 2 into A m upon A g under root 2g, into under root h t, minus under root h t minus. This is the time of pouring when we allow the gate to enter into the cavity, from the bottom of the mold.

Now, let us take an example and see how these different types of pouring, either from top or bottom is going to affect the pouring time. So, let us see if you have a problem like if you have a cavity, which has the dimension as 20 by 10 by 5. So, dimension of cavity 20 by 10 by 5 each. So, you can have as this. So, what you see is, this is your 20, 10 and 5. Now in this case, if you go for top gating and. So, top gating you will have entry of liquid metal from here, using a pouring cup and this height is given as 5 inch, and the area here is given as gate area is 1 inch square.

For this casting, you have to find what will be time taken using the top gating, as well as using the bottom gating. So, if you take top gating, what will happen using the top gating time will be volume by volumetric flow rate? So, volume is 1000 inches cube, divided by in the case of root 2g h. So, area is 1 inch square, into root 2g h. So, in the case of that system it is 386. So, this will be 386 into root h. So, root h is 5; g value is 386 inch per Second Square. So, in that case you can take it as close to 27.7. So, it will be thousand divided 27.7 into root 5.

Now, in the case of bottom gating, as we see it will be 2 times A m. So, A m is nothing but it is 200 by A g. So, A g is 1 into root 2g. So, this is root 2 into 386, that is 27.7, under root h t into minus h t minus h m. Now in this case, in the case of bottom gating what you see is, your h t was 5 and was 5.

So, what happens here? It will be root 5 minus 0. So, it will be taken as 2 into 200 into 5 upon 27.7 roots 5. So, that is 2000 upon 27.7 roots 5. What we have done is, you have under root 2 into 386 basically the value of g has been taken as 386 inches per centimeter square. So, that is why under root 2 g will be 227.7 it has been taken as. And here what you did is, we did is that we multiplied at the numerator as well as the denominator by root 5. So, it becomes 5 and then in the denominator extra root 5 comes. So, it will be 2000 upon 27.7 multiplied by root 5. It was 1000 divided by 27.7 into under root 5.

So, what we see is, in the case of top gating, and in the case of bottom gating. So, what we see is in the case of top gating, the time taken is half of the time taken in case of bottom gating. So, if you are given now in this case what we see is, you have the height of the total height as well as the height of the mold or the cavity is same, that is why this term has vanished here in this case, but that will not be the always the case, in that cases the h t and h m will be different. And in that case you can use this formula and find the value of the pouring time using the top as well as the bottom gating. So, this is how you calculate the top gating and the bottom gating pouring times.

Now, comes what to do when you have the parting lines gate? So, in the case of parting line gates what we see is, in the case of parting line gates, we have basically 2 portions to be filled. Half of the portion will be filled using the top gate principles. So, first portion will be the calculation of the pouring time using the top gating principle, we can look at the figure and try to make it out how to find the pouring time in case of parting gates. So, in the case of parting gates what will happen?

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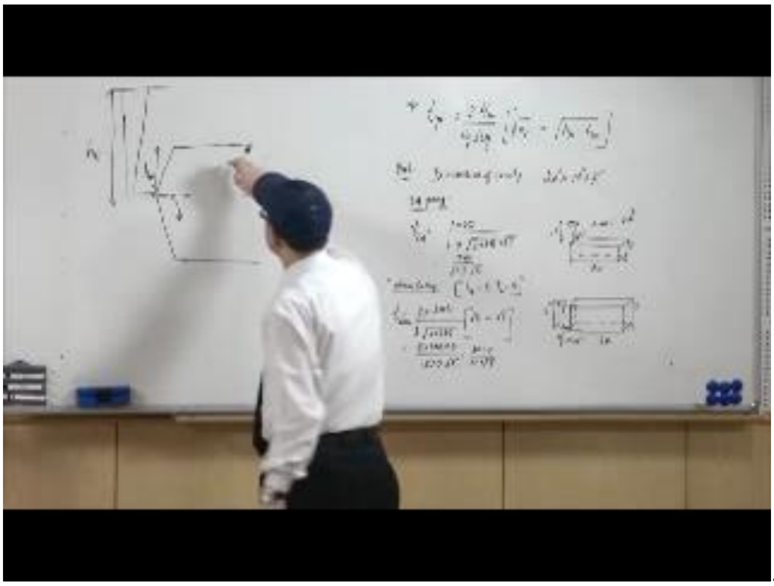
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Now, we have entry from here. So in the case of parting gates, the metal which will enter; so suppose this is certain head. Now, the metal which will enter this will go first and fill the bottom portion. So, in this case the formula that is volume upon the velocity at this point, that is under root 2 g h t, into area at this gate. So, that will be calculated to find the pouring time calculation in the lower half of the domain; then when we come into the upper half portion of the domain, then in that portion you have to calculate the pouring time using this formula. So, depending upon this height, this will be h m. So, for this portion it will be simply this volume divided by area at this point, and velocity at this point. And for this A gain you have h t and h m, so you will use this formula and you will find the time calculated, time required to fill this cope half of the mold; and then you add these 2 portions, and for the parting line gates, you can calculate this pouring time in this fashion.

So, in this way you can calculate the pouring time for different types of gates. Although there are many empirical formulas which are established while pouring, but this is the way you can see that how it is derived by using the top or bottom or parting line gating, you can find the pouring time for different cases.

Thank you.