Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology- Part-1

Module- 18

by
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Hello, and welcome to this manufacturing process technology part1 from module 18.

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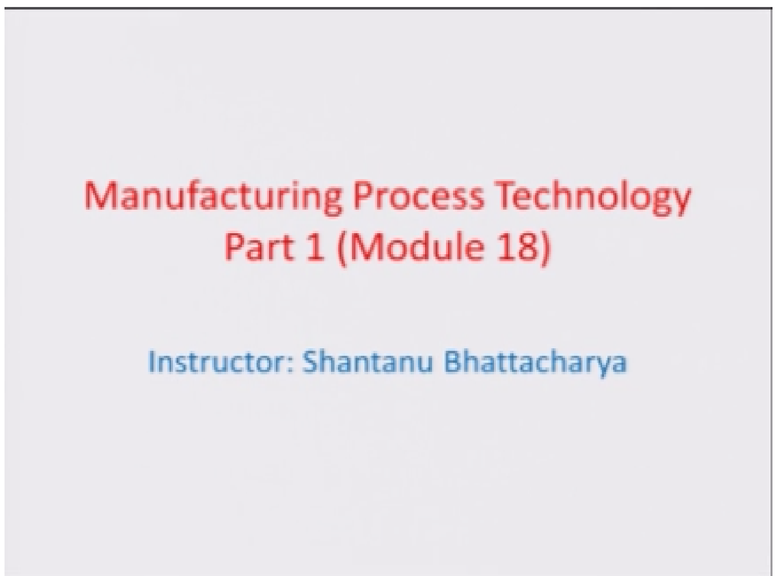

We were discussing about the two different cases of vertical gating and the bottom gating system and we recorded that the time of filling in both the cases I could be found out from two different approaches without considering friction.

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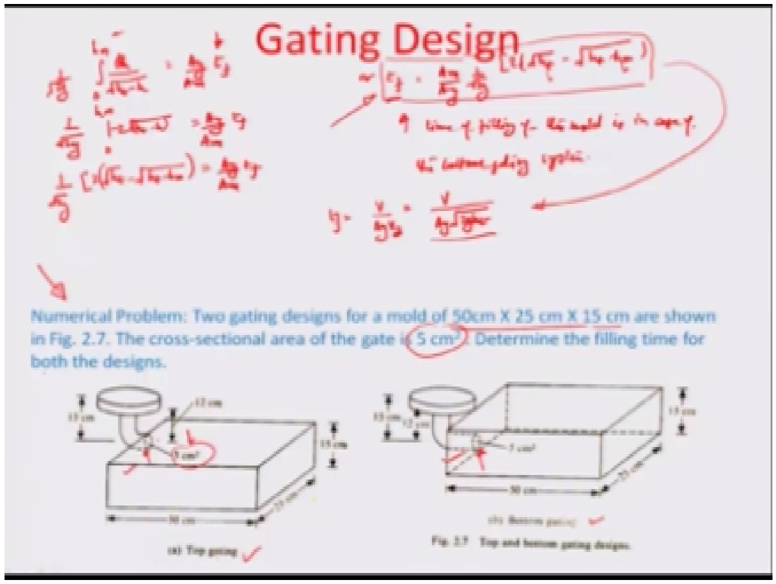

So in one approach we try to estimate the time of filling with the values which comes because of the bottom gating system and this t_f came out to be the area of the mold per unit area of the gate by into times of $1/\sqrt{2g} x 2\sqrt{h_t - h_m}$, where h_t is the height of poring basin h_m is the height of the mold above same the domain. $t_f = \frac{A_m}{A_g} \frac{1}{\sqrt{2g}} \left[2 \left(\sqrt{h_t} - \sqrt{h_t - h_m} \right) \right]$ In the case of vertical gating system as done earlier the total time of filling was recorded as a volume of the mold times of the gate area, times of gate velocity v3 and this was recorded as only $A g = \sqrt{2ght}$, okay.

So there is a little difference you know in the way that they have calculated and also the estimation of the time of filling and we tried to discuss a numerical problem where we would assume a certain gate region and in one case a bottom gating system another case a top gating system and then actually physically try to calculate what is the time of filling of both the molds. So let us do that so in this particular illustration as you can see.

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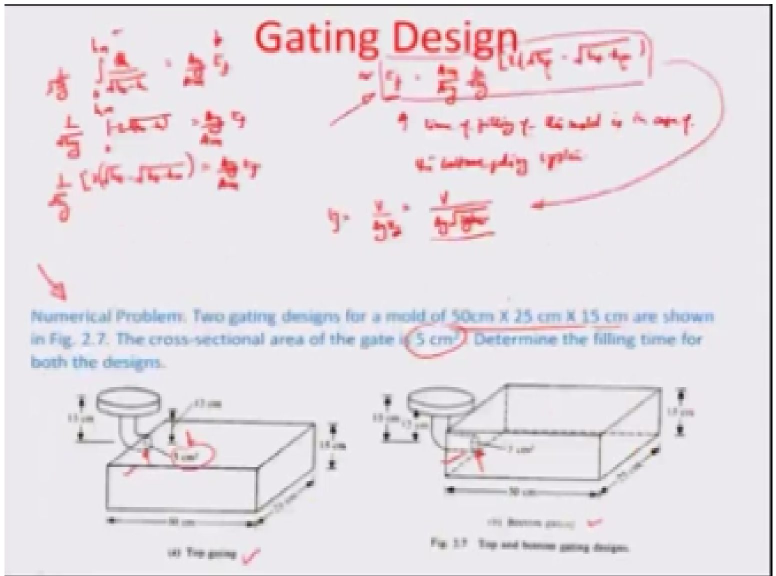

On the top gate has a diameter of $5cm^2$ and we can say that supposing we wanted to calculate the velocity head v3 at this particular point write about here let us say this is the point 3 so the v3 here can come out to be $\sqrt{2g}$ times of in this case h_t which is actually height of the mold above the gate region and I can assume this to be 15 cm, right so this comes out as $2x981cm/sec^2$ the value of gx15cm/sec, so this comes out to be 171.6cm/sec.

And if I calculate the volume of this mold as has been provided in the expression or in the problem statement it is $15x25x15cm^3$ okay, and the gate area here Ag has been given to be $5cm^2$ so the total time of filling assume the, assuming the first model here the top gating system becomes equal to the 50x25x15/5x171.6 because 5 is the gate area and cm^2 and this is the velocity gate velocity in cm/sec, okay so this comes out to be equal to 21.86sec.

And the other example problem here for the bottom gating system shows that here the h_t=15cm and h_m=15cm as well so the mold height is the same as the height of the riser and so therefore again if I use the equation 2 here which was about how t_f would be calculated as area of the mold by area of the gate divided by 1 by $\sqrt{2g}[2\sqrt{h_t}-\sqrt{h_t-h_m}$ so in this particular case the, so the h_t here is obviously 15cm as you can see, but you know the differential h_t-h_m is really over and above what height is there of the poring basin from the top of the mold, okay. So if I just that is a way that we have assumed this before earlier.

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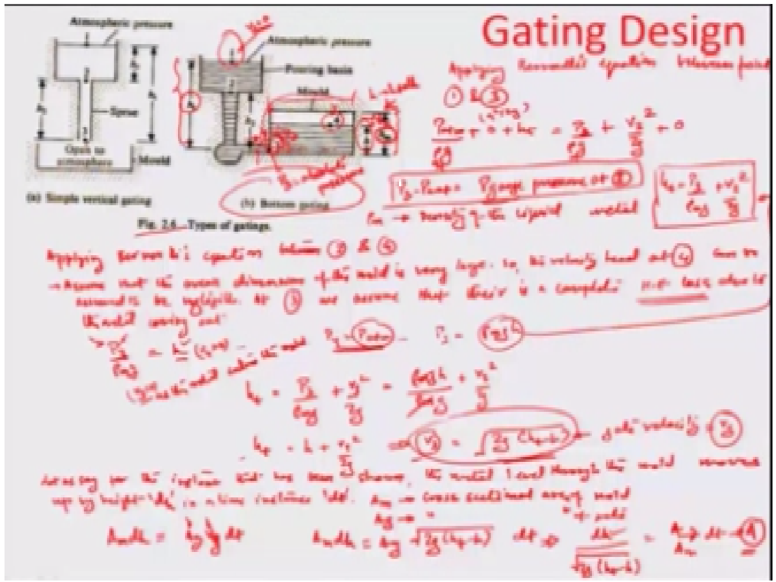

If you may look at you know the problem statement here this h_t-h_m really is the height from the top of the mold all the way to the top of the poring ladle, okay so in this particular case if I may just closely have a look.

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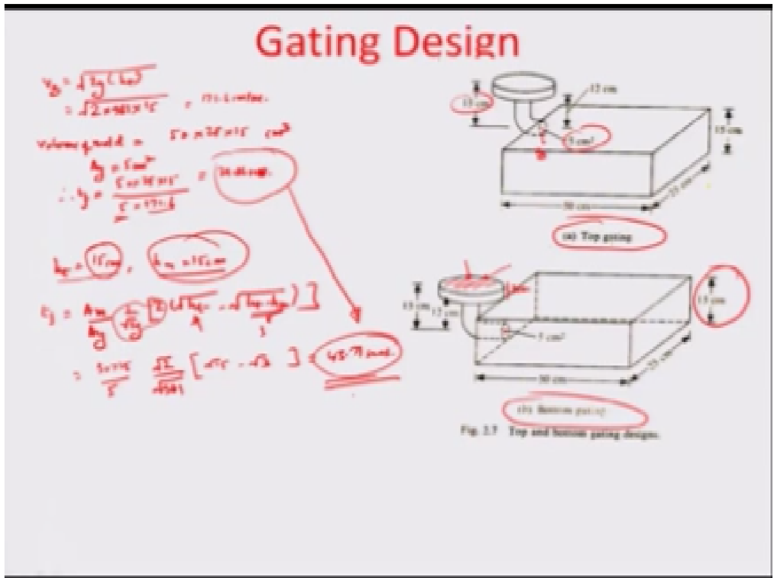

The height of the top portion or the poring ladle from the you know the total mold height that differential is only 3cm, so this h_t-h_m actually although the mold height is 15cm as you can, you may recall and it is all about how you are locating this datum line for the sake of calculation so this becomes equal to 3cm okay, so I have t_f found out as 50x25 divided by the gate area which is again 5x$\sqrt{2}$/$\sqrt{981}$ that is $\sqrt{2g}$ coming out of these two terms okay, [$\sqrt{15}$-$\sqrt{3}$] which in this case becomes much, much higher 43.71 sec.

So you can see that merely by changing the gating system from a top gating to a bottom gating system obviously, the metal enters the mold much slower and the overall time that is needed by the metal to fill up the mold is much, much higher, okay. so having said that, that is how the gating design system works and then there are very integrate problems associated with casting and one of the problems we generally come is called aspiration and there is a particular you know energy balance crisis which will created which is kind to going to kind of in gas or maybe you know just pull out atmospheric air or dissolve the gas around in the whole casting material in the liquid metal, okay.

And mold is carefully made permeable with the view point that all the gases which are dissolved should go out rather than gases being taken in.

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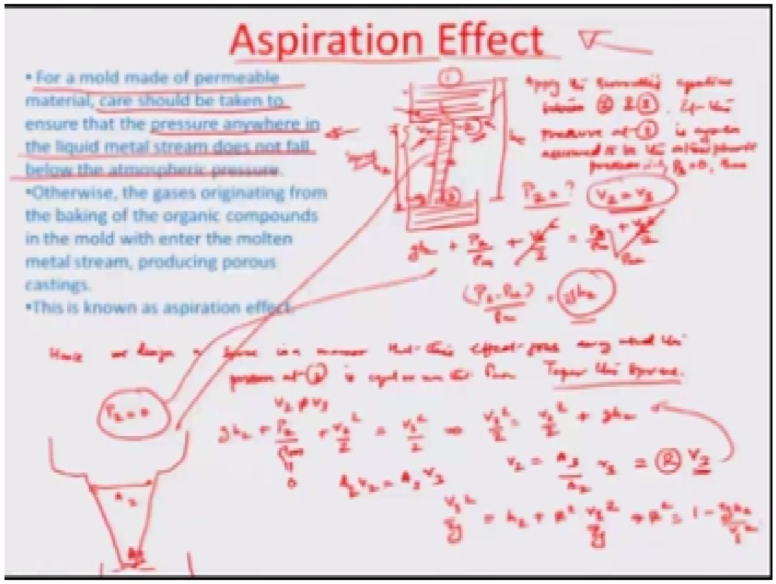

So for a mold made of permeable material you know you should take care that the pressure anywhere in the liquid metal stream does not fall below the atmospheric pressure. So obviously permeability is more to a certain that the pressure inside is more than outside and then the gas actually which is desoluablizing should be able to escape, but in it should not be that by engineering design you are able to make some shape or size or venturi where it is the other what around and the pressure inside falls below the atmospheric pressure so that there is a in gasing of the atmosphere into the mold.

So this effect is known as aspiration and it is actually only an effect created by geometric considerations and how it is created can be just illustrated particularly in the vertical gating designs and you know if I just look at how a vertical gating is again going to happen let us say for example, this is the poring basin okay, and we are trying to pore the liquid metal through a vertical pipe into the mold kept right about here which is also open to atmosphere.

And I think I had done this calculation earlier that how the time of filling etcetera could be estimated, but there is a problem, there is a potential problem which happens because of the way that these energy balance equation is applied at the various zones of the mold. So there were three zones which were of importance to us two zones which are of importance to us, one was the zone 1 which was at the top here and then we calculated that all the way to the gate region that is zone 3 what is going to be the velocity based on this zone 1, okay.

But there is another important point here which is important from the point of this aspiration effect as I have been mentioning which is the point 2 okay, so if I really apply now the energy balance equation between 2 and 3 so let us say I apply the Bernoulli's equation between 2 and 3 and if the pressure at 3 is again assumed to be the atmospheric pressure that is $P_3=0$ then P_2 which is actually the pressure in this particular zone write about here becomes you know can be obtained from the energy balance equation.

So I assume that because this is a cube of constant cross section or constant diameter the velocity of 2 should be actually equal to the velocity of 3, so $v_2=v_3$ because there is no change in the cross sectional area and so if constant discharge is assumed and there is a continuity which is assumed of the material then there should not be any change in the velocity of v_2 vis-à-vis is the velocity at v_3, and by apply between 2 and 3 the energy balance equation becomes gh_2 which is actually the height of the point 2 as can be seen here from here to here is height h_2 and from here all the way to here is height h_t, okay.

So gh2 plus the pressure at 2 divided by density of the liquid metal $\rho m+v2^2/2$ becomes equal to the pressure at $3/\rho m+v_3^2/2$ $\frac{P_3}{\rho_m}+\frac{v_3^2}{2}$ and $v_2=v_3$ these guys go away and we are left with the simple case that the pressure at 3 obviously is the atmospheric pressure P atmospheres so the pressure at 2 or the gage pressure at 2 let us say P_2-P atmosphere the gage pressure at 2 becomes equal to $-gh_2$ so this is actually a negative pressure at 2 and it will actually pull on all the gases from the atmosphere which is either solubilized in the system or also in this particular permeable mold and through this permeable mold and so there is going to be gas accumulation in this region because of a negative pressure which is lesser than the atmospheric pressure.

So how do you solve this problem is a very critical question, so hence now you design a sprue in a manner and sprue typically is this particular part as I think I have recalled many times earlier so sprue in a manner that this effect goes away and the pressure at 2 is either equal to more than the atmospheric pressure. So the only way to do it is to taper the sprue let us assume the limiting case where the $P_2=0$ and not negative that means it is same as the gage pressure so the gage pressure is 0 or P_2-P atmosphere is basically equal to 0 so assuming that in this particular equation again all the way here and I do not assume $v_2=v_3$.

So let us not take $v_2=v_3$ because of the tapered design of the sprue, so I would have $gh_2+P_2/\rho m$ which is 0 in this particular case plus $\frac{v_2^2}{2}$ equals you know the atmospheric pressure which is now base lined so we take this gage pressure at 0, at 3 at 0 is $\frac{v_3^2}{2}$. So in other words, we are having $\frac{v_3^2}{2}$ becomes equal to $\frac{v_2^2}{2}$ $+gh_2$ okay, and from the principle of continuity obviously if instead of this I design something like a tapered sprue like this which is going into a mold then obviously if the area here is a_2 and the area here right now is a_3.

So a_2v_2 should be equal to a_3v_3 from continuity equation therefore v_2 can be represented as a_3/a_2xv_3 which is actually equal to some aspect ratio here R okay, or you can say that this is the aspirator ratio R a_3/a_2xv_3, so if I substitute this back into the equation here we get $v_3^2/2g$ becomes equal to h_2+R^2)x($v_3^2/2g$) or in other words the aspiration ratio that is needed R^2 is $R^2=1-\frac{2gh_2}{v_3^2}$ okay, so that is how you basically design an aspirator which is represented more simplified manner in this particular figure here.

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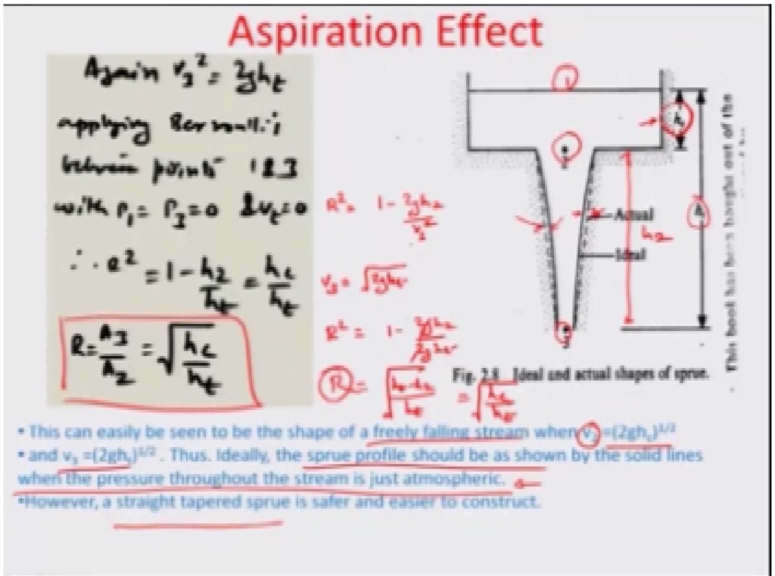

$$v_3^2=2gh_t$$

So you have designed at tapered sprue and you have applied the Bernoulli's so that the R becomes equal to $\sqrt{h_c}$/ht, so from the earlier example problem I already have told you this R^2 to be equal to $1-2gh_2/v_3^2$ and you know that the gate velocity v_3 is $2gh_t$ as that is how it has been estimated, so can have the R^2 to be equal to $R^2=1-\frac{h_2}{h_t}=\frac{h_c}{h_t}$ so which becomes equal to $\sqrt{h_t}$-h_2/h_t okay, and h_2-h_t-h_2 is really this particular height you know hc which we are talking about this is h_2 if you may remember so we have R as $\sqrt{h_c}$/ht.

$$R=\sqrt{\frac{h_c}{h_t}}$$

So whatever be the, between the poring basin height and the you know the height of the differential height of the basin over the sprue okay, so that root of that determines what is the aspiration ratio R in this particular case. So it can easily be seen that the v_2 mostly occurs like a shape of a free falling stream because obviously it is $(2gh_c)^{1/2}$ and h_c is basically this height right here in the same manner you know by applying Bernoulli's between the point 1 and 2 you can apply and calculate.

Similarly v_3 again between v_2 and v_3 is actually becoming $\sqrt{2gh_t}$ so again a freely falling stream height so ideally the sprue should be shown by the sort of solid lines which you can see here because then it will generally follow that under root equation and be like a freely falling stream.

But when the pressure throughout the stream then you know you can say that throughout the stream the pressure is actually atmospheric pressure you go okay, but it is safer and easier to construct a straight tapered sprue as has been by this dotted lines here because following this curve and equation so that I can get a curved profile becomes a little comparison from operational stand point.

So with this I think I will try to end this particular module, but the next module we will try to get another you know factor into modeling of the casting which is the friction factor which you will see changes the para time quite a big and then the time of filling etcetera gets altered heavily because of that friction factor. So with this I would like to end my lecture today thank you for patiently listening to it, thank you.

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