Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 1

Module- 17

by
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Hello and welcome to this manufacturing process technology part 1 module 17. In the last module we were discussing about.

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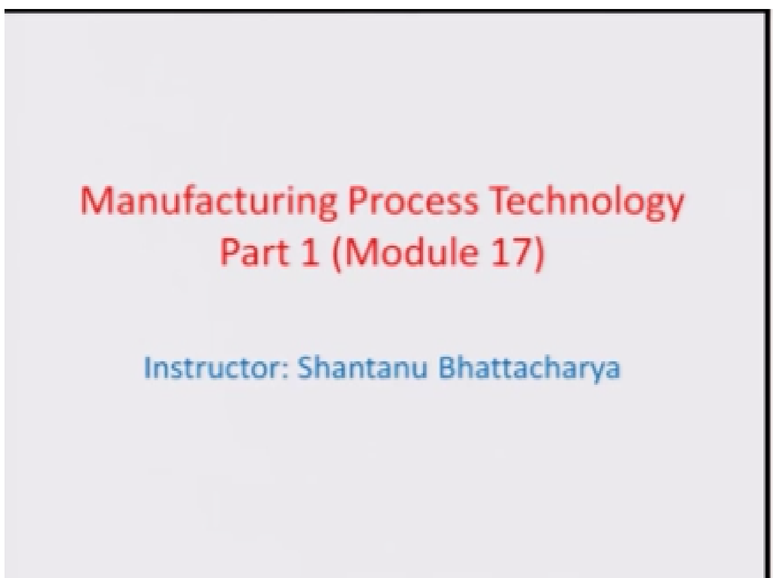

The simple vertical grading system and we try to develop an equation there; you could actually estimate the timing of filling of a mould volume V, with by estimating again the gate velocity and having an idea of the area of gate cross section. So let me just tell into that, a little bit just for recall sakes.

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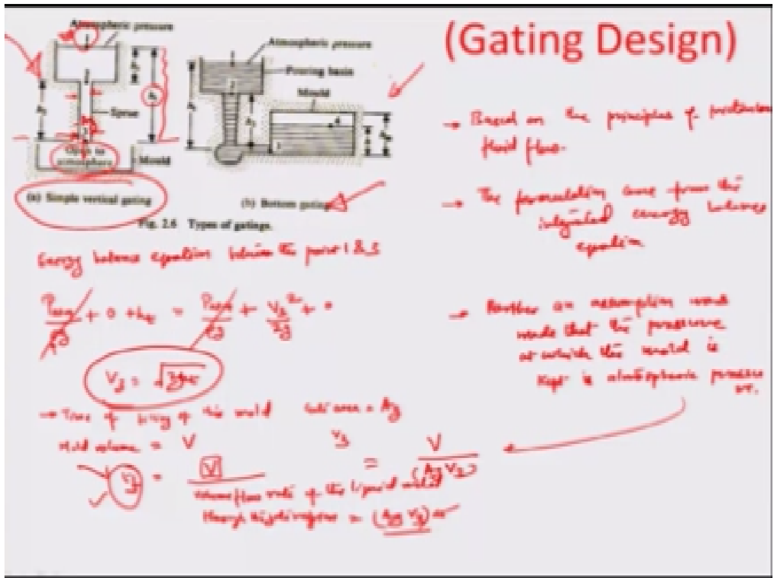

So we had a actually investigated this particular design right here and we had formulated this t_f value oaky which were under certain presumptions, that this was essentially based on the principles of frictionless fluid flow and the formulation came from the integrated energy balance equation. Further an assumption was made that the pressure at which, the mould is kept is atmospheric pressure. So this let the estimation of the t_f value at the time of filling up the mould.

Let us now look at into the other design that is bottom gating design and try to estimate how we can apply, the equation in this particular case okay.

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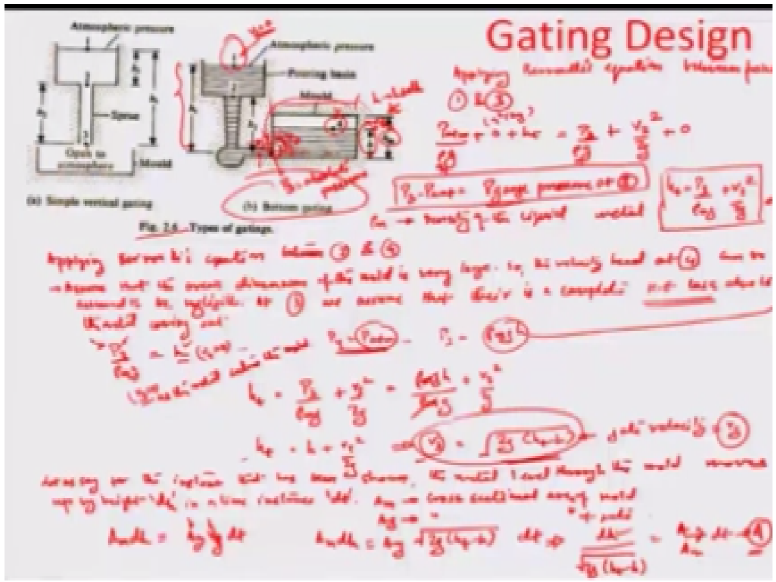

So let us say in this (b) part of this figure then if you apply, for equation between points 1 and 3 points 1 is here, points 3 is gate right of here. So at 1 we get that the obviously the atmospheric pressure here atmosphere, is the pressure at point 1 divide this by density of liquid metal times, excretion to the gravity low. We have a velocity head here which is completely 0, we assume that there is no velocity at the top of poring rays and V0 is 0 and so this 0 is the velocity head v^2, otherwise $\frac{v_1^2}{2g}$ and then you have h_t as the total potential head.

That is available at the top point 1 here of the poring basin. So this is the point 1 and if we do the energy balance at point 3, we have the pressure here let us say for example is illustrated as P_3 so we have $P_3/\rho g$ which is the absolute pressure here. So we recall that this the absolute pressure at v3 and obviously the gate pressure would be difference to the atmospheric, so P_3 minus P atmosphere would really be the gage pressure.

I can say at point 3, so P gage would be the gate pressure point, so this p3/ ρg plus velocity, let suppose the velocity at this particular point is V3 because the fluid is running from a certain potential, you know there is the change in the potential energy in the fluid because it is running from a certain height *ht* all the way to the datum line, which is somewhere around this corner here right about where the v3 is estimated. So the $v3^2/2g$ and then obviously the height from the datum line here, that you consider is consider as 0.

$$P_{atm}/\rho g+0+h_t=P_3/\rho g+\frac{v_3^2}{2g}+0$$

$$v_3=\sqrt{2gh_t}$$

So really having a head loss between the point 3, 0 line at the datum line, so obviously in this particular case, we just write this as ρ_m, just to avoid the confusion ρ_m is the density of liquid metal. So if I now apply the same equation once again, so applying equation now between 3 and 4, so basically we have 1 point here for right about here and the point 3 that we have just calculated, so we have to do an energy balance between 3 and 4, point 3and point 4, and we assume we make some assumption here.

One assumption is here, that we assume that the overall dimension of the mould is very large, so the velocity had at 4 can be assumed to be negligible. Obviously the assumption may not be seem to be practicable but if you consider the fact that the area that is feeding the gate A_g is to small in the comparison to the overall dimension of the mold, in this case mould height in chamber probably the diameter is probably several times, may be 100 times more than the gate area.

So you can consider that for the instant of time that we are considering, the velocity or the kinetic at 4, may be negligible because the rate of rise, because whatever the small amount of metal as entered the mould cavity may not be significant because it get distributed the whole area of the mould, you know which is very big number. So we assume that to be negligible and so we can probably also, say that at 3, we assume that there is a complete kinetic energy loss due to the metal coming out.

So you can see that at this point 3 because the gate region is to narrow and the metal is coming out into the open into a very large area, we can assume that this kinetic energy which was there just before the entry of the gate and the moment it has entered the zone 3, that means it is into the mould now and which is the zone 3 that we are considering here will be. So there the kinetic energy is completely lost to the system or we can assume for this particular case, the energy equation will be $P_3/\rho g$ is equal to the height h.

So we are assuming v4 equal to 0, we are also in a way to assuming v3 to be completely lost as the metals enters the mould. So this is just about the same instance of time, the only thing is it has just entered the mould from the cross sectional area and we are assuming that the amount of kinetic energy to the mould is negligible in comparison to, you know the overall mould sizes extra. Sorry the kinetic energy is negligible because of the overall largeness of the mould size extra and it is as if that, if you droplets from the small gate region into a bigger mass of a fluid.

So the kinetic energy addition is very low and so we are assuming this v3 beyond the gate region is equal to 0 for that reason similarly v4 is 0 and we assume that the P3 is the gauge pressure, so basically what we are talking about is the difference of pressure between p3 and p at 4 where p4 is equal to p atmospheric pressure. So the gauge pressure is always as you have recalled here with respected to the atmospheric pressure.

So we can say P3 minus P at atmospheric the **gauge** pressure here, I will call that p3 okay because we are now getting a base line of the atmospheric and neglecting the p atmosphere everywhere, just like we did it in past year where we talked about you know this particular equation here ht equal to $p3/\rho mg + v3^2/2g$ okay. So from here we can probably obtain the value of p3 equal to $\rho m gh$, if I substitute the value of p3 in this equation write about here we get $ht = p3/\rho mg + v3^2/2g$ or in other words this is equal to $\rho mgh/ \rho mg$.

Mind you h is the height at the point 4 that is why I am taking the potential at h here, so $\rho mg + v3^2/2g$. so this gets eliminated completely and we are left with a situation where we have ht equal to $h + v3^3/2g$ by other words v3 becomes equal to 2g ht minus h under the root. So that is what the gate velocity just prior to the entry that means we are still not entering the mould but prior to entry of the mould is actually is given by this term v3 right about here. So this we can consider to be the gate velocity v_g in particular case.

Now let us go a little further and try to see what happens you know for the instance shown, so let us say for the instance that has be shown, the metal level in the mould moves up through height *dh* in a time instance dt. So I say the height goes from h to h + dh in time interval dt while the gate is continuously feeding the metal and the energy balance equation holds in that particular condition. Let A_m be the cross sectional area of the mould and Ag the cross sectional area of gate.

So you have now that A_m times of dh, so that is the area of the mould times of dh equal to Ag times of Vg, times of dt oaky, so v is the gate velocity, A is the gate area and dt is the time instance which is there. So if I assume all this together and put together, you know what happens to let say, if I put the value of the gate velocity from the previous equation, which I have obtained here into this equation right about this, we get A_m times of dh is actually equal to Ag times of √2g (ht – h) dt. By other words if I just assembled this equation in the right manner, I have dh /√2g ht minus h equal to Ag / A_m Dt.

$$A_m dh = A_g v_g dt = A_g \sqrt{2g(h_t - h)} dt$$

$$\frac{dh}{\sqrt{2g(h_t - h)}} = \frac{A_g}{A_m} dt$$

So if we solve this equation, let us call this equation A, if we solve this equation I should be able to get a relationship for the height versus time from which I should be further able to find out what is the time of the filling of the mould.

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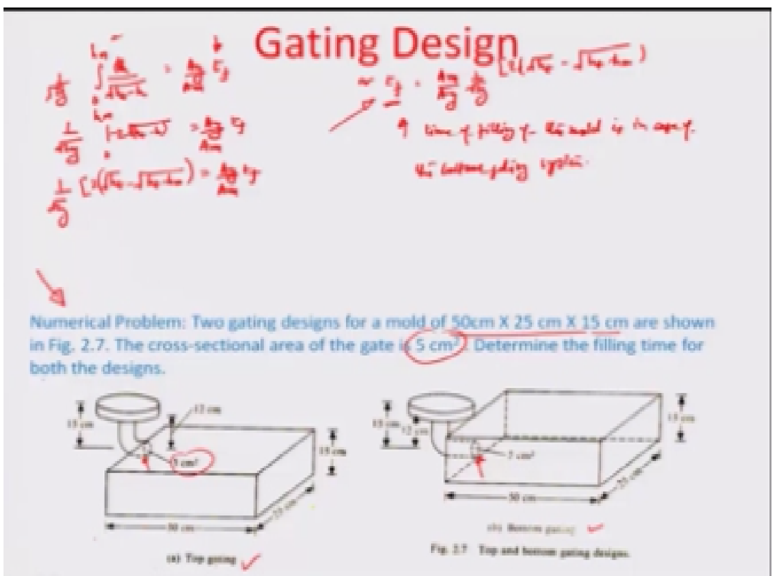

So let say, if I just integrate this equation on both sides 1/√2g is taken common 0 to the particular height of the mould H_m remember the overall height that would happen by this Δh addition would ultimately this whole height which is given by height of mould H_m. So 0 to Hm dh/ √ht- h equal to Ag/ Am times of let us say it takes *tf* time to fill up the whole mould, so that the heights goes from the existing h value with dh addition all the way to Hm. So this is how we would integrate and so the final form that would generate is 1/√2g times of 0 to h_m minus 2ht – h that is what comes from the integral.

$$\frac{1}{\sqrt{2g}} \int_0^{h_m} \frac{dh}{\sqrt{(h_t - h)}} = \frac{A_g}{A_m} \int_0^t dt$$

Ag/Am times of tf in other words if I just substitute the limits here I should have limits of integration substitute we have $\frac{1}{\sqrt{2g}}\left[2\left(\sqrt{h_t}-\sqrt{h_t-h_m}\right)\right]=\frac{A_g}{A_m}t_f$ or in other words $t_f=\frac{A_m}{A_g}\frac{1}{\sqrt{2g}}\left[2\left(\sqrt{h_t}-\sqrt{h_t-h_m}\right)\right]$, if the riser is used then *tf* should include the filling time of riser, so basically this is what the time of filling of the mould is in case of the bottom gating system. So in both these assumption whether it is vertical of bottom gating what we have really assumed is that there is no friction really on changing the velocity head.

For example the velocity at 3 or the gate velocity vg would be heavily influenced, in real case because of friction which happens between the channel walls or the runner walls and the liquid metals as it moves. So there would be a higher level of assumption that we have to take can probably a little higher model which we have to investigate, when we talk about what would happen, if suppose there is lot of friction between the metal fluids stream or the metal stream and the side walls okay.

But as if now this assumption is kind of gives a thumb rule estimation of the total timing of the filling of the mould and we will probably going to some numerical problems and try to see would vary time wise or value wise, if we go from a top gating to bottom gating system. So let us say you have these two gating system which are illustrated in this figure and I am going to just mention this problem probably in the interest of time solve this in later of module.

So we want to estimate the time of filling of this mould which is about 15cm into 25cm to 15cm and the cross sectional area of the gate is given to be 5cm^2, so that is very important here. In one case the gate is at the bottom of the mould as you can see here and other case it is at the top of the mould and you want to see what are the different filling times, given your filling just a liquid iron and the density extra can be assumed of the liquid iron.

So we will see if there is really any difference of time between these two approaches of filling of the mould. So with this I close on this module and we will try solving this problem in next module thank you.

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