Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology –Part-1

Module 19

By
Prof. Shantanu Bhattacharya

Hello and welcome to this manufacturing process technology part 1 module 19.

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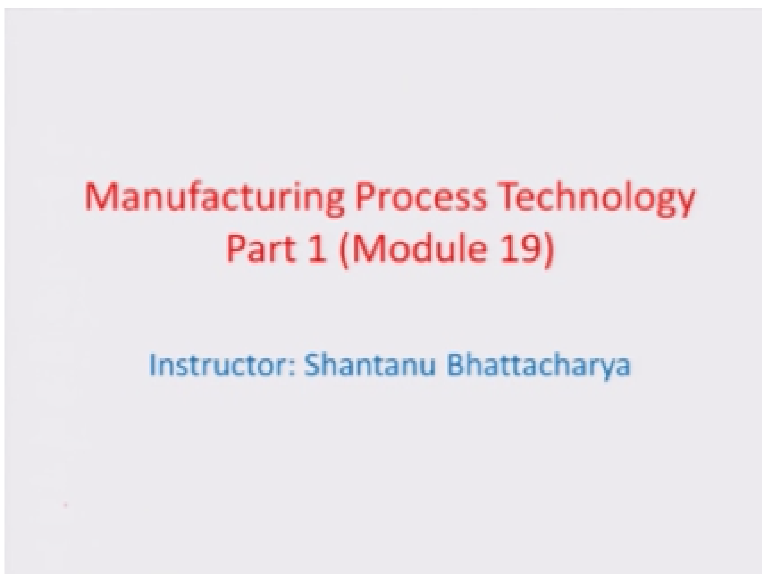

A brief recap of what we did in the last lecture or last module we were talking about the energy balance equation on a simple casting problem with two different orientations one was the vertical gating system another was the horizontal gating system we were also discussing about the aspiration effect which was because of the formulation of a negative pressure at somewhere in the center of the runner just because of uniform cross section of the of this proof.

So we actually discussed that in such a negative pressure is detrimental to the effect of castings because to the quality of the castings because there is a chance of in gassing into the mold because of the high porosity and you know various gases like hydrogen and said I have included in the castings would actually result in a change in strength of the of the cast.

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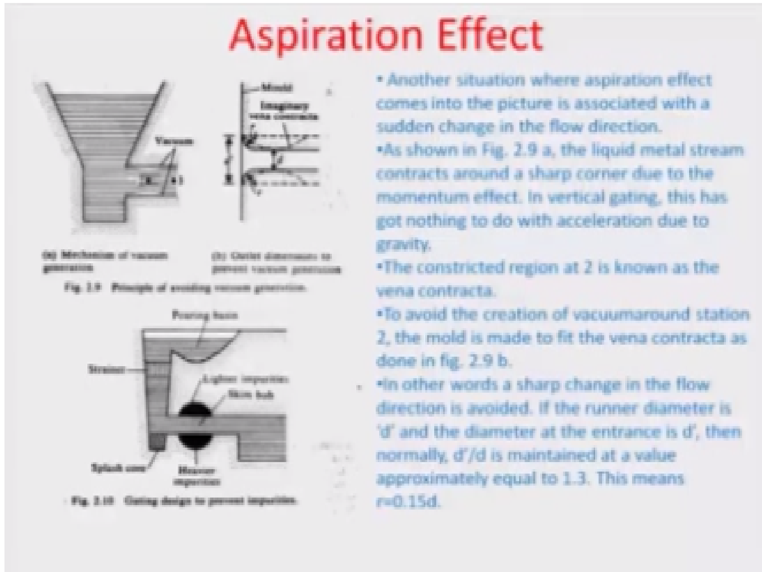

So today we are going to actually look into another interesting effect which is also known as formation of this vena contracta so another situation where the aspiration effect comes into picture is associated with a sudden change in the flow direction you can see here this is the pouring basin this is the sort of a you know bit runner which is actually running just perpendicular to this proved which is just below the pouring Basin and there is a sudden change indirection of the liquid metal.

And because of that there is a contraction which happens and it contracts around a sharp corner due to the momentum effect suddenly there is obviously change in the direction of the velocity so there is going to be a change in momentum because of the change in direction of the velocity and this change in momentum would take some time to get formulated so in fact the flow develops here after some span of length is crossed over by the by the liquid metal.

So in verity gating this is not really a problem because basically having acceleration due to gravity and the problem would be more prominent in the bottom gating or horizontal gating systems the constricted region to as I earlier mentioned is known as the vena contracta you can see here this really is the you know the radius which would come of the particular stream and are in fact is the radius here right about here d is really the amount of contraction a depend by d would be the ratio of the contraction which would happen diametrically.

So that is how there is always a tendency of a low pressure formation because of that to avoid the creation of vacuum around the station to the mold is made to fit as the vena contracta I itself so the mold is designed like a vena contracta you can look at the dotted line here which say show the mole design should be so tentative mold design.

So that this rapid contraction does not take place if the runner diameter is capital *d* as small *d* as you can see here and the diameter of the indents in *d* that normally d'/d is maintained at a value of approximately 1.3 so that is how this an r is really about fifteen percent of *d* so that is what are the design guidelines for doing this kind of a vena contracta a shape and mold.

So the commonly used items which are there in the gating design which I probably have mentioned earlier but not to the total details is the pouring basin which is obviously the you can see here right about here the complete shape here so it actually contains the liquid metal and reduces the eroding force of the liquid metal stream coming direct from the furnace a constant pouring head can also be maintained by using a power in basin.

So whatever stresses the mold has to take are really along this region without letting the actual mold shape being intact or not getting the started there is a strainer which is normally a ceramics you know strainer than this proves which removes impurities or drawers so it is like a filtration system made up of again a refractory material, splash core a ceramic splash core placed at the end of this proved you can see right about here which also reduces the loading force of the liquid metal stream.

So basically it is a sort of a reinforcement that you are making hair of high strength so that there is no erosion in the sand around the mold, then there is a scheme Bob you can see right about here it is a trap placed in the horizontal gate to prevent heavier and lighter impurities from entering the mold obviously because of a sort of a you know outflow of this particular material there is a tendency of the lighter material to rise on the surface and get collected all here and slowly because we are talking about a heavy Reynolds number flow

So there would not be much diffusion migration between the mainstream and this dross collected right about here okay so that is how the skim Bob so you have all these different pouring basin strainer splash code and skim Bob being a part of the gating design to prevent the impurities from going so now I would just look at a slightly different variant of the strategy that we did earlier for energy balance and horizontal gating system.

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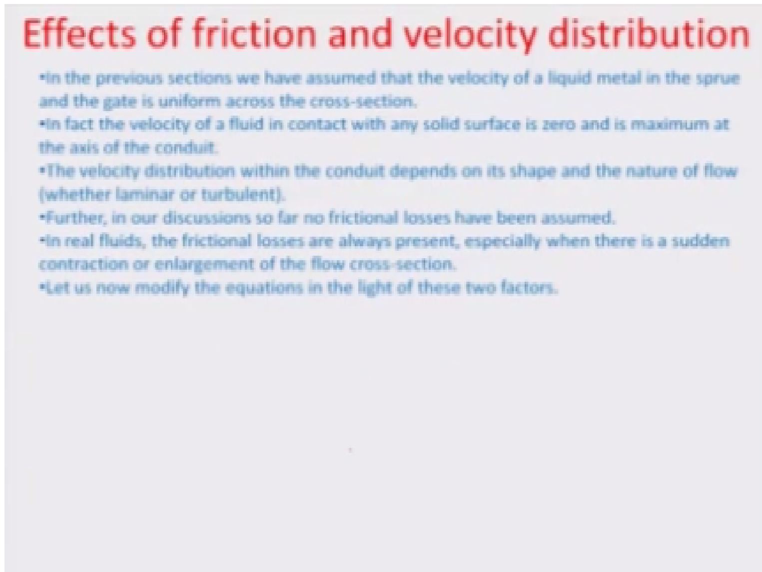

So there we considered ideal situation where there was no frictional effect as such and you know there was no effect because of the velocity distribution but in unfortunately in the real world you do have this no slip zones and a parabolic flow profile which results in some loss by itself and also you know there is a pipe friction which would be there because there is a some amount of flow distance that the liquid metal has to undertake in order to reach the mold and this is through the runner and also this prove and you know the pouring basin.

So therefore there is also a loss because of that and then there is a energy loss also because of the sudden contraction which would happen in different places or even sudden expansion sometimes depending on how the pouring beside a patient is designed with respect to the sprue okay so because of all these different effects the actual energy balance equation may vary quite a bit and that is what we are going to study now.

So in you know the velocity distribution within the conduit depends on its shape and nature of flow the laminar or turbulent and will assume the frictional losses so the non uniform velocity distributions can be accounted for by modifying of the kinetic energy term in the energy balance equation by replacing with v dash square by β where v' is the average velocity and is a constant for circular conduits can be treated as for the laminar flow 0.5 okay.

So this is for circular conduits so this is for the laminar flow case further and can be treated as 1.0 for turbulent flow in circular card wings so basically that is how we will try to modify the kinetic energy term okay in terms of its different properties of flow you know with within the spruce and runner channels before the metal reaches the actual mold.

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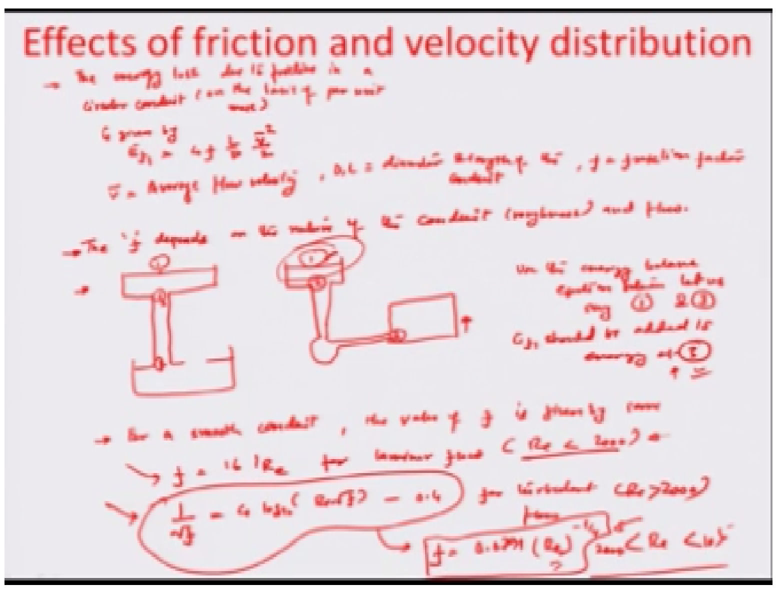

So the energy loss due to friction in a circular conduit and these are some of the assumptions were borrowing from elementary fluid mechanics and basically the more important part that has to be seen here is the application that how these energy loss is going to change the time of filling etcetera related to the cast so I am not going to actually prove the how the loss balance equation or how the energy loss balances happens for a circular conduit for a laminar or a turbulent flow case.

But I am going to assume some of the things from elementary fluid mechanics to sort of estimate the time of flow which is more important here for the liquid metal to go into the mold. so on the basis of per unit mass it is given by energy loss is given by this term E_{f1} which can be recorded as for $e_{f1}=4f\frac{l}{D}\frac{\acute{v}^2}{2}$ again V basically the average velocity capital D, L all are the diameter and length of the conduit which is in question so just write down as diameter and length of the conduit and f of course is the friction factor.

And infact is variable based on if the flow is laminar or transitional or turbulent so the F depends on the nature of the conduit particularly associated with the conduit roughness and also the flow the type of low whether it is laminar or turbulent so while using the integrated energy balance equation between one and two the E_f .one really should be added to the energy at the point too okay.

So if I just were to recall the way that you know we had set up the what is the horizontal gating problem I would just so this right here was the vertical gating system designed where we talked about the point one which was somewhere on the top of the pouring basin endpoint to somewhere at the beginning of the runner and obviously 0 point 3 which was somewhere just before the entry to the mold.

So that is how we had figured out of this vertical gating similarly for the horizontal gating system if you may recall we had a pouring basin opening up into a sprue again which was slightly tapered to avoid the aspiration of X and there of course was a runner which was designed to enter into the mold as if the mold gets filled up from bottom up you know so it is like that is why I called bottom gating system so this was point 1 this was point2 and write about this entry here was point 3.

So that is how we had actually studied both the system so if I were to in this particular case use the energy balance equation between let us say 1 and 3 then obviously E_{f1} one should be added to energy at 3 okay because this is the energy loss that would happen from the overall energy which is available at one for the material to be successfully able to withstand the frictional effects on the wall side of the conduit so for a smooth conduit of the value of f.

Again borrowing from fluid mechanics is given by some empirical you know quantities of value so f is recorded as $f = 16/\Re$ for laminar flow probably corresponding to Re you know less than 2000 so basically it considers you know the even the transitional as well as the laminar flow both and the F can be related to again the Reynolds number in little different manner as illustrated here for turbulent flow typically are greater than 2000.

So I can probably solve this and approximate the total friction factor here f as $0.071\,\Re^{-1/4}$ for a Reynolds number mostly turbulent so varying between let us say 2100 and very high 10 to the power of 5or so you know which is like quite high Reno same also we will assume this to be the friction factor and I am not going to get into the details of how these arrived because we have borrowed this from the fluid mechanics so f basically would be used in our case to calculate what is the friction factor which will be added again to the three side.

So that this is the loss in energy to the energy head that is available at one because of the potential head of the material so that you know the actual time can be estimated in this manner so this kind of brings us to you know the two very important factors which would be responsible for energy losses and the Bernoulli's equation so one of them is obviously the friction factor which is a function of how smooth or rough the walls is and in a circular conduit.

We have seen how to estimate that using the factor f which f where f is a function really of the Reynolds number so between the let us say for the laminar or the transitional region f is kind of different and then for the turbulent region F would be again different sobering few cases where the metal head that is available or the liquid metal head that is available is very small will mostly use the transitional the turbulent regime for the Reynolds number estimation and some simultaneously.

Again determination of friction factor but only in the case where the metal head available for you know pouring head which is there in then the basin is almost towards the end where all the pouring basin metal has-been consumed so in that case probably there may be an instance where some time delay may happen because of a small amount of metal remaining within the pouring basin which will probably flow with laminar in the laminar regime.

So there you may have to estimate f in a little different manner so having said that we wanting to sort of make a final form of equation where the velocity this distribution you know losses because of velocity distribution or effects because of velocity distribution to the kinetic energy and the and the frictional factor which I have just calculated have to be incorporated in the total energy balances the other remaining issue which I would like to cover in the next module is basically that because of entrance effects because obviously the liquid metal here does not have a constant cross section.

They can do it while running the conduit may bend for example from the sprue to the runner or even from the runner to the gate region of the of the mold or sometimes there may also be effects because of sudden contraction or expansion of the flow paths and so there has to be a energy loss accounted for in the Bernoulli's principle because of that variation as well so once we do that probably in the next module will couple all these different losses that means the effect because of velocity distribution effect.

Because of wall friction and effect because of these entrance effects entrance of the liquid metal into different cross sections and then put a final formulation which would talk about the correct energy balance you know and the in the real situation so far what we estimated in terms of time of filling etcetera was really an ideal case so with this I would like to close this module and look forward to do the entrance effects in the next module thank you.

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