IMPACT OF FLOW OF FLUIDS IN FOOD PROCESSING AND PRESERVATION

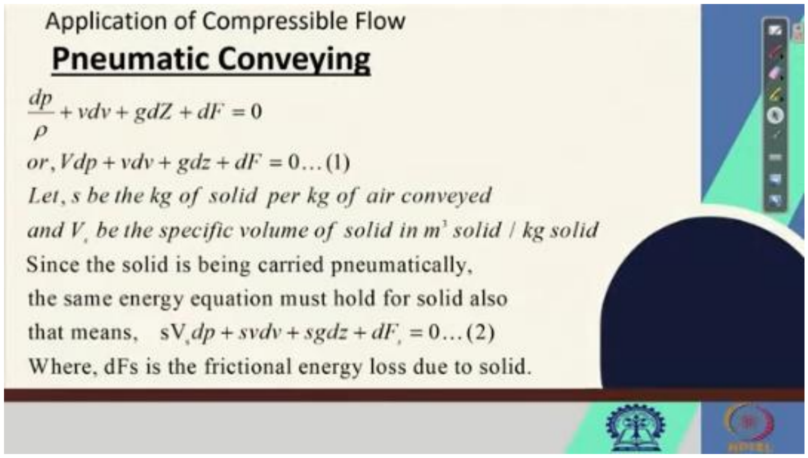
Lecture50

LECTURE 50 : PNEUMATIC CONVEYING

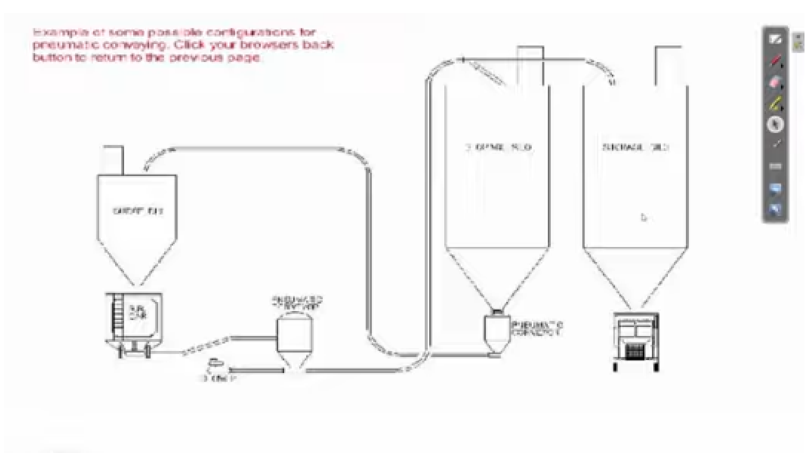
Good afternoon, my dear boys and girls, students, and friends. We have come to the virtual end class of my portion. Professor Viya will take, as I said earlier, the class on the flow of fluid, and the fluid is non-Newtonian, and maybe some other flows, like flow through filter media, right. Now, we have come to the last class, which is pneumatic conveying.

So, pneumatic conveying, being the last class, it is like taking from one end to the other end. That can be horizontal or vertical. So, obviously, you can understand that maybe Bernoulli's equation could be used. Right, which you have used earlier in many cases. So, we say that pneumatic conveying, okay.

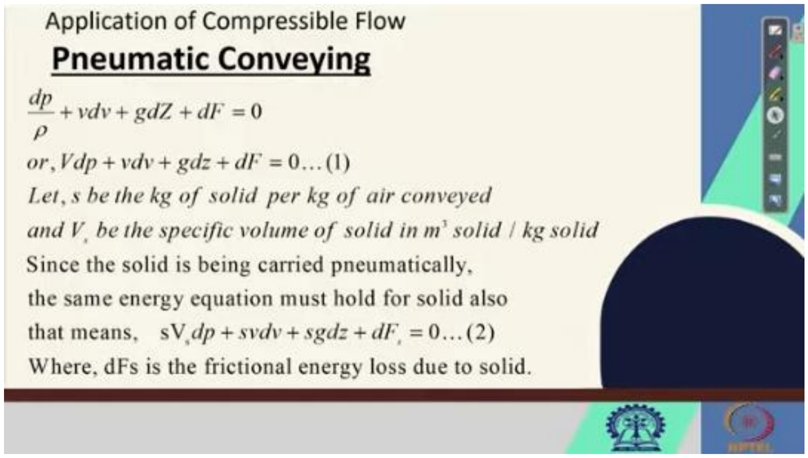
So, for this application, compressible fluid flow is also taken care of, that we have seen in the compressible fluid flow, that applying Bernoulli's equation, we write dP over rho plus vdv plus gdz plus dF is equal to 0. This we rearrange to write instead of rho, capital V, that is specific volume, VdP plus vdv plus gdz plus dF is equal to 0, right. Now, let us take s, small s, with a kg of solid per kg of air conveyed.



Here, pneumatic—ok, before that, I should also explain—ok, with a diagram, I can easily explain, and you can also easily understand what you are conveying, right, with the help of a pump and other things. You are conveying from one end to the other end, right. So, thereby, you are storing, etc. So, so much of the pipeline you have to pass through, and this can be also done with some assumptions—maybe the actual difference will not be so very high.

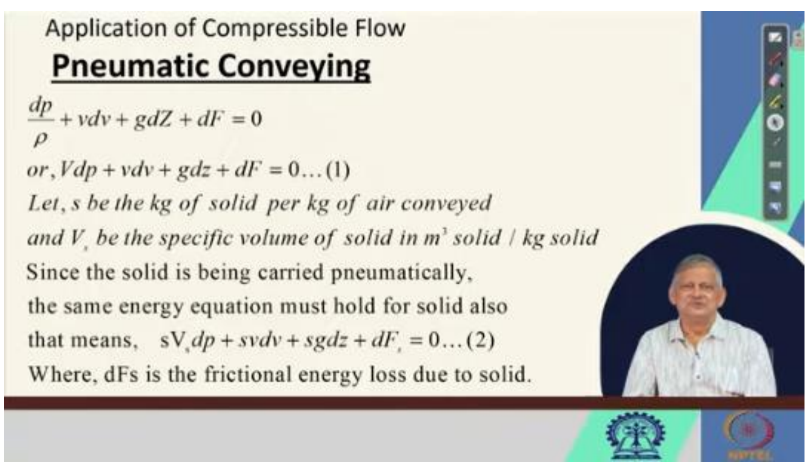


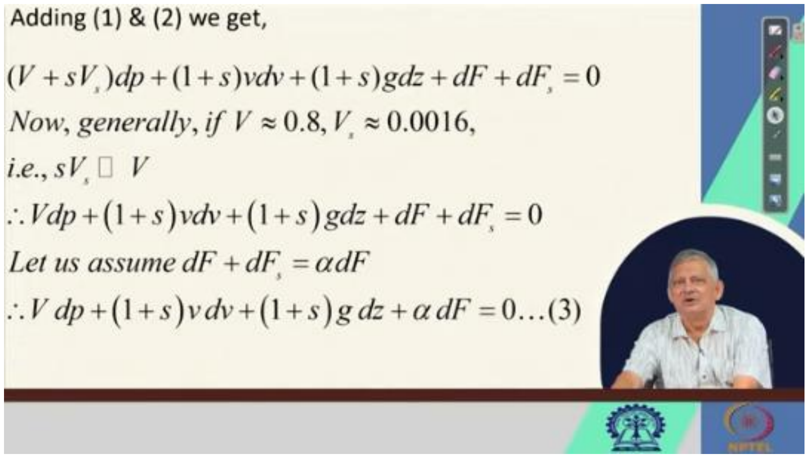
So, we considered that s be the kg of solid per kg of air conveyed, and V_S be the specific volume of the solid in meter cube solid per kg solid. Since the solid is being carried pneumatically, the same energy equation we can—we can apply. This is the fundamental assumption because we are carrying solid, we are considering it to be similar to the gas where pneumatic conveying is used, right.



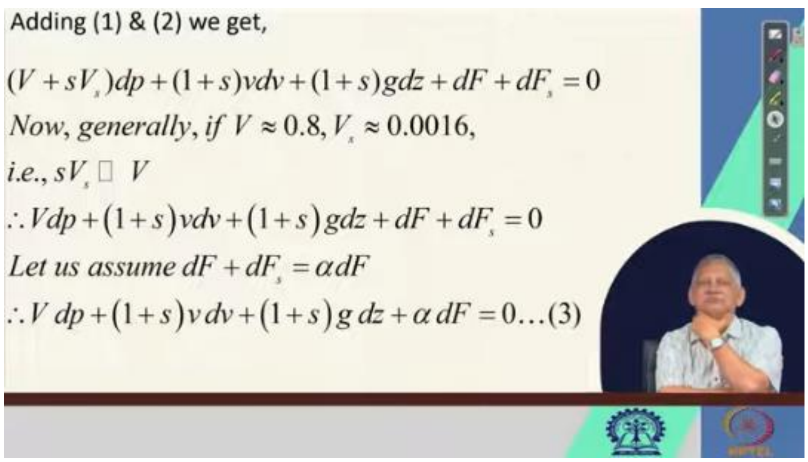
Since the solid is being carried pneumatically, we can assume that the same energy equation must or should hold for the solid also. So, this means that this is giving some idea. This means that sV_sdP plus svdv—that v is small, and earlier V was capital—that is the specific volume with dp and velocity with v dv plus sg dz, right. This is the distance plus dFz or dF_s equals to 0.

in the same manner as we have done for the air or for the fluid. The same way only the difference we have taken V_s as the specific volume of the solid, s as the amount of solid per kg of air conveyed and we have taken V_s as the specific volume of the solid all others remaining similar right. where dF_s is the frictional energy loss due to the solid dF_s, earlier it was dF right. Now, applying these two by adding we can write that V plus sV_s dp plus



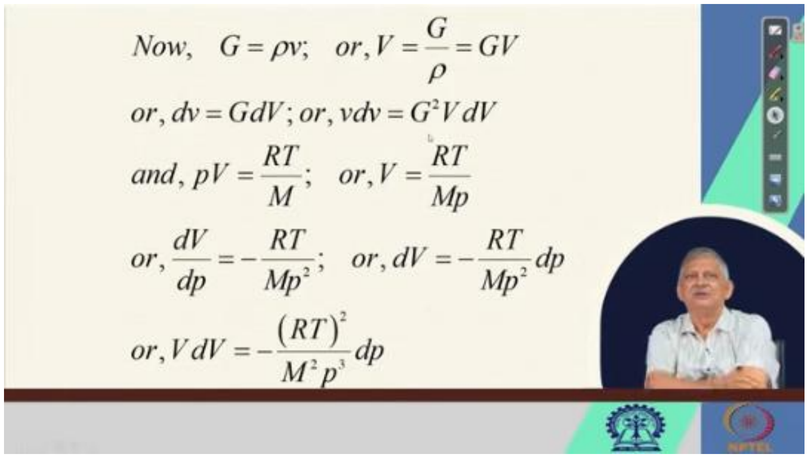


1 plus s into vdv plus 1 plus s into gdz. plus dF plus dF_s is equal to 0 right. This we added the two equations and rearranged. So, after that we can write separating the variables like V plus s V_s dp plus 1 plus s v dv plus 1 plus s g dz plus dF plus dF_s is equal to 0 right.

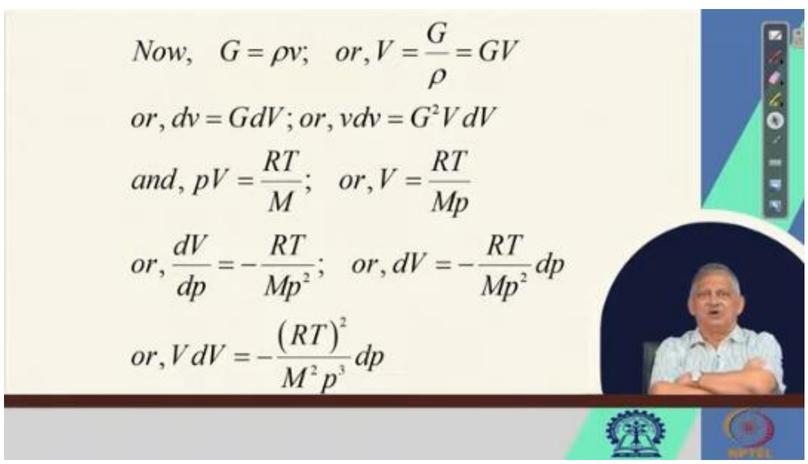


Now, generally V capital V that is the specific volume of the fluid is say roughly around 0.8. Whereas, specific volume of the solid is much much less, like 0.0016. So, we can say that V_s, V_s is much lower than V. So, we can neglect sV_s. So, we can rewrite VdP plus 1 plus s into v dv plus 1 plus s into g dz plus dF plus dF_s is equal to 0. Now, we have two frictional or two force terms one is dF and the other is dF_s.

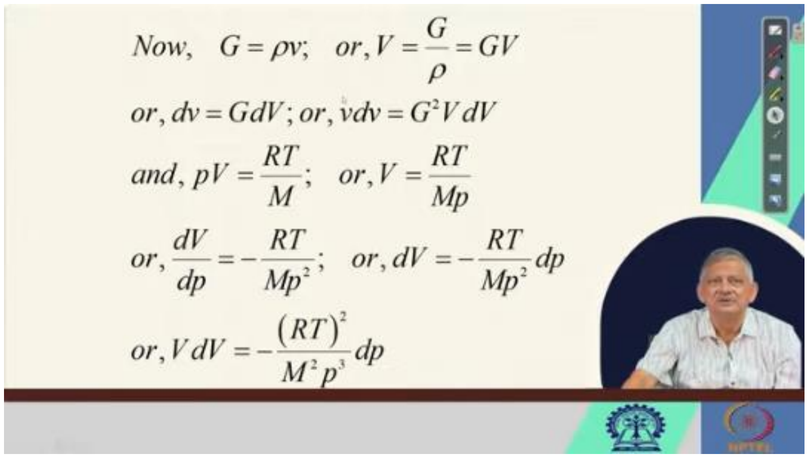
So, if we add these two dF and dF_s, then we can write alpha dF that is equal to dF plus dFs is equal to alpha dF, where alpha has some value. Therefore, we can rearrange and rewrite the earlier equation V dp capital V dp plus 1 plus s into vdv plus 1 plus s into g dz plus alpha dF this is equal to 0. right. Then if we substitute as capital G equals to rho v prime or capital V is equal to G by rho is equal to G capital V that is rho is equal to G capital V.

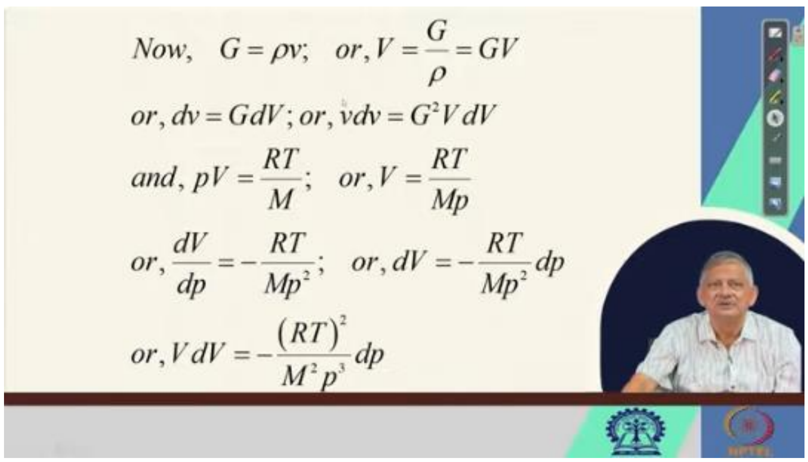


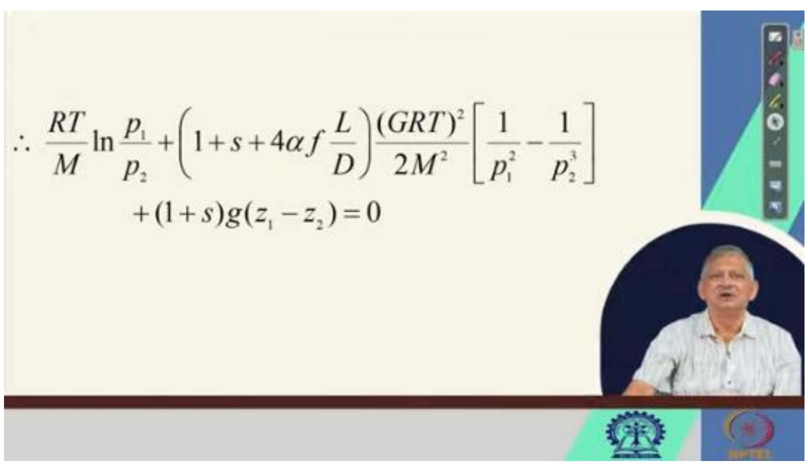
Therefore, we can also write small dv is equal to capital G dV. Let us look into the previous dv here ok, small dv is equal to capital G capital dV. or v d v is equal to G square capital V d V and P V is equal to R T over M or V is equal to R T over M P. Therefore, we can write capital dV over dP is equal to minus RT over MP square or dV is equal to minus RT over MP square dP. Hence, we can write capital V dV is equal to RT square by M square P cube dP, right.



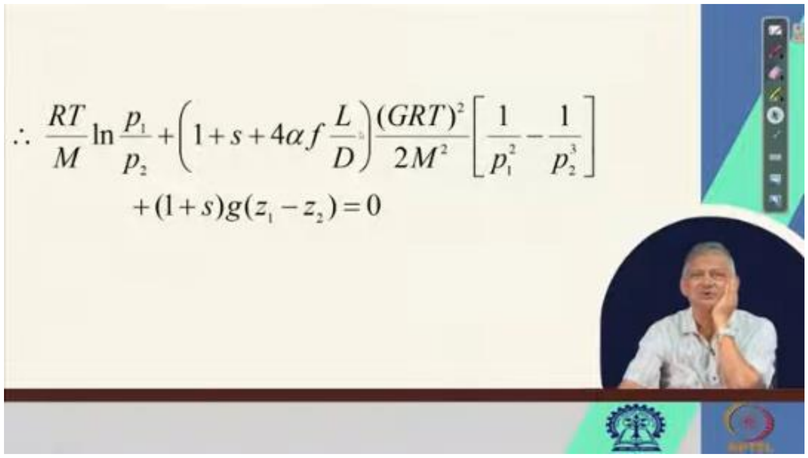
d V over d P is R T by, minus R T by M P square, or, d V is minus R T by M P square d P. So, V d V is minus R T whole square, because, R T by M P, R T whole square by M square. and P cube, ok into d P ok. Now, we can write that R T by M into ln P_1 by P_2 plus 1 plus s plus 4 alpha f L by d into G R T whole square by 2 M square into 1 by P_1 square minus 1 by P_2 square plus 1 plus s into g into into z_1 minus z_2 equals to 0. So, R T over M ln P_1 over P_2 plus 1 plus s plus 4 alpha 4 alpha f L by D into GRT

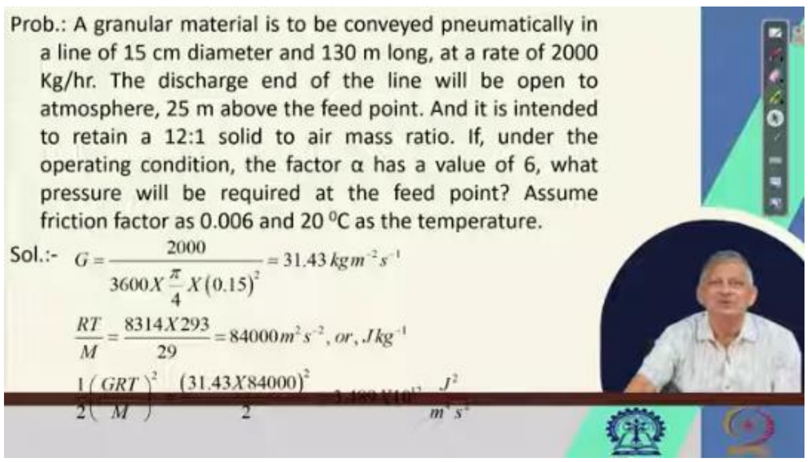




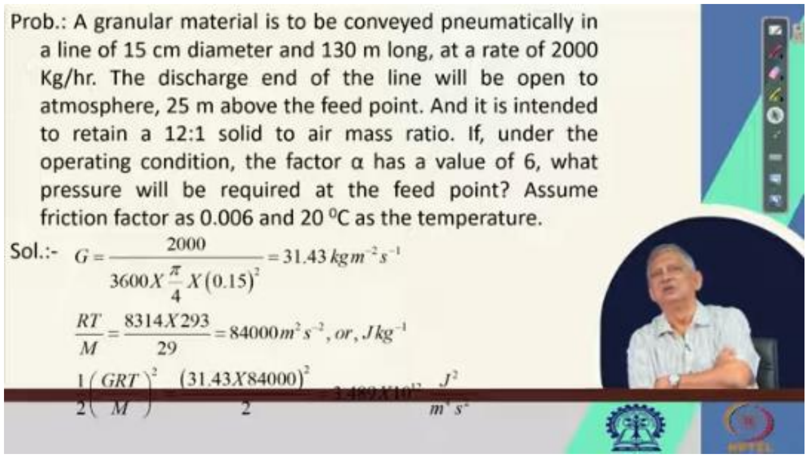


Whole square divided by 2 M square into 1 by P_1 square minus 1 by P_2 cube plus 1 plus s into g into z_1 minus z_2 is equal to 0. So, this is a correlation. Alpha, F, L, D, M, G, R, T, P_1, P_2, s, and G, of course, all are Z_1, Z_2, that is also, not less, are required to be known. For example, a granular material is to be conveyed pneumatically. In a line of 15 centimeters and 130 meters long at a rate of 2000 kg per meter cube.

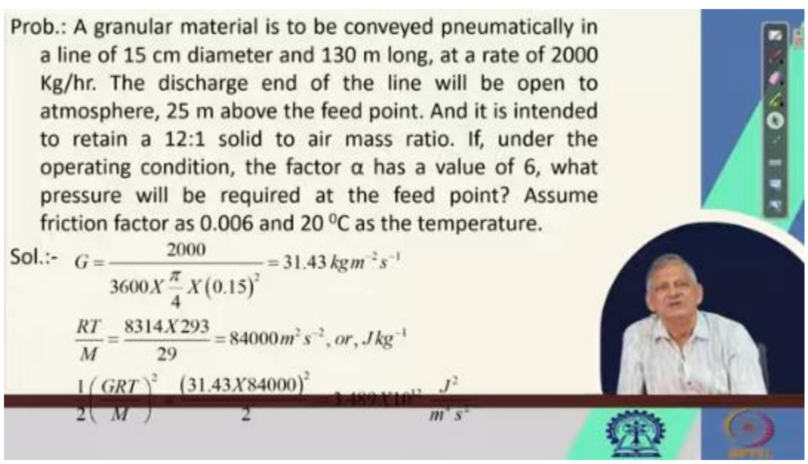




The discharge end of the line will be open to the atmosphere 25 meters above the feed point. And it is intended to retain a 12:1 solid-to-air mass ratio, 2 solid-to-air mass ratio, 12:1. If under operating conditions the factor Alpha has a value of 6, what pressure will be required at the feed point, assuming the friction factor is 0.006 and the temperature is 20 degrees centigrade. So, if we go quickly through the problem, a granular material is to be conveyed pneumatically in a line of 15 centimeters diameter, 15 centimeters is not very big, and 130 meters long at a rate of 2000 kg per hour.

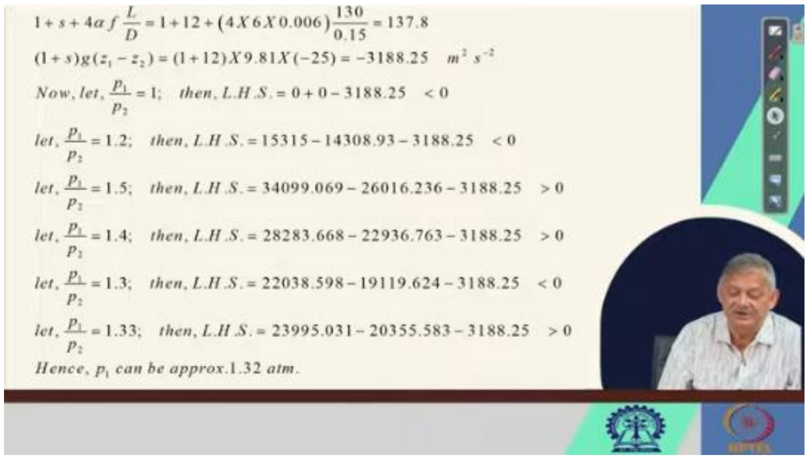


The discharge end of the line will be open to the atmosphere 25 meters above the feed point, and it is intended to retain a 12:1 solid-to-air mass ratio. The factor alpha has a value of 6. What pressure will be required at the feed point, assuming the friction factor is 0.006 and 20 degrees centigrade as the temperature, right? Now, individually, we do. First, we find out the value of g, that is 2000 by 3600 into pi by 4 into d square is 0.15 whole square, that is 31.43 kg per meter square per second, that is the mass flux. Now, R T by M is 8314 into 293 by 29 is equal to 8400 meter square per second square is joules per kg.



Therefore, we can write G R T by 2, G R T by M whole square. is equal to 31.43 into 8400 by 2 whole square that is equal to 3.189 into 10 to the power 12 joule square per meter square right. We rewrite that 1 plus S 4 alpha f L by D as 1 plus 12 plus 4 into 6 into 0.006 into 130 by 0.5. 0.15 rather is equals to 137.8 and 1 plus s g into z1 minus z2 is equals to 1 plus 12 into 9.81 into minus 0.25 is equal to minus 3188.25 meter square per second square. Now let us assume that P1 by P2 is 1, then our left hand side becomes 0 plus 0 minus 3, 188.25 is less than 0.

Let P_1 over P_2 is 1.2. then left hand side becomes 1531514308.933188. Let P_1 by P_2 is 1.5, so gradually we are increasing Then left hand side that becomes equal to 34099.069 minus 26016.236 minus 31.88.25 this is greater than 0 that means, it lies between 1.2 and 1.5. So, take another intermediate that is 1.4, ln of P_1 by P_2 of 1.4 or P_1 by P_2 of 1.4, then left hand side becomes 28283.668 minus 22936.763 minus 31.88.25 greater than 0.



So, therefore, between 1.4 and 1.5, we have also said P_1 is or P1 is to P_2 is 22038.598 minus sum 19119.624 minus 31.88.24 is less than 0. Again that means, it is lying between 1.3 and 1.4. So, let P_1 by P_2 is 1.33, then left hand side is equal to 2399.01. 2 is minus 20355.583 minus 31.8 31.25 is 0 right. Therefore, we can see that P1 lies

between 1.3 and 1.35. So, by couple of more iterations, it has been found that 1.32 is very very good, ok. P1 can be approximately 1.32 atmosphere right. So, with this we have come to the end of the course.

There we have taken care of all the aspects of fluid flow right from the establishment of the very famous Hagen-Poiseuille's equation and also the universal equation that is called Navier-Stokes equation we have developed for one dimension and two dimension, but we could not have done for three dimensions because three dimensions means it is like spherical. So, we could not do spherical because it is very time consuming and very lengthy, but we have done for 2 that is for Cartesian coordinate and for cylindrical coordinate x y z and r theta z. We have done for pipe flow and many others which are related to pipe flow.

We have done through inclined faces where the surface is stationary. So, the surface next to this solid surface is clinging to this surface either this is clinging or that is clinging whatever it be it is clinging to the surface. We have also shown that when the surface is also moving under different situations, different conditions, how the treatment is to be done, right? Those things we have shown, we have seen. Here we have done apart from all these many many other things like we have seen that the velocity through annular space.

Because that is very important for many heat exchangers. So, you have seen heat exchangers and the flow behavior through them, which we have also observed. We have seen that apparently it is not so useful, but we have also seen pneumatic conveying, and we have observed flow through small orifices, which can be called nozzles, and we have seen the flow behavior for nozzles.

and many small orifices. We have also seen how the velocity profile changes with the inclination of the surface. So, these are the things we have seen. Now, the only thing left for this course is the flow of fluids that are non-Newtonian, not Newtonian.

I have covered all Newtonian parts, but the non-Newtonian part will be covered by Professor Bujia, who will also teach flow through your filter media, right? So, with this, I thank you all for listening to the classes carefully, and now I presume that you will all register for the course and appear in the exam to get the grade. Okay, so thank you very much. Thank you.