Course on Momentum Transfer in Process Engineering
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Lecture 57
Module 12
Problem and solution (Continued)

Yeah, so we have done a problem let us do another problem and this solving problem will help you in assessing the situations that you have to keep in mind not only in mind the values will give you idea really if you are working in industry. So that more and more problems you solve more and more you come across with the ideas with the real applications, right? So let us then do the similar problem.

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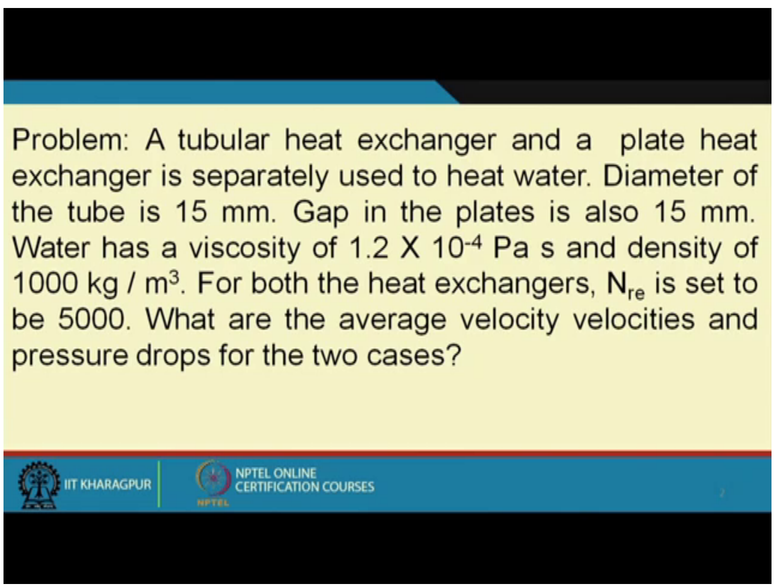

A tubular heat exchanger and a plate heat exchanger is separately used to heat water. Diameter of the tube is 15 millimeter. Gap in the plates is also 15 millimeter. Water has a viscosity of 1.2 into 10 to the power minus 4 Pascal second and density of 1000 kg per meter cube. For both the heat exchangers Nre is said to be 5000. What are the average velocity and pressure drops for the two cases, right? I think this we should change this should be R capital, so by mistake it was so R capital should be, right?

So in the previous one also it was there Re but I did not change, so you please change that r is capital, okay. So we repeat, A tubular heat exchanger and a plate heat exchanger is separately used to heat water. Diameter of the tube is 15 millimeter. Gap in the plates is also 15 millimeter. Water has a viscosity of 1.2 into 10 to the power minus 4 Pascal second and density of 1000 kg per meter cube. For both the heat exchangers Nre is said to be 5000. What are the average velocities and pressure drops for the two cases?

If you remember in this previous problem we also dealt with a similar one and we said we saw rather that the it was for a juice and the property values where different a little may not be very widely different but different and we saw that tubular heat exchanger had higher velocity as well the pressure drop compare to those of the plate heat exchangers, right? And this was true when the flow was not laminar but somewhere intermediate we took if we remember we took around 3000 as the Reynolds number, but here we have taken Reynolds number to be 5000.

So it is no more that laminar flow that is what we have done for the previous one for pressure drop calculation, right? That Hagen Poiseuille delta P we cannot directly use, right? I hope you have by this time you have done many other problems solutions also, so here instead of Hagen Poiseuille some other formulation we have use and that I hope you have come across or you can understand or make out that what could be that, right?

So that is why (())(4:59) in this case I am we are comparing or rather there can be a comparison between the fluid in the earlier case it was a juice and in this case it is water and viscosities and densities are also quite different, right? So that should also tell on both the velocities as well the pressure drops, right? Now let us look into how far really it is telling on the values, right?

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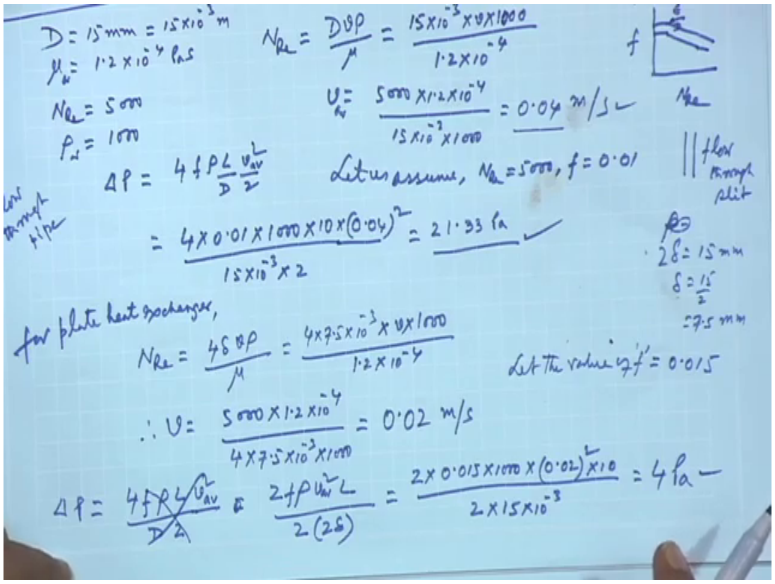

So let us see that whatever has been told we have been said that for tubular heat exchanger the given things are diameter of the tube is 15 millimeter is equals to 15 into 10 to the power minus 3 meter, right? Viscosity of the fluid or water mu w is 1.2 10 to the power minus 4 Pascal second, right? And Reynolds number given is 5000, right? And density that is rho of water given is 1000, right?

So since it is a pipe flow, flow through the pipe we can use directly use that relation of NRe is equals to D v rho by mu, right? So D is given as 15 10 to the power minus 3, v we have to find out, rho is given 1100, mu we have not 1100 it is 1000 and mu we have 1.2 10 to the power minus 4 Pascal seconds, right? So if that be true, then let us also take this that let us also take, okay v is equal to of course these are all v average, v average is equals to then NRe is 5000 into 1.2 into 10 to the power minus 4 over 15 times 10 to the power minus 3 times 1000, right? So this has gone there v is there v average is so.

So let us look into how much it is, it is 5000 into 1.2 into 10 to the power minus 4 is so much divided by 15 divided by 1000 divided by 10 to the power minus 3 it is 0.04 meter per second, if you remember when it was a juice to my memory it was much more than this, velocity was much more than this it was not 0.04 somewhere it is at least 4, 5 times greater than that, right? So just check, okay. So velocity has become so much and now let us look into the pressure drop, right?

Now since it is not the laminar flow and the flow is turbulent 5000 turbulent so we need to apply the that relation where it is with the fanning friction factor. So delta P is equals to 4 f, right? Rho L by D v square by 2 if we remember correctly v average by 2, so this was the fanning friction factor, right? So what we need from the fanning friction factor chart Moody's chart that if you remember that we had said NRe versus f, right? That was given for different epsilon value or epsilon by D these values where there and from the Moody's chart we can find out what is the value of f, right?

Since we do not have here that Moody's chart let assume that corresponding to NRe equals to 5000, right? The value of f of course we need to know the epsilon by D the value of f say it can 0.01, right? Let us assume it, then we can find out the value of delta P that 4 into 0.01 into rho is 1000 into L, L was given 10 meter if I remember let us look into, right? 5015 millimeter diameter of the tube same density this was, okay gap in the plates is so much, okay.

Then so it is 1000 into 10 meter over into v average, right? L by D, D is 15 into 10 to the power minus 3, right? And this is 2 v average v came out to be 0.04 square, right? So if we look at this, then we can see that 0.04 v square so it is square into 10 into 1000 into 0.01 into 4 is equal to divided by 15 divided by 2 divided by 10 to the power minus 3. So this came to be equal to 21.33 Pascal, right? And just check corresponding to this velocity delta P for the turbulent flow we have done for the laminar (flo) or intermediate when the flow is intermediate there we have found out that what is the value of pressure drop and what is the value of velocity.

Now we have also found out of course the fluid is a different that is for water what is the value for this, right? If there is a little time we will go back to the previous problem and do this same for the pressure drop, because velocity for pipe flow will also more or less similar, okay. Now for tubular heat exchanger it was like that, for plate heat exchanger if we look at that value NRe and this is case of course plate heat exchanger like the earlier one we say that this is the flow through slit this is flow through pipe and this is flow through slit, right? Because the gap is very small and it is moving through that, right?

So for plate heat exchanger we can write that NRe is equals to 4 del v rho by mu, so it is 4 and del same sorry del same 2 del is 15 so del is 15 by 2 that is 7.5 millimeter. So we write 4 into 7.5 into 10 to the power minus 3 into v we have already found out that is to be, v we have to find out, okay so v into rho is 1000 divided by mu is 1.2 into 10 to the power minus 4. Therefore v comes out to be NRe is 5000 into 1.2 into 10 to the power minus 4 divided by 4 into 7.5 into 10 to the power minus 3 into 1000, right?

So this comes out to be let us see how much it comes out, so 5000 into 1.2, right? Into 10 to the power minus 4 divided by 4 divided by 7.5 divided by 1000 divided by 10 to the power minus 3 it is 0.02 it was in this case 0.04, in this case 0.02 meter per second, right? Now the question comes for the delta P, right? What will be the delta P, now if we see that delta P through the slit the expression for that it is again in this case this for the pipe it was assumed to be 0.01 now for the slit let the value of f from of course NRe versus f corresponding to that we can get value of f to be equals to say 0.015, right?

So if it is like that, then we had earlier assumed it is 0.01 so let us say it is 0.015, right? So then we get that delta P is equals to that 4 f rho, right? L by D v square average by 2, right? And this is of course not 4 f this was for pipe, so for slit we write 2 f rho v average square, right? L divided by 2 into 2 del, right? So this is what is for the flow through the slit. So that comes to be 2 into 0.015, right? Into 1000 into v average we have found out 3.02 into L was 10 and this is 2 into 2 del, 2 del is 15, right? So 15 millimeter so 15 10 to the power minus 3, right?

Now if we look at this value calculate it then it comes to be say 2 times 0.015 times 1000, right? Times 0.02 square times 10 is equal to this divided by 2 divided by 15 divided by 10 to the power minus 3, right? So that comes to be 4, right? This is equal to 4 Pascal, right? So here it was again high, here it is low. Now I said that the two cases we have dealt with both for laminar as well turbulent, but I said that if we look at the previous problem where it was laminar or not laminar it was intermediate and in that intermediate the values of delta P and v what we got that was for the that was for your juice apple juice if I remember, right?

Now if we do the same for turbulent one, for the apple juice let us look into how the value is different, right? Let us look for turbulent how the value is different, let me open that this was the problem, right?

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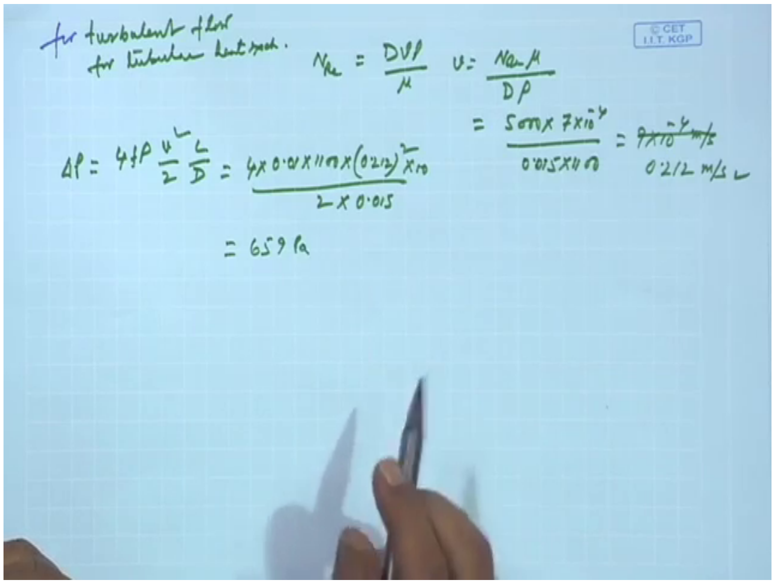

So instead of 3000, okay. Let us do for the yeah, so what we get that for turbulent flow for tubular heat exchanger, right? NRe for apple juice apple sauce is equals to D v rho by mu and (())(25:23) of and D was we have to find out v so v is NRe mu over D rho, right?

So NRe in this case 5000 mu it was 7 10 to the power minus 4, right? And D is D was 0.015 and rho was 1100, right? So if we see what is the value, right? It is 5000 into 7 into 10 to the power minus 4 divided by 3.5 divided by 1100 it is 9 10 to the power minus 4 meter per second, right? So velocity has gone down, right? So 5000 when the Reynolds number is so high 5000 so this is 7 10 to the power minus 4, right? 0.015 and it is 1100 so 5000 into 17 rho minus 4 actually we might have done something wrong let us look into once again it was 7 10 to the power minus 4 viscosity, yes so the value should not go so low because Reynolds number has gone up so 5000 into 7 into 10 to the power minus 4, right? Divided by 0.015 is equal to divided by 1100, 0.1 that is what not so this was wrong it is 0.12 meter per second, and if we look at what is the value? It was 0.127 so velocity has gone up, right? Similarly if we look at the pressure drop delta P, delta P was 4 f rho v square by 2 12 by D, right? And it was 4 f we took say 0.01, right? Into 1100 into v we got 0.212 square by 2 into L was 10 and D is 0.015, right?

So if we look at that, then also we see this is 4 into 0.01 into 1100 into 0.212 square is equal to this into 10 so much divided by 2 divided by 0.015 is equal to 659, so it is 659 Pascal, okay 0.17 okay so 659 and if we look at what is the value for delta P, it was 126 Pascal. So that means when from laminar flow or it was not laminar intermediate, so when it is like that from intermediate to to the other one that is turbulent it went up the both the velocity and the pressure drop went very high, right? Thank you.