Course on Momentum Transfer in Process Engineering
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Lecture 46
Module 10
Generalized coefficient of Reynolds number

Yeah, in the previous class we also discussed about the flow through slits, right? For Non-Newtonian fluid and if we remember that we had come to this point, yeah (())(0:51) flow through slits it was so we came we found out average velocity and yes we came up to this that is average velocity is like that and it was n plus 1 by 2 n plus 1 v max, right?

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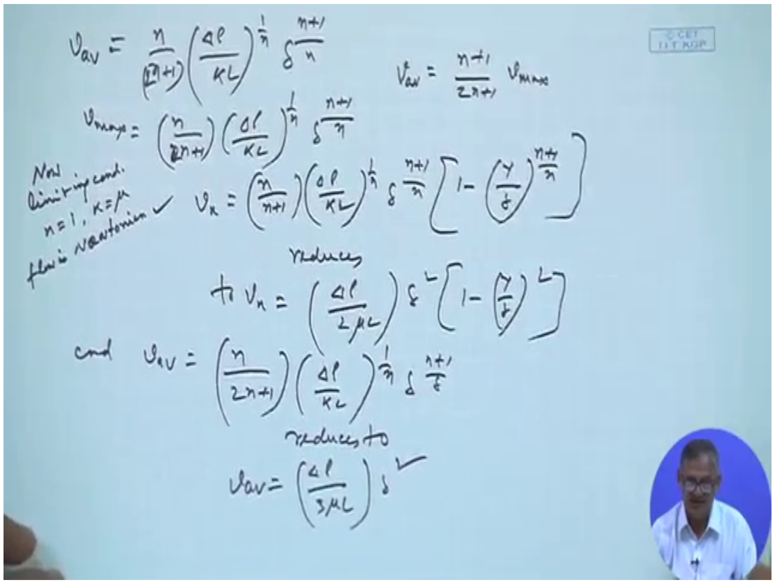

Now if we look into this that v average was for the n by n plus 1 for the Newtonian fluid Non-Newtonian fluid by delta P into rather delta P by kL to the power 1 by n del to the power n plus 1 by n del to the power 1 plus n this was v average, right? And v max we had like this n by n plus 1 into delta P by kL to the power 1 by n del to the power n plus 1 by n, right? So this was for v max and this was for v average, right? And from there we can write v average is equals to n plus 1 by 2 n plus 1 this was n by 2 n plus 1, no (())(2:42) not this v average 2 n plus 1 that is what I am thinking.

So n plus 1 by 2 n plus 1 v max is v average, right? So if this be true, then we can say that if we put now that limit or limiting condition that is at n is equals to 0, k is equals to mu this flow is

Newtonian, right? Flow is Newtonian in that case vx is equals to n by n plus 1 into delta P by kL to the power 1 by n del to the power n plus 1 by n into 1 minus y by del this to the power n plus 1 by n this was general velocity and this reduces to vx is equals to delta P by 2 mu L to del square into 1 minus y by del whole square this.

And v average which was n by 2 n plus 1 into delta P by kL to the power 1 by n, right? Into del to the power n plus 1 by del and this reduces to v average is equals to delta P by 3 mu L del square, right? So now these are really the proof that the limiting conditions do exist and do conside with the equations derived earlier, right?

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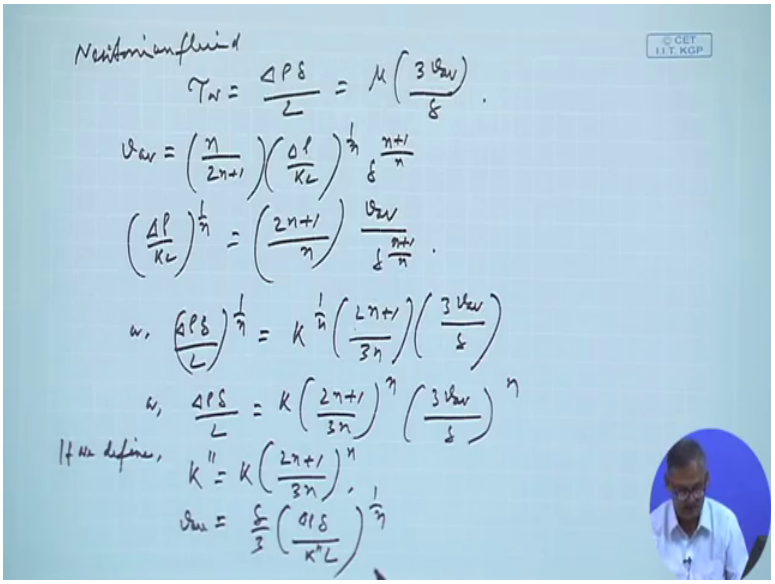

Now for Newtonian fluid what we have seen earlier tau w is equals to delta P del by L is equals to mu into 3 v average by del, right? Now re-writing this equation if we say that v average is equals to n by 2 n plus 1 into delta P by kL to the power 1 by n del to the power n plus 1 by n, right?

So this we can write that delta P by kL to the power 1 by n is equals to 2 n plus 1 by n into v average by del to the power n plus 1 by n, right? Or we can write delta P del, right? Delta P del by L to the power 1 by n this is equals to k to the power 1 by n into 2 n plus 1 by 3 n, right? Into 3 v average by del, right? Because this one del we have taken out 1 by n del to the power 1 by n so 1 del remains, right? So del so here it is del 1 by n so that is n when it is inverse there and yeah it goes to this side and inverse so it is okay.

So that means we can write that delta P del over L is equals to this was 1 by n so k that goes out then 2 n plus 1 by 3 n to the power n and 3 v average over del to the power n, right? Now if we define k double prime is equals to k into 2 n plus 1 by 3 n to the power n, right? Then v average can be written as del by 3 delta P del by k prime L into rather to the power 1 by n k double prime L to the power 1 by n, right?

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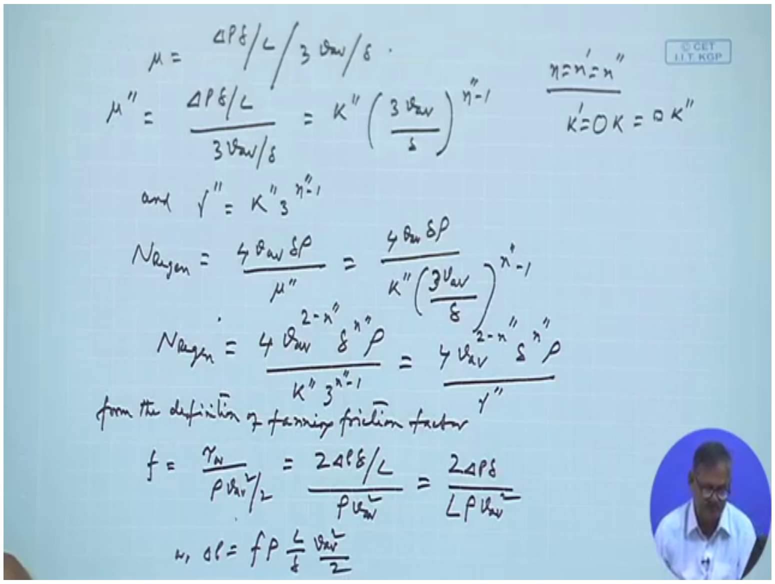

So we established earlier that for Non-Newtonian liquids through a slit if the we established that mu is equals to delta P del by L over 3 v average by del, right?

So keeping the same ratio we can write mu double (())(9:39) is equals to delta P del over L over 3 v average over del, right? So this is k double prime 3 v average over del, right? This to the power n minus 1 and gamma double prime is equals to k double prime 3 to the power n double prime minus 1, right? So it should be since it is k double prime so v (())(10:19) should be double prime, right? So because n is equals to n prime is equals to n double prime so there is no change, but k is equals to something into k prime is something into k is equals to again another thing into k double prime.

So it is not that all the time this n has to be, but it is rightly that instead of n prime if we write n, then it may misleading that is why when k is k prime n is n prime when k is k, n is n sorry and when k is kept double prime n is also in the double prime that should be written, right? So if gamma is so much, then Nre general we can write to be 4 v average del rho divided by mu double prime which is 4 v average into del rho divided by k double prime 3 v average by del whole to the power n double prime minus 1, right?

So if this is true, then we can write Nre general is equals to 4 v average to the power 2 minus n double prime del to the power n double prime rho by k to the power rather k double prime 3 to the power n double prime minus 1 that is equals to 4 v average to the power 2 minus n double prime del to the power n double prime rho divided by gamma double prime, right? So from the definition of fanning friction factor we can write f is equals to tau at the wall divided by rho v average square divided by 2 that is 2 delta P del by L by rho v average square, right? This is equals to 2 delta P del over L rho v average square, right?

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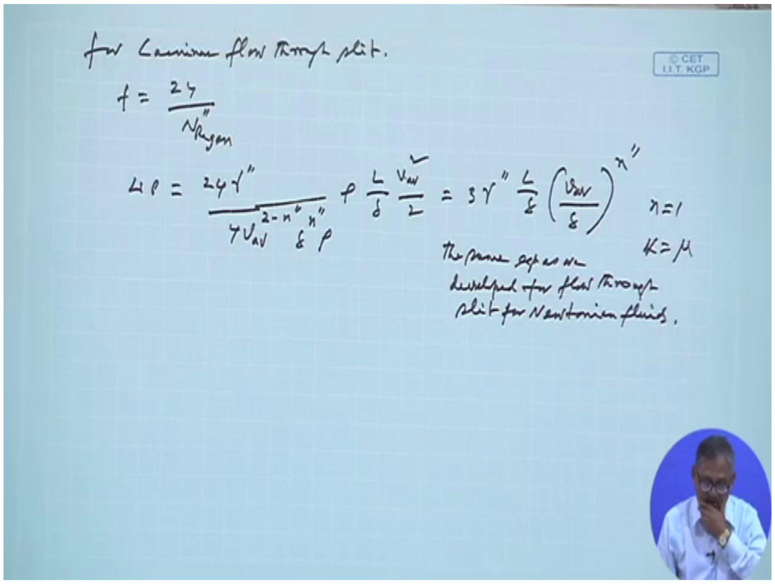

Or delta P is equals to f rho L by del v average square divided by 2, right? Now for Laminar flow through slit we write f is equals to 24 by Nre general double prime, right? Then delta P is equals to 24 gamma double prime by 4 v average to the power 2 minus n double prime into del to the power n double prime into rho L by del, then v average square by 2 so that is equals to 3 gamma double prime L by del to the power v average by del to the power n double prime. Now this if we substitute n is equals to 1 and k is equals to mu, then we get the same equation as we developed for flow through slit for Newtonian fluids, right?

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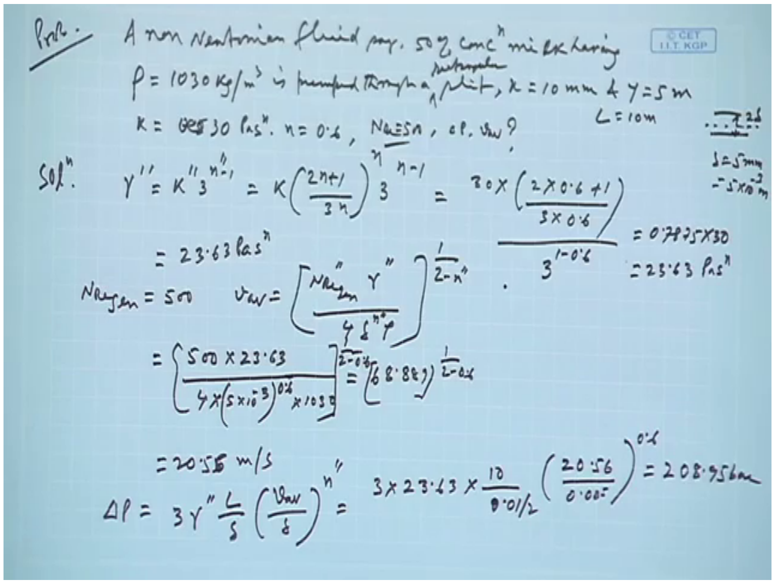

So this is what we can say that this is okay, now if we do a similar problem we have done earlier that is say if we formulate the problem like this that Non-Newtonian fluid, right? Say 50 percent concentrated milk having density rho is equals to 1030 kg per meter cube, right? And is pumped through a slit that dimension of the slit is like this that dimension is like this x is equals to 10 millimeter and y is equals to 5 meter, right? Of a rectangular slit (())(18:02) through a rectangular slit that slit is x is 10 millimeter that is the width and the other I mean thickness and the other one is 5 meter, right?

And rest of the things are like this that the consistency coefficient k is equals to say 0.5 and milk it was say not 0.5 30 Pascal second to the power n and n is 0.6 so if the Reynolds number is Nre is 500, right? So what is the pressure drop and v average? So that is if we formulate the problem like this, then how can we proceed, right? So let us see the solution what can be the solution if you remember that what we did earlier a similar thing here gamma prime is equals to gamma double prime is equals to k double prime 3 to the power n double prime minus 1 is equals to k into 2 n plus 1 by 3 n to the power n into 3 to the power n minus 1. So this is equal to 30 into 2 into 0.6 plus 1 divided by 3 into 0.6, right? Divided by 3 to the power 3 n, right? So k is 30, okay n is 0.6, fine and this is so much so this to the power 1 minus 0.6 because 3 to the power n minus 1 so if goes divided by this then 3 to the power 1 minus n.

So this is like that, so this comes to equal to let us look into that calculator so it is 2 into 0.6 plus 1 divided by 3 into 0.6, right? Is so much divided by x to the power 1 minus 0.6 that is 0.4 that is 0.7875, right? This into 30 is there, 23.63, right? So much Pascal second to the power n, right? So this is gamma that is 23.63 Pascal second to the power n, right? Now if gamma is that, then for Nre general given is Nre general that is equals to 500, right? So that is what we have given that for Nre general 500 so we can write v average is equal to Nre general double prime gamma double prime by 4 del to the power n double prime rho to the power 1 by 2 minus n double prime, right?

So this we can write that this is equals to 500 Nre general gamma double prime has been found 23.63, right? And this is 4 into this del is given as 10 millimeter so 10 millimeter is this thickness, right? So it is 2 del, so only del is 5 millimeter, right? So that is 5 into 10 to the power minus 3 meter, right? So we can write that 4 into 5 into 10 to the power minus 3 to the power 0.6 into 1030, right? So this is equal to if we look at this is equal to 500 into 23.63 (())(25:12) is equal to divided by 4 divided by 5 into 10 to the power minus 3 to the power 0.6 is equal to this divided by 1030 68.889 so 9 68. this is also there to the power 1 by 2 minus 0.6, right? 68.889 to the power 1 by 2 minus 0.6, so that is to the power y, right? 1 divided by 2 minus 0.6, right?

So this comes to 20.55, right? So that came to be 20.55 say 56 meter per second, therefore delta P can be written as delta P is 3 gamma double prime L by del v average by del n double prime, so this is 3 into 23. this is 23.63 that we found out as gamma double prime 3 into 10, right? This is 10 by 0.1, L is that is length other side so L remains same this is y and L is equals to 10 meter, right? 10 divide by D, D is 0.01, right? 2 del so this is 0.01 divided by 2, right? And v average is 20.56 divided by 0.005, right? To the power 0.6.

So this comes on calculation 208.95 bar, right? So this way we can find out that what is the pressure drop and velocity and we can do the similar thing in our system, right? So this we can do and say there is no time left so we tell you that thank you for this class.