INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-34
Problem Solving

with
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Hello I welcome you all in this course of refrigeration and air conditioning today we will solve certain problems on depth design before we solve any problem on duct design I would like to discuss the air handling units the air handling units are nothing but the fence or blowers okay.

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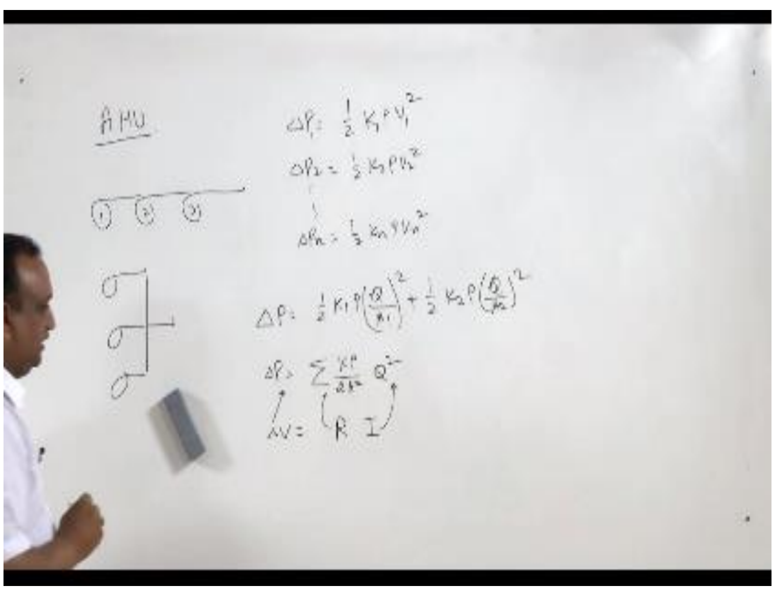

It can be in a single fan or a bank offense and friends can be connected in series suppose very high pressure is required then fans will be connected in series if high flow is required then friends will be connected in parallel now suppose pressure drop in fan Δ p is equal to half K row V2 now this is p1 and p1 this is p1 now Δ p2 is going to half k2density same v^2 and so on we have ΔP n is equal to half K n row Vn2 right a total pressure or equivalent pressure that is Δp is going to be equal to half K1 K1 row Q discharge is same because when they are connected in series discharge is same Q/ A1 whole square plus half K2 row Q/A2 whole square and so on.

And then ΔP can be written as ∑ k row by 2A2 Q2 this is you can find this analogous to ΔV is equal to IR sorry either it is reversed are into I now this I equivalent to analogous to Q2 and this is resistance and this is potential difference now if they are connected in series and if they are character winds are connected in parallel how the pressure and discharge are going to be affected suppose they are connected in series.

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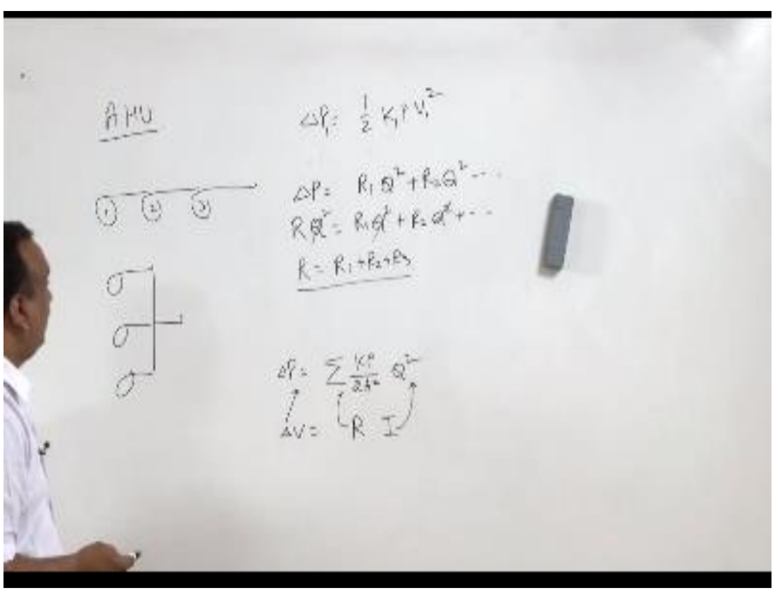

Δp is equal to R1 $Q1^2$ plus R2 Q22 and so on and Δp itself is our cue so RQ is equal to Q2 square is equal to R1 Q2 are not it is not one two three because we are connected in series discharge is say volumetric discharge is same R2 Q2 and so on now this Q will be cancelled out and R is equal to R1 + R2 + R3 so if we have the value of R1 R2 and R3 if they are connected in series it will be total R will be algebraic sum of these values of our now suppose friends are connected in parallel if friends are connected in parallel.

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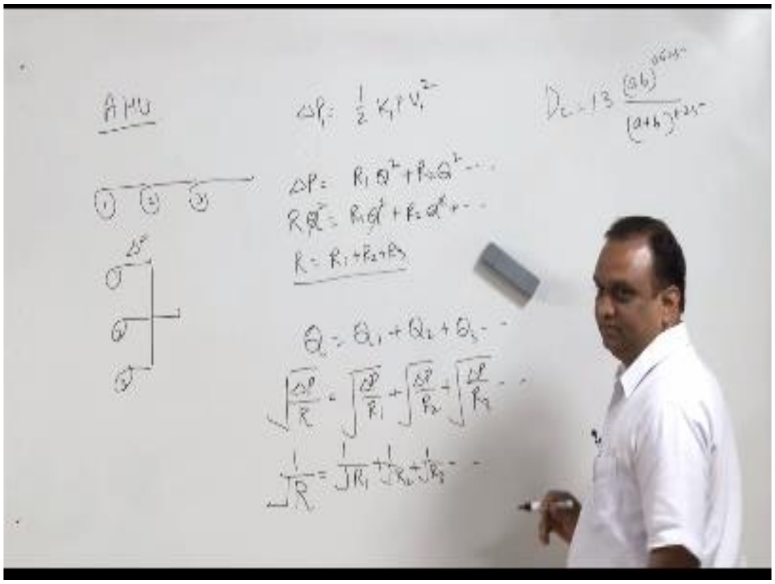

In that case Δ P is going to remain constant and Q is equal to Q1+ Q2 + Q3 and so on this is one two three and if there are more numbers then it is going up it can go to n now Q we know that it is ΔP upon under root Δp upon are under root Δp upon R1 + under root Δ p R2 plus under root Δp upon R2 R3 and so on so if they are connected in parallel then equivalent resistance will be 1 by under root R1 + 1 by under root R2 +1 by under root R3 and so on that is one thing second is if you remember in earlier lecture I told you that equivalent diameter equivalent diameter in a dark paste 1.3 if it is are rectangular duct then A B raised to power 0.625 divided by A + B raised to power 0.25 right.

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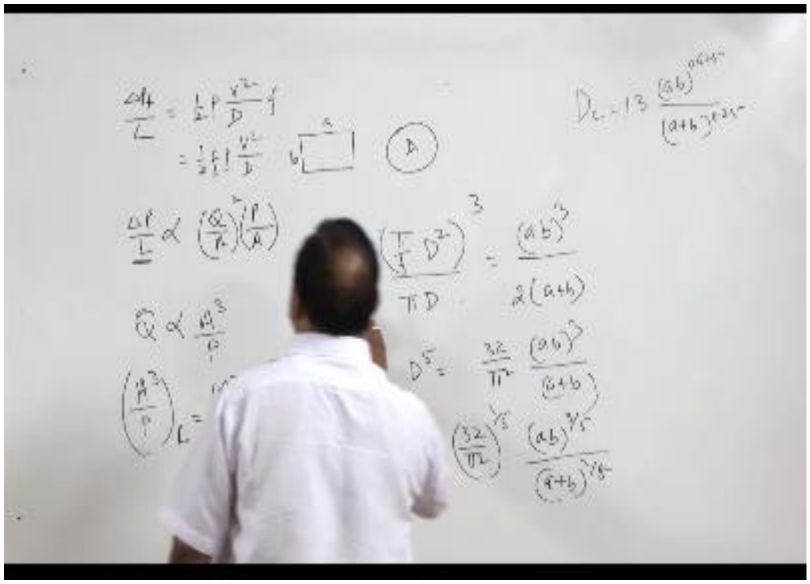

In this case if we take friction loss in a dark then it is equal to half P V2 by D multiplied by F friction coefficient and that is equal to half P V^2 by D now Δ P upon L if this friction is constant this is also constant it is equal to V over D and that is equal to v2 is nothing but Q by a whole square and D is again we can take A and P is perimeter this is proportional to product of these two now in the duct system if we take the equivalence in that case we assume that this is constant when this becomes constant then this charge through that became becomes positional to a cube by P is the cross section area p is the perimeter.

Now we have two ducks one is rectangular having side a and B another is circular having diameter D now if the fixture loss in both the ducks is same coefficient of friction in square and in the rectangular and this circular duct is same density of the air is same then A3 by P in a rectangular duct or a circular duct is equal to A3 by P in a rectangular duct the further A3 is Л by 4 D2 divided by Л D3 sorry it is not this cube it is A3 so cube is equal to A3 is AB3 divided by 2a +b this is the parameter of this rectangular duct and this is the cross section area of the rectangle now if you simplify this is going to be equal to D raised to power 5 is equal to 32 divided by Л2.

AB3 by A+B and here D equivalent diameter is equal to 32 by Л2 raise to power by 1.5 ab raised to power 1.5 is equal to 3 by 5 a + b raised to power 1 by 5 now here d again de colon this is D equivalent.

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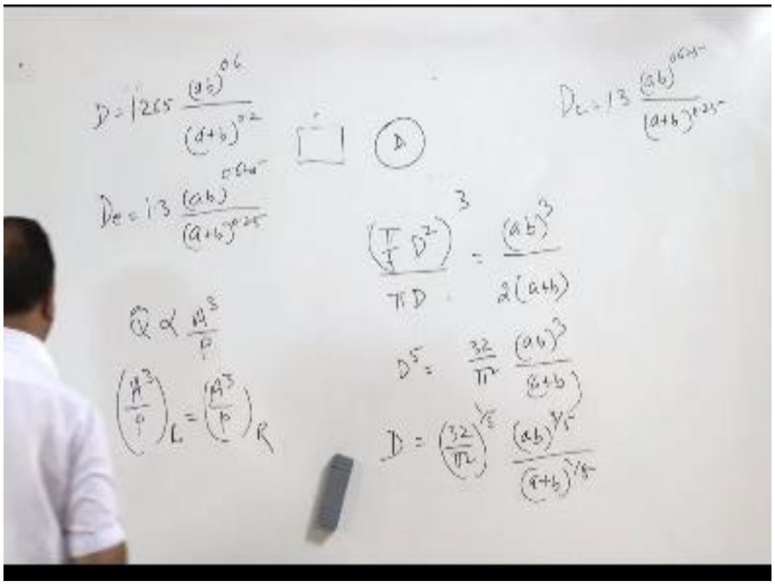

Is equal to 32 Л2 raise to power 1.5 is going to be equal to 1 .2 65 1.26 5 ab raised to power 0.6 and a + b raised to power 0.2 now the average velocity are not same if you look at the average velocity in a square that this rectangular duct and this roundup are not same and with the help of some experimental investigations also this formula is modified as d equivalent is equal to 1.3 ab raised to power point 6 25 divided by a +b raised to power 0.25 this is how we get this formula and this formula is very useful if we know the value of a and b if it is a square that then definitely a is equal to b so if equivalent diameter is road to us a is equal to B we can find the value of a and b if there is a rectangular.

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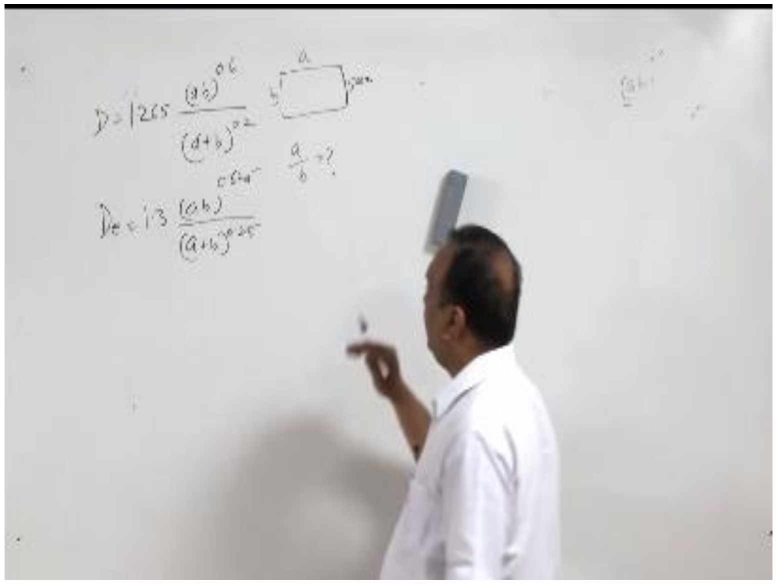

That then we must have the aspect ratio sorry a by b and then we can find the value of a and B or in some of the cases we say okay depth of the depth is restricted to 500mm now depth of the depth means b is 0 point 5 meter and then we can find the value of a so there are several ways of finding out the dimensions of the depth whence we have the equivalent diameter of the depth now we will take a live example.

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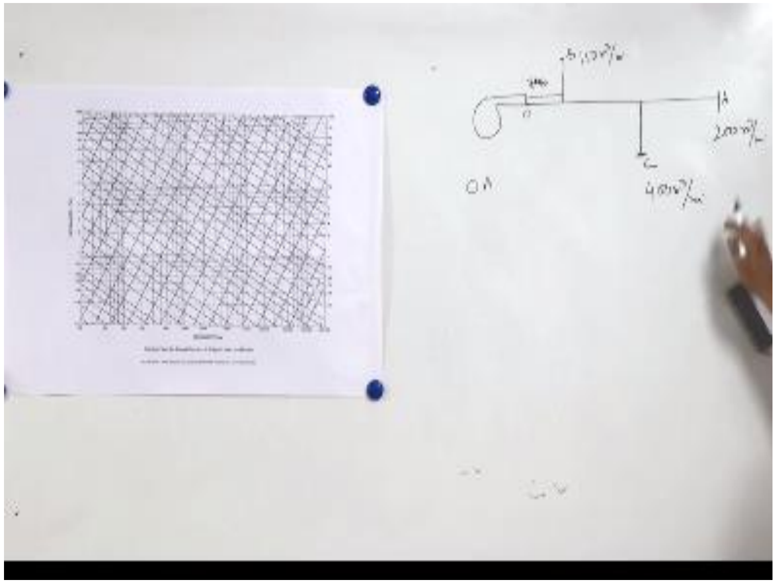

Suppose I have to design it up I have to design it out and I assume any depth network I assume any depth network and depth network let us say there is a pump that is one opening a another opening b third opening c let us have this depth and losses in the bending are compensated by the depth length okay so here we will not consider losses in change in the direction or dynamic losses in this duck network now suppose in this network we can have okay let us take the simple example now here in this case I have to have I want to have certain discharge let us say here 200meter cube per minute at be let us say 150 meter cube per minute here.

We can take let us say 400 meter cube per minute so there are three openings that can be very that network can be very complicated diagram I am just taking one simplified system so that you can understand how the duct system is designed so we have taken only three opening ABC we can have a more opening also here let us say this a b c d e right so see they will not be opening then de it is again bifurcated 200 something like that we can have a network but for the sake of understanding of the design process we have taken only three openings now in this case some minimum velocity has to be maintained in the main depth.

This is main depth so this is 0a a minimum velocity is required suppose the airflow in duct is very low in that case the first of all the size of the duct will increase and some microorganism may also develop especially this happens in the when there is a band in the duct some steel air remains some dead air remains in the conference of the depth suppose there is a sharp turn so in the corners of the depth here some stale air may remain and this may provide grounds for the development of microorganism which is not desired so some minimum velocity has to be maintained so minimum velocity in the depth few minutes suppose here we are maintaining 7 meter per second 7 meter per second velocity is maintained so first of all we will take the total discharge.

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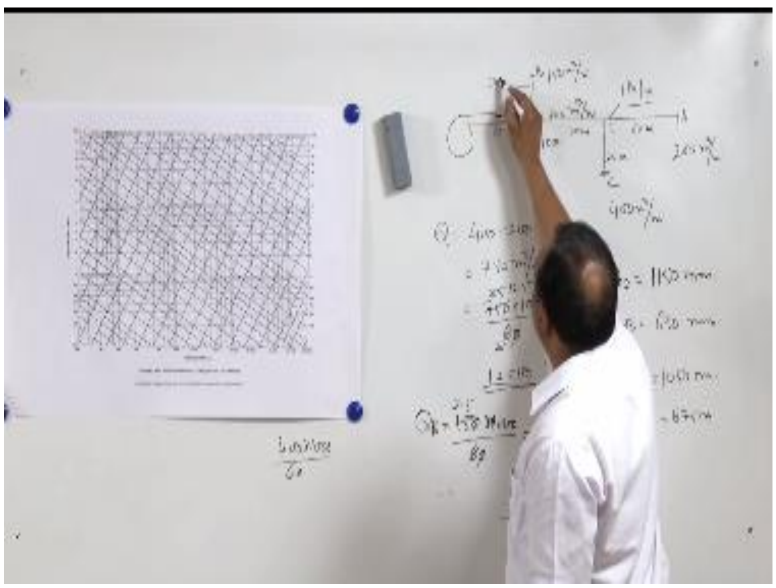

Total discharge Q is how much 400 + 200 + 150 it is 750 m^3/minute now this 750 m^3/minute has to be converted into liters per second so that is going to be 750x1000/60 and this is 12.5 so 12, 5 and 12,500 that is 12,500 liters per second, let me check with the calculator also 750x1000/60 yes, 12,500 yes l/sec right here now for this discharge we have this 7 m/sec velocity 12,500 discharge, right. Friction yes that friction suppose we have adopted one this constant friction in r the main depth and in the branches that is one Pascal per meter and this 7 meter per second is minimum velocity.

So 7 meter per second minimum velocity then we have to write as so we will remove this rider 7 meter per second initially we remove this one writer. We have only one Pascal per meter, one Pascal per meter and this much off discharge so for one Pascal per meter and this much of discharge this is approximately 12,500 and one Pascal per meter, one Pascal per meter is this much so we will be getting this point, right.

Now here you can see the velocity is already more than 7 meter per second so we wanted to ensure that the velocity should remain I mean it is not part of this problem but velocity is remains more than 7 meter per second so here if you look at the velocity is 12 meter per second in the diameters 12,500 we have taken here this is the point for o, right. Now OB not OB OABC now OD can with their joins is so diameters OD, if I have to calculate diameter of the OD then diameter of the OD is between this 1000 and 1250 so let us say 1150, 1150mm will be getting diameter of OD.

Now DB, DB is also one Pascal per meter but the discharge is 150 so for 150 QB 150 m^3 per minute so it is 1000x60 2.5 2500 so we look for the discharge of 2500 so 2000 this is 3000, 2500 will come somewhere here this is a log-log scale 2,000 3,000 2500 will come somewhere here and from 2500 again we will draw a vertical line and we locate the point and this is going to be the diameter of the deck and that is going to be equal to OD so DOD so DB is going to be equal to 630 mm.

Similarly diameter of D diameter of D is the flow through D is total flow is 750-150 600 m^3/min or it is going to be how much 10,000 flow through DB is 10,000 liters per second so again 10,000 we look for and at 10,000 liters per second we will take the diameter here it will come straight away it will come here10,000 so it will come here it will be around thousand fifty1050. So diameter of D is equal 1050 mm.

Now again how much air is remaining with us is 600 m_3/min out of this 400 is going to this side so if I want to find the diameter of C right, then 600 out of 600 400 is coming to this side so 400 again I will convert 400 into liter per second then it is 1000/60 sorry, 1000 so 400x1000/60 is will be 400x1000 60 is going to be 6666, so 6666 will come somewhere here and then we will go get a diameter this is 800 and this is 1000 so it is going to be 875 mm.

So DEC 875 mm likewise we can calculate all the diameters, right. so diameters of all that can be calculated in this way, now pressure drop now for pressure drop in order to have pressure drop we should have the length of the deck and pressure loss in due to change in the direction or the dynamic pressure loss has been compensated by increasing the length of the deck for the sake of convenience suppose this length is 10 meter this is 50 meter and this is 60 meter this is 20 meter and this is also 20 meter.

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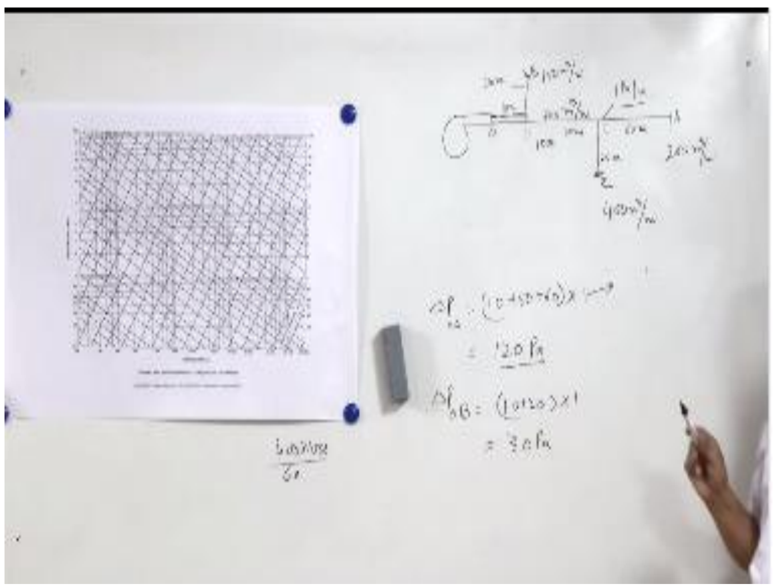

Now in this case pressure drop, total pressure drop in the longest deck will be 10m+50m+60m multiplied by 1 Pascal per meter that is the pressure drop per meter length and it is going to be 120 Pascal. Now pressure drop between O to A is 120 Pascal, pressure draw between O and B ΔPOA is this and ΔPOB is going to be equal to (10+20)x1=30 Pascal so pressure drop between this and this is 30 Pascal, pressure drop between this and this is 120 Pascal.

Now in this case what is going to happen if we take pressure drop of 30 Pascal and deck diameter we already calculated how much we calculate the diameter here 1150 no, no, no dB we have not calculated okay, so if you look at the pressure drop between this and this so definitely pressure drop here is less, length is less most of the air will try to leave at B so we will have to provide dampers. So between this point and every outlet the pressure drop has to remain constant.

So this additional 90 kilo Pascal will come through dampers otherwise what is going to happen the most of the air will be short-circuited. Now we can make the circuit damper free we can make the circuit damper free how we can do that we can do that if we assume that.

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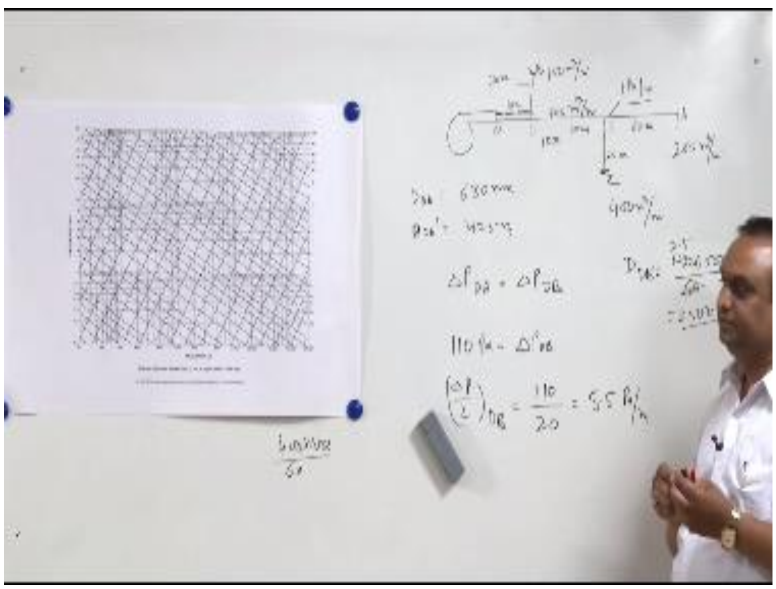

ΔP between DA=ΔP between DB now ΔT between DA is 110 Pascal and ΔTP between DB is suppose ΔPDB this is should be equal to ΔPDB and then we can say that the per unit length pressure drop (ΔP /L)DB can be 110/20 so that is going to be equal to 5.5 Pascal per meter so instead of providing a damper instead of providing a damper we can reduce the diameter of the deck then I will show you how, so for 150 suppose for the equal friction by third diameter of DB is equal to 150x1000/ 60 so 2.5 2500, so 2501 so this is 2500, 2501diameter of DB was 630, 630 mm diameter of DB for equal friction method.

Now what we have done we have assumed that pressure drop between D and A and D and B are same and then pressure drop per unit length between DB is 5.5 kilo Pascal, so instead of coming here again we will have to go up to 5.5 it will be somewhere discharged how is what was the discharge you know 2500 so it is going to be 5.5, 5.5somewhere here on the same line simply the discharge will be something like this, so here you can see the diameters of the deck has reduced to only 425 mm D diameter of DP′= 425 mm here the diameter is 630 and it is reduced to around 425 mm and if you reduce the diameter then we do not require damper here.

So this is how this network can be temper free also where many more networks if you look at the books you will find a number of deck networks and you can use this chart for the deck design for those networks that is all for today. Thank you very much.

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