MARINE ENGINEERING

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Lecture11

Heat flow through pipes and walls

conduction through cylindrical pipe your life heat conduction through cylindrical pipe your life is easy when you have flat plate and heat is getting conducted from one surface to another surface okay but if you have cylindrical pipe circular pipe like this okay then how this heat transfer will be going on what x x value or thickness value will be taking okay because r 1 r 2 okay r 1 r 2 if you see this area is changing okay when area is changing when i you you can't use directly the formula whatever you have used for k a del t by del x right so here formula will change. Here, formula is this, q equals minus ka dt by dr. You have to take differential form because your area is changing, equals minus ka, k means area. Which area?

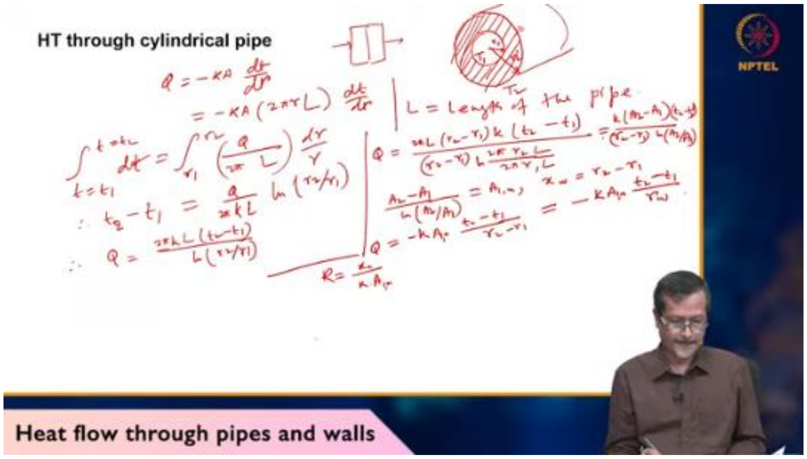
This surface area. So, 2 pi r, 2 pi means your parameter into L. surface area because from inside temperature T1 and outside temperature T2, like it is a common circular pipe. In circular pipe, inside temperature may be higher, outside temperature may be lower. So, heat is transferring from inside to outside.

So, area will be the whole cylindrical surface area. That is why 2 pi RL and DT by DR. So, L equals length of the tube pipe or tube whatever you say. So, you have to integrate to get this dT dr and q all this. So, T equals T2 T equals T1 dr equals r1 r2 q by 2 pi rL 2 pi r has gone.

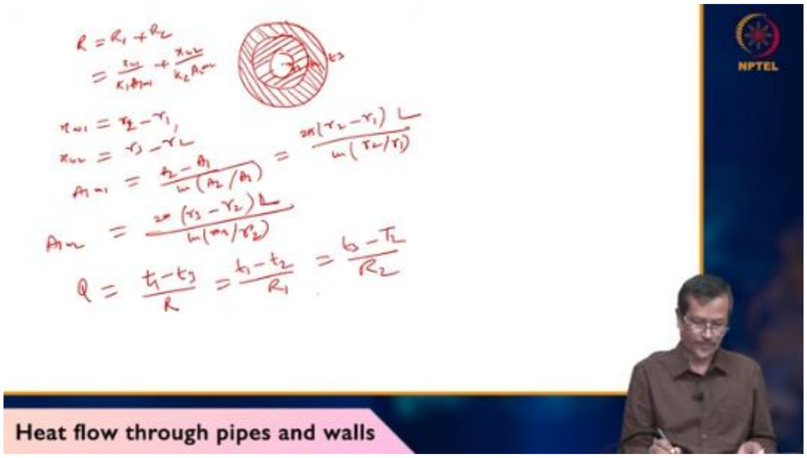
So, dr pi r, r, r, they have put here because this is a constant term. So, T2 minus T1, T2, this is dt, this will be dt. So, T2 minus T1 equals q by 2 pi r, 2 pi kl logarithm of dr by r log will come, so r2 by r1.

Therefore, q equals 2 pi kl 2 pi kl T2 minus T1 divided by logarithm of natural log r2 by r1. Now Q equals 2 pi L R2 minus R1 k T2 minus T1 R2 minus R1 R2 minus R1 up and down both multiplied 2 pi denominator and numerator both 2 pi R2 L 2 pi R1 L this is logarithmic So, this will give k A2 minus A1 T2 minus T1 divided by R2 minus R1 logarithm of A2 by A1. Now, A1, A2 are the inside and outside surface. So, Q

Now, A2 by minus A1 by logarithm of A2 by A1 inside outside surface area, A1m, they have taken this notation and xw equals R2 minus R1. This will give Q equals KAM1m T2 minus T1 r2 minus r1 or minus ka1m T2 minus T1 by rw and here r equals r equals xm by k1 a 1 m now r equals r 1 plus r 2 so if you have two pipes i'll be giving different shading so that there will be no confusion confusion okay so t 1 t 2 t 3 and so r equals r 1 plus r 2 equals x w 1 k 1 a 1 m 1 plus x w 2 k 2 a 2 m 2



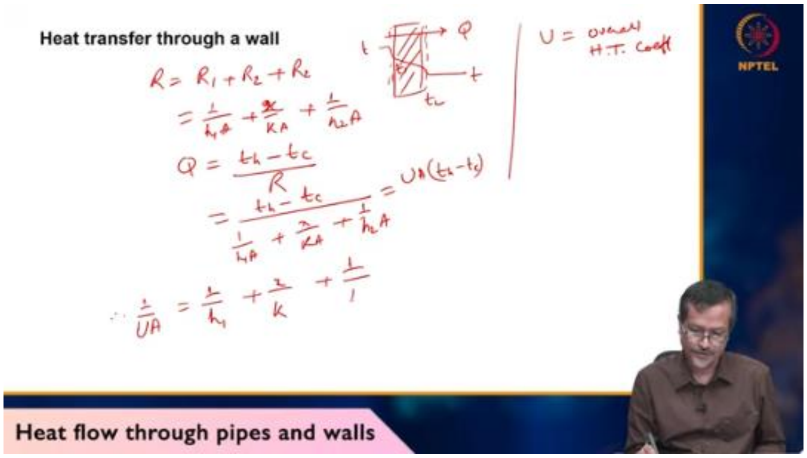
okay x w 1 equals r 2 minus r 1 equals then x w 2 equals r 3 minus r 2 so a 1 m 1 equals a 2 minus a 1 logarithm of a 2 minus a 1 not minus it will divide equals 2 pi r 2 minus r 1 l by logarithm of R2 by R1. A1 m2 2 pi R3 minus R2 L divided by logarithm of R3 by R2. The rate of heat transfer will be and Q rate of heat transfer is Q equals T1 minus T3 divided by R equals T1 minus T2 by R1 equals T3 by minus T2 by R2 from which the interface temperature T2 can be evaluated.



So, heat conduction through a wall, you have a wall. Now, what will happen? There will be one boundary layer, both side. And through boundary layer also, there is some gradient will be created. T, T, T2, T1.

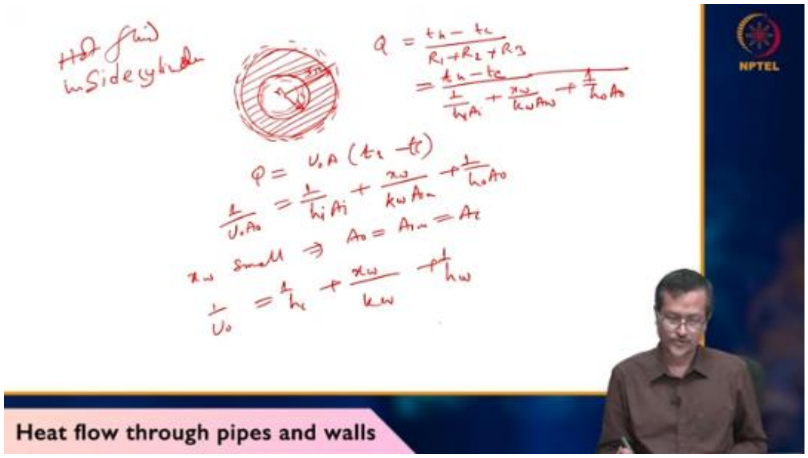
And this flow rate will be, heat flow rate is Q. So, R equals R1 resistance left side plus resistance of the metal plus resistance of the other side because of boundary layer. So, the formula will be like 1 by H1A plus 1 by X by KA plus 1 by H2A. The same area you are using Q equals TH minus T cold plus T hot minus T cold divided by R. So, this will be like TH minus T cold 1 by H1A plus X by KA plus 1 by H2A equals UA TH minus TC.

So, U is called overall heat transfer coefficient. U is called overall HT coefficient. So, 1 by UA, therefore, 1 by UA equals 1 by H1 plus X by K plus 1 by H2. So, hot fluid through a pipe.



Now, I have one pipe. Again, here inner one boundary layer created and outside also one boundary layer created. okay and this is my pipe i'm shedding the pipe so that it will be clear this is okay now small r maybe r1 r2 i can make so q equals th minus t cold r1 plus r2 plus r3 equals t h minus t cold divided by 1 by h 1 a plus x w k w a w plus 1 by h o a o okay so o means outside h i or inside okay i can put so q equals u a this is hot fluid inside cylinder hot fluid inside cylinder so outside temperature is lower inside temperature is higher th minus tc so 1 by u o a o equals 1 by h 1 a 1 plus x w

k w a 1 m plus 1 by h o a o h 1 or h i i can write so if x w small so a o a 1 m a i all equal So, 1 by u o equals 1 by h i plus a x w. kW plus 1 by hW. So, this is taken from Picanhag book. So, if anything goes wrong, please go through the book.

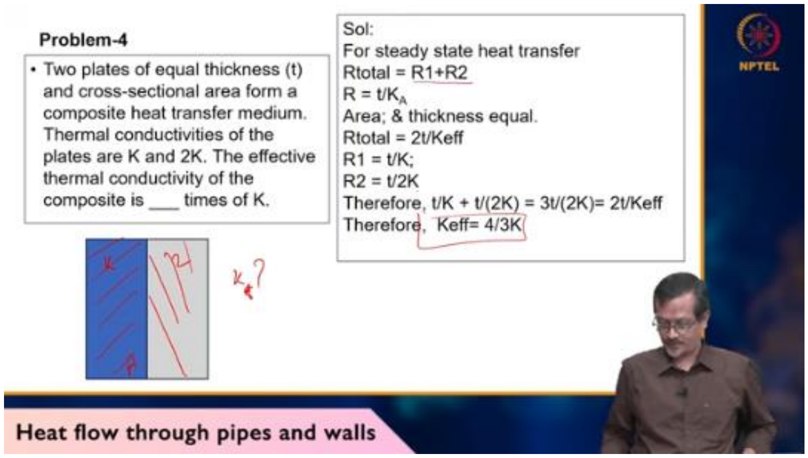


Non-dimensional numbers. So, I already discussed non-dimensional numbers like Reynolds number, Prandtl number, Nusselt number. There will be some other numbers like Grashop number, Grashop number and many other numbers are there. So, basically for our convective heat transfer coefficient, we will be using this Reynolds number, Prandtl number, Nusselt number. okay this number is very common actually for any fluid flow we are using so the formula is u d rho by mu so nu is kinetic viscosity uh it for this formula is mu by rho and unit also you should remember meter square per second okay uh Reynolds number less than 2000

This is called laminar and more than 2000, about then it will be a turbulent. Why laminar and turbulent will be required? When turbulent is there, so we will have more heat transfer coefficient because of force convection. Nusselt number, already I have given formula, hd by k Prandtl number. mu CP by K and H equals function of diameter viscosity is rho mu K CP okay and Nusselt number and plant number many formula may be there but one formula is this like a Nusselt number

equals 0.023 Reynolds number power 0.8 Prandtl number power n. So, n equals 0.4 for heated fluid and equals 0.3 when fluid is cooled. Now, you see the simpler problem two plates of equal thickness here one plate Another plate is here, cross section area and cross section area from a composites heated medium. Thermal conductivity k is 2 k, area you can assume A. The effective thermal conductivity of the composite is, so you can see the formula. The steady state heat transfer total R1 plus R2.

So, RT by kA area and thickness equal. are total 2 T k effective. So, R1 T by k, R2 T by 2 k. So, therefore, T by k plus T by 2 k equals 3 T by 2 k. So, 2 T by k effective. So, therefore, k effective is 4 by 3. If you see add all this and it will become a 4 by 3 k. Another problem is that circular tube transporting hot fluid given data is given circular tube



hot fluid is it is transporting so outer diameter 0.5 meter inner temperature T inner temperature 80 outer temperature 25 degree and radius 0.4 this is 0.5 and per meter length of the tube heat transfer. So, Q value already you have to use the formula 2 pi L Ti minus To log Ro by Ri. So, if you put directly the formula the values from the formula then you can get directly 15487 watt per meter.