Surface Facilities for Oil and Gas Handling

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Introduction to Heat Exchanger-02

Heat transfer from a fire tube. A fire tube flame inside a tube or pipe surrounded by process fluid ok. So, the heat will be transferred using radiation, convection from fluid to inside surface ok, one pipe is here. So, initially it will be reaching to wall radiation and convection ok. So, when radiation is happening it will not be heating up the fluid, now that will be heating up directly solid ok. So, radiant convective heat transfer from flame to inside surface of the tube, then conduction will be happening after that from inside metal there will be conduction ok.

So, after conduction again there will be convection if it is going to another fluid domain ok, convection heat transfer from outside surface to the oil. So, here convection will be happening ok. So, inside wall it will be conduction ok. So, from flame to wall any solid body normally conduct convection and radiation will be playing role ok.

So, common heat flux rate water common heat flux rates ok. So, water like 10000 design heat flux rate Btu Btu per hour feet square ok. So, glycol you have seen right previous lectures we have seen 7500 again amine it is 7500 ok. So, just some rough some value some so that you can get some idea what will be the heat flux rate ok. And fire tube area fire tube equals heat duty heat duty including losses Btu per hour and design flux rate ok.

So, we will try to calculate some electrical analogy electrical electrical analogy ok. So, let us say one heat transfer surface is like this and you have 3 layers of metal let us say copper aluminium iron. So, one layer will have conductivity KA this is A metal this is B metal different heat transfer conductivity KC ok. So, 3 different metal I have taken and temperature let us say T1 T inlet or T outlet or T inner surface T outer surface ok. And T1 T2 T then length or thickness of the of the metals x1 x2 x3 x4 ok the distance.

So, if T1 is high let us say 100 this is 10 ok. So, initial KA temperature higher after metal KA T2 temperature will be like this Ti T1 not T T2 T1 and then maybe T2 then maybe T3 T3 or To ok. So, if thermal conductivity equal then it will be straight line it is not equal. So, that is why it can curve will be different ok. Now what is the heat transfer rate from A B C D A to B A to B heat transfer rate equals minus KA delta T by L equals minus KA area what is the area? Area we assume 1 ok.

Let us say area equals 1 for all cases surface area this area actually ok. This this surface area 1 del T del T equals Ti minus Ti minus T1 and L L means x1 ok. Now let us say q A B q B C minus K B into A1. So, del T again T2 minus T1 minus T2 x2 q B B C C D C D equals minus K C T2 minus To divided by x3. Now all the heat flux actually equal q A B equals q B C equals A B B C C D q C D equals q all heat loss equal because you there is no energy loss we are assuming ok.

So, there is no energy loss because of energy conservation. So, all heat fluxes are equal. Now del T1 A to B surface temperature difference Ti minus T1 equals q A B by K A. T1 minus T2 equals q B C K A T2 minus T3 q C D by K A. If I have A value instead of 1 then I will have A also area also ok.

So, now, you if I add 1 2 3 if I add 1 2 3 then it will be coming like Ti minus To equals q A B 1 by K A plus 1 by K B plus 1 by K C X should be also coming X will be coming x2 x3. So, x1 x2 x3 ok. Now q A B equals q actually. So, q equals del T divided by x A by K A plus x B by K B plus x C by K C ok. So, del T equals del T del Ti I assume equals del Ti Ti minus To ok.

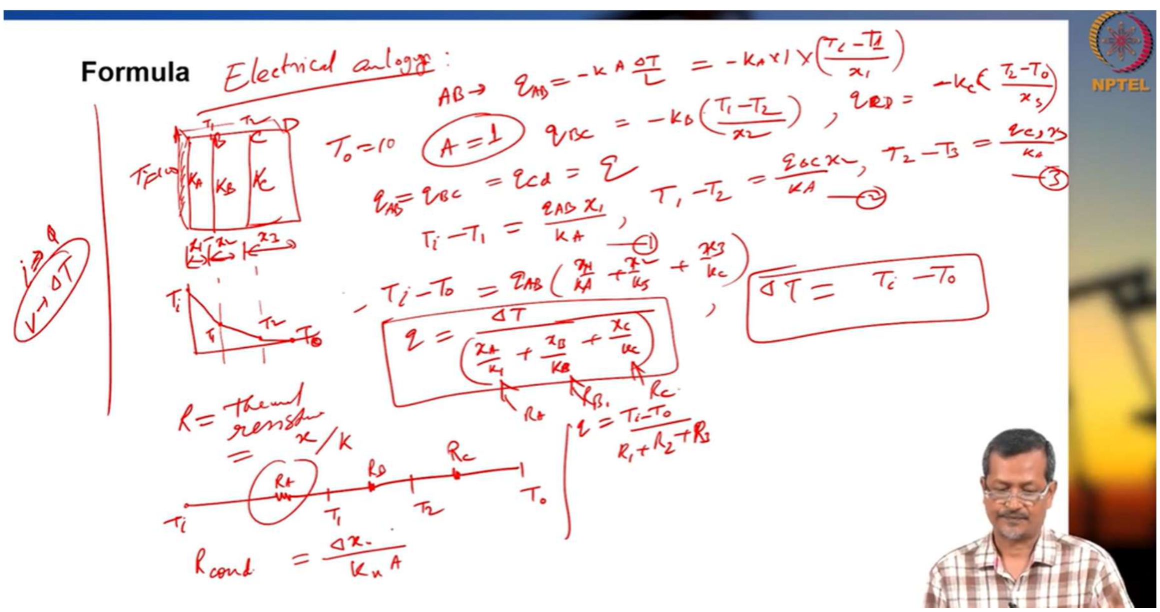
So, q is coming like this. Now, if I make electrical analogy R thermal resistance R equals thermal resistance equals del x by K or x by K or del x by K ok I write K x by K. Now if I make thermal analogy so, Ti T1 T2 To. So, this is R A R B R C ok this is R A this is R B this is R C ok R conductivity because del x n by K n A area. So, q equals Ti minus To R1 plus R2 plus R3 ok.

So, whenever you are creating electrical analogy so, I I will be implying as a q heat transfer rate ok. Resistance already you have seen here R resistance we are showing and voltage temperature difference voltage will be del T actually temperature difference. So, temperature difference high more current will be passing ok. So, this way you compare electrical system with thermal heat transfer system. So, heat transfer through radial pipe so, you have I have pipe like this ok.

So, h t through radial pipe. So, in that case q equals minus K 2 pi R L dt by dr ok. So, T equals Ti at R equals Ri equals To at R equals Ro ok. Now, if you analyze properly like this you take only one phase this is Ri Ro radius this is thermal conductivity K. So, q equals minus q equals minus K dt by dr 2 pi R L 2 pi R L.

So, Ri Ro integrating dr by R equals 2 pi R L q dt To Ti. So, therefore, q will be coming K 2 pi R L Ti minus To logarithm of Ro Ri. So, q equals K Al Ti minus To Ro minus Ri. So, A 2 pi L Ro minus Ri logarithm of Ro Ri R L Ro minus Ri logarithm of Ro by Ri . So, Ti t1 t4 you can say t2 t3 t4 or t ok.

So, this is logarithm of R 1 by R 2 2 pi K A L logarithm of R 3 by R 2 2 pi K A B L R 3 by R 4 2 pi K C L. So, q is coming 2 pi L t1 minus t4 logarithm of R 2 by R 1 K A plus logarithm of R 3 by R 2 by K B plus logarithm of R 4 minus R 3 logarithm R 4 by R 3 divided by K C. So, this is the formula coming. If I have multiple layers t1 t2 t3 t4 ok R 1 R R 1 R 2 R 3 R 4 ok. So, outside temperature t4 inside temperature t1 ok.



So, if a multiple layer then this will be your general formula for radial heat transfer through pipe. A circular tube transports hot fluid given data Ro 0.5 Ti 80 degree centigrade Ro 0.4 outer temperature 25 degree. So, first you draw ah pipe ok.

So, pipe Ri is given Ro. So, Ri given 0.4 Ro given 0.5 K value is given 10 watt per meter K. So, q per meter length you have to calculate.

So, formula is that q per meter equals K 2 pi L Ti minus To logarithm of Ro by Ri. So, the value is like 10 2 pi L Ti 80 minus 25 by logarithm of 0.5 by 0.4 equals 15487 watt per meter.

So, this is the solution. So, another problem ah 2 plates of equal thickness. So, equal thickness is T T ah cross sectional area from composite heat transfer medium thermal conductivity of K and 2 K effective thermal conductivity of the composites K effective you have to find. So, for steady state heat transfer ah total resistance R 1 plus R 2 ok resistance sectional and R resistance equals T by K. So, area and thickness equal A ah let us say this is A this is B area A and area B equal and thickness also equally given. So, total R is becoming like ah 2 T by K effective.

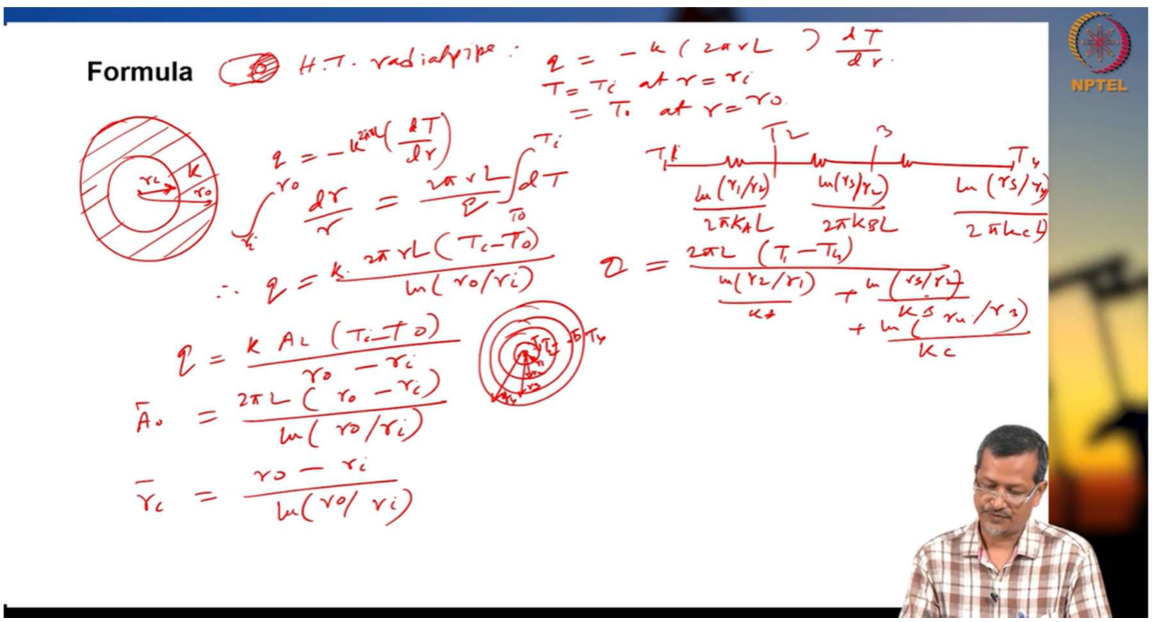
So, R 1 T by K R 2 T by 2 K. So, therefore, T by K T by 2 K equals 3 T by 2 K 2 T by K A. So, this one and this one it will come like this 4 3 by K. So, problem ah we have taken from gate 2017 and oil emulsion having 15 percent water cut. So, water cut 15 percent ah by weight ah is being treated in a horizontal heater heater horizontal heater heater you are you are using ah and ah oil emulsion, emulsion ah flow rate is 6000 kg per hour ok. So, how much water is there? So, 15 percent water is there 6000 water plus oil is 6000.

So, 15 percent 6000 into 15. So, 900 kg per hour. So, Q oil this is Q water I can write Q oil equals ah 6000 into 0.85. So, it is going 5100 kg per hour ok oil and water percent ah amount we got. The inlet temperature T inlet temperature of the emulsion 30 and operating temperature heater heater 40 T operating 40 degree centigrade.

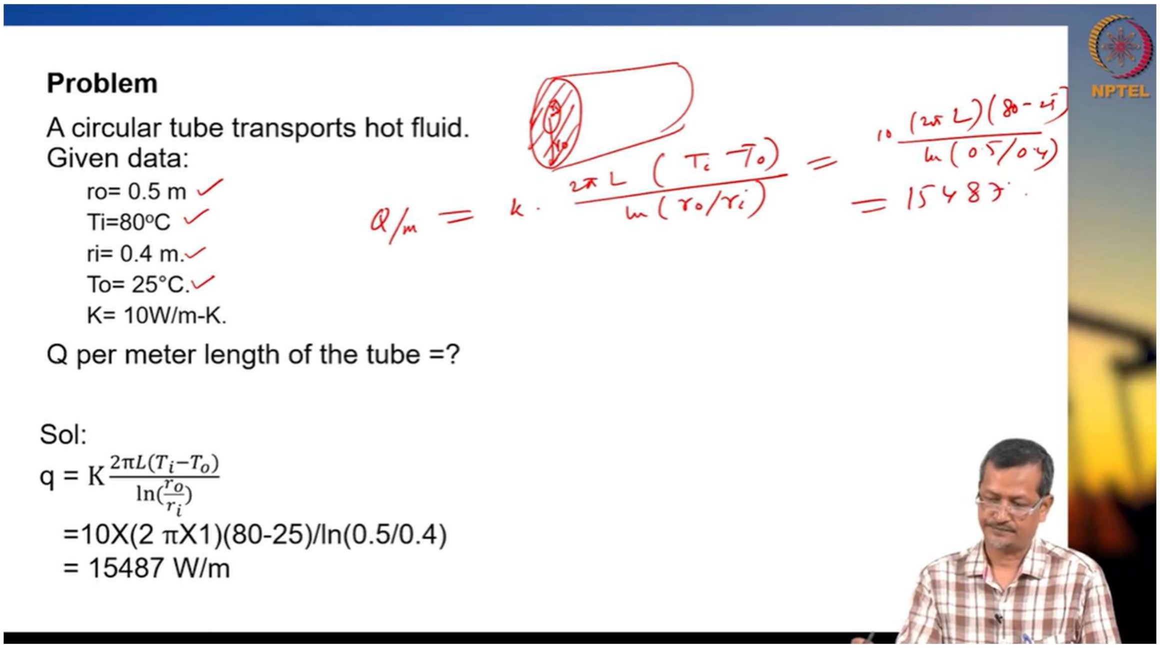
The specific heat capacity C ah for water C for oil 0.5 C for water 1 assuming 10 percent heat input loss 10 percent loss ok. The total heat energy required to break the emulsion ah total heat energy H e heat energy I am writing like this how much will be heat energy ok. So, water cut we got ah oil flow rate we got.

So, 0.9 heat energy equals heat oil plus heat water heat oil heat water. So, how much it will be like 5100 into oil 0.5 temperature increasing 42 40 to 30 ah yeah temperature increasing ah 30 to 40. So, 40 minus 30. So, that I will get positive value plus 900 into 1 into ah 40 minus 30 same temperature actually.

So, this total is coming 34500 divided by 0.9 equals 38333.3 k C L per hour ok. So, this much of heat energy should be input. So, another problem from gate again saturated steam 0.



5 atmospheric pressure and 90 degree centigrade condenses on a vertical pipe 2 centimetre outside diameter ah vertical pipe 2 centimetre outside diameter 2 centimetre ah 40 length ah the average conduction heat transfer coefficient K given 1200 watt per metre square k outside surface temperature T surface temperature given 85 degree the enthalpy values are given H steam and steam 2660 k j per kg you should remember the unit k j per kg H ah condensate liquid 375 ok. So, enthalpy values are given internal energy you got. So, how much energy you have given actually difference of these two amount that much of energy you have given actually rate of steam condensation you have to calculate ok.



So, Q equals U A del T mean temperature increase. So, U 2 pi R L del T M equals 12000 U value given into 2 pi into 0.

101 R is given ah into del T M 0.4 ah this L 0.4 and then del T M 90 minus 85. So, it is coming 1507.

96 watt. So, enthalpy change ah happened. So, total heat given. So, let us M is the rate of ah condensation ok. So, rate of condensation is M into 2285 ah into 1000 divide 1000 divide by 3600 actually 2285 is coming like this ah these two difference is giving 2285 ah k j per kg. So, k j kilo joule is there. So, that is why 1000 came and hour is given that is why 3600 came.

So, it is coming 1507.96 it is given a calculated from here ok. So, therefore M equals 2.375 kg per hour ok this is the answer. This is the simplest problem in a parallel flow heat exchanger ah parallel flow heat exchanger phase we draw parallel flow parallel flow means like one going down ah. Hot fluid enters 100 and leaves 50 cold fluid enters 30 and leaves 40 if heat losses are ignored then LMTD.

So, this is very direct question actually LMTD equals del T 1 how much del T 1 equals 100 minus 40 equals 60 del T 2 equals 50 minus 30 equals 20. So, LMTD equals del T 1 minus del T 2 logarithm of del T 1 by del T 2 ok. So, 60 minus 20 by logarithm of 60 divide by 20. So, this value will be coming 36.

4 degree centigrade ok. So, if units are different for example, inlet temperature outlet temperature if units are different or any unit different then you have to convert into proper unit then you try to calculate otherwise you will get wrong result. So, thank you very much for today lecture next day we will start heat exchangers. Thank you very much.