MARINE ENGINEERING

By

Prof. Abdus Samad

IIT Madras

Lecture29

Boiler efficiency

boiler efficiency. So, boiler will have normally two types of efficiency, one will be direct efficiency, another will be indirect efficiency. Direct efficiency calculation is like this, energy output divided by energy input, not here, energy input. So, in formula if I write Q equals H, capital H minus small h divided by Q into gcv, into 100.

So, Q quantity of steam generated kg per hour or kg per second whatever you like you can put. H is enthalpy of the steam kilo calorie they have given you can change unit also. H enthalpy of water. So, here all calorie given. So, they are using calorie, but if you can use if you want to use joules for that also you can use.

Joule also energy unit, calorie also energy unit, heat is energy. Gcp gross calorific value of the fuel ok. Now, boiler indirect efficiency formula is 100 minus 1, 2, 3, 4. So, 1 is dry gas, fuel gas losses. This is losses actually.

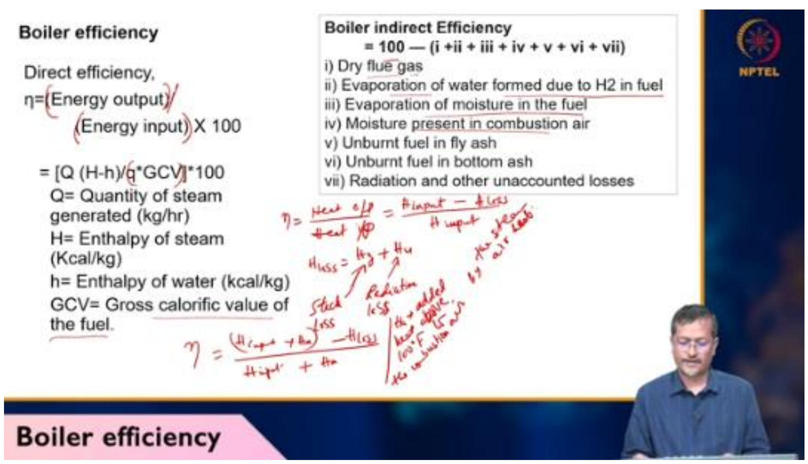
Initially, you are assuming 100 percent energy is going. Now, how much losses are there? indirectly you are trying to calculate how much energy actually you are giving to your steam. Evaporation loss, evaporation of water formed due to hydrogen in fuel. proportion due to moisture, moisture present in combustion.

all this parameter if you know then you can add and minus 100 minus of all these losses. in that way indirectly you can calculate boiler performance. So, boiler efficiency another formula we can write eta equals heat output by heat input Heat output by heat input, IP I am writing, IP means input, slash P means output. Input will be more and output will be less.

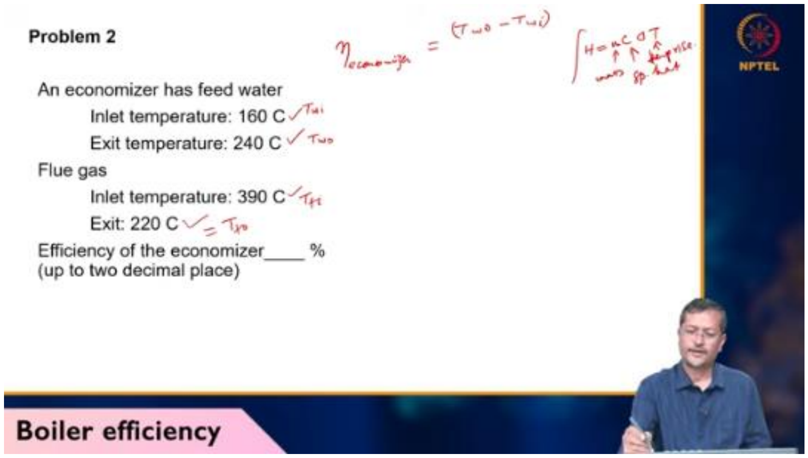
So, heat input minus heat loss divided by heat input. I can write H input. So, hit loss, H loss equals Hg plus Hu. So, Hg stack loss, stack loss means after burning flue gas going out of to the atmosphere so that loss some energy it will take so that that loss is called stack loss and hu is radiation loss because it is metallic system so some radiation will be happening okay radiation losses uncounted for and manufacturer margins so manufacturer will also have some margin so that much of loss you are adding here

input and the efficiency becomes, so eta becomes h i input plus h a minus h loss divided by h put plus h a. So, h a is added heat above 100 degree centigrade added heat above 100 degree Fahrenheit to the combustion chamber. because of that certain losses will be there. Combustion chamber added heat to the combustion by this steam not combustion chamber, combustion air by the steam air heater.

So, sometime steam will be heating inlet air. So, that much of losses will be there because that is added as a HA. this formula also can be used if the data is given. For example, if I input data h a data h loss data is given then eta uh boiler efficiency you can calculate now we'll try to solve some problem uh first problem is on economizer an economizer economizer has a feed water inlet temperature 160 degree exit temperature to 40 degree flue gas inlet temperature 390 exit temperature 220 degree efficiency of the economizer i have to calculate so uh t



I can write here TWI, TW economizer has feed water, TWO is it, flue gas TFI, TFO and then we have to calculate eta economizer. TWI how much energy it is taking? Twi minus Two minus Twi mc you can I can write like heat some to increase heat. So, heat equals mc delta T mass specific heat into delta T means temperature difference temperature rise. Now, here is another problem.



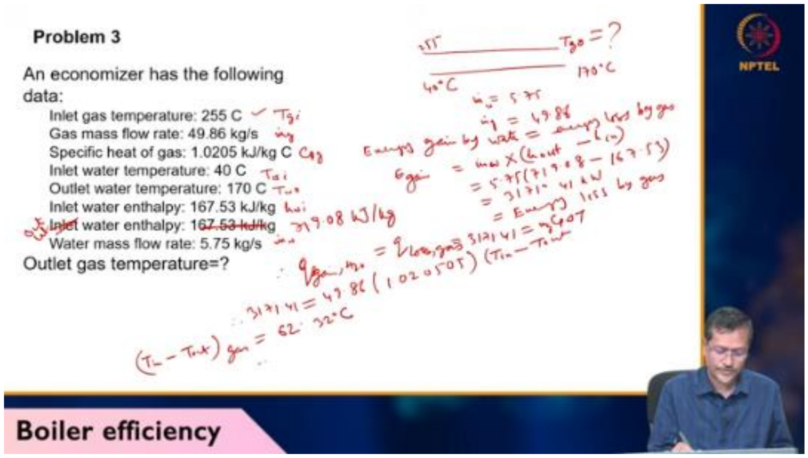
An economizer has following data. Inlet gas temperature to 55 degree centigrade. So, TGI gas mass flow rate mg given specific heat of gas cp gas inlet water temperature temperature water inlet outlet water temperature t w o inlet water enthalpy h water i inlet water enthalpy okay this should be repeated water must flow it m water dot outlet gas temperature i have to find so let's say i have one economizer inlet temperature 255 and outlet gas temperature so t o t gas outlet is not given inlet water temperature is given 40 degree centigrade outlet water temperature 170 degree centigrade okay water mass flow rate is given 5.75

and gas flow rate is given 49.86. Now, energy gain by the feed water, energy first energy gain by water, energy gain by water equals energy loss by gas. e gain equals m dot water equals h out minus h in okay so it is becoming into 5.75 719.08 this will be outlet enthalpy it is given as 719.08 kg per kg 719.08 minus 167.53 so it is coming 3171.41 kilowatt therefore the energy gain by water is this one now energy loss by gas equals energy loss by gas.

So, therefore, Q gain H2O equals Q loss gas equals 3171.41. equals mcp delta t therefore 317 1.41 equals 49.86 it is given the gas mass flow rate into 1.020505 it is given the specific heat of gas and temperature difference t in minus T out. So, therefore T in minus T out gas equals 62.32 degree centigrade. So, therefore T out is coming 255 minus 62.32 equals 192.67 degree centigrade.

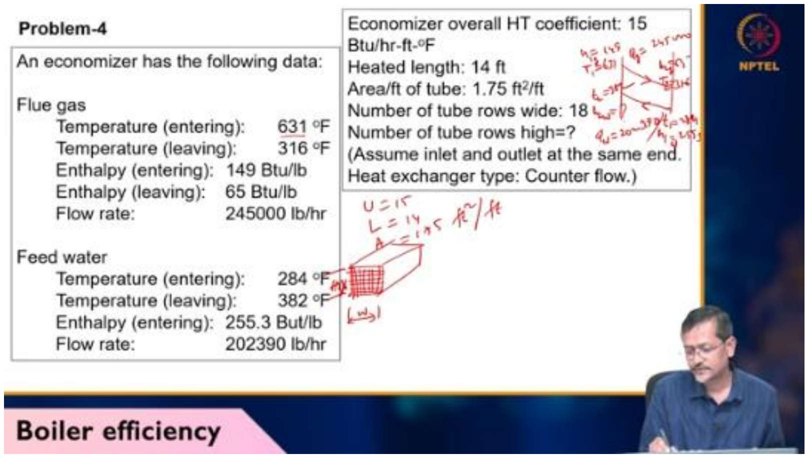
So, this is your answer. Another problem on economizer, an economizer has the following data, flue gas temperature entering 631 and it is actually counter flow heat exchanger. So, first I have to draw counter flow thing, there in flue gas temperature entering 631, just flue gas temperature will be higher than water temperature, so 631 and living 316 and enthalpy entering 149. 149 BTU per LB H 1 T 1 H 2 equals enthalpy leaving 65 and T 2 equals this flow rate also given Q gas 24500 and T small t I am putting for water 284 And enthalpy

H1 equals 255.3 and T2 equals 382, it is gaining heat, so temperature will be more than entering temperature.



H2, maybe H water I can write, water, H gas, H2 gas. So, H2 water is not given. but flow rate is given q water is given 2 0 2 3 9 0 ok these values are given so economizer overall heat transfer coefficient also given u also given 15 heated length 14 feet and area of tube is given 1.75 feet square per feet So, number of tube rows, number of tube rows wide and high, wide and high means like this. I can assume this is wide and this is high.

So, how many rows are there? Wide means like 1, 2, 3, 4, 5, this is high wise and wide wise like this. So, I will have many tubes like this. so these are my tubes the circle circle I am drawing that there is actually a tube okay number of tube high you have to calculate so vertically how many tubes are there you have to calculate assume inlet and outlet at the same end heat exchanger type counter flow same end means actually you have to use even number of tube so how to solve it to solve it so flue gas entering temperature T F 1 6 3 1 T F out 3 1 6 degree Fahrenheit so you are taking degree Fahrenheit so all must be degree Fahrenheit so gas sensible heat entering so H flue gas enthalpy 1 4 9 B T U power L B



and qg gas flow rate is given qg is given 245 245 000 lb per hour pound per hour feed water entering t water 1 284 degree fahrenheit t h h w 1 is given 255.3 b t british thermal unit per lb so you should remember this units also british thermal unit water flow rate q water 202390 lb per hour feed pump discharge feed pump discharge pressure, that is not required actually for calculation, feed water temperature leaving, feed water temperature. So, TW2 is given 382 degree Fahrenheit, economizer heat transfer coefficient, overall heat transfer coefficient is given 15 BTU hour feet degree Fahrenheit. Heated length is given 15 and area per feet is given 1.75 per feet and number of tube wide, number of tube N wide is given 18 and N high we have to calculate and they are saying this is counter flow heat exchanger.

okay so counter flow means first you have to do this counter flow thing okay going like this and i already have written this six three one two three one six and entering two eight four two three eight two okay uh now del sg equals del not del sg del q QG equals QG1, I should not write Q, rather I will write H. Del HG equals HG1 minus HG2. So, it will be giving 149 minus 65 equals 84 BTU per pound. Okay, feed water enthalpy rise del H. del H water how much water is taking energy from gas it is del H water taking water taking energy from gas now I can do the energy balance del H into W Q W

equals del q gas into del h w del h gas okay now this will be giving del h equals del del h w will be del q s h g into 8g into q g by q w so this will be having 84 minus two four five zero zero zero divided by two zero uh two three three nine zero so this is coming one zero one point seven b t u per pound Now, because this is counter flow heat exchanger, so the LMTD you have to calculate logarithmic mean temperature difference. You can, to understand this one you have to go to previous lecture, heat transfer. So, T del T1 del T2, so del T1 minus del T2 divide by logarithm of del T1 by del T2.

So, what is my del T1? del T1 is 6 3 1 minus 3 8 2 minus del T2 3 1 6 minus 2 8 4 divided by 3 8 2 8 4 divided by del T1 6 3 1 logarithm of minus 3 8 2 divided by 3 1 6 minus 2 8 4. So, if I solve this one, if I calculate this one, then 105.6 degree Fahrenheit is coming. Now, economizer surface area, surface area given A. So, therefore, del QG WG equals UA LMTD. Now, therefore, A equals del Q, not QG, I will write HG, UALMTD.

So, del HG into WG gas, why WG, I am writing QG. So, QG divide by LMTD, LMTD into U. So, required number of tubes rose number of tube rows high SLNWA equals. So, total heat transfer divided by LNWA. So, this will becoming 29.5.

So, number of tube rows number of equals 30. Why 30? Because starting and ending at the same point, so it will be even number. So, this problem is taken from your book Boiler Combustion Marine Engineering book, book Marine Engineering by Harrington, page number 125.

okay so if there is any issue just please try to go through the book uh thank you very much for today's lecture next day we will start new topic thank you