MARINE ENGINEERING

By

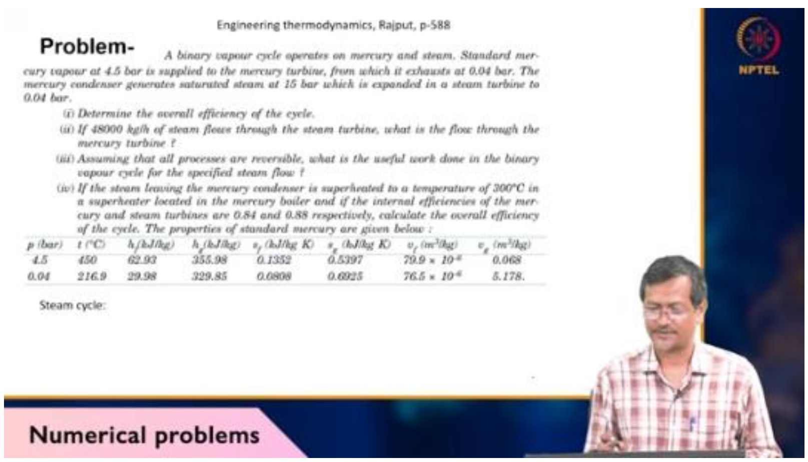
Prof. Abdus Samad

IIT Madras

Lecture54

Numerical problems

we will see one problem. This is taken from engineering thermodynamics book. T.S. Rajput book is there. The binary vapor per cycle.



So, binary cycle problem. First I have to draw T.S. diagram. So, mercury and Hg and H_2O. They are taken to fluid. Standard mercury vapor at 4 bar is supplied to mercury turbine.

\this is 4 bar. okay turbine will be here somewhere maybe superheated they are not saying anything so let's say okay okay okay uh so this is turbine now uh market i mean from which exhaust 0.4 bar so that means this pressure is 0.4 bar the this is 0.4 bar They generate saturated steam 15 bar. The mercury condenser generates saturated steam at 15 bar which is expanded in steam. It is producing steam at 15 bar.

So that means this is 15 bar. At bar which expanded in a steam turbine. So this will be expanded in a steam turbine to 0.04 bar. 0.04 bar okay so it roughly you draw first okay but here you see that uh my drawing something okay bar is different this is 15 bar 15 bar should be upper right then 0.4 bar okay anyway just you roughly draw this one they determine overall efficiency of the cycle And if 4800 kg steam flows through the steam turbine, what is the flow through the mercury turbine?

So, Hg, mass of Hg you have to calculate. This is the mass of water is given. Assume that the process is reversible, isentropic processes. What is the useful work done in the binary cycle for specific steam flow rate? first one by one we try to solve.

the data is given actually because market table may not be available every time. they have given data pressure and pressure temperature given then fluid gas entropy of fluid entropy of gas. specific volume of fluid, specific volume of gas is given. For stream cycle, data is not given actually, but if I give you for your exam, then I will be giving you the data. For this problem, as it is, I have taken from book, so they have not given, but they are asking to take from the table.

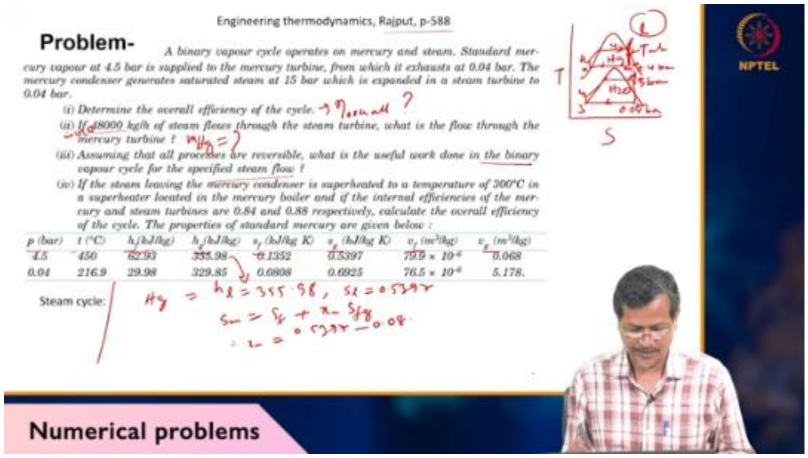
Rather, I will give in exam, in question paper itself, so that you can solve. So, for mercury cycle, For HG cycle HL is given HL 355.98 you can see HL. So the naming they have given like this L this one actually L then M this is K. L, M, K. This is N. L, M, N, K. And the other cycle 2, 3, 4 and 1.

This is 1. So, you can draw one clear diagram. So, H, G, H, L. H, L means like point here in TS diagram. 355 is given here. Next is SL. SL also given.

You can see 0.5397. Okay. So SM equals SF plus XMSFG. X means dryness fraction. How much fraction of liquid is there?

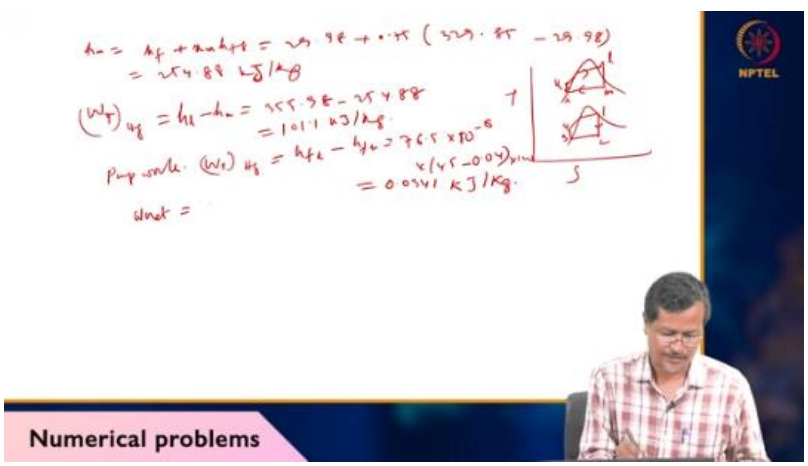
Okay. So from there Xm we get 0.5397 minus 0.0808. 0.6925 minus 0.0808. This is the formula.

From there, we can get 0.75. Now, Hm. Hf plus X8. xm h hfg equals 29.98 plus 0.75 329.85 minus 29.98 okay so this is giving hm value 254.88 kg per kg okay so work obtained from the mercury w t h g cycle h l minus h m you can remember this t s diagram okay so l m n k and this one was one two three



four hl minus hm so three five five point nine eight minus two five four point eight eight equals one zero one point one k j per kg okay so pump work w pump for hg h f k minus h f n K and N, you can see the pump work here. So, 76.5 into 10 power minus 5, 10 power minus 6 into 4.5 minus 0.04 into 100. So, this is giving value 0.0341 kg per kg. So, network.

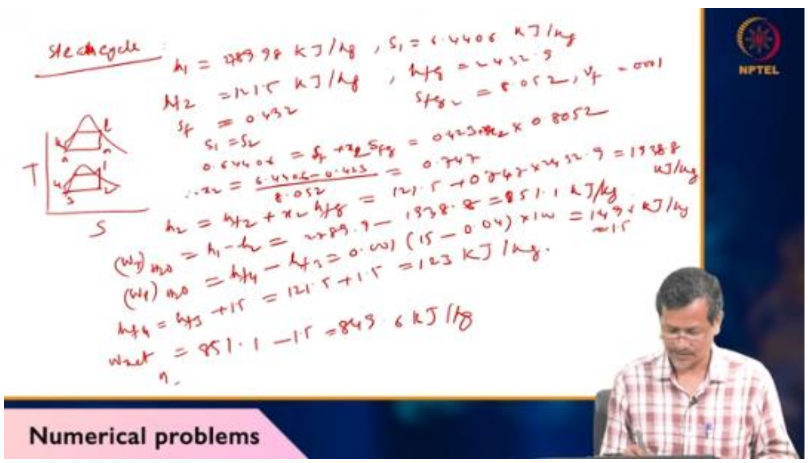
equals 101.1 minus 0.0341 because 101.1 kg per kg q l q 1 equals h l minus h f k how much heat is given into the system so 355.98 minus 29.98 326 kg per kg now eta mercury cycle W net by Q1 equals 101.1 divided by 326 is giving 31 percent. now steam cycle. just we have to copy from book for steam cycle. steam cycle.



For steam cycle, this data actually you have to collect from your table. In exam, I will give. H1 equals 282789.98 kg per kg. S1 equals 6.4406 kg per kg. h f 2 1 to 1.5 kg per kg h f g this value will be coming from a tabular chart okay two four three two point nine s f equals zero point four three two s f g two uh sfg 805 8.052

VF 0.001 S1 equals S2. Again TS diaram must be there in front of me otherwise it will be very difficult to understand. L M N K 1 2 3 4 so now 0.64406 equals sf plus x2 sfg equals 0.423 in plus x2 into 0.8052 therefore x2 equals 6.4406 8.052 minus 0.423 equals 0.747 so h2 equals hf2 minus x2 hfg equals 1 to 1.5 plus 0.747 into 2432.9 1938.8 kg per kg okay so work done work done steam so h1 minus h2 equals two seven eight nine point nine minus one nine three eight point eight equals eight five one point one kg per kg w pump h2o

pump work is coming hf4 minus hf3 equals 0.001 15 minus 0.04 into 100 equals 1496 kg per kg equals 1.5 about okay so hf4 HF3 plus 1.5 equals 1 to 1.5 plus 1.5 equals 1 to 3 KJ kg. W net 851.1 minus 1.5 849.6 KJ per kg. ETA steam. Eta H2O is better.



H2O cycle efficiency W net by Q equals 849.9, 849.6, 2666.6 equals 0.318 equals 31.8%. so next is overall efficiency. Eta overall. Eta overall means eta h2o plus eta hg plus eta h2o minus eta h2o eta hg. Already you have seen this formula.

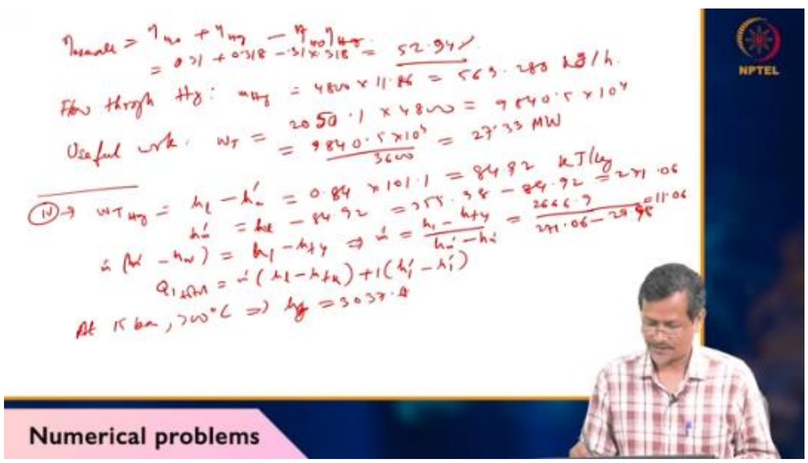
So this is giving 0.31 plus 0.318 minus 31 into 318 is equal to 52.94%. So this is your overall efficiency. Now flow through market turbine. Flow through HG turbine. Okay, mHg equals 4800 into 11.86 equals 569.280 kg per hour.

kg per hour, kilogram per hour. Useful work. So, useful work W total, W turbine total it is coming 2050.1 into 4800 equals 9840.5 into 10 power 4. So, this is giving 9840.1. 0.5 into 10 power 4 divided by 3600 per hour for hour we are doing this one.

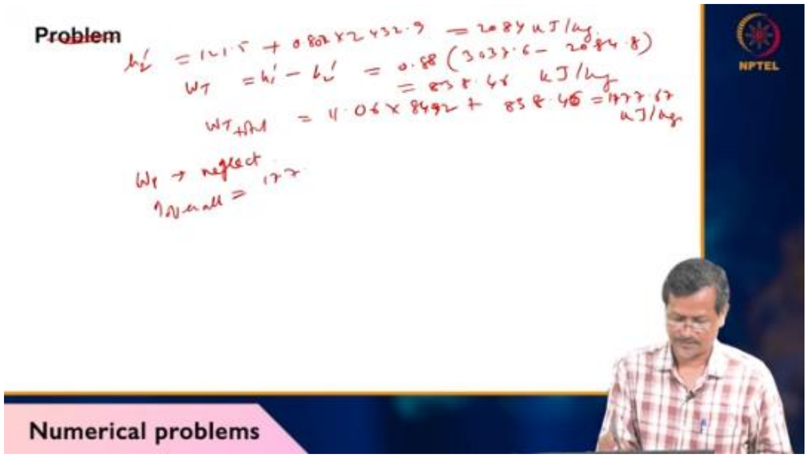
So, it is coming 27.33 megawatt. So, overall efficiency. Now, you see this fourth part of this problem. If the steam leaving mercury condenser superheated to a temperature 300 degree centigrade. in a superheated, superheater located in a mercury boiler and if the internal efficiency of the mercury and steam turbine are 0.84 and 0.88 respectively, calculate overall efficiency.

For the new condition, we have to calculate overall efficiency. So, for that we have to do like this. So, for fourth part of this problem, WT Hg equals HL minus HM dash 0.84 into 101.184.92 kg per kg. HM dash equals HL

minus 84.92 equals 355.98 minus 84.92 271.06 so m dash h m dash minus h n dash equals h 1 minus h f 4 h 1 minus h of 4 so this is giving m dash h 1 minus h f 4 h m dash minus h n dash 2 2 6 6 6.9 2 7 1.06 minus 2 9.98 because 1 1.06 so q 1 total m dash h l minus h f k plus 1 h 1 minus h 1 dash okay so at 15 bar 300 degrees centigrade h g equals 3037.6 kg per kg Sg 6.918 kg per kg so so this is giving 3853.26 x2 dash equals 6918 minus 0.423 divided by 8.052 equals 0.8 So, H2 dash equals 121.5 plus 0.807 into 2432.9 equals 2084 kg per kg.



W turbine equals H1 dash minus H2 dash equals 0.883037. So, 2 minutes, up to 2 minutes, 2, 3 line I have to write, nothing to, 303, 3037.6 minus 2084.8, so 838.46 kg per kg, so WT total, 11.06 into 84.92 plus 838.46 1777.67 kg per kg so WP neglect so eta overall 1777.67 divided by 3853.26 equals 46.13 percent okay okay thank you very much for today's lecture next day we'll start new topic thank you


Problem
h2' = 121.5 + 0.802 × 2432.9 = 2084 kJ/kg
WT = h1' − h2' = 0.88 (3033.6 − 2084.8)
= 838.48 kJ/kg
WT+HM = 4.06 × 8492 + 838.48 = 1777.67 kJ/kg
Wp → neglect
ηoverall = 177
NPTEL
Numerical problems