MARINE ENGINEERING

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Lecture52

Numerical Problems

Now, we will try to solve some problem. these problems are basically from gate papers. Let us see the problem. In a simple Brayton cycle, the pressure ratio is given 8. Rp is given 8 Brayton cycle or gas training cycle and temperature at the entrance of compressor.

T1 is given 300, 1400 temperature at the entrance and, okay, this is T1 and so that means I have to draw my T-S diagram, T-S 1, 2, 3, 4. T1 is given and T3 also given 1400 K. Both compression and gas turbine have isentropic efficiency eta is in 0.8, eta is in for both turbine compressor both the for the gas assume constant volume constant value of CP so CP value 1 kg per kg given specific heat ratio is given 1.4 neglect changes for kinetic potential energy calculate power required and calculate thermal efficiency it a thermal and WC theta thermal maybe I will put TH.

Now, I have to calculate these two parameters. Now, Rp is given 8 that means P2 by P1 is given and gamma also given 1.4. process 1 to 2, 1 to 2 process. So, what is happening? Actual compression happening, 1 to 2 isentropic compression.

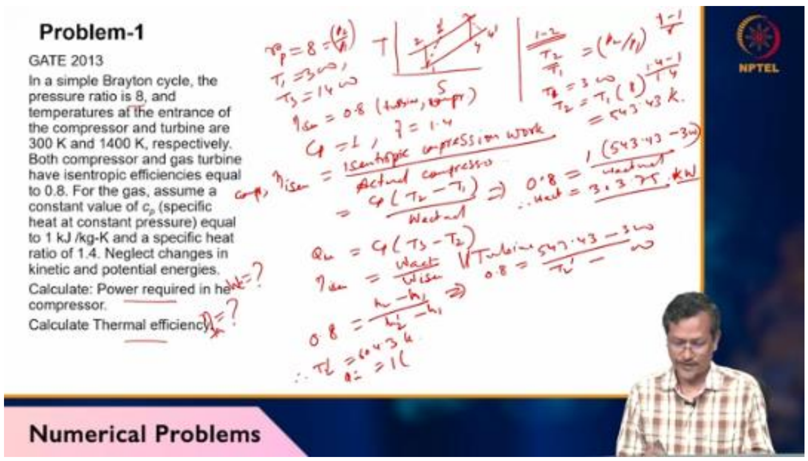
2 dash 4 dash. 1 to 2 actual process, 1 to 2 irreversible process or energy will be lost. for reversible adiabatic compression process T2 by T1, T2 by T1 equals T2 by P1 gamma minus 1 by gamma. T2 equals 300 T1 equals 300.

T2 equals T1 into 8 divided by 1.4 minus 1, 1.4. this value is coming 543.43 K. Now, eta isentropic efficiency, eta isentropic. isentropic compression work, isentropic compression for compressor. for compressor, compression divide by actual compression. So, Cp T2 minus T1 W actual.

Now, this gives like eta isentropic given 0.8 and Cp given in the problem is 1 and T2 value we just calculated 543.43 and T1 value we know 300, W actual. therefore, W actual equals

303.75. This is the answer we are asking, unit kilowatt. Now, to calculate efficiency first Q in equals Cp T3 minus T2 bracket eta isentropic W actual by W isentropic turbine so H 2 minus H 1 H 2 dash minus H 1 okay so 0.8 the value is given so this will be giving 0.8 equals five four three point four three minus 300 divided by T 2 dash minus 300

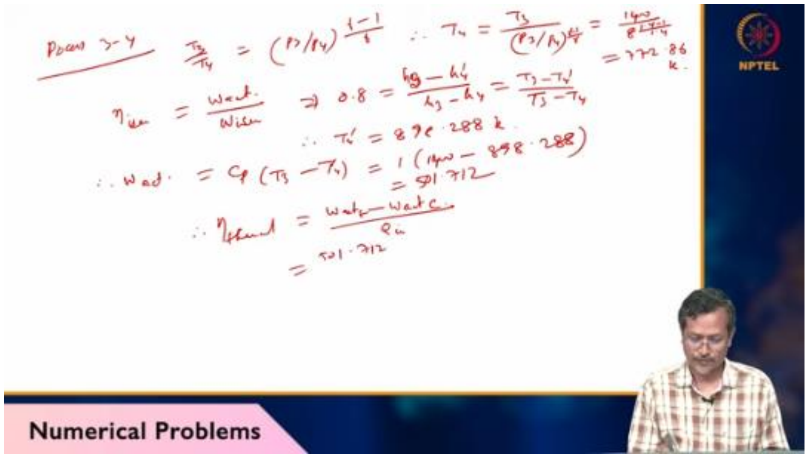
Therefore, T2 equals 604.3 k. So, we got the T2 value. We got T2 dash value. Q in equals 1 and T3 you can we are calculating here T3 value we know 1400 given and T2 value we just calculated 604.3. So, this is giving 795.7 kg per kg and



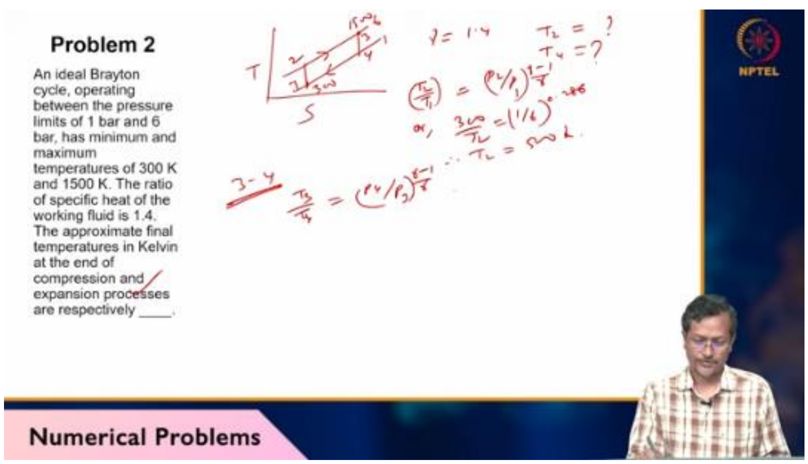
Process 3 to 4, T3 by T4 equals P3 by P4 gamma minus 1 by gamma. Therefore, T4 equals T3 by P3 by P4 gamma minus 1 by gamma equals 1400. divided by 8, 1.4, minus 1, 1.4. this value is coming 772.86 k. Now, eta isentropic, eta isentropic equals W actual by W isentropic. implies 0.8 h h3 minus h4 dash h3 minus h4 equals t3 minus t4 dash t3 minus t4 so therefore t4 dash equals 898.288 k so

Now, W actual equals CpT3 minus T4 equals 1400 minus 898.288. So, this is giving 501.712. What is eta isen, eta thermal equals W actual minus W actual turbine by W actual compressor divided by Q in. this is giving 501.712 minus 304.3 divided by 795.7 into 100.

So, this is giving 24.8 percent. So, this is your answer. Another problem is an ideal Brayden cycle operating between two pressure limits 1 bar and 6 bar. That means TS diagram showing this is 1, this is 6, within that pressure limit is working. Temperature also given, minimum temperature means here minimum temperature will be there 300, maximum will be 1500.



The ratio of specific heat, gamma is giving 1.4. it will be like this the approximate final temperature in kelvin at the end of compression expansion process respectively so t 1 2 3 4 so t 2 t compression expansion process so t 4 we have to find so work is very simple actually here cp by cv given so adiabatic condition if i apply t 2 by t 1 equals P 2 by P 1 gamma minus 1 by gamma equals imply imply or 300 divided by T 2 1 by 6 0.286 so this will be giving T 2 equals 500 K Now, again for the process 3-4, 3-4 process if we consider then T3 by T4 very simple problem this one equals P4 by P3 gamma minus 1 by gamma. from there you are getting T4 equals 900 k, this is your answer.



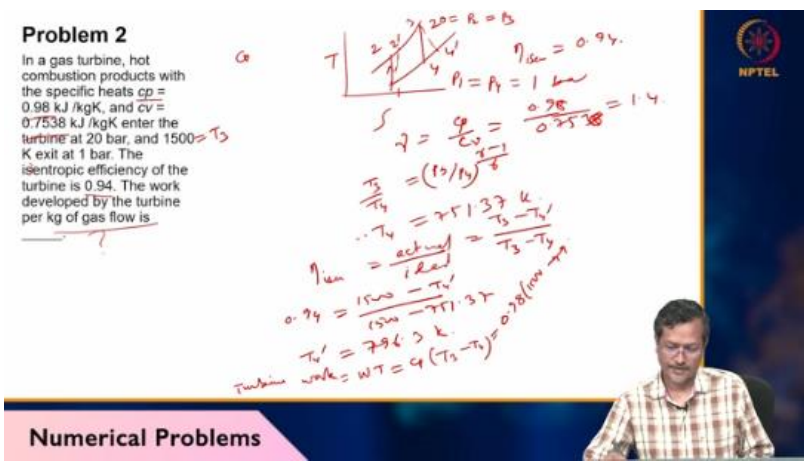
again similar problem in a gas turbine cycle hot combustion product with the specific case Cp is given 98 Cp also given. Cp by Cp can calculate from here and enters turbine 20 bar and 1500 k exits at 1 bar the isentropic efficiency given work developed by the turbine per kg of gas flow is. you have to calculate work per kg of gas. first you draw TS diagram with two pressure line 1 to 2, 3 to 4. 1, 2 dash, 3, 4 dash.

This is given 20 bar, this is given 1 bar, lower one 1 bar. Cp is given 0.98, H isentropic is given 0.94, eta isentropic 0.94 Cv, Cp given, T3 also givenT3 equals 1500, this is T3, P2, this is P2 equals P3, P1 equals P4 equals 1 bar and gamma you can calculate Cp by Cv equals 0.98 by 0.7538 these values are given.

it is coming 1.3. Now, applying general equation for the reversible adiabatic process in 3 and 4. T3 by T4 equals P3 by P4 gamma minus 1 by gamma. this value will be giving T4 equals 751.37 you see the previous calculations so same way you can calculate eta isentropic actual output divided by ideal so T3 minus T4 dash T3 minus T4 so this will be giving 0.94 equals 1500 minus T4 dash

1500 minus 751.37 so this will be giving t4 dash equals 796.3 k so turbine walk wt equals cp t3 minus t4 equals We can write 0.98. The value is given already. T3 1500 given 796.3. It is 793.796.3.

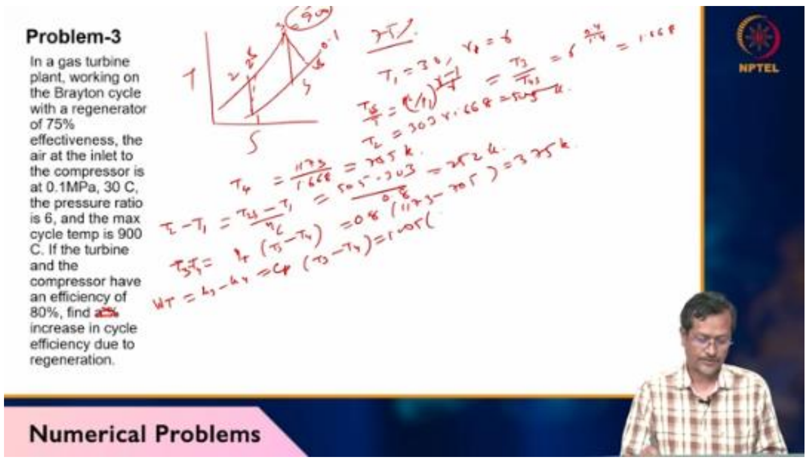
this is giving 698.64 kg per kg. This is your answer. you see another problem in a gas domain plant working on a Brayton cycle with regenerator. TS diagram we draw TS 1, 2, 3, 4 Brayton cycle with regenerators efficiency 75 percent 75% regenerative efficiency is there, effectiveness is there, air inlets, air inlet 0.1 MPa, 0.1 MPa, 30 degree centigrade, so T1 equals 30 degree centigrade, pressure ratio 6, maximum cycle temperature is given is equals to 900 T3.



If the turbine and compressor have efficiency 80%, both are having efficiency 80%, find increase in cycle efficiency due to regeneration. again T2 dash sorry T4 dash. Now, T2 minus by T1 equals P2 by P1 gamma minus 1 by gamma equals T3 by T4, 4s or 4 equals 60.4 by 1.4, 1.668.

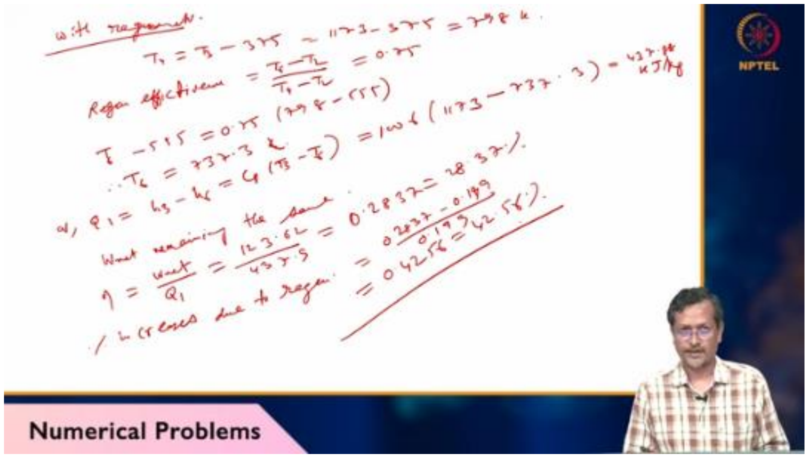
T2 equals 303 into 1.668, 505. T4 equals 1173 by 1.668 equals 705K. T2 minus T1, T2. better I will write this is 2SS. T4SS.

T2 minus T1 T2s minus T1 eta c equals 505 minus 303 divided 0.8 equals 252.k. So, Wt equals first T3 minus T4 eta t t3 minus t4 equals 0.8 1173 minus 705 375 k now t wt equals h3 minus h4 equals cp t3 minus t4 is 1.005 this cp value t 3 minus t4 375 equals 376.88 kj per kg so wc equals cp t2 minus t1 1.005 into 252 253.26 kj per kg okay so t2 equals 252 plus 303 five five five k q1 equals h3 minus h2 equals cp t3 minus t2 so this value is giving six to one point zero nine kg per kg so eta equals w



p minus w c divided by q 1 3 7 3.88 minus 2 5 3.26 6 to 1.09 equals 19.9 percent with regenerator now we have added regenerator T4 equals T3 minus 375 equals 1173 minus 375 798 okay regenerative effectiveness effectiveness because T6 minus T2 divided by T4 minus T2 equals 0.75 so T6 minus 5 5 5 because 0.75 7 9 8 minus 5 5 5 therefore T6 equals 7 3 7 point 3 K or Q 1 equals H 3 minus H 6 equals CP T 3 minus T 6 1 point 0 0 6 1 1 7 3 minus 7 3 7 1 3 plus 4 3 7 point 8 8 kg per kg now the blue net remaining the same so eta equals w net q1 equals one two three point six two four three seven point nine equals one zero point two eight three seven equals twenty eight point three seven percent increase

due to regeneration equals 0.2837 minus 0.199 0.199 equals 0.4256 42.56 percent. this is your answer. thank you very much for today's lecture. Next day, we will start new topic, we will discuss turbine thing. Thank you very much.


NPTEL
with regeneration.
T4 = T3 − 375 = 1173 − 375 = 798 K.
Regen effectiveness = (T6 − T2)/(T4 − T2) = 0.75
T6 − 555 = 0.75 (798 − 555)
∴ T6 = 737.3 K
∴ Q1 = h3 − h6 = cp (T3 − T6) = 1005 (1173 − 737.3) = 437.88 kJ/kg
Wnet remaining the same.
η = Wnet/Q1 = 123.62/437.5 = 0.2832 = 28.32%
% increases due to regen. = (0.2832 − 0.199)/0.199 = 0.4256 = 42.56%
Numerical Problems