Ref. No. Ex/PE/T/221/2019

B.E. POWER ENGINEERING SECOND YEAR SECOND SEMESTER SUPPLEMENTARY EXAM – 2019

SUBJECT: Engineering Thermodynamics-II

Time: Three Hours **Full Marks 100**

Different question of the same Part should be answered at one Place.
Use of steam Table, Refrigerant *R134a* and enthalpy table are allowed.
Psychrometric chart will be supplied, if required

Part - A

1. a) Considering the 1st Tds equation and 2nd Tds equation show that $\therefore (c_p - c_v) = \frac{Tv\beta^2}{K_T}$ where β = volume expansivity and K_T =isothermal compressibility 10

b) What is Joule Thomson Coefficient? Write the expression for Joule Thomson coefficient and determine its value for ideal gas. 6

OR

a) State what is the importance of thermodynamic property relation? 4

b) Derive 1st and 2nd T-ds equations. 4

c) Derive the expression of change of enthalpy of a thermodynamic system during a process. From it show that for an ideal gas $dh = Cp.dT$ 8

Part - B

Answer any two

2 a) Compare air standard efficiency of Otto, Diesel and dual cycle for same compression ratio and same maximum pressure and temperature with p-v and T-s diagrams. 4

b) Show an air standard Otto cycle on p-v and T-s diagram clearly stating the processes. Derive its thermal efficiency in terms of compression ratio. 8

c) A Diesel engine has compression ratio of 16 and cut-off takes place at 6 % of the stroke. Find air standard efficiency of the cycle. 6

3 i) A gas-turbine power plant operating on a Brayton cycle has a pressure ratio of 7. The gas enters the compressor at 0.1 MPa, 27°C. Maximum cycle temperature is 927°C. Assuming a compressor and turbine efficiency of 90% each, determine (a) the back work ratio, (b) the turbine exit temperature and (c) cycle efficiency. Show the actual cycle on p-v and T-s diagram 10+2+2

ii) Determine the % increase in efficiency if a regenerator of 95% effectiveness is introduced in the above system. 4

4. A steam power plant operates on Reheat Rankine cycle where water enters the boiler at 15 MPa and reheater at 2 MPa. Temperature at HP and LP turbine entry point is 450°C. The condenser pressure is 100 kPa. Water flow rate through the system is 1.74 kg/s. Determine the power used by the pump, the power produced by the cycle, the rate of heat transfer in the reheater and the thermal efficiency of the system. 18

5 A steam power plant operates on an ideal regenerative Rankine cycle. Steam enters the turbine at 6 MPa and 450°C and is condensed in the condenser at 20 kPa. Steam is extracted from the turbine at 0.4 MPa to heat the feed water in an open feed water heater. Water leaves the feed water heater as a saturated liquid. Show the cycle on a *T-s* diagram, and determine (*a*) the network output per kilogram of steam flowing through the boiler and (*b*) the thermal efficiency of the cycle. 18

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Part - C

Answer any two

6 (a) Define Relative Humidity and Humidity Ratio. Obtain the expression which relates these two parameters. 4

(b) Water at 40°C enters a cooling tower at a rate of 200 kg/s. The water is cooled to 25°C in the cooling tower by the air which enters the tower at 1 atm, 20°C, 60% relative humidity and leaves saturated at 30°C. Neglecting the power input to the fan, determine (a) the volume flow rate of dry air entering the cooling tower, and (b) the required mass flow rate of the makeup water. 12

7. a) An ideal gas refrigeration cycle using air as the working fluid is to maintain a refrigerated space at $-3°C$ while rejecting heat to the surrounding medium at 30°C. If the pressure ratio of the compressor is 3, determine (*a*) the maximum and minimum temperatures in the cycle, (*b*) the coefficient of performance, and (*c*) the rate of refrigeration for a mass flow rate of 0.2 kg/s. Treat air as ideal gas. 8

b) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.1 and 0.7 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. Show the cycle on a *T-s* diagram with respect to saturation lines. Determine (*a*) the rate of heat removal from the refrigerated space and the power input to the compressor, (*b*) the rate of heat rejection to the environment, and (*c*) the coefficient of performance. 8

8.a) Define one tonne of refrigeration and determine its value in KW. 4

b) Why R-134a is better choice than R-12 or R12 when used as refrigerant? 4

c) Atmospheric air enters the insulated flow duct of an air conditioner at 35°C, 100 kPa, and $\Phi = 75\%$, and it exits the duct at 10°C, 100 kPa and $\Phi = 100\%$. The condensate comes out of the duct at 10°C. Find the amount of condensate removed form the air? Also calculate the amount of heat to be removed per kg dry air flowing through the device. 8

Part - D

9 a) Octane (C_3H_8) is burnt with dry air. The volumetric analysis of product on a dry basis is CO_2-10.02%; O_2-5.62%; CO-0.88%; N_2-83.48%. Determine,(a) the air-fuel ratio, (b) the percentage of theoretical air used and (c) the amount of H_2O that condensed at the product is cooled to 25°C at 100 KPa 13

b) What is adiabatic flame temperature? When its value will be maximum? 2+1

OR 16

Ethane (C_2H_6) gas enters a steady-flow combustion chamber at 25°C and 1 atm and is burned with 50 percent excess air, which also enters at 25°C and 1 atm. After combustion, the products exit at 1000 K. Assuming complete combustion, determine the heat transfer per kmol of Ethane.