BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
Second Semester (2023-2024)
APPLIED THERMODYNAMICS (ME F217)
Comprehensive Examination – Regular - (Open Book)

Saturday, December 09, 2023

Max Marks = 70 **Maximum Duration 3 hrs**

Instructions

- ***Calculators and Other Utensils:***
  Please use your own calculators and other necessary utensils. Exchange of calculators and other utensils during the exam is not allowed.
- ***Thermodynamics Table Book:***
  Carry your own Thermodynamics Table Book. Sharing of table books during the exam is strictly prohibited.
- ***Textbooks and Handwritten Notes:***
  Only the designated textbook (original hardcopy or printed or photocopy) and handwritten class notes are allowed. Additionally, you are not allowed to bring and use in any other textbooks, printed slides, printed PowerPoint presentations, or printed or photocopied answer manuals.
- ***Answer Sheets:***
  Start each answer from a fresh page in your answer booklet (Mandatory).

1. (a) What is the lowest temperature that air can attain in an evaporative cooler if it enters at 1 atm, 302 K and 40 percent relative humidity? Show the process in psychrometry chart.

   (b) Air at10°C dry bulb temperature and 90% relative humidity is to be heated and humidified to 35°C dry bulb temperature and 22.5°C wet bulb temperature. The air is pre-heated sensibly before passing to the air washer in which water is recirculated. The relative humidity of the air coming out of the air washer is 90%. This air is again reheated sensibly to obtain the final desire condition. Find by using psychrometry chart: (i) the temperature to which the air should be preheated, (ii) the total heating required, (iii) the makeup water required in the air washer, and (iv) the humidifying efficiency of the air washer. **[5+15 = 20]**

2. An ice plant using NH_3 as refrigerant works between -15°C and 35°C and produces 10 tons of ice per day from water supplied at 0°C. The ice temperature is -5°C. Assuming simple saturated cycle and using the following properties of NH_3, determine:

   (i) The capacity of the refrigeration system required.

   (ii) The discharge temperature

   (iii) The diameter and stroke of the compressor cylinder if its speed is limited to 1250 r.p.m. Take L/D as 1.2 and volumetric efficiency of the compressor as 0.75.

   (iv) The power of the motor required to run the compressor if the isentropic efficiency is 85% and mechanical efficiency of 95%.

   (v) The theoretical and actual C.O.P. **[15]**

Use the below properties of NH_3 and take compressor entry is <u>point 1</u> and evaporator entry is <u>point 4</u>.

Temperature (°C)	Pressure (bar)	Specific enthalpy (kJ/kg)		Specific entropy (kJ/kg –K)		Specific Volume (m^3/kg)
		h_f	h_g	s_f	s_g	v_g
35	13.5	1167.1	1.124	1.282	4.930	0.096
-15	2.36	1280.8	0.630	0.457	5.549	0.509

3. An air-standard dual cycle has a compression ratio of 16 and a cut-off ratio of 1.15. At the beginning of compression P_1 = 95 kPa and T_1 = 300 K. The pressure increases by a factor of 2.2 during the constant volume heat addition process. If the mass of air is 0.04 kg, draw p-v plot and determine **by using the Annex-I ideal gas table only:**

   (a) The heat addition at constant volume and at constant pressure, each in kJ.

   (b) The network of the cycle, in kJ

   (c) The heat rejection, in kJ

   (d) The thermal efficiency. **[10]**

4. Consider an ideal gas-turbine cycle with two stages of compression (during 1st stage of compression the working fluid entre the compressor at point 1) and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 4. The air enters each stage of the compressor at 390 K and each stage of the turbine at 1320 K. Draw T-s diagram and determine the back work ratio and the thermal efficiency of the cycle, assuming (a) no regenerator is used and (b) a regenerator with 75 percent effectiveness is used. Use variable specific heats by using **text book ideal gas data table.**

   [15]

5. An engine working on Otto cycle is supplied with air at P_1 = 0.1 MPa, T_1 = 35°C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency, and the mean effective pressure. Assume constant specific heat and for air: γ = 1.4. **[5]**

6. Calculate the cycle efficiency and steam consumption in kg/kW-hr for Carnot cycle and Rankine cycle using steam between pressures of 30 bar and 0.04 bar. The steam is dry saturated at 30 bar. Take turbine entry is at point 1. Also, determine the pump work in each case and finally comment on the results. **[5]**

****