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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.TECH ASE, ASE+AVE **Semester – III**
Subject (Course): Thermodynamics and Heat Engines **Max. Marks : 100**
Course Code :GNEG 241 **Duration : 3 Hrs**
No. of page/s:02
Note: Steam tables need to be provided

Section A: Answer all the question given below (4 x 5 = 20 Marks)

1. What is the difference between a closed system and an open system? Explain about change of state, path and process.
2. Explain about first law of thermodynamics using real life examples. Explain the first law for a closed system undergoes a change of state.
3. What is a Carnot cycle? Explain the process involved in Carnot cycle using P-V and T-S Diagram.
4. Explain about isentropic process, why isentropic expansion and compression process are most efficient, express the work done relations for isothermal, isobaric, polytropic process?

Section B: Answer the following Questions given below (4×10=40 Marks)

5. (a).The specific heats of a gas are given by $c_p = a + kT$ and $c_v = b + kT$, where a,b and k are constants and T is in K. Show that for an isentropic expansion of this gas

$T^b v^{a-b} e^{kt} = constant$

(b). 1.5 kg of this gas occupying a volume of 0.06 m^3at 5.6 MPa expands isentropically until the temperature is 240^0C. If a=0.946, b=0.662, and k=10^{-4}, calculate the work done in the expansion.

6. A mass of 1000 kg of fish initially at 1 bar, 300 K is to be cooled -20^0C. The freezing point of fish is -2.2^0C, and the specific heats of fish below and above the freezing point are 1.7 and 3.2 kJ/kg K respectively. The latent heat of fusion for the fish can be taken as 235 kJ/kg. Calculate the exergy produced in the chilling process. Take T_0=300 K and p_0=1 bar.

7. A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (a) Find the velocity at the exit from the nozzle. (b) if the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3/kg, find the mass flow rate?

8. Ten grams of water at 20^0C is converted into ice at -10^0 C at constant atmospheric pressure. Assuming the specific heat of liquid water to remain constant at 4.2 J/gK and that of ice to be half of this value, and taking the latent heat of fusion of ice at 0^0 C to be 335 J/g, calculate the total entropy change of the system?

Section C: Answer All the following Questions given below (2×20=40 Marks)

9. (a). An ice making plant produces ice at atmospheric pressure and at 0^0C from water. The mean temperature of the cooling water circulating through the condenser of the refrigerating machine is 18^0C. Evaluate the minimum electrical work in kWh required to produce 1 ton of ice. (The enthalpy of fusion of ice at atmospheric pressure is 333.5 kJ/kg) (10 Marks)

   (b) Derive Gibbs Function of a mixture of a inert ideal gases, explain about internal energy, enthalpy and specific heats of gaseous mixtures? (10 Marks)

10. (a). Explain about operation of IC Engines and State the four process of Diesel Cycle. Discuss about two stroke and four stroke engines. (5 Marks)

    (b). An ideal Diesel cycle with air as the working fluid has a compression ratio of 18 and a cutoff ratio of 2. At the beginning of the compression process, the working fluid is at 14.7 psia, 80°F, and 117 in^3. Utilizing the cold-air standard assumptions, determine (*a*) the temperature and pressure of air at the end of each process, (*b*) the net work output and the thermal efficiency, and (*c*) the mean effective pressure. (15 Marks)

(OR)

11. (a). What are the four basic components of the steam power plant? What do you understand by steam rate and heat rate? Why Carnot cycle is not practical for a steam power plant? (5 Marks)

(b). Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 10 kPa. Determine (a) the thermal efficiency of this power plant, (b) the thermal efficiency if steam is superheated to 600°C instead of 350°C, and (c) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 600°C. (15 Marks)

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Section A: Answer all the question given below (4 x 5 = 20 Marks)

1. Explain about Intensive and Extensive Properties, what do you mean by equilibrium, explain about mechanical, thermal and chemical equilibrium process.
2. Explain zeroth law of thermodynamics; explain the difference between universal gas constant and characteristic gas constant?
3. What do you understand by path function and point function, what are exact and inexact differentials, explain in the context of work and heat?
4. Define enthalpy. Why the enthalpy of an ideal gas depends only on temperature?

Section B: Answer All the following Questions given below (4×10=40 Marks)

5. A mass of 0.25 kg of an ideal gas has a pressure of 300 kPa, a temperature of 80^0 C and a volume of 0.07 m^3. The gas undergoes an irreversible adiabatic process to a final pressure of 300 kPa and final volume of 0.10 m^3during which the work done on the gas is 25 kJ. Evaluate the c_p and c_v of the gas and the increase in entropy of the gas?
6. Calculate the decrease in available energy when 25 kg of water at 95^0C mix with 35 kg of water at 35^0C, the pressure being taken as constant and the temperature of the surrounding being 15^0C (c_p of water =4.2 kJ/kg K).
7. Steam at 5 MPa and 400°C enters a nozzle steadily with a velocity of 80 m/s, and it leaves at 2 MPa and 300°C. The inlet area of the nozzle is 50 cm^2, and heat is being lost at a rate of 120 kJ/s. Determine (*a*) the mass flow rate of the steam, (*b*) the exit velocity of the steam, and (*c*) the exit area of the nozzle.

8. Calculate the entropy change of the universe as a result of the following process

(i). A copper block of 600 g mass and with C_p of 150 J/K at $100^0$is placed in a lake at 8^0C.

(ii). The same block, at 8^0C is dropped from a height of 100 m into the lake

(iii). Two such blocks, at 100 and 0^0C, are joined together.

Section C: Answer the following Questions given below (2×20=40 Marks)

9. (a). A house hold refrigerator is maintained at a temperature of 2 ^{0}C. Every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only a small change in the temperature of the refrigerator. The door is opened 20 times a day, and the refrigerator operates at 15 % of the ideal COP. The cost of work is Rs. 2.50 per Kwh. What is the monthly bill for this refrigerator? (10 Marks)

(b). Derive Steady Flow Energy Equation using Control Volume approach and express the application of SFEE to various Devices? (10 Marks)

10. (a). Explain about Vapor power cycle using a schematic diagram, T-S Diagram and express the net work output and efficiency? (5 Marks)

(b). A cyclic steam power plant is to be designated for a steam temperature at turbine inlet of 380^0 C and an exhaust pressure of 0.12 bars. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 18 %. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition (15 Marks)

(OR)

11. (a). How do the inefficiencies of the turbine and the compressor affect (*i*) the back work ratio and (*ii*) the thermal efficiency of a gas-turbine engine? What is the back work ratio? What are typical back work ratio values for gas-turbine engines (5 Marks)

(b). A simple Brayton cycle using air as the working fluid has a pressure ratio of 8. The minimum and maximum temperatures in the cycle are 310 and 1160 K. Assuming an isentropic efficiency of 75 percent for the compressor and 82 percent for the turbine, determine (*a*) the air temperature at the turbine exit, (*b*) the net work output, and (*c*) the thermal efficiency. (15 Marks)