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T 3364

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2008.

Sixth Semester

Mechatronics Engineering

MH 1002 — THERMODYNAMICS AND HEAT TRANSFER

(Regulation 2004)

Time : Three hours | Maximum : 100 marks

(Use of approved steam and refrigeration tables and charts and heat and mass transfer data book is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the first law for a closed system undergoing a cycle.

2. Define irreversibility.

3. Give any two advantages of multistage air compressor.

4. What is an air standard cycle?

5. What are the four basic components of a steam power plant?

6. Define refrigerating effect.

7. Differentiate between conduction and convection.

8. State Fourier law of conduction.

9. What is the physical significance of Reynolds number?

10. What is the Stefan - Boltzmann law?

PART B — (5 × 16 = 80 marks)

11. (a) (i) A quantity of a substance in a closed system is made to undergo a reversible process, starting from an initial volume of 1 m^3 and an initial pressure of 10^5 Pa. The final volume is 2 m^3. Compare the work done by the substance, (1) the pressure times volume remains constant (2) the pressure is inversely proportional to the square of the volume. (8)

(ii) During one cycle the working fluid in an engine engages in two work interactions : 15 kJ to the fluid and 44 kJ from the fluid and three heat interactions : two of which are known 75 kJ to the fluid and 40 kJ from the fluid. Evaluate the magnitude and direction of the third heat transfer. (8)

Or

(b) (i) A nozzle is a device for increasing the velocity of a steadily flowing fluid. At the inlet to a certain nozzle the specific enthalpy of the fluid is 3025 kJ/kg and the velocity is 60 m/s. At the exit from the nozzle the specific enthalpy is 2790 kJ/kg. The nozzle is horizontal and there is a negligible heat loss from it. Calculate : the velocity of the fluid at exit ; the rate of flow of fluid when the inlet area is 0.1 m^2 and the specific volume at inlet is 0.19 m^3/kg and the exit area of the nozzle when the specific volume at the nozzle exit is 0.5 m^3/kg. (8)

(ii) Air enters a gas turbine system with a velocity of 105 m/s and has a specific volume of 0.8 m^3/kg. The inlet area of the gas turbine system is 0.05 m^2. At exit the air has a velocity of 135 m/s and has a specific volume of 1.5 m^3/kg. In its passage through the turbine system, the specific enthalpy of the air is reduced by 145 kJ/kg and the air also has a heat transfer loss of 27 kJ/kg. Determine (1) the mass flow rate of the air through the turbine system in kg/s (2) the exit area of the turbine system in m^2 and (3) the power developed by the turbine system in kW. (8)

12. (a) (i) A single stage reciprocating air compressor takes in air at 1 bar and 15°C. The conditions at the end of suction are 0.97 and 30°C. The discharge pressure is 6 bar. The clearance is 5% of the stroke. The compression and expansion follows $pv^{1.3}$ = Constant. Find the volumetric efficiency of the compressor. (8)

(ii) To increase air standard efficiency of an Otto cycle, the compression ratio is increased by 40% and it has been found that the increase in thermal efficiency of the cycle is 14%. Find out the initial compression ratio and thermal efficiency. (8)

Or

(b) (i) Show that the efficiency of the Otto cycle depends only on the compression ratio. (6)

(ii) A compression ignition engine has a stroke 27 cm, and cylinder diameter of 16.5 cm. The clearance volume is 434 cm^3 and the fuel injection takes place at constant pressure for 4.5 % of the stroke. Find the efficiency of the engine assuming it works on the diesel cycle. (10)

13. (a) (i) With a neat sketch explain the working of Babcock Wilcox boilers. (8)

(ii) Briefly discuss about the properties of the refrigerants. (8)

Or

(b) (i) With a T-s diagram, explain the principles of vapor compression cycle. (8)

(ii) Distinguish between fire tube boiler and water tube boiler. (8)

14. (a) A plane wall 10 cm thick generates heat at the rate of 30 kW/m^3, when an electric current is passed through it. One face of the wall is insulated and the other face is exposed to 25°C air. If the convective heat transfer coefficient between the air and the exposed surface of the wall is 50 W/m^2 K, determine the maximum temperature in the wall. The thermal conductivity of the wall material is 3 W/m K.

Or

(b) A steam pipe is covered with two layers of insulation, the first layer being 3 cm thick and the second 5 cm. The pipe is made of steel (k = 58 W/m K) having an ID of 160 mm and OD of 170 mm. The inside and outside film coefficients are 30 and 5.8 W/m^2 K respectively. Calculate the heat loss per metre of pipe, if the steam temperature is 300°C and the air temperature is 50°C. The thermal conductivity of the two insulating materials is 0.17 and 0.093 W/m K respectively.

15. (a) (i) A domestic hot water tank 0.5 m diameter and 1 m high is radiating to the surroundings. The surface emissivity and temperature are 0.8 and 80°C, and the ambient temperature is 2°C. Compute the heat lost by radiation from the tank. What is the reduction in heat loss, if the tank is coated with aluminium paint of emissivity 0.3? (8)

(ii) A cylinder of 25 mm diameter is initially at 150° C and is quenched by immersion in an 80°C oil bath, which moves at a velocity of 2 m/s in cross flow over the cylinder. What is the initial rate of heat loss per unit length of the cylinder? (8)

Or

(b) (i) Assume that a person can be approximated as a cylinder of 0.3 m diameter and 1.8 m height with a surface temperature of 25°C. Calculate the body heat loss while this person is subjected to a 15 m/s wind, whose temperature is –5°C. (8)

(ii) Two large parallel planes of emissivity 0.8 and 0.6 are maintained at temperature of 560°C and 300°C respectively. Compute the radiant heat exchange per square metre between them. (8)
