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J 3325

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

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. Distinguish between open and closed system.

2. State Clausius statement of second law.

3. List any two advantages of multi stage air compressor.

4. List down the assumptions made in the ideal air standard analysis.

5. Represent a typical Rankine cycle using p-V and T-s diagrams.

6. Differentiate refrigeration from heat pump.

7. State the Fourier law of heat conduction.

8. Define thermal diffusivity.

9. What are the values of critical Reynolds numbers for (a) flow over a flat plate (b) flow over a circular tube?

10. What is the physical significance of Grashof number with reference to heat transfer by natural convection?

PART B — (5 × 16 = 80 marks)

11. (a) (i) A certain quantity of air has an initial pressure of 140 kN/m^2 and volume 0.14 m^3. It is then compressed to a pressure of 700 kN/m^2, while the temperature remains constant. Determine the final volume of the air and workdone during the process.

(ii) A steady flow of steam enters a condenser with a specific enthalpy of 2300 kJ/kg and a velocity of 350 m/s. The condensate leaves the condenser with a specific enthalpy of 160 kJ/kg and a velocity of 70 m/s. Calculate the heat transfer to the cooling fluid per kg of steam condensed.

Or

(b) (i) An inventor claims to have developed a new device which receives heat from boiling water at 100° C and rejects it at 20° C. He claims the device would achieve an efficiency of 25%. How do you rate his claim? What is the maximum efficiency you would think as realistic?

(ii) A heat engine operates between a source temperature of 700° C and a sink temperature of 25° C. Determine the least rate of heat rejection per kW output of the engine.

12. (a) A single stage air compressor is required to compress 1 kg of air from 1 bar to 4 bar. The initial temperature is 27° C. Compare the work requirement in the following cases :

(i) isothermal compression

(ii) compression with $pV^{1.2}$ = constant and

(iii) isentropic compression.

Or

(b) (i) Explain the working principle of a four stroke diesel engine with a sketch.

(ii) The initial pressure and temperature of an Otto cycle are 1 bar and 26° C. The compression ratio is 8. If the maximum temperature of the cycle is limited to 1080° C, determine (1) thermal efficiency of the cycle and (2) work developed per kg of air.

13. (a) (i) Sketch the diagram of a Babcock Wilcox boiler and explain the function of its main components.

(ii) 30 tonnes of ice from and at 0° C is produced in 24 hours by an ammonia refrigerator. The temperature range in the compressor is 298 K to 258 K. The vapour is dry saturated at the end of compression. Assume a COP of 60% of the theoretical and calculate the power in kW required to drive the compressor. Latent heat of ice is 334.72 kJ/kg.

Or

(b) (i) With the help of a diagram, discuss the working of a vapour compression refrigeration cycle.

(ii) Consider a 300 MW steam power plant which operates on a simple ideal Rankine cycle. Steam enters the turbine at 10 MPa and 500° C and is cooled in the condenser at a pressure of 10 kPa. Show the cycle on a T-s diagram with respect to saturation lines and determine (1) the quality of the steam at the turbine exit (2) the thermal efficiency of the cycle and (3) the mass flow rate of the steam.

14. (a) (i) Prove that the thermal resistance offered by a hollow long cylinder of constant thermal conductivity is given by, $R = \ln(r_1/r_2)/2\pi L k$.

(ii) The wall of a building consists of 10 cm of brick (k = 0.69 W/ m °C), 1.25 cm of Celotex (k = 0.048W/m°C), 8 cm of glass wool (k = 0.038 W/m°C) and 1.25 cm of asbestos cement board (k = 0.74 W/m°C). If the outside surface of the brick is at 5°C and the inside surface of the cement is 20° C, calculate the heat flow rate per square meter of wall surface.

Or

(b) (i) A metal pipe of 10 cm OD is covered with a 2 cm thick insulation (k = 0.07 W/m °C). The heat loss from the pipe is 100 W per meter of length when the pipe surface is at 100° C. What is the temperature of the outer surface of the insulation?

(ii) Consider a steel sphere (k =10 W/m K) with an inside radius of 5 cm and an outside radius of 10 cm. The outer surface is to be insulated with fibre glass insulation (k = 0.05 m °C) to reduce the heat flow rate through the sphere by 50%. Determine the thickness of the fibre glass.

15. (a) (i) Air at 10° C is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60° C, calculate at x = 0.3 m, the heat transfer rate.

(ii) Assuming a man as a cylinder of 40 cm diameter and 1.72 m high with a surface temperature of 40° C, calculate the heat lost from the body, while standing in wind flowing at 20 km per hour at 20° C. Take the properties of air at 30° C and use the relation, $Nu_D = 0.027\ Re_D^{0.805}\ Pr^{0.333}$.

Or

(b) (i) A vertical plate 0.5 m high and 1 m wide is maintained at a uniform temperature of 124° C. It is exposed to ambient air at 30° C. Calculate the heat transfer rate from the plate.

(ii) Two black discs of diameter 50 cm are placed parallel to each other concentrically at a distance of 1 m. The discs are maintained at 700° C and 250°C respectively. Calculate the heat transfer between the discs per hour, when no other surface is present except the discs.
