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B.Tech. Degree IV Semester Regular Examination in Marine Engineering April 2021

19-208-0402 THERMAL ENGINEERING AND HEAT TRANSFER

(2019 *Scheme*)

Time: 3 Hours Maximum Marks: 60

(5 × 15 = 75)

I. (a) The chemical analysis of Bituminous coal gave the following ultimate analysis C = 81.5%, H = 4.5%, S = 0.8%, O = 2.6%. The remainder consists of incombustible solid. Determine: (10)

(i) Stoichiometric air to fuel ratio.

(ii) The actual mass of air supplied per kilogram of fuel when 20% excess air is required for complete combustion.

(iii) The mass of the products of combustion per kilogram of fuel.

Assume that air contains 23% oxygen and 77% nitrogen by mass.

(b) Write short note on adiabatic Flame temperature. (5)

OR

II. (a) A gas turbine employs a heat exchanger with a thermal ratio of 72%. The turbine operates between the pressures of 1.01 bar and 4.04 bar and ambient temperature is 20°C. Isentropic efficiencies of compressor and turbines are 80% and 85% respectively. The pressure drop on each side of the heat exchanger is 0.05 bar and in combustion chamber 0.14 bar. Assume combustion efficiency to be unity and calorific value of the fuel is 41800 KJ/Kg. Calculate the increase in efficiency due to heat exchanger over for that simple cycle. Assume C_p = 1.024 KJ/Kg.K and is constant throughout and ratio of specific heats to be 1.4. For simple cycle the air fuel ratio is 90:1 and for heat exchange cycle the turbine entry temperature is same as simple cycle. (10)

(b) Explain the various methods to improve the work ratio of Gas turbine Plants. (5)

III. (a) A single acting reciprocating air compressor has cylinder diameter and stroke of 200 mm and 300 mm respectively. The compressor sucks air at 1 bar and 27°C and delivers at 8 bar while running at 100 r.p.m Find: (10)

(i) Indicated power of the compressor;

(ii) Mass of air delivered by the compressor per minute;

(iii) Temperature of the air delivered by the compressor.

The compression follows the law $PV^{1.25}$ = C. Take R as 287 J/kg K.

(b) Obtain an expression for the Volumetric efficiency of compressor in terms of clearance volume and swept volume. (5)

OR

IV. (a) A two- stage single acting reciprocating compressor takes in air at the rate of 0.2 m^3/s. The intake pressure and temperature of air 0.1MPa and 16°C. The air is compressed to a final pressure of 0.7 Mpa. The intermediate pressure is ideal and intercooling is perfect. The compression index in both the stages is 1.25 and the compressor runs at 600 r.p.m. Neglecting clearance Determine: (10)

(i) The intermediate pressure.

(ii) The total volume of each cylinder.

(iii) The power required to drive the compressor.

(iv) The rate of heat rejection in the intercooler.

Take C_p = 1.005 kJ/kg K and R = 0.287 kJ/kg K.

(b) Write short notes on compressed Air motors. (5)

(P.T.O.)

V. (a) Consider a person standing in a room at 20°C with an exposed surface area of 1.7 m^2 The deep body temperature of the human body is 37°C, and the thermal conductivity of the human tissue near the skin is about 0.3 W/m-°C. The body is losing heat at a rate of 150 W by natural convection and radiation to the surroundings. Taking the body temperature 0.5 cm beneath the skin to be 37°C, determine the skin temperature of the person. (10)

(b) Explain Critical thickness of insulation. (5)

OR

VI. (a) Hot water at an average temperature of 90°C is flowing through a 15 m section of a cast iron pipe (k = 52 W/m-°C) whose inner and outer diameters are 4 cm and 4.6 cm, respectively. The outer surface of the pipe, whose emissivity is 0.7, is exposed to the cold air at 10°C in the basement, with a heat transfer coefficient of 15 W/m^2-°C. The heat transfer coefficient at the inner surface of the pipe is 120 W/m^2-°C. Taking the walls of the basement to be at 10°C also, determine the rate of heat loss from the hot water. (10)

(b) Explain Fourier law of heat conduction with assumptions. (5)

VII. (a) The top surface of the passenger car of a train moving at a velocity of 70 km/h is 2.8 m wide and 8 m long. The top surface is absorbing solar radiation at a rate of 200 W/m^2 and the temperature of the ambient air is 30°C. Assuming the roof of the car to be perfectly insulated and the radiation heat exchange with the surroundings to be small relative to convection, determine the equilibrium temperature of the top surface of the car. The properties of air at 30°C are Pr = 0.7282, Kinematic viscosity= 1.608×10^{-5} m^2/s, k = 0.02588 W/m-°C. (10)

(b) Explain the significance of non dimensional numbers used in convective heat transfer. (5)

OR

VIII. (a) Explain Shape Factor. Show that shape factor between two radiating surface is a function of geometry only. (10)

(b) State and explain Kirchhoff's law. (5)

IX. (a) Derive the expression for effectiveness of parallel flow heat exchanger in terms of Number of Transfer units and capacity ratio. (10)

(b) What do you mean by Fouling in heat exchangers? (5)

OR

X. (a) Derive the LMTD for counter flow heat exchanger. Show that the LMTD for counter flow is always greater than parallel flow heat exchanger. (10)

(b) Write short notes on types of heat exchanger. (5)

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