B. Tech Degree III Semester Examination in Marine Engineering, November 2009

MRE 303 THERMODYNAMICS AND HEAT TRANSFER

Time : 3 Hours Maximum Marks : 100

I. (a) Prove that the efficiency of an engine working on a reversible cycle depends only on the temperature of source and sink and is independent of working fluid. (8)

(b) A reversible engine operator between temperatures T_1 and T ($T_1 > T$). The energy rejected by this engine is received by a second reversible engine at the same temperature T. The second engine rejects the heat at temperature T_2 ($T_2 < T$). Prove that

(i) $T = (T_1 + T_2)/2$ if the engines produce same work output

(ii) $T = \sqrt{T_1 T_2}$, if the engines develop the work at the same efficiency. (12)

OR

II. (a) Discuss the following fuel properties :

(i) Fuel volatility
(ii) Vapor pressure
(iii) Vapor/Liquid ratio
(iv) Octane/Cetane rating
(v) Knock inhibitors. (5 x 2 = 10)

(b) A fuel contains by mass 88% C, 8% H_2, 1% S and 3% ash (silica). Calculate the stoichiometric air. (10)

III. (a) State the effects of following parameters in a Rankine Cycle :

(i) Steam pressure at inlet to turbine
(ii) Steam temperature at inlet to turbine
(iii) Steam pressure at exhaust. (10)

(b) Determine the thermal efficiency, work ratio and specific steam consumption of a Carnot cycle operating with a boiler pressure of 10 MPa and a condenser pressure of 5 KPa. Assume that the steam enters the boiler as saturated liquid and leaves as saturated vapour. (10)

OR

IV. (a) Explain the term missing quality as used for steam engines. How it is caused and how it is reduced? (10)

(b) During a test on double acting single cylinder steam engine running at 200 rpm the IHP developed was 120. Cylinder bore and stroke are 30 cm and 37.5 cm respectively. Diameter of the piston rod is 6 cm. Steam is admitted at 11.25 Kgf/cm^2 for 1/3rd of the stroke. Exhaust pressure is 666 mm of Hg vacuum when barometer reads 740 mm of Hg. Determine the diagram factor. Use 1 Kgf/cm^2 = 0.9806 bar. (10)

V. (a) Explain the effect of friction on the performance of a steam nozzle. Explain the same on the Temperature-Entropy, and Enthalpy-Entropy diagram. (8)

(b) A single stage impulse turbine rotor has a diameter of 1.2 m running at 3000 rpm. The nozzle angle is 18°. Blade speed ratio is 0.42. The ratio of the relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3° smaller than the inlet angle. The steam flow rate is 5 Kg/s. Draw the velocity diagram and determine the following :

(Turn Over)

(i) Velocity of whirl
(ii) Axial thrust on end bearing
(iii) Blade angels
(iv) Power developed. (12)

OR

VI. (a) Discuss the following applied to steam turbines :
(i) Degree of reaction
(ii) Reheat factor
(iii) Pressure lubrications. (10)

(b) Steam at a pressure of 10 bar and dryness fraction of 0.9 is discharged through a convergent divergent nozzle to a back pressure of 0.1 bar. The mass flow rate is 10 Kg/KW-hr. If the power developed is 200 KW, determine –
(i) Pressure at the throat
(ii) Number of nozzles required if each nozzle has a throat of rectangular cross section of 5 mm x 10 mm, if 10% of the overall isentropic enthalpy drop reheats by friction the steam in the divergent portion. (10)

VII. (a) State Fourier's Law of one-dimensional heat conduction equation and obtain an expression for the thermal conductivity in terms of T_1, T_2, Q/A and Δx for this case. Explain the significance of the minus sign associated with the statement of Fourier's Law of heat conduction as stated earlier. (10)

(b) A refrigerant flows in a 4.8 cm outside diameter copper tube with 0.713 cm wall thickness. The inside surface temperature is –15°C and the room temperature is 21°C. Determine the thickness of insulative pipe-covering (K = 0.74 W/mK) required to reduce the heat gain to the pipe by 25% for the case in which forced connection heat transfer occurs with h = 56.78 W/m^2K. (10)

OR

VIII. (a) Explain the concept of a black body and enunciate the main laws of radiations. Also, describe an arrangement by which a black body can be achieved in the laboratory. (10)

(b) The temperature at the inside surface of a hollow silver sphere is 85°C and at the outside surface is 15°C. The inside diameter is 5 cm and the outside diameter is 7.5 cm. The value of K for silver is 425 W/mK. Find the rate of heat flow. (10)

IX. (a) Explain the difference between (i) natural and forced convections and (ii) laminar and turbulent flow. (10)

(b) Air at 20°C and at atmospheric pressure flows at a velocity of 166 m/s past a flat plate 1 m long which is maintained at a constant temperature of 150° C. What is the average heat transfer rate per unit area of plate? The properties of air at a mean temperature of 85°C are as follows :

$\mu = 2.1087 \times 10^{-5}$ Kg/ms
K = 0.0306 W/mK
Cp = 1.0098 KJ/KgK
Pr = 0.695 (10)

OR

X. (a) Describe the difference between a parallel flow and a counter flow cooler, showing graphically how the temperatures vary with the length. (10)

(b) Define the Reynolds, Nusselt, Prandtl and Stanton numbers. Explain the principle of dimensional analysis as applied to heat flow. (10)

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