B. Tech. Degree III Semester Supplementary Examination in Marine Engineering December 2014

MRE 303 THERMODYNAMICS AND HEAT TRANSFER

Time: 3 Hours   Maximum Marks: 100

(5 x 20 = 100)

I. (a) State the second law of thermodynamics as per   (8)
        (i) Kelvin-Planck statement (ii) Clausius statement
    (b) A reversible heat engine operates between two reservoirs at temperatures of   (12)
        600°C and 40°C. The engine drives a reversible refrigerator which operates
        between reservoirs at temperatures of 40°C and – 20°C. The heat transfer to
        the heat engine is 2000 kJ and the net work output of the combined engine
        refrigerator plant is 360 kJ.
        (i) Evaluate the heat transfer to the refrigerant and the net heat transfer to
             the reservoir at 40°C.
        (ii) Reconsider (i) given that the efficiency of the heat engine and the
             COP of refrigerator are each 40% of their maximum possible values.

OR

II. (a) What do you understand by high grade energy and low grade energy?   (8)
    (b) Calculate the decrease in available energy when 25 kg of water at 95°C mix   (12)
        with 35 kg of water at 35°C, the pressure being taken as constant and the
        temperature of the surrounding being 15°C. C_p of water = 4.2 kJ/kgk.

III. (a) What are the four basic component of a steam power plant?   (8)
     (b) A cycle steam power plant is to be designed for a steam temperature at turbine   (12)
         inlet of 360°C and an exhaust pressure of 0.08 bar. After isentropic expansion
         of steam in the turbine, the moisture content at the turbine exhaust is not to
         exceed 15%. 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.

OR

IV. (a) Write notes on Feed Water Heaters.   (8)
    (b) In a single-heater regenerative cycle, the steam enters the turbine at 30 bar,   (12)
        400°C and the exhaust pressure is 0.10 bar. The feed water heater is a direct-
        contact type which operates at 5 bar. Find (i) the efficiency and the steam rate
        of the cycle and   (ii) the increase in mean temperature of heat addition,
        efficiency and steam rate, as compared to Rankine cycle (without regeneration).
        Neglect pump work.

V. (a) What are the types of nozzles? Explain the expansion of steam through these nozzles. (8)

   (b) A steam nozzle supplied at 7 bar and 275°C discharges steam at 1 bar. If the diverging portion of the nozzle is 50 mm long and the throat diameter is 5 mm, determine the cone angle of the divergent portion. Assume 10% of the total available enthalpy drop to be lost in friction in the diverging port. Also determine the velocity and temperature of steam at the throat. (12)

OR

VI. (a) Explain the difference between impulse turbine and reaction turbine. (8)

   (b) In a stage of an impulse turbine provided with single row wheel, the mean diameter of the blades is 1m. It runs at 3000 rpm. The steam issues from the nozzle at a velocity of 350 m/sec and the nozzle angle is 20°. The rotor blades are equi-angular. The blade friction factor is 0.86. Determine the power developed if axial thrust on the end bearing of a rotor is 120 N. (12)

VII. (a) What is meant by temperature gradient? Derive the Fourier's equation for conduction heat transfer. (10)

   (b) A 16 cm outer diameter pipe of 4 mm thickness carrying saturated steam is covered with insulating material of 4 cm thick of conductivity 0.085 W/m°k. The inside film heat transfer co-efficient is 1165 W/m^2 °K and outside film co-efficient is 12 W/m^2 °K. The material of the pipe is having a co-efficient of 45 W/m^2 °K. It is found that heat loss is more and it is proposed to add another layer of 4 cm thick insulating material of the same quality without changing other conditions. Determine the percentage reduction in the heat transferred. (10)

OR

VIII. (a) Explain the concept of Black body and Grey body. (8)

   (b) A 40 cm diameter steel pipe with 8 cm thick 85% magnesia lagging is concentrically suspended in a 2.2 m diameter concrete tunnel. For the outer insulation surface, temperature is 50°C and the film co-efficient of free convection excluding radiation is taken as 9.3 W/m^2 °K. If the ambient air and concrete surface temperatures are 35°C, find the equivalent film co-efficient of radiation and total heat loss from 50 m of pipe. Assume emissivity of the surface as 0.8. (12)

IX. (a) Derive the expression for the LMTD of a counter flow heat exchanger. (10)

   (b) A heat exchanger has 17.5 m^2 area available for heat transfer. It is used for cooling oil at 200°C by using water available at 20°C. The mass flow and specific heat of oil are 10000 kg/hr and 1.9 kJ/kg K and the mass flow and specific heat of water are 3000 kg/hr and 4.187 kJ/kg K. If the overall heat transfer co-efficient is 300 W/m^2 – K, estimate the outlet temperature of oil and water for parallel flow and counter flow arrangements by using LMTD method. (10)

OR

X. (a) Explain the working of regenerative heat exchanger. (10)

   (b) A 180 kW steam engine has a steam consumption of 9.5 kg per kW-hr. The back pressure of the engine which is approximately the same as the condenser pressure is 0.15 bar. The temperature of the condensate is 35°C. The cooling water temperature at inlet and outlet are 18°C and 34°C respectively. Estimate the quantity of cooling water required per hour if the steam exhausted to the condenser is dry. (10)

***