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***B.Tech. Degree IV Semester Examination in
Marine Engineering May 2019***

**MRE 1402 THERMODYNAMICS AND HEAT TRANSFER
(2013 Scheme)**

Time: 3 Hours

Maximum Marks: 100

(5 × 20 = 100)

- I. (a) Show that efficiency of all reversible heat engines operating between the same temperature levels is the same. (10)
- (b) A domestic food freezer maintain a temperature of -15°C . The ambient air temperature is 30°C . If heat leaks into the freezer at a continuous rate of 1.75 kJ/s , what is the least power necessary to pump this heat out continuously. (10)
- OR**
- II. (a) Write short notes on (i) Stoichiometric air (ii) Excess air (iii) Equivalence ratio (iv) Dissociation (v) Vapour pressure. (10)
- (b) Ethylene (C_2H_4) is burnt in a steady flow combustor with dry air. Orsat analysis of the combustion products gave the following results. $\text{CO}_2 - 9.7\%$, $\text{CO} - 1.1\%$, $\text{O}_2 - 4\%$, and $\text{N}_2 - 85.2\%$. Find the actual air and excess air. (10)
- III. (a) Plot the T-s diagram of a ideal regenerative cycle. Prove that efficiency of regenerative cycle is equal to that of Carnot cycle. (10)
- (b) In a Rankine cycle steam at 20 bar, 300°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser where it is condensed to saturated liquid water. The pump feeds back the water into boiler. Assuming ideal processes, find (i) the net work per kg of steam, (ii) cycle efficiency (iii) Specific Steam Consumption. (10)
- OR**
- IV. (a) Describe velocity compounding and pressure compounding in turbines showing variation of pressure and velocity during steam expansion. (10)
- (b) Steam issues from the nozzle of a De-Laval turbine with a velocity of 1000 m/s . The nozzle angle is 20° , mean blade velocity is 400 m/s , the blades are symmetrical, the mass flow rate is 1000 kg/hr , friction factor is 0.8. Determine (i) blade angles (ii) axial thrust on the rotor turbine (iii) work done per kg of steam (iv) power developed (v) blade efficiency. (10)
- V. (a) Derive an expression for the work done in a single stage air compressor with clearance. (10)
- (b) A single stage reciprocating air compressor has a swept volume of 2000 cm^3 and run at 800 rpm . It operate on a pressure ratio of 8, with a clearance of 5% of the swept volume. Assume NTP room conditions and at inlet ($P = 101.3 \text{ kPa}$, $T = 15^{\circ}\text{C}$) and polytropic compression and expansion with $n = 1.25$. Calculate (i) indicated power (ii) volumetric efficiency (iii) mass flow rate (iv) Free air delivery (v) isothermal efficiency. (10)

OR

(P.T.O.)

- VI. (a) What is perfect inter cooling in a compressor? Explain work saved due to perfect inter cooling with the help of a diagram. (10)
- (b) A gas is compressed in a two stage reciprocating compressor from 1 bar, 300 K to 9 bar. Assuming perfect inter cooling, estimate the compressor work and the total heat transfer (Take $R = 0.287$ kJ/kg.K, $C_p = 1.042$ kJ/kg K, and $n = 1.3$). (10)

- VII. (a) What is Fourier's law of conduction. Derive an expression for heat flow through a cylindrical wall. (10)
- (b) A cold storage room has walls made of 0.23 m of brick on the outside, 0.08 m of plastic foam and finally 1.5 cm of wood on the inside. The outside and inside temperatures are 22°C and -2°C respectively. If the inside and outside heat transfer coefficients are respectively 29 and 12 W/m²K and the thermal conductivities of brick, foam, wood are 0.98, 0.02 and 0.17 W/mK respectively, determine (i) the rate of heat removed by refrigeration if the total wall area is 90 m² (ii) temperature of the inside surface of the brick. (10)

OR

- VIII. (a) Write notes on radiation heat transfer. (8)
- (b) Two black parallel planes 1×1 m are separated by a distance of 1 m. One plane is maintained at 500°C and the other at 200°C . The planes are located in a large room where walls are at 25°C . What is the net heat transfer between the planes. (12)

- IX. (a) Derive an expression for LMTD for a heat exchanger. (10)
- (b) An oil cooler for a lubrication system has to cool 1000 kg/hr of oil ($C_p = 2.09$ kJ/kg K) from 80°C to 40°C by using a cooling water flow of 1000 kg/hr available at 30°C . Give your choice for parallel flow or counter flow heat exchanger with reasons. Estimate the surface area of the heat exchanger, if overall heat transfer coefficient is 24 W/m²K (C_p of water = 4.18 kJ/kg.K). (10)

OR

- X. (a) Explain natural convection and forced convection. (10)
- (b) Explain the following dimensionless numbers and its physical importance. (10)
- (i) Prandtl number (ii) Nusselt number (iii) Reynold's number (iv) Stanton number (v) Grashof number.
