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B.Tech. Degree IV Semester Examination in Marine Engineering June 2015

MRE 1402 THERMODYNAMICS AND HEAT TRANSFER

Time: 3 Hours Maximum Marks: 100

$(5 \times 20 = 100)$

I. (a) What do you understand by the term reversibility when used in the thermodynamic sense? Prove that the efficiency of an engine working on a reversible cycle between the temperature limits T_1 and T_2 is equal to $T_1 - T_2 / T_1$ and show that no engine can be more efficient than this when working over the same temperature range.

(b) The following is the composition of a sample fuel gas used in a gas engine: $CH_4 = 82\%$, $C_2H_2 = 6\%$, $CO = 1\%$, $CO_2 = 4\%$, $N_2 = 7\%$. Calculate the air required for complete combustion of $1 m^3$ of the sample and find the percentage analysis of the dry products of combustion by volume.

(c) Explain the term entropy and show by means of sketches and how the lines of constant volume and constant wetness can be drawn on a T – S chart for water and steam.

OR

II. (a) Prove that for a given temperature range, the efficiency of the Carnot cycle cannot be exceeded by any other heat engine. Why have certain air standard cycles been adopted for internal combustion engines and why are actual engine efficiencies so low when compared with them?

(b) Derive a general expression in terms of the initial and final temperatures and volumes for the increase in entropy of a gas when heated.

(c) Show the throttling expansion of a vapor on a T-S diagram and explain.

III. (a) Describe the Rankine cycle, illustrating your answer with sketches of p-v and T-S diagrams. Show how the cycle is modified in the ordinary steam engine.

(b) A steam engine receives steam at 19 MPa in dry conditions and expansion takes place in the cylinder to 5kPa followed by exhaust at 4.5 kPa. If the expansion follows the law pv = constant, calculate the work done per kg of steam. Neglect clearance and wire drawing effects.

(c) Draw the velocity diagram for a Parsons reaction turbine and derive an expression for the efficiency considering the heat drop.

OR

IV. (a) Distinguish between impulse and reaction turbines and indicate by curves the variation of pressure and velocity in a reaction expansion and in the nozzles and blading of a velocity compounded impulse turbine.

(b) State what is meant by expansion of steam (i) under stable adiabatic conditions (ii) under conditions of supersaturation.

(c) Steam is expanded in a nozzle from 12 MPa with 60° C of superheat to 2 MPa. The expansion is supersaturated. Determine (i) the isentropic heat drop (ii) the actual heat drop and (iii) the degree of undercooling.

(P.T.O.)

V. (a) With the help of suitable figures, derive an expression for the work done in single stage air compressor.

(b) What do you understand by multistage compression with and without clearance?

(c) A two stage air compressor with perfect intercooling takes in air at 1 bar pressure and 30° C following the law $pv^{1.3}$= constant in both stages. The compressed air is delivered at 12 bar from the H.P cylinder to an air receiver. Calculate, (i) the minimum work done per kilogram of air and (ii) the heat rejected to the intercooler per kilogram of air.

OR

VI. (a) Draw the pv diagram for a three-stage compressor with perfect intercooling and explain.

(b) Explain the working of an air motor with a neat sketch.

(c) A two stage single acting reciprocating compressor takes in air at the rate of 0.25 m^3/s. Intake pressure and temperature are 1 bar and 24°C respectively. The air is compressed to a final pressure of 9 bar. The intermediate pressure is ideal and intercooling is perfect. The compression index is 1.25 and the compressosr runs at 15 rps. Neglecting clearance, determine (i) the intermediate pressure (ii) the total volume of each cylinder (iii) the power required to drive the compressor.

VII. (a) What do you mean by "optimum insulation thickness"? What are the important factors that should be taken into account while determining this thickness?

(b) Explain Stefan-Boltzmann law of radiation bringing out its significance.

(c) Saturated steam at 4 kg/cm^2 guage pressure flows through a 2 inch horizontal pipe (outside diameter 60 mm) in a room at 30°C. Neglecting the resistance of the pipe wall, calculate the rate of heat loss by combined convection and radiation from the pipe and also the rate of condensation of steam. The emissivity of the pipe surface is 0.79 and that of the wall of the room is 0.75. Also calculate the percentage reduction in heat loss and the corresponding radiation heat transfer coefficient, if the pipe is coated with an aluminium paint having ε =0.35.

OR

VIII. (a) Explain spectral radiation intensity bringing out its significance.

(b) Write the expressions for thermal resistance of a wall, an annular cylinder and a spherical shell.

(c) Derive an expression for heat transfer between fluids separated by a cylindrical wall.

IX. (a) Distinguish between natural and forced convective heat transfer.

(b) What is the physical significance of Nusselt number?

(c) Air at 100 kPa and 28° C flows over a flat plate at a speed of 1 m/s. Calculate the hydrodynamic boundary layer thickness using the solution obtained by an exact mathematical analysis at distances of 30 cm and 50 cm from the leading edge. The viscosity of air at 28°C is 1.9×10^{-5} kg/m s.

OR

X. (a) How does the hydrodynamic boundary layer thickness change with increasing velocity of fluid?

(b) Define Prandtl number and Stanton number.

(c) Water at 4°C enters a horizontal carbon steel pipe 100mm inside diameter and 114 mm outside diameter lagged with a 30mm thick layer of polyurethane foam insulation (k = 0.019 $W/m^\circ C$). The velocity of water in the pipe is 1.5 m/s. If heat loss from the insulated pipe occurs by free convection to an ambient at –20°C, calculate the length of pipe section at the end of which formation of ice crystals will start.

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