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H.P.A.S. (Main)—2011

MECHANICAL ENGINEERING—II

Time : 3 *Hours* *Maximum Marks :* 150

Note :— Attempt total *five* questions. Question No. 8 is compulsory. Use of calculator, steam tables, Mollier diagram, psychometric chart and refrigerant property table is permitted. Assume missing data, if any, suitably.

1. (a) What do you understand by entropy ? Derive the expression for the "inequality of Clausius" related to entropy. Also discuss the physical significance of the expression. 15

P.T.O.

(b) A heat exchanger increases the temperature of the incoming air flowing at a velocity of 40 m/s, from 20°C to 900°C. The air after heat exchange goes to a turbine at a same velocity and expands until temperature falls to 600°C. After turbine air at velocity of 70 m/s is taken to nozzle where it further expands until temperature reaches to 450°C. If flow and C_p of air is taken as 4 kg/s and 1.005 kJ/kgK respectively, find :

(i) Rate of heat transfer in heat exchanger.

(ii) Power developed in turbine and velocity at exit of nozzle, assuming there is no heat loss in the system. 15

2. (a) Derive Euler's equation of motion of fluid and write the same in X, Y and Z directions. Show that integration of Euler's equation results into Bernoulli's equation. Also mention the conditions for applicability of Bernoulli's equation. 15

(b) A total of 15 liters per second of oil is pumped through two pipes in parallel, one 15 cm diameter and other 13 cm in diameter, both pipes being 1500 meters long. The specific gravity of the oil is 0.97 and the kinematic viscosity 9 cm^2 per second. Calculate the flow rate through each pipe and the power requirement of the pump assuming overall efficiency of pump as 80%. 15

3. (a) Derive generalised equation for work done and efficiency in case of simple impulse steam turbine. Also find out the condition for maximum efficiency. 15

(b) A velocity of steam entering a simple impulse turbine is 900 m/s, and the nozzle angle is 25°. The mean peripheral velocityof blades is 300 m/s and blades are symmetrical, find :

(i) Blade angles for entry without shock.

(*ii*) For mass flow of 0.8 kg/s, diagram power and efficiency.

(*iii*) If the relative velocity is reduced by friction to 80% of that of inlet, estimate axial thrust, diagram power and efficiency. 15

4. (*a*) Explain improvement in efficiency and work ratio of gas turbine by incorporating intercooling, regeneration and reheating. Also discuss their limitations. 15

(*b*) Dry steam at 400°C is flowing through a steel pipe of 15 cm outer diameter and 13 cm inner diameter. The steel pipe is located in a large room and is covered with 7 cm asbestos insulation of conductivity 0.70 W/mK. The surroundings are at 20°C. For the inner pipe surface convective heat transfer coefficient

is 600 W/m^2K and for the outer surface it is 10 W/m^2K which includes radiation and convection. The emissivity of the surface is 0.86. Find :

(i) Heat transferred per meter length of the pipe.

(ii) Equivalent radiation film coefficient

(iii) Convective heat transfer coefficient for outer surface.

Assume thermal resistance offered due to steel pipe neglected. 15

5. (a) Explain the importance extended surfaces (fins). Derive the generalised equation of heat transfer from, a rectangular plate fin of uniform cross-section and extend the equation for a fin with insulated end. 15

(b) Air at 20°C is flowing along a heated flat plate at 134°C at a velocity of 4 m/s. The plate is 3 m long and 2 m wide. Calculate local heat transfer coefficient at $x = 0.5$ m and heat transfer from first 50 cm of the plate. Take air properties at 77°C, density 0.998 kg/m^3, specific heat at constant pressure 1.009 kJ/kg C, kinematic viscosity 20.76×10^{-6} m^2/s, conductivity 0.03 W/mK, Prandtl No. 0.697. 15

6. (a) Explain absorption refrigeration system and derive the expression for C.O.P. Also discuss the effect of generator, condenser and ambient temperature on C.O.P. 15

(b) A building has RSH gain 310 kW and RLH gain 100 kW as cooling load. The building is to be maintained at 25°C and RH 50%. Outdoor air is at 28°C and 50% RH, and 10% by mass of air supplied to building is outdoor air. If the air supplied to the space is not to be at temperature lower than 18°C, find :

(i) Minimum amount of air supplied to the space in m^3/s.

(ii) Volume flow rates of return air and exhaust air or outdoor air.

(iii) State and volume flow rate of air entering the cooling coil.

(iv) Capacity, ADP, BPF and SHF of the cooling coil. 15

7. (*a*) Explain boiling water reactor nuclear power plant, also discuss its merits and demerits. 15

(*b*) Discussing the need of a fuel injection system, explain various fuel injection systems, being used. 15

8. Explain any *four* of the following : 30

(*i*) Second law efficiency

(*ii*) Turbulent flow through pipe

(*iii*) Boiling and condensation

(*iv*) Free and froced convection

(*v*) Cavitation in hydraulic turbines

(*vi*) Utilisation of solar energy for generation of electricity.