2016

MECHANICAL ENGINEERING - PAPER-II

Time Allowed : 3 Hours

Full Marks : 200

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

Answer may be written either in English or in Bengali but all answers must be in one and the same language.

Answer any five (5) questions

1. a) Distinguish between the terms 'change of state', 'Path', and 'Process'.

b) Define specific heats at constant pressure and at constant volume.

c) Write the steady flow energy equation for a single stream entering and a single stream leaving the control volume and explain various terms in it.

Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7m/s velocity, 100kPa pressure and 0.95m^3/kg volume, and leaving at 5m/s velocity, 700kPa pressure and 0.19m^3/kg volume. The internal energy of air leaving is 90kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from air at the rate of 58kW. Compute the rate of shaft work input to the air in kW. Also find the ratio between the inlet pipe diameter to the outlet pipe diameter.

d) A heat engine is used to drive a heat pump. The heat transfers from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of the heat transfer to the circulating water to the heat transfer to the heat engine.

6+4+(3+12)+15=40

2. a) What is an air standard cycle? Why are such cycles conceived?

b) Show that the efficiency of the Otto cycle depends only on the compression ratio.

c) In a gas turbine plant, working on the Brayton cycle with a regenerator of 75% effectiveness, the air at the inlet to the compressor is at 0.1 MPa, 30^{0}C, the pressure ratio is 6 and the maximum cycle temperature is 900^{0}C. If the turbine and the compressor have each an efficiency of 80% find the percentage increase in cycle efficiency due to regeneration.

10+10+20=40

P.T.O.

3. a) Why are steam turbines compounded? With neat sketches describe different methods of compounding.

b) Show that, the maximum diagram efficiency of the single stage impulse turbine is $\cos^2\alpha$. Where α is the nozzle angle.

c) Differentiate between water tube and fire tube boilers.

(5+10) + 15+10=40

4. a) A 300 MW thermal power station is to supply power to a system having maximum and minimum demand of 240MW and 180MW respectively in a year. Assuming the load duration curve to be a straight line, estimate the load factor and the capacity factor.

b) Define specific speeds for both the pump and the hydraulic turbine. State their significance.

c) A centrifugal pump running at 900 RPM and delivering $0.3 m^3/s$ of water against a head of 25m, the flow velocity being 3m/s. If the manometric efficiency is 82%, determine the diameter and width of the impeller. The blade angle at outlet is 25^0.

15+10+15=40

5. a) Derive an expression for the force exerted on submerged vertical plane surface by the static liquid and locate the position of centre of pressure.

b) In a vertical pipe conveying oil of specific gravity 0.8, two pressure gauges have been installed at A and B where the diameters are 16 cm and 8 cm respectively. A is 2 meters above B. The pressure gauge readings have shown that the pressure at B is greater than at A by $0.981 N/cm^2$. Neglecting al losses calculate the flow rate.

c) What is a Pitot tube? How will you determine the velocity at any point with the help of Pitot tube?

12+16+12=40

6. a) Describe with a neat sketch the working principle of a crankcase scavenged two-stroke engine.

b) What are the essential features of the good commercial Carburetor for automotive engine?

c) The mechanical efficiency of a single-cylinder four-stroke engine is 80%. The frictional power is estimated to be 25kW. Calculate the indicated power and brake power developed by the engine.

d) State the differences in the knocking phenomena of S.I and C.I engines.

10+10+10+10=40

7. a) Assuming negligible heat losses from the tip derive the expression for temperature distribution and heat transfer along a straight fin with uniform cross sectional area. Why insulated-tip solution is is important for the fin problems?

b) Define Reynolds number. Why is it important?

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c) Engine oil is to be cooled from 80^0 C to 50^0C by using a single pass, counter flow, concentric tube heat exchanger with cooling water available at 20^0C. Water flows inside a tube with an ID D_i= 2.5cm at a rate of m_w= 0.08kg/s, and oil flows through the annulus at a rate of m_{oil}=0.16kg/s. Assuming overall heat transfer coefficient is 72.2 w/ ($m^2\,^0$C) calculate the tube length required. Specific heat of engine oil is 2009 J/kg ^{0}C and specific heat of water is 4180J/^{0}C.

(12+4)+6+18=40

8. a) Define dry bulb temperature, wet bulb temperature, wet bulb depression and dew point temperature.

b) Describe operation of a vapour compression refrigeration cycle using p-h and T-s diagrams. Why superheating of the refrigerant in the evaporator is desirable ?

c) A refrigerator machine uses Ammonia as the working fluid. The temperature of Ammonia in the evaporator coil is 0^0C and Ammonia leaves the evaporator at dry saturated condition. If condenser exit temperature is 27^0C determine the compressor exit temperature of Ammonia and COP. Assume specific heat of Ammonia vapour is 2.85kJ/kg K.
Thermodynamic Properties of Ammonia are as follows :

Temperature(^{0}C)	h_f(kJ/kg)	s_f(kJ/kgK)	h_g(kJ/kg)	s_g(kJ/kgK)
0	343.15	1.4716	1605.4	6.0926
27	470.43	1.9122	1627.7	5.768

8+(8+4)+20=40