INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Mechanical Engineering

Date : Time : **2** hours Full Marks : **100** No. of students : **140**

Mid-Sem. 2015 Sub. name: **Applied Thermo-Fluids-I** Sub.No.: **ME40701**

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All questions in Part-A and Part-B are compulsory.

Part-A (Internal Combustion Engines)

1. By a suitable diagram, identify the following on the diagram itself: BDC, TDC, bore, stroke length, crank, connecting rod, small end, big end. **(1x8=8)**
2. An engine has a crank radius 10 cm. If this is a square cylinder, having a compression ratio of 10, find out the stroke volume (cc) and the clearance volume (cc). **(5+5=10)**
3. Draw the actual indicator diagram of a four-stroke SI engine on the plot of air standard cycle itself and explain the difference on the processes. Draw the valve timing diagram of the four strokes and explain. **(5+5=10)**
4. A four stroke 50 kW diesel engine (square cylinder) running at 3000 rpm has indicated thermal efficiency of 45% and mechanical efficiency of 85%. The calorific value is 40 MJ/kg. The A/F ratio is 20. It has a volumetric efficiency of 80% and the compression ratio of 10. Find out (a) the engine size (cc), (b) its bore (cm), (c) indicated mep (kPa). **(6+3+3=12)**
5. A four-stroke air-standard diesel engine has a compression ratio 18. The inlet conditions are 27^{o}C and 101 kPa. The cut-off ratio is 2. Find out (a) the temperature (in ^{o}C) at the end of the compression and (b) the heat addition (kJ/kg). Take γ=1.4 and c_p=1.005 kJ/kg.K. **(5+5=10)**

Part-B (Refrigeration & Air conditioning)

Wherever necessary, make suitable assumptions and state them clearly

6. It is proposed to build a solar energy based cold storage of **1 TR** refrigeration capacity. At design conditions, the cold storage has to be maintained at a temperature of **2^{o}C**, when the ambient heat sink temperature is **43^{o}C**. Two options (a) and (b) are to be considered and the option that results in **minimum initial cost** is to be selected.
   Option (a): A 2-temperature, vapour compression system that is driven by the electrical power generated by a Solar Photo Voltaic (SPV) collector system. The solar-to-electrical conversion efficiency of the system is **15 %**, cost of SPV collector is **Rs. 12000/- per m^2** of collector area and cost of the vapour compression system (excluding solar collector cost) is **Rs. 50000/-**. COP of the vapour compression refrigeration system is **30 %** of the COP of an ideal system operating between the storage space and sink temperatures.
   Option (b): A 3-temperature vapour absorption system that is driven by a solar thermal collector system which generates thermal energy at **80^{o}C**. The solar-to-thermal conversion efficiency of the system is **60 %**, cost of solar thermal collector is **Rs. 1500/- per m^2** of collector area and cost of the vapour absorption system (excluding solar collector cost) is **Rs. 110000/-**. COP of the vapour absorption refrigeration system is **70 %**

of the COP of an ideal system operating between the storage space, sink and heat source (solar collector) temperatures.

Solar radiation is available at an average rate of **600 W/m^2** of collector area. Suggest a suitable system based on minimum initial cost. All costs other than the costs of refrigeration system and collector are same for both the systems. **(15)**

7. A single stage vapour compression system that uses propane (R290) as refrigerant consists of a Liquid-to-Suction Heat Exchanger (LSHX). The system operates at an evaporator temperature of **7^{o}C** and a condensing temperature of **54^o**C. The refrigerant at a mass flow rate of **0.1 kg/s** leaves the evaporator as saturated vapour (**h_g = 582.4 kJ/kg**) and is superheated by **10K** by exchanging heat with the liquid refrigerant in the LSHX. The state of refrigerant at the exit of condenser is saturated liquid (**h_f = 349.9 kJ/kg**). The specific heat of vapour at evaporator pressure is **1.84 kJ/kg.K** and the isentropic work of compression **58 kJ/kg**. The compressor has an isentropic efficiency of **70%**. From the data given, find a) Refrigeration capacity in kW, and b) COP. **(10)**
8. With the help of a suitable diagram and relevant equations, prove that when the **index of compression and index of expansion are equal**, the specific work of an ideal reciprocating compressor remains same with or without clearance. **(10)**
9. A **4-cylinder**, ammonia (R717) compressor running at **1250 RPM** operates over a pressure ratio (**p_c/p_e**) of **6**. Each cylinder of the compressor has a displacement volume of **1 litre** and a clearance volume of **80 cc**. At the inlet to the compressor, the refrigerant is at a pressure of **208 kPa** and a temperature of **2^{o}C**. The isentropic index of compression is **1.285**. Find a) the power input to the compressor in kW, b) Mean effective pressure in kPa, and and b) the refrigerant capacity in kW if the refrigeration effect is **1120 kJ/kg**. Assume the refrigerant vapour to behave as an ideal gas. Universal gas constant = **8.314 kJ/kmol.K**. **(15)**

Given: 1 TR = 3.517 kW

End of the question paper