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Question Paper Code : 20856

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2022.

Fourth/Sixth Semester

Mechanical Engineering

ME 8493 — THERMAL ENGINEERING – I

(Common to Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours Maximum : 100 marks

1. Use of Approved Steam Tables and Mollier charts is permitted.
2. Missing data if any may be suitably assumed.
3. Draw neat sketches, wherever necessary.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Compare Otto cycle with Diesel cycle.
2. List any four uses of Mollier chart.
3. How will you improve the isothermal efficiency of the compressor?
4. The free air delivered per minute is less than the displacement of the compressor. Why?
5. Write a short note on the rating of SI engine fuels.
6. What is called "scavenging" in 2-stroke SI engine?
7. "Supercharging/Turbo charging is preferred in C.I. engine than S.I. engine". Justify the statement.
8. List any four advantages of CRDI system over mechanical injection system.
9. What is meant by regeneration in gas turbine? How it improves the thermal efficiency of a simple open cycle turbine plant?
10. How "reheating" process improves the thermal efficiency of a simple open cycle gas turbine plant?

PART B — (5 × 13 = 65 marks)

11. (a) For an engine working on the ideal Dual cycle, the compression ratio is 10 and the maximum pressure is limited to 70 bar. If the heat supplied is 1680 kJ/kg, find the pressures and temperatures at the various salient points of the cycle and the cycle efficiency. The pressure and temperature of air at the commencement of compression are 1 bar and 100°C respectively. Assume C_p = 1.004 kJ/kg K and C_v = 0.717 kJ/kg K for air.

Or

(b) Consider a steam power plant operating on the ideal reheat Rankine cycle. Steam, enters the high pressure turbine at 15 MPa and 600°C and is condensed in the condenser at a pressure of 10 kPa. If the moisture content of the steam at the exit of the low pressure turbine is not to exceed 10.4%. Determine

(i) the pressure at which the steam should be reheated and

(ii) thermal efficiency of the cycle. Assume the steam is reheated to the inlet temperature of the high pressure turbine.

12. (a) A single-acting two stage air compressor with complete intercooling delivers 10.5 kg/min of air at 16 bar. The suction occurs at 1 bar and 27°C. The compression and expansion processes are reversible, polytropic index n = 1.3. The compressor runs at 440 rpm.

Calculate:

(i) The power required to drive the compressor (2)

(ii) The isothermal efficiency (3)

(iii) The free air delivery (2)

(iv) The heat transferred in intercooler (2)

(v) If the clearance ratios for L.P. and H.P. cylinders are 0.04 and 0.06 respectively, (4)

Calculate the swept and clearance volumes for each cylinder.

Or

(b) Derive an expression for the work done in compressing air in a single stage compressor with index of compression 'n'. Write analogous expression for a two stage compressor with perfect intercooling and hence arrive at the condition for minimum work.

13. (a) Explain in detail the various stages of combustion in a compression ignition engine with pressure time diagrams. Also compare it with combustion in spark-ignition engines.

Or

(b) Draw actual valve timing diagram for petrol engine. Provide reasons for early opening of exhaust valve and late closing of inlet valve. What is meant by valve Overlapping? Mention its disadvantages.

14. (a) Explain the construction and working principle of a battery ignition system with a neat sketch. Mention its advantages and limitations over magneto ignition system.

Or

(b) A Morse test on a four cylinder resulted in the following data: Brake power with all cylinders working = 21.7 kW, Brake power with No.1 cylinder cut-off = 15.5 kW, Brake power with No.2 cylinder cut-off = 15.6 kW, Brake power with No.3 cylinder cut-off = 15.7 kW, Brake power with No.4 cylinder cut-off = 15.5 kW. Calculate the Brake Power, indicated power, friction power, mechanical efficiency and indicated thermal efficiency, if the engine uses 0.07 kg of fuel per minute. Calorific value of fuel is 44 MJ/kg.

15. (a) A gas turbine power plant of 800 kW capacity takes the air at 1.01 bar and 15°C. The pressure ratio of the cycle is 6 and maximum temperature is limited to 700°C. A regenerator of 75% effectiveness is added in the plant to increase the overall efficiency of the plant. The pressure drop in the combustion chamber as well as the regenerator is 0.15 bar. Assume

The isentropic efficiency of the compressor = 80%

The isentropic efficiency of the turbine = 85%.

Determine the plant thermal efficiency.

Neglect the mass of the fuel.

Or

(b) A gas turbine has a pressure ratio 6:1 and a maximum cycle temperature of 600°C. The isentropic efficiencies of the compressor and turbine are 0.82 and 0.85 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 15 kg/s. Take: c_p = 1.005 kJ/kg K and γ = 1.4 for the compression process, and take c_p = 1.11 kJ/kg K and γ = 1.333 for the expansion process.

PART C — (1 × 15 = 15 marks)

16. (a) A steam turbine plant using regenerative feed heating cycle generates 27000 kW through a directly coupled electric generator. Steam at 60 bar and 450°C is supplied to the turbine. The condenser vacuum is 73 mm of Hg. The steam is extracted from the steam turbine at 3 bar. The heating of the feed water is done in direct contact heater. Assuming the turbine efficiency of each portion of expansion as 87%. Find

(i) the steam bleed/kg of steam supplied to the turbine. (8)

(ii) The steam generated per hour. (7)

Assuming that 10% of generator output is used to run the pumps, the overall efficiency of the plant if the boiler efficiency is 90% and alternator efficiency is 95% and mechanical efficiency from the turbine to generator is 98%. Consider the pump work in calculating the input to the boiler.

Or

(b) From the data given below, calculate indicated power, brake power and provide the heat balance sheet for a two-stroke diesel engine run for 20 minutes at full load.

Speed	:	350 rpm
Mean effective pressure	:	3.1 bar
Net brake load	:	640 N
Fuel consumption	:	1.52 kg
Cooling water	:	162 kg
Cooling water temperature rise	:	25°C
Air used/kg of fuel	:	32 kg
Room temperature	:	25°C
Exhaust temperature	:	305 °C
Barometric pressure	:	1.013 bar
Cylinder bore and stroke	:	200 and 280 mm
Brake diameter	:	1 m

The fuel has a calorific value of 43,900 kJ/kg and steam formed per kg of fuel in exhaust = 1.4 kg. Let R = 0.287 kJ/kg K, C_p for dry exhaust gases = 1.0 kJ/kg K and C_{ps} for superheated steam = 2.09 kJ/kg K.

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