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15ME43

Fourth Semester B.E. Degree Examination, Feb./Mar. 2022 Applied Thermodynamics

Time: 3 hrs.

Max. Marks: 80

**Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of thermodynamic data book is permitted.**

Module-1

- 1 a. Define: (i) Compression ratio (ii) Cut-off ratio (iii) Explosion ratio (iv) Expansion ratio (08 Marks)
- b. An engine working on dual combustion cycle takes in air at 1 bar and 30°C. The clearance is 8% of the stroke and cut-off takes place at 10% of the stroke. The maximum pressure in the cycle is limited to 70 bar. Find : (i) Temperatures and pressures at the salient points (ii) Air standard efficiency. (08 Marks)

OR

- 2 a. With a schematic diagram, explain how inter-cooling improves the thermal efficiency of open cycle gas turbine plant. (04 Marks)
- b. With a neat sketch, explain the working of turbo jet. Show the processes on T-S diagram. (04 Marks)
- c. In a regenerative gas turbine cycle, air enters the compressor at 1 bar, 15°C, pressure ratio is 6. The isentropic efficiency of compressor and turbine are 0.8 and 0.85 respectively. The maximum temperature in the cycle is 800°C. The regenerator efficiency is 0.78. Assume for air $C_p = 1.005 \text{ kJ/kgK}$, $\gamma = 1.4$, for hot gases $C_p = 1.1 \text{ kJ/kgK}$, $\gamma = 1.32$. Find cycle efficiency. (08 Marks)

Module-2

- 3 a. Why is ideal regenerative cycle impracticable? (03 Marks)
- b. Write a note on feed water heaters. (04 Marks)
- c. A simple Rankine cycle works between pressures of 30 bar and 0.04 bar. The initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption. (09 Marks)

OR

- 4 a. With a neat sketch, explain the working of binary vapour cycle. Show the processes on T-S diagram. (08 Marks)
- b. In a reheat cycle, the initial steam pressure and the maximum temperature are 150 bar and 550°C. If the condenser pressure is 0.1 bar and moisture at condenser inlet is 5% and assuming ideal processes, determine: (i) Reheat pressure (ii) Cycle efficiency (iii) Steam rate. Assume reheat temperature as 550°C. (08 Marks)

Module-3

- 5 a. Define the following:
 (i) Stoichiometric air (ii) Excess air
 (iii) Percent excess air (iv) Combustion efficiency (08 Marks)
- b. The gravimetric analysis of a sample of coal is given by as follows: C = 82%, H₂ = 10%, ash = 8%. Calculate: (i) Stoichiometric A/F ratio (ii) The analysis of products by volume. (08 Marks)



OR

- 6 a. Describe the phenomena of detonation in SI engine. Mention the parameters affecting detonation. (08 Marks)
- b. A four cylinder petrol engine has a bore of 60 mm and a stroke of 90 mm. Its rated speed is 2800 rpm and it is tested at this speed against brake which has a torque arm 0.37 m. The net brake load is 160 N and the fuel consumption is 8.986 lit/h. the specific gravity of petrol is 0.74 and it has LCV of 44100 kJ/kg. A Morse test was carried out and cylinders are cut-out in the order 1, 2, 3 4 with corresponding brake loads of 110, 107, 104 and 110N. Calculate:
- (i) Brake thermal efficiency (ii) Mechanical efficiency
(iii) Brake specific fuel consumption (iv) Indicated mean effective pressure. (08 Marks)

Module-4

- 7 a. For a Bell-Coleman refrigeration cycle. Show that $COP = \frac{T_1}{T_2 - T_1}$ where T_1 and T_2 are temperature of air before and after compression. (08 Marks)
- b. 28 tonnes of ice at 0°C is produced per day in an ammonia refrigerator. The temperature range in the compressor is from 25°C to -15°C, The vapour is dry saturated at the end of compression. Assuming a COP of 62% of theoretical, calculate the power required to drive the compressor. Take latent heat of ice as 335 kJ/kg. (08 Marks)

OR

- 8 a. Derive the relation between specific humidity and relative humidity. (03 Marks)
- b. Explain the following by showing the process on psychrometric chart:
- (i) Cooling with dehumidification of air
(ii) Heating and humidification of air (05 Marks)
- c. With a schematic diagram, explain the working of winder air conditioning system. Show the processes on psychrometric chart. (08 Marks)

Module-5

- 9 a. What are the applications of compressed air? (04 Marks)
- b. Define volumetric efficiency of an air compressor. Derive the expression for volumetric efficiency in terms of clearance and pressure ratios. (06 Marks)
- c. Atmospheric air at 1 bar and 27°C taken into a single stage reciprocating compressor. It is compressed according to the law $PV^{1.3} = C$ to the delivery pressure of 6 bar. The compressor takes 1 m³ of air per min. The speed of the compressor is 300 rpm. Stroke to diameter ratio is equal to 1.5:1, mechanical efficiency of the compressor is 0.85. Calculate:
- (i) Indicated power and isothermal efficiency
(ii) The cylinder dimensions and power of motor required to drive the compressor. Neglect clearance. (06 Marks)

OR

- 10 a. For a steam nozzle show that critical pressure ratio $\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$. (08 Marks)
- b. Steam is supplied at a pressure of 11 bar and 0.97 dry to a convergent divergent nozzle and expands down to a back pressure of 0.3 bar. The throat area is 5 cm² and 12% of the total enthalpy drop is lost in the divergent part. Determine:
- (i) Steam flow rate (ii) Nozzle outlet area
Assume maximum discharge condition. (08 Marks)
