8E4051

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B. Tech. (Sem. VIII) (Main/Back) Examination, April/May - 2012
Mechanical Engg.
8ME3 Gas Turbine & Gas Power Plant

Time : **3** Hours] [Total Marks : **80**
[Min. Passing Marks : **24**

*Attempt any **five questions**, selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Use of following supporting material is permitted during examination.
(Mentioned in form No. 205)

1. Nil 2. Nil

UNIT - I

1 (a) A Gas Turbine cycle is developed with a separate LP Power turbine in which gas leaving HP turbine is passed through the heat exchanger before it enters LP turbine and then to LP turbine. Draw this cycle on T-S diagram and find out its efficiency. Show that for all values of c and t, efficiency is higher than that of normal scheme. **6**

(b) A closed cycle regenerative gas turbine operating with air as the working medium. Assume the following data : p1=1.4 bar, T1 = 310 K, p2/p1 = 5, T_{max} = 1050 K, effectiveness of regenerator is 100%, net output = 3000 kW. Assuming the compression and expansion to be isentropic, Calculate

(i) thermal efficiency and
(ii) mass flow rate of air per minute **10**

2 (a) Explain effects of reheating gases on work output and efficiency of a gas power cycle with the help of T-P diagram. **6**

(b) A Gas turbine plant works between temperature limits of 300 K and 900 K. The pressure limits are 1 bar and 4 bar. Estimate the thermal efficiency of plant and the shaft power available for external load in kW. Assume mass rate of flow of air to the compressor as 1600 kg/min.

10

UNIT - II

3 (a) Clearly mention the difference between actual gas turbine cycle and theoretical gas turbine cycle.

8

(b) A gas turbine operating at a pressure ratio of 11.3137 produces zero net work output when 476.354 kJ of heat is added per kg of air mass. If inlet air total temperature is 300 K and the turbine efficiency is 71%. Find compressor efficiency and the temperature ratio. Assume $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg K for the whole cycle.

8

4 (a) The efficiency of the compressor and Turbine of a gas turbine are 70.42% and 71% respectively. The heat added in the combustion chamber per kg of air is 476.354 kJ/kg. Find a suitable pressure ratio that the work ratio is 0.0544. Also find corresponding temperature ratio. The inlet total temperature of air is 300 K.

(b) Explain the concept of combined cycle. May we call this binary vapour cycle. If η_1 and η_2 are the effectiveness of the two cycles, what would be the overall efficiency ?

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UNIT - III

5 (a) Explain the working principle of Ramjet Engine.

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(b) A turboprop aircraft is flying at 600 km/h at an altitude where the ambient conditions are 0.458 bar and –15°C. Compressor pressure ratio 9:1. Maximum gas temperature 1200 K. The intake duct efficiency is 0.9 and total head isentropic efficiency of compressor and turbine is 0.89 and

0.93 respectively. Calculate the specific power output in kJ/kg thermal efficiency of the unit taking mechanical efficiency of transmission as 98% and neglecting the losses other than specified. Assume that exhaust gases leave the aircraft at 600 km/h relative to the aircraft.

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6 (a) Classify the jet propulsion engine and discuss the performance characteristics of Ramjet engine.

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(b) In a turbojet unit with forward facing ram intake, the jet velocity relative to the propelling nozzle at exit is twice the flight velocity. Determine the rate of fuel consumption in kg/s, when developing a thrust of 25000 N under the following conditions.

Ambient pressure and temperature : 0.7 bar; 1°C

Compression total head pressure ratio : 5:1

Flight speed : 800 k

CV of fuel : 42000 kJ/kg

Ram efficiency : 100%

Isentropic efficiency of compressor : 85%

Isentropic efficiency of turbine : 90%

Isentropic efficiency of nozzle : 95%

Combustion efficiency : 98%

Turbine pressure ratio : 2.23

Assume the mass flow of fuel is small compared to mass flow of air and that working fluid throughout has the property of air at low temperature. Neglect the extraneous pressure drop. Assume $C_{pg} = C_{pa} = 1.005$ kJ/kg K.

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UNIT - IV

7 (a) Discuss the factor affecting combustion chamber performance.

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(b) In a single-stage impulse turbine the nozzle discharges the fluid on to a blades at an angle of 65° to the axial direction and the fluid leaves the blades with an absolute velocity of 300m/s at an angle of 30° to the axial direction. If the blades have equal inlet and outlet angles and there is no axial thrust, estimate the blade angle, power produced per kg/s of the fluid and the blade efficiency.

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8 (a) Discuss the combustion process with the help of block diagram. 8

(b) Gas at 7 bar and 300°C expands to 3 bar in an impulse turbine stage. The nozzle angle is 70° with reference to the exit direction. The rotor blades have equal inlet and outlet angles, and the stage operates with the optimum blade speed ratio. Assuming that the isentropic efficiency of nozzle is 0.9, and that the velocity at entry to the stage is negligible, deduce the blade angle used and the mass flow required for this stage to produce 75 kW. Take C_p = 1.15 kJ/kg K. 8

UNIT - V

9 (a) What are the site selection criteria of Steam and Diesel power plants ? Also draw the schematic of Layouts of these power plants. 8

(b) Write short note on combined cycle power plant. 8

10 (a) Describe with a neat sketch the working of free piston engine. 8

(b) Explain various difficulties associated with the development of gas turbine materials. 8