Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH(AUE)/SEM-8/AUE-823/2012

2012

GAS TURBINE ENGINE

Time Allotted : 3 Hours | Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Thermodynamic cycle for working of gas turbine engine is

a) Diesel cycle b) Dual Cycle

c) Brayton Cycle d) Sterline Cycle.

ii) As pressure ratio increases, efficiency of Joule cycle

a) decreases b) increases

c) remains constant d) no relation.

iii) Turboprop engine develops

a) shaft power b) thrust power

c) shaft & thrust power d) none of these.

iv) Function of inlet duct is to

a) provide sufficient air supply to engine

b) prevent surges

c) ensure uniform pressure and velocity to commpressor inlet

d) all of these.

v) The compressor used in gas turbine engines is

a) centrifugal b) axial

c) reciprocating d) both (a) and (b).

vi) The pressure ratio of the modern gas turbine power plant is

a) 5 : 1 b) 10 : 1

c) 15 : 1 d) 20 : 1.

vii) Adding of heat exchanger to a simple ideal cycle

a) improves work output

b) reduces work output

c) improves efficiency

d) improves both efficiency and work output.

viii) The isentropic efficiency of the modern compressor is

a) 65% b) 75%

c) 85% d) 90%.

ix) Pressure rise in a ramjet is achieved by a

a) Diffuser

b) Centrifugal Compressor

c) Axial flow Compressor

d) None of these.

x) Large amount of combustion takes place in a combustor in the

a) primary zone b) secondary zone

c) dilution zone d) in all places.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. State the assumptions made in an ideal cycle analysis of gas turbines. How are the actual cycles different from ideal cycles ?

3. Mention the various advantages and disadvantages of a turboprop engine.

4. Briefly explain the process of combustion in a gas turbine combustion chamber.

5. Mention the advantages and disadvantages of gas turbine engine over reciprocating engines.

6. Derive the expression of specific work output and the efficiency of a simple cycle with a heat exchanger.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Derive the expression for specific work output and the efficiency of a simple cycle. Draw their trends as a function of pressure ratio. 5 + 2

   b) A gas turbine cycle has a perfect heat exchanger. Air enters the compressor at a temperature and pressure of 300 K and 1 bar and discharges at 475 K and 5 bar. After passing through the heat exchanger the air temperature increases to 655 K. The temperature of air entering and leaving the turbine are 870°C and 450C. Assuming no pressure drop through the heat exchanger, compute

      i) the output per kg of air

      ii) the efficiency of the cycle

      iii) the work required to drive the compressor. 8

8. a) Define polytropic efficiency. Derive suitable expression for polytropic efficiency. 5

b) A gas turbine operating at a pressure rato of 11.3137 produces zero net work output when 476.354 kJ of heat is added per kg of air. If the inlet air total temperature is 300 K and the turbine efficiency is 71%, find the compressor efficiency and the temperature ratio. Assume, γ = 1.4 and C_p = 1.005 kJ/kg K for the whole cycle. 10

9. A simple turbojet unit operates with a maximum turbine inlet temperature of 1200K, a pressure ratio of 4.25 : 1 and a mass flow of 25 kg/s under design conditions, the following component efficiencies may be assumed :

Isentropic efficiency of compressor : 87%

Isentropic efficiency of turbine : 91·5%

Propelling nozzle efficiency : 96·5%

Transmission efficiency : 98·5%

Combustion chamber pressure loss : 0·21 bar

Assume for air C_{pa} = 1·005 kJ/kg K and γ = 1·4 and for gas C_{pg} = 1·147 kJ/kg K and γ = 1·33.

Calculate the total design thrust. Also calculate the total thrust and specific fuel consumption taking into consideration the nozzle choking condition. Assume that the unit is stationary at sea level, where the ambient condition may be taken as 1 bar and 293 K. Assume air fuel ratio of 50. 15

10. What are the different types of combustors used in gas turbine engines and what are the factors affecting the performance ? Explain the various processes of combustion in combustion chamber. Describe the requirements of the combustion chamber. 4 + 6 + 5

11. What is meant by thrust ? Derive the thrust equation for a general propulsion engine. With a sketch describe the different parts of a turbojet engines. What are the advantages and disadvantages of turboject engines ?

3 + 7 + 5

12. a) Show the variation of isentropic efficiency for various polytropic efficiency as a function of pressure ratio. 5

b) In a gas turbine plant air enters the compressor at 1 bar and 7° C. It is compressed to 4 bar with isentropic efficiency of 82%. The maximum temperature

at the inlet to the turbine is 800°C. The isentropic efficiency of the turbine is 85%. The calorific value of the fuel used is 43.1 MJ/kg. The heat losses are 15% of the calorific value. Calculate the following :

i) Compressor work in kJ/kg

ii) Heat supplied in kJ/kg

iii) Turbine work in kJ/kg

iv) Net work in kJ/kg

v) Thermal efficiency

vi) Air/Fuel ratio

vii) Spcific fuel consumption in kg/k Wh

viii) Ratio of compressor work to turbine work. 10