Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (EE-N)/SEM-4/ME(EE)-411/2011

2011

THERMAL POWER ENGINEERING

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) A safety valve mainly used with locomotive and marine boilers is

      a) lever safety valve

      b) high pressure and low water safety valve

      c) dead weight safety valve

      d) spring loaded safety valve.

   ii) When the enthalpy or total heat of steam is h kJ/kg and the enthalpy or sensible heat of feed water is h_{f1} kJ/kg, then the factor of evaporation is given by

      a) $\frac{h - h_{f1}}{2257}$ b) $\frac{h + h_{f1}}{2257}$

      c) $\frac{h \times h_{f1}}{2257}$ d) $\frac{h \pm h_{f1}}{2257}$.

iii) The constant pressure gas turbine works on

a) Rankine cycle b) Carnot cycle

c) Brayton cycle d) Any of these.

iv) A carburettor is used to supply

a) petrol, air and lubricating oil

b) air and diesel

c) petrol and lubricating oil

d) petrol and air.

v) The basic limitation of natural circulation boilers is that they

a) operate at sub-critical pressure only

b) operate at supercritical pressure only

c) are large requiring large footprint & head space

d) are unreliable in load following characteristic.

vi) The open hydraulic system

a) has one drum to separate water from steam as well as to act as a reservoir to provide working fluid circulation

b) has two drums — one steam drum and one mud drum

c) has no drum at all

d) operate by virtue of density difference of its working fluid.

vii) For supersonic flow, a convergent passage acts as a

a) diffuser

b) nozzle

c) diffuser or nozzle, depending on Mach number

d) none of these.

viii) When the steam entering a nozzle is dry and saturated, the value of critical pressure ratio is

a) 0·528 b) 0·487

c) 0·577 d) none of these.

ix) When $M = 1$ occurs at the throat, the flow is called

a) choked flow b) steady flow

c) stagnation flow d) none of these.

x) From the same compression ratio the efficiency of Otto engine is

a) more than the efficiency of diesel engine

b) less than the efficiency of diesel engine

c) equal to the efficiency of diesel engine

d) none of these.

GROUP – B

(Short Answer Type Questions)

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

2. a) Define the following :

   i) Equivalent evaporation

   ii) Factor of evaporation.

   b) Define and classify heat engines. 3 + 2

3. What are the basic elements of an electrostatic precipitator ? State in brief its working principle. 2 + 3

4. A gas turbine unit has a pressure ratio of 6 : 1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0·80 and 0·82 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when air enters the compressor at 15°C at the rate of 16 kg/s. Take $C_p = 1 \cdot 005$ kJ/kg K, γ = 1·4 for the compression process. Take $C_p = 1 \cdot 11$ kJ/kg K, γ = 1·33 for the expansion process. 5

5. a) What is the difference between ultimate analysis and proximate analysis of coal ?

   b) How does the percentage moisture affect the quality of coal ?

   c) How does sulphur occur in coal ?

   d) What is the effect of volatile matter in the combustion process ? 1 + 1 + 1 + 2

6. Derive the efficiency of Petrol engine air standard cycle. 5

7. Prove that the condition of maximum discharge through nozzle is given by $\frac{P_2}{P_1} = \left[\frac{2}{n+1}\right]^{\frac{n}{n-1}}$. 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

8. a) Show condition for maximum efficiency of a 50% reaction turbine is given by $\eta_{max} = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$, where α is the angle at which the steam enters the blade.

   b) What are the methods of governing a steam turbine ? Describe any one methods of governing of steam turbine. 7 + 8

9. An impulse stage of a turbine has two rows moving blades separated by fixed blades. The steam leaves the nozzle at an angle of 20° with the direction of motion of blades. The blade exit angles are : first moving 30°, fixed 22° and second moving 30°. If the isentropic heat drop for the nozzle is 186 kJ/kg and nozzle efficiency is 90%, find the blade speed necessary if the final velocity of steam is to be axial. Assume a loss of 15% in relative velocity for all blade passages. Find also the blade efficiency and stage efficiency. 15

10. Air is drawn in a gas turbine unit at 15°C and 1·01 bar and pressure ratio is 7:1. The compressor is driven by the H.P. turbine and L.P. turbine drives a separate power shaft. The isentropic efficiencies of compressor and the H.P. and L.P. turbines are 0·82, 0·85 and 0·85 respectively. If the maximum cycle temperature is 610°C calculate :

    i) The pressure and temperature of the gases entering the power turbine

    ii) The net power developed by the unit per kg/s mass flow

    iii) The work ratio

    iv) The thermal efficiency of the unit.

    Neglect the mass of the fuel and assume the following :

    For the compression process $c_{pa} = 1 \cdot 005$ kJ/kg K and $\gamma = 1{\cdot}4$.

    For the combustion and expansion process :

    $c_{pg} = 1 \cdot 15$ kJ/kg K and $\gamma = 1{\cdot}333$. 15

11. a) Define carburetion in I.C. engine.

    b) A reaction turbine uses 9000 kg of steam per hour. At one point in the turbine, the blades are 20 mm high and discharge angle of both fixed and moving blades is 20°. The steam leaves the fixed blade at a pressure of $0 \cdot 32$ N/mm^2 with a dryness fraction of 0·95 and a velocity of 120 m/s. Assume the ratio of axial velocity of flow to blade velocity as 0·70 at entry to and 0·76 at exit from the moving blade, assuming a tip leakage of 6% of the total steam, determine

        i) speed of the turbine in rev/minute

        ii) power developed. 5 + 10

12. a) Describe valve timing for 4-stroke engine.

b) An engine working on the dual cycle has a cylinder bore of 20 cm and stroke of 40 cm. The compression ratio is 14·5 and the pressure ratio of the constant volume heat addition process is 1·5. The constant pressure heat addition cut-off takes place at 4·9 per cent of the stroke. Determine, the air-standard efficiency. (Assume $\gamma = 1{\cdot}4$)

6 + 9

13. a) What is the physical basis of natural draught produced by a chimney ?

b) Prove that the height h_w (in mm of water column) that produces static draught is given by $h_w = 353\,H\left[\frac{1}{T_a} - \frac{1}{T_g}\left(\frac{m_a + 1}{m_a}\right)\right]$, where T_a is the absolute temperature of atmospheric air, T_g is the average absolute temperature of flue gases and m_a is the mass of air supplied per kg of fuel.

c) Prove that the condition for maximum discharge through a chimney is $\frac{T_g}{T_a} = 2\left(\frac{m_a + 1}{m_a}\right)$, where the absolute temperature of atmospheric air is T_a, the average absolute temperature of flue gases is T_g and m_a is the mass of air supplied per kg of fuel. Hence prove that the height $(h_w)_{max}$ (in mm of water column) that produces static draught for maximum discharge is $(h_w)_{max} = \frac{176 \cdot 5\,H}{T_a}$ where the chimney height is H m.

2 + 8 + 5