# ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2007

# THERMAL POWER ENGINEERING

## SEMESTER – 4

Time : 3 Hours ] [ Full Marks : 70

## GROUP – A

## ( Multiple Choice Type Questions )

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Water required for attemperation is taken from

a) boiler drum b) economiser

c) any one of (a) and (b) d) feed pump. ☐

ii) Which of the following types of boiling is desired in Riser of power-plant boiler ?

a) Film boiling b) Nucleate boiling

c) both (a) and (b) d) none of these. ☐

iii) 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) operates by virtue of density difference of its working fluid. ☐

iv) Locomotive boiler is a

a) fire tube boiler b) water tube boiler

c) bent tube boiler d) once through boiler. ☐

v) For 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. ☐

vi) 50% reaction turbine means

a) enthalpy drop in moving blades is same as enthalpy drop in fixed blades

b) enthalpy drop in moving blades is more than enthalpy drop in fixed blades

c) enthalpy drop in moving blades is less than enthalpy drop in fixed blades

d) none of these. ☐

vii) The overall efficiency of thermal power plant is equal to

a) Rankine cycle efficiency

b) Carnot cycle efficiency

c) Regenerative cycle efficiency

d) Boiler efficiency × turbine efficiency × generator efficiency. ☐

viii) Detonation in SI engines can be prevented by

a) decreasing flame speed

b) using fuel having short ignition lag

c) using fuel with lower octane number

d) reducing flame travel distance. ☐

ix) In the Curtis stage of a turbine

a) velocity remains constant

b) pressure remains constant

c) velocity and pressure both remain constant

d) volume of steam remains constant. ☐

x) The value of $K$ for a steam passing through a nozzle depends on

a) back pressure at the exit of nozzle

b) shape of the nozzle

c) state of dryness of steam

d) load on the prime mover. ☐

xi) Balanced draught is created by

a) chimney b) induced and forced draught fan

c) correct air-fuel ratio d) velocity of steam. ☐

xii) The amount of water evaporated in kg/kg of fuel burnt is called

a) equivalent evaporation from and at 100°C

b) evaporation capacity of a boiler

c) boiler efficiency

d) none of these. ☐

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following. $3 \times 5 = 15$

2. Describe briefly different boiler mountings.

3. What are the effects of regeneration on Brayton cycle efficiency ?

4. Derive the expression of power required at the blade to run a turbine.

5. Define and sketch steam nozzle. Explain various types of nozzles in use.

6. Write a short note on electrostatic precipitator with a neat sketch.

7. Discuss the knocking phenomenon in SI and CI engines. Describe Cetane number and Octane number.

## GROUP – C

### ( Long Answer Type Questions )

Answer any *three* questions. $3 \times 15 = 45$

8. a) Derive an expression for the efficiency of Otto cycle in terms of compression ratio. 5

   b) A 6-cylinder diesel engine operates on 4-stroke cycle. The bore of each cylinder is 95 mm and stroke is 120 mm. Speed of engine is 2400 r.p.m. Orifice diameter = 30 mm. Coefficient of discharge, $C_d = 0{\cdot}62$.

   Time to consume 100 c.c. diesel = 19·3 sec. Fuel density = 0·831 gm/c.c. Density of air = 1·17 kg/m$^3$. Manometric water head = 197 mm.

   Brake Drum = 300 mm. Rope diameter = 20 mm. Brake load = 56 kg.

   Calculate,

   i) Brake power

   ii) Brake thermal efficiency if calorific value of diesel is 43000 kJ/kg

   iii) Volumetric efficiency

   iv) Brake mean effective pressure. $4 \times 2\frac{1}{2}$

9. a) Sketch the Babcock and Wilcox boiler neatly and level it. 7

b) Find the number of and length of the superheater coils of 50 mm diameter and 5 mm thick to be provided if the steam at the exit is 60 bar, 50 degree Celcius flows with a velocity of 10 m/s and mass flow rate 80 kg/sec. Due to restriction of material the heat flux in the superheater coils is to be limited to 140 kW/sq.m for superheated steam at $P = 6{\cdot}0$ bar

| *t ( deg.C )* | *v ( cubic m/kg )* | *u ( kJ/kg )* | *h ( kJ/kg )* | *s ( kJ/kg )* |
|---|---|---|---|---|
| 455 | 0·05214 | 2988·9 | 3301·8 | 6·7193 |
| 500 | 0·05665 | 3082·2 | 3422·2 | 6·8803 |
| 550 | 0·06101 | 3174·6 | 3540·6 | 7·0288 |

and at 60 bar for saturated vapour $h = 2784{\cdot}3$ kJ/kg. 8

10. a) Derive an expression for (i) force, (ii) work done, (iii) diagram efficiency in a single stage impulse turbine and draw its velocity diagram. 8

b) Explain the term 'compounding' in steam turbine. Why is compounding needed in steam turbine ? Explain pressure compounded impulse turbine showing pressure and velocity variations along the axis. 7

11. a) During the trial of a single acting oil engine, cylinder diameter 200 mm, stroke 280 mm, working on two-stroke cycle and firing every cycle, the following observations were made :

Duration of trial = 1 hr

Total fuel used = 4·22 kg

Calorific value = 44670 kJ/kg

Proportion of hydrogen in fuel = 15%

Total number of revolutions = 21000

Mean effective pressuure = 2·74 bar

Net brake load applied to a drum of 1 m diameter = 600 N

Total mass of cooling water circulated = 495 kg

Inlet temperature of cooling water = 13°C

Outlet temperature of cooling water = 38°C

Air used = 135 kg

Temperature of air in test room = 20°C

Temperature of exhaust gases = 370°C

Assume ; $C_p$ ( gases ) = 1·005 kJ/kg-K.

$C_p$ ( steam ) at atmospheric pressure = 2·093 kJ/kg-K.

Calculate the thermal efficiency and draw up the heat balance. 8

b) Steam having pressure of 10·5 bar and 0·95 dryness is expanded through a convergent-divergent nozzle and the pressure of steam leaving the nozzle is 0·85 bar. Find the velocity at the throat for maximum discharge conditions. Index of expansion may be assemed as 1·135. Calculate mass rate of flow of steam through the nozzle. 7

12. a) A steam boiler fitted with an economizer generates steam at the rate of 5 ton/ton of coal.

Equivalent evaporation from and at 100°C = 5·5 ton/ton of coal

Boiler feed water temperature at economizer inlet = 100°C

BFW temp. at boiler inlet = 180°C

Temperature of air supplied to the boiler = 30°C

Temperature of flue gases entering the economizer = 400°C

Weight of flue gases produced per ton of dry coal = 15 ton

Mean specific heat of flue gases = 0·2 k.cal/kg/°C

Calorific value of coal = 5400 k.cal/kg.

Determine :

i) the boiler efficiency ( thermal )

ii) the economizer efficiency

iii) the combined efficiency. 8

b) A solid fuel contains 74% carbon and 16% ash. The ash discharge from the furnace contains 20% carbon.

Estimate :

i) the weight of carbon lost in ash per kg of fuel

ii) the percentage of carbon burned

iii) the heat lost by the incomplete combustion. 7