**B.E. (E.E.) Part-III 5th Semester Examination, 2011-12**

# Heat Power (ME-506)

**Time-3 hours** **Full Marks: 70**

**Use separate answer script for each half.**
**Answer SIX questions, taking THREE from each half.**
**The questions are of equal value.**
**Use of Steam Table, Mollier Diagram and Psychrometric Chart allowed.**

## FIRST HALF

1. (a) Classify air compressors. State some uses of compressors and compressed air.
   (b) In a two stage air compressor, in which intercooling is perfect, prove that the work done in compression is a minimum when the intermediate pressure is the geometric mean between the initial and final pressures.
   (c) What are the advantages of multistage compressor?

2. (a) Explain the following terms for compressor :
   (i) Free air delivered (ii) Volumetric efficiency (iii) Isothermal efficiency
   Assuming intake conditions same as free air conditions, find an expression of the volumetric efficiency of a reciprocating compressor.
   (b) The indicated power of a single stage double acting air compressor, running at 130 r.p.m., is 7.25 kW. It takes air at 1.01 bar and delivers at 10.1 bar. Assuming the law of compression and expansion as $PV^{1.35}$ = constant, find the diameter and stroke of the cylinder.
   Take piston speed = 215m/min, volumetric efficiency = 88%. Find also the clearance volume as percentage of stroke volume.

3. (a) What is the difference between internal combustion and external combustion engines? Give example of each.
   (b) Explain any one method of measuring brake power of an I.C. engine.
   (c) During the test on a four cylinder petrol engine, working on the four stroke cycle with a compression ratio of 6 and fitted with a rope brake dynamometer, the following readings are taken:
   Effective brake arm=0.5m, dead load on brake=230N, spring balance reading=30N, indicated mean effective pressure=7bar, engine speed=2500r.p.m., fuel consumption=9kg/s, calorific value of fuel=44000kJ/kg, cylinder bore=85mm, engine stroke=100mm.
   Find (i) i.p. and b.p of the engine (ii) mechanical efficiency (iii) brake thermal efficiency, and (iv) relative efficiency on b.p. basis assuming $\gamma$=1.4.

4. (a) Differentiate between First law and Second law of thermodynamics.
   (b) Deduce the steady flow energy equation, explaining the meaning of each term.
   (c) A steam turbine operating under steady flow condition receives steam at the following state: pressure=13.5bar, specific volume=0.145$m^3$/kg, internal energy=2585kJ/kg, velocity=32m/s. The state of steam leaving the turbine is: pressure=0.38bar, specific volume=4.35$m^3$/kg, internal energy=2345kJ/kg, velocity=94m/s. The rate of heat loss to the surroundings =0.25kJ/s and the rate of steam flow=0.36kg/s.
   Calculate (i) power developed by the turbine (ii) areas of inlet and outlet pipes.

5. Write short notes on any three of the following:
   (a) Morse test.
   (b) Comparison between Two-stroke and Four-stroke cycle engines.
   (c) Brayton cycle.
   (d) Comparison between reciprocating and rotary compressors.
   (e) Classification of internal combustion engines.

## SECOND HALF

*Attempt **Three** questions from this half. All questions carry equal marks. Use of steam table/Mollier diagram allowed.*

6. (a) Define mean temperature of heat addition for a Rankine cycle and briefly discuss, with relevant diagrams, how the performance of a Rankine cycle can be improved.

   (b) Differentiate between closed type and open type feed water heater.
   For a steam power plant operating on a simple non-reheat Rankine cycle the steam enters the turbine at 3 MPa, 400°C and expends isentropically to a condenser pressure of 0.01 MPa. Estimate the specific work output of the turbine. If an open (direct mixing) type feed water heater, operating at an intermediate pressure of 0.4 MPa is introduced which uses turbine extraction steam (at the same pressure) to preheat the condensate up to the corresponding saturation temperature, estimate the required extraction steam quantity per kg of the steam flow at the turbine inlet. Neglect the pumping work.

7. (a) With a neat and labeled diagram, describe a natural circulation water-tube boiler. What are mountings and accessories of a boiler?

   (b) Define 'equivalent evaporation' for a boiler.
   A boiler produces saturated steam at 1.25 MPa at a rate of 1800 kg/h, while feed water is supplied at 50°C. If the coal consumption is 210 kg/h and the CV of coal is 27.4 MJ/Kg, estimate the equivalent evaporation (in kg/kg of fuel) and the thermal efficiency of the boiler.

8. (a) With a neat sketch, briefly describe an evaporative condenser.

   (b) Define 'vacuum efficiency' for a surface condenser and state how air leakage into a vacuum condenser affects its performance.
   The condenser trial run at a power plant gave the following operating data:

| | |
|---|---|
| Condenser vacuum reading: | 680 mm Hg |
| Barometer reading: | 764 mm Hg |
| Mean condenser temperature: | 36°C |
| Cooling water inlet temperature: | 20 °C |
| Cooling water outlet temperature: | 32 °C |

Find out the following performance parameters for the condenser:

(i) Partial pressure of air and that of steam
(ii) Mass of air present per cubic meter of condenser volume
(iii) Vacuum efficiency and
(iv) Corrected vacuum w.r.t. standard barometer

Assume, $R_a = 0.287$ kJ/kg-K and 1 mm Hg = $1.33 \times 10^{-3}$ bar = 0.133 kPa

9. (a) Show that for steam flow through frictionless adiabatic nozzle, neglecting the velocity at the inlet, the exit velocity (V) is given by the relation:

$$V = 44.72\sqrt{\Delta h}$$

Where, $\Delta h$ is drop of specific enthalpy and V is measured in m/s.

(b) Justify the requirement of a divergent section in a supersonic nozzle, using the expression describing the interrelation among the change in pressure, change in fluid velocity and the flow Mach number.
Define critical pressure ratio for a steam nozzle and find its value considering superheated steam flow, assuming n = 1.3.

10. (a) Define Wet Bulb Temperature (WBT) and Dew Point Temperature (DPT) and differentiate between the two using a relevant T-S or a psychrometric diagram. At what condition of air, both the temperature will have the same value?

(b) Ambient air condition at a certain point of time on a day is recorded as 35°C DBT and 40% RH. Find the corresponding vapor partial pressure, specific humidity and the dew point temperature. Also, estimate the specific enthalpy of the moist air.