Code No. : 5203/S

FACULTY OF ENGINEERING

B.E. IV/IV (Mech.) I Semester (Suppl.) Examination, June 2012

THERMAL TURBO MACHINES

Time: 3 Hours] [Max. Marks : 75

Note : *i) Answer **all** questions in Part **A** and **any five** questions from Part **B**.*

*ii) Answer to the questions of Part – **A** must be at **one** place and in the **same** order as they occur in the question paper.*

*iii) Missing data if **any** may **suitably** be assumed.*

*iv) Use of data of book is **permitted**.*

PART – A **(25 Marks)**

1. Define Mach cone and Mach angle.
2. Draw Fanno curve on h-s plane and prove that at maximum entropy point, the velocity of fluid is sonic velocity.
3. Draw velocity diagram for centrifugal compressor with radial blade, backward and forward impellers.
4. Why compounding is required for impulse turbine ?
5. Draw the schematic diagram and temperature-entropy diagram for open-cycle gas turbine with inter cooling.
6. If the flow is sub-sonic, how area of cross sections of nozzle and diffuser will vary ?
7. How normal shock is formed ?
8. Define surging of a compressor.
9. Draw pressure-velocity variations across the blades in s-stage velocity compounded impulse turbine.
10. Why pre-whirl is used for centrifugal compressor ?

PART – B

(50 Marks)

11. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperatures at exit and entry is 3.74. If the pressure and temperature of the gas at exit are 2.5 bar and 1273 K respectively, determine

   i) Mach number, pressure and temperature of the gas at entry

   ii) The heat supplied per kg of the gas and

   iii) Maximum heat, that can be supplied.

12. a) Derive an expression for adiabatic energy equation and from that deduce Prandtl-Meyer relation for normal shock flow.

   b) The ratio of exit to entry area in a subsonic diffuser is 4.0. The Mach number of a jet of air approaching the diffuser at p_0 = 1.013 bar, T = 290 K is 2.2. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine the

      i) Mach number, temperature and pressure at the exit of the diffuser and

      ii) The stagnation pressure loss between the initial and final states of the flow. Depict graphically the static and stagnation pressure variation from the diffuser entry to diffuser exit.

13. A centrifugal compressor running at 9000 rpm delivers 600 m^3/min of free air. The air is compressed from 1 bar and at 293 K to a pressure of 4 bars with an isentropic efficiency of 82%. Blades are radial at outlet of impeller and the flow velocity of 62 m/s is assumed constant throughout the impeller. The outer radius of impeller is twice the inner radius and slip factor is assumed as 0.9. The blade loading coefficient of 0.9 may be assumed at inlet. Determine :

   i) final temperatures of air,

   ii) theoretical power required

   iii) impeller diameters at inlet and outlet

   iv) breadth of impeller at inlet

   v) impeller blade angle at inlet and

   vi) diffuser blade angle at inlet.

14. For one stage of an impulse turbine, isentropic nozzle heat drop = 185kJ/kg, nozzle efficiency = 90%, nozzle angle = 20°, velocity coefficient = 0.95, velocity of steam at the entry of nozzle is 30 m/s, rate of blade speed to whirl component of steam speed is 0.5, find

    a) blade angles if the steam leaves axially,

    b) work done per kg of steam,

    c) friction loss over the blades per kg of steam

    d) kinetic energy loss per kg of steam,

    e) blade efficiency,

    f) power developed, and

    g) axial thrust, if the steam flow rate is 10 kg/sec.

15. Air enters at 1 bar and 15°C into the compressor at constant pressure open cycle gas turbine plant and leaves the compressor at 6 bars. Temperature of the gases entering the turbine = 700° C. Pressure losses in the combustion chamber = 0.1 bar, Isentropic efficiency of the compressor = 80%, Isentropic efficiency of the turbine = 80%, Efficiency of the combustion = 90%, Take $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg-K for the air and gases. Find

    i) The quantity of the air circulation in the system, if the plant develops 1200 kW,

    ii) Heat supplied per kg of air circulation and

    iii) Thermal efficiency of the cycle. Neglect the mass of the fuel.

16. Explain the working principle of Pulse-jet and compare its salient features with Ram-jet with neat sketches.

17. An axial flow compressor having 8 stages and with 50% reaction design compresses air in the pressure ratio of 4 : 1. The air enters the compressor at 20° C and flows through it with a constant speed of 90 m/s. The compressor rotates with a mean blade speed of 180 m/s. Assume isentropic efficiency of compressor is 82%, $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg-K, calculate

    i) work done on the compressor and

    ii) blade angles.
