Code No. : 5203

FACULTY OF ENGINEERING

B.E. IV/IV (Mech.) I – Semester (Main) Examination, December 2011

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 impulse function.
2. Draw Reyleigh curve on h-s plane and prove that at maximum entropy point, the velocity of fluid is sonic velocity.
3. Define surging of compressor and what are its affects.
4. Draw pressure-velocity variations across the blades in three pressure compounded impulse turbine.
5. Draw the configuration diagram and temperature-entropy diagram for open cycle gas turbine with regeneration.
6. Define propulsive efficiency and thermal efficiency of jet propulsion system.
7. Define stalling of compressor.
8. How blade efficiency, nozzle efficiency and stage efficiency of steam turbines are inter-related ?
9. List of the differences between the axial flow compressor and centrifugal compressor.
10. Express the ratio of stagnation temperature to static pressure in terms of Mach number for isentropic flow.

PART – B

(50 Marks)

11. A convergent-divergent nozzle is provided with a pipe of constant cross section at its exit : the exit diameter of the nozzle and that of the pipe is 40 cm. The mane coefficient of friction for the pipe is 0.0025. Stagnation pressure and temperature of air at the nozzle entry are 12 bar and 600 K respectively. The flow is isentropic in the nozzle and adiabatic in the pipe. The Mach numbers at the entry and exit of the pipe are 1.8 and 1.0 respectively. Determine:
    i) the length of the pipe
    ii) diameter of the nozzle throat
    iii) pressure and temperature at the pipe exit depict graphically the static and stagnation pressure variation from the nozzle entry to the pipe exit.

12. A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bars, 340 K and 180 m/s respectively. Determine :
    i) the pressure and velocity at exit
    ii) stagnation pressure and stagnation temperature and
    iii) force exerted on the diffuser walls.

13. 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 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.

14. In a Parsons reaction turbine running at 1500 rpm, the available enthalpy drop of steam for the expansion is 65 kJ/kg. If the mean diameter of the rotor is 1 metre, find the number of the rows of the moving blade required. Assume stage efficiency as 80%, blade outlet vane angle is 20° and speed ratio is 0.7.

15. In an open cycle constant pressure gas turbine, air enters the compressor at 1 bar 300 K. The pressure ratio is 4:1. The isentropic efficiencies of compressor and turbine are 78% and 85% respectively. The air fuel ratio is 80:1, calculate the power developed and thermal efficiency of the cycle if the flow rate of air is 2.5 kg/sec. Assume Cp = 1.005k J/kg-K, $\gamma = 1.4$ for air, Cpg = 1.147 k J/kg-K. $\gamma = 1.33$ for gases. R = 0.287 k J/kg-K, calorific value of fuel is 42000 kJ/kg.

16. A single eye, single stage centrifugal compressor delivers 18 kg of air per second with a pressure ratio of 4, when running at 14500 rpm. The pressure and temperature of the air at the suction side are 1.013 bar and 16°C. Assume slip factor = 0.9, work input factor = 1.04, isentropic efficiency = 7.5%. Find :

    i) the input power required to drive the compressor and

    ii) blade angle at the impeller eye, if the root and tip diameter are 15 cm and 35 cm respectively.

17. 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_o = 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.