Code No. 9204

FACULTY OF ENGINEERING

B.E. 4/4 (Mech.) I – Semester (Main) Examination, Dec. 2014 / Jan. 2015

Subject: Thermal Turbo Machines

Time: 3 Hours **Max.Marks: 75**

Note: *i) Answer all questions from Part A. Answer 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) Candidate is advised not to attempt more questions than required.
iv) Missing data if any may suitably be assumed.
v) Use of data of book is permitted.
vi) Unless otherwise stated γ =1.4, Cp=1.005 kJ/kg.

PART – A (10x2.5 = 25 Marks)

1 Express sound velocity in terms of bulk modulas.
2 Prove that at maximum entropy point on Rayleigh curve, the velocity of fluid is sonic.
3 Explain flow through convergent-divergent nozzle and how normal shocks are formed.
4 Define cone angle and explain velocity of sound in different regions of fluid flow.
5 Define slip factor of compressor with neat diagram.
6 Define degree of reaction of compressor and how it is different from turbines.
7 Draw pressure-velocity variations across the blades in pressure compounded impulse turbine.
8 Define friction loss and thrust developed by steam turbine.
9 Draw the configuration diagram and temperature-entropy diagram for open cycle gas turbine with regeneration.
10 List out the merits and demerits of solid propellant over liquid propellant.

PART – B (5x10 = 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 mean 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 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 exist.

13 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 receptively. Determine (i) the pressure and velocity at exit, (ii) stagnation pressure and stagnation temperature and (iii) force exerted on the diffuser walls.

14 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 impellor and the flow velocity of 62 m/s is assumed constant throughout the impellor. The outer radius of impellor is twice the inner radius and slip factor is assumed as 0.9. The blade area coefficient of 0.9 may be assumed at inlet. Determine: (i) final temperatures of air, (ii) theoretical power required (iii) impellor diameters at inlet and outlet, (iv) breadth of impellor at inlet (v) impellor blade angle at inlet and (vi) diffuser blade angle at inlet.

15 An axial flow compressor with an overall isentropic efficiency of 85% draws air at 20^{o}C and compresses it in the pressure ratio of 4:1. The mean blade speed and flow velocity are constant throughout the compressor. Assume 50% reaction blading and taking blade velocity as 180 m/s and work input factor as 0.82, calculate (i) flow velocity and (ii) number of stages. Assume $\alpha = 12^{o}$ and $\theta = 42^{o}$.

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

17 In an open cycle constant pressure gas turbine, air enters the compressor at 1 bar and 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 = 1.005 kJ/kg-K, γ = 1.4 for air, Cpg = 1.147 kJ/kg-K, γ =1.33 for gases, R = 0.287 kJ/kg-K, Calorific value of fuel = 42 MJ/kg.

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