U.S.N | | | | | | | | | | |

P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

Fifth Semester, B.E. - Mechanical Engineering

Semester End Examination; Dec. - 2014

Turbo Machines

Time: 3 hrs *Max. Marks: 100*

***Note** : i) Answer any **FIVE** full questions selecting at least **TWO** full questions from each part.*
ii) Assume suitable missing data if any.

PART - A

1. a. Derive alternate form of Euler's turbine equation and explain each energy component 10

   b. Define degree of reaction. Draw the velocity triangles for the following values of degree of reaction. (i) R = 0.5 (ii) R =1 10

2 a. Define utilization factor and vane efficiency. 4

   b. Derive an expression for the relation between degree of reaction and utilization factor. 10

   c. Air flows axially through an axial flow turbine at a mean radius of 0.2 m. If tangential component of absolute velocity is reduced by 20 m/s during its passage through the rotor, find the power developed by the turbine for flow rate of 100 m^3/s at a point, where the pressure and temperature are 1 bar and 27° C. The rotational speed of the rotor is 3000 rpm. ρ =1.16 kg/m^3. 6

3 a. Obtain an expression as shown below for energy Transfer E and degree of relation R as a function of discharge blade angle β_2 for a turbo machine. Sketch the nature of variation of E and R with respect to β_2 as it varies from 0° to 180° and discuss the salient features of the graph. 12

$$E = 2V_{f_2}^2 \left(\cot\beta_2 - 2\right) \qquad R = \frac{2+\cot\beta_2}{4}$$

   b. In an inward flow turbine, the water falls with a velocity of 30 m/s on a runner with a series of curves vanes. The runner rotates at 280 rpm. The vanes have inlet and outlet diameters of 1.7 m and 0.85 m. The angle of the guide makes with the periphery of the wheel is 30°. Water after doing work on the runner discharges with an absolute velocity of 3 m/s at an angle of 130º to the wheel tangent. Find the power developed by the runner if the rate of flow is 380 lit/sec. Also find the vane angles at inlet and outlet. 8

4 a. Define: 6

   (i) Slip factor (ii) Power input factor (iii) Pressure coefficient

   b. Explain briefly: 6

   (i) Compressor Stall (ii) Surge

Contd…2

c. An axial compressor has the following data. Entry condition 1 bar 20°C, degree of reaction - 50%, Mean blade ring diameter =36 cm. rotation speed =18000 rpm, Blade height at entry – 6 cm, blade angle at rotor and stator exit = 65°, axial velocity = 180 m/s, mechanical efficiency = 0.967. 8

Find: (i) Blade angle at rotor and stator inlet (ii) Power required to drive the compressor.

PART – B

5 a. Derive an expression for the maximum hydraulic efficiency of a Pelton wheel in terms of bucket velocity coefficient and discharge blade angle. 10

b. A Pelton wheel has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 lit/sec under a head of 30 m. The jet deflects at an angle of 160°. Calculate the power and efficiency of the turbine. Assume $C_v = 0.98$. 10

6 a. The following data is given for a Francis turbine, net head = 70 m, speed = 600 rpm, shaft power = 370 kW, $n_0 = 0.80$, $n_H = 0.95$, flow ratio = 0.25, breadth ratio = 0.1, outer diameter of the runner = 2 x inner diameter of the runner. The thickness of vanes occupies 10% circumferential of the runner. Velocity of flow is constant and discharge is radial at outlet. Determine: i) Guide blade angle ii) Runner angle at inlet and outlet iii) Diameter of the runner at inlet and outlet iv) Width of the wheel at inlet. 12

b. A Kaplan turbine produces 30000 kW under a head of 9.6 m while running at 65.2 rpm. The discharge through the turbine is 350 m^3/s. The diameter of the runner is 7.4 m. The hub diameter is 0.432 times the tip diameter. Calculate: i) Turbine efficiency ii) Specific speed of turbine iii) Speed ratio based on tip diameter iv) Flow ratio. 8

7 a. What is compounding of steam turbine? Explain with the help of a schematic diagram a two row velocity compounded turbine stage. 10

b. An axial flow single stage steam turbine has a mean rotor diameter of 55 cm and runs at 3300 rpm. The speed ratio is 0.45 and blade velocity coefficient is 0.91. If the nozzle angle at the rotor inlet is 20°, Find: i) Rotor blade angles assuming axial exit ii) Draw the inlet and exit velocity triangles iii) Power output per unit mass flow rate. 10

8 a. Explain in brief: i) Priming ii) Cavitation in pums 6

b. Define the following: i) Suction head ii) Delivery head iii) Manometric head iv) NPSH 4

c. A centrifugal pump runs at 950 rpm. Its outer and inner diameter are 500 mm and 250 mm. The vanes are set back at 35° to the wheel/rim. If the radial velocity of water through the impeller is constant at 4 m/s. Find the angle of vane at inlet, the velocity and direction of water at outlet and work done by the impeller per kg. Entry of water at inlet is radial. 10

* * * * *