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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. - 2015

Turbo Machines

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting at least **ONE** full question from each unit.*
ii) Assume suitably missing data if required

UNIT - I

1 a. Derive Euler's turbine equation and hence obtain the alternate form of Euler turbine equation. 10

b. An inward flow radial reaction turbine has axial discharge at outlet with outlet blade angle 45º.The radial velocity of flow is constant. The blade speed at the inlet is twice that at exit. Express the energy transfer per unit mass and degree of reaction in terms of inlet angle α_1. Assume $V_m = (2g_c)^{1/2}$. At what values of α_1 will the degree of reaction be zero and unity? What are the corresponding values of energy transfer for unit mass? 10

2 a. Define:
(i) Degree reaction ii) Utilization factor 4

b. Show that utilization factor is, 6

$$\Sigma = \frac{v_1^2 - v_2^2}{v_1^2 - Rv_2^2}$$

c. Water enters on inward flow turbine at an angle of 22º to the tangent is the outer rim and leaves the turbine radially. The speed of the wheel is 300 rpm and the velocity of flow is constant, 3 m/s. Find the necessary angles of the blades when the inner and outer diameter of the turbine are 30 cm and 60 cm respectively. If the width of the wheel at the inlet is 15 cm. Calculate the power developed. Thickness of the blade can be neglected. 10

UNIT - II

3 a. With a neat sketch explain the working of principle of a Pelton Turbine. 6

b. Define:
(i) Hydraulic efficiency (ii) Volumetric efficiency of a hydraulic turbine. 4

c. For a Pelton wheel the speed is 900 rpm, the speed ratio is 0.448. The available head is 100 m. The discharge through the nozzle is 40 lt/sec, the coefficient of velocity is 0.98. If the overall efficiency of the turbine is 0.8 find; 10
(i) Power developed (ii) Specific speed
(iii) Blade speed (iv) Impeller diameter (v) Jet diameter

4 a. For a Pelton turbine prove that the $\eta_{max} = \frac{1 + c_b Cos\beta_2}{2}$ 10

Contd…2

b. A Pelton wheel is to be designed for a head of 60 m, when running at 200 rpm. The Pelton wheel develops 95.55 kW. The velocity of bucket is 0.45 times the velocity of the jet, the overall efficiency is 0.85 and efficient of velocity is equal to 0.98. Find the diameter of the jet, diameter of the wheel and the number of buckets on the wheel. 10

5 a. What is draft tube? Explain the functions of a draft tube. 4

b. Derive the expression for the efficiency of the draft tube. 6

c. A Francis turbine working under a head of 260 m develops 16118 kW at a speed 600 rpm. The volume flow rate through the machine is 7 m^3/s. If the outer diameter of the wheel is 1.5 m and axial width at the inlet is 13.5 cm. Find; 10

(i) Overall turbine efficiency (ii) Hydraulic efficiency (iii) The inlet angle of guide blades and the rotor blades. Assume $\eta_{vol} = 0.98$, velocity at the exit of the draft tube is 17.7 m/s.

6 a. With a neat sketch show the sectional arrangement of a Kaplan turbine. 6

b. A Kaplan turbine produces 58,800 kW under a head of 25 m which has an overall efficiency of 90%. Taking the value of speed ratio $\phi = 1.6$, flow ratio $\Psi = 0.5$ and hub diameter is 0.35 times the outer diameter. Find the diameter and the speed of the turbine. 6

c. A conical draft tube having inlet and outlet diameter 1.5 m and 1.75 m respectively discharge water at outlet with a velocity of 3 m/s. the total length of the draft tube is 6.5 m and 1.5 m is immersed in water. If the frictional losses in draft tube is 0.25 x velocity head at outlet. Calculate the pressure head at, the runner outlet and efficiency of draft tube. 8

UNIT - IV

7 a. Explain the need for compounding. Explain pressure compounded impulse turbine. 10

b. In a Parson's turbine running at 1500 rpm the available enthalpy drop for an expansion is 63 kJ/kg. If the mean diameter of the rotor is 100 cm. Find the number of moving rows remained. Assume η stage as 0.8, blade outlet angle 20º and speed ratio 0.7. 10

8 a. Show that the maximum blade efficiency is given by $\eta_{blade,\max} = \frac{\cos^2\alpha_1}{2}\left(1+C_bK\right)$. 10

b. One stage of an impulse turbine consists of a nozzle and one ring of moving blade. The nozzle is machined 22º and the blade tip angles are both 35º,

(i) If the velocity of steam at the exit from the nozzle is 660 m/s find the blade speed and diagram efficiency neglecting losses. 10

(ii) If the relative velocity of steam is reduced by 15% in passing through the blade ring, find the efficiency and end thrust on the shaft when the blade ring develops 1700 kW.

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UNIT - V

9 a. Explain:
(i) Static head (ii) Manometric head. 4

b. Explain the various losses occurring during operation of a centrifugal pump. 6

c. A centrifugal pump having outer diameter equal to 2 times the inner diameter and running at 1000 rpm working against ahead of 30 m. The velocity of flow through the impeller is constant and equal to 2.5 m/s. The vanes are set back at an angle of 40º at the outlet. If the outer diameter is 50 cm and the width at the outlet is 5 cm. Calculate; 10
(i) Vane angle at inlet
(ii) Work done by the impeller on water per second
(iii) Manometric efficiency

10 a. Explain:
(i) Monometric efficiency
(ii) Mechanical efficiency
(iii) Overall efficiency of a centrifugal pump. 6

b. Sketch and explain different type of centrifugal pump casing. 6

c. A centrifugal pump is to discharge 0.118 m^3/s of water at a speed of 1450 rpm against a head of 2.5 m the impeller diameter is 25 cm and its width at the outlet is 5 cm and manometric η is 75%, calculate the vane angle at the outlet. 8

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