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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 - 2016/Jan - 2017

Turbo Machines

Time: 3 hrs *Max. Marks: 100*

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

UNIT - I

1 a. Define and classify turbo machines and compare them with positive displacement machines. 10

b. An inward flow radial reaction turbine has axial discharge at outlet with outlet blade angle 45^{o}. 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 $U_m = (2g_c)^{1/2}$. At what values of α_1 will degree of reaction be zero and unity? What are the corresponding values of energy transfer for unit mass? 10

2 a. Derive the relation between utilization factor and degree of reaction. 6

b. Compare impulse and reaction turbine. 4

c. In an inward radial flow hydraulic turbine, water enters with absolute velocity of 15 m/s with nozzle angle of 15º. The speed of the rotor is 400 rpm. The diameter of the rotor at inlet is 75 cm and diameter at the outlet is 50 cm. The fluid leaves the rotor radially with an absolute velocity of 5 m/s. Determine; 10

i) The blade angles ii) Energy transfer per unit mass

iii) Degree of reaction and utilization factor.

UNIT - II

3 a. Derive and explain all the unit quantities and explain their significance. 10

b. A Pelton wheel has a mean bucket speed of 10 m/s with jet water flowing at a rate of 700 lit/s, under a head of 30 m. The buckets deflect the jet through an angle of 160º. Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0.98. 10

4 a. For a Pelton wheel derive the condition for maximum efficiency. 10

b. A Pelton wheel is having a mean bucket diameter of 1 m and is running at 1000 rpm. The net head on the Pelton wheel is 700 m. If the clearance angle is 15º and discharge through nozzle is 0.1 m^3/s. Find; 10

i) Power available at the nozzle ii) Hydraulic efficiency of the turbine.

Contd….2

UNIT - III

5 a. Explain construction and working of Francis turbine. 10

b. An inward flow reaction turbine has a exist diameter of 1 m and its breadth at inlet is 250 mm. If the velocity of flow at inlet is 2 m/s, find the mass of water passing through the turbine per second. Assume 10% of area of flow is blocked by blade thickness. If the speed of the runner is 210 rpm and guide blades make an angle of 10º to the wheel tangent, draw the inlet velocity triangle and find; 10

i) The runner vane angle at inlet ii) Velocity of wheel at inlet

iii) The absolute velocity of water leaving the guide vanes

iv) The relative velocity of water entering the runner blade.

6 a. Define and derive the expression for the efficiency of the draft tube. 4

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

c. The hub diameter of a Kaplan turbine working under a head of 12 m is 0.35 times the diameter of runner. The turbine running at 100 rpm. If the vane angle of the extreme edge of runner at inlet is 15º and flow ratio is 0.6. Find; 10

i) Diameter of the runner ii) Diameter of boss iii) Discharge through the runner

The velocity of whirl at outlet is given as zero.

UNIT - IV

7 a. Explain need for compounding and explain pressure-velocity compounding. 10

b. A single stage impulse steam turbine has a diameter of 1.5 m and running at 3000 rpm. The nozzle angle is 20º, speed ratio is 0.45, Ratio of relative velocity at the outlet to that at inlet is 0.9. The outlet angle of the blade is 3º less than the inlet angle. Steam flow rate is 6 kg/s. Draw the velocity diagram and find the following : 10

i) Velocity of whirl ii) Blade angles

iii) Axial thrust iv) Power developed.

8 a. Show that for a steam turbine, maximum blade efficiency, with usual notations is given by,

$$\eta_{blad\ max} = \left[\frac{\cos^2 \alpha_1}{2}\right]\left[1 + C_b k\right].$$ 10

b. The following data refers to a particular state of a Parson's reaction turbine,

Speed of the turbine – 1500 rpm, Maximum diameter of rotor – 1m

Stage efficiency – 0.8, Blade outlet angle – 20º 10

Speed ratio – 0.7

Determine the available isentropic enthalpy drop in the stage.

Contd….3

UNIT - V

9 a. Define the following with respect to centrifugal pump :

i) Overall efficiency

ii) Static head

iii) Manometric head

iv) Net positive suction head

v) Manometric efficiency — 10

b. For a centrifugal pump show that the pressure rise in the impeller neglecting the friction and other losses is given by $\frac{1}{2g}\left[v_{f_1}{}^2 + u_2^2 - v_{f_2}{}^2 \cos ec^2\phi\right]$ — 10

Where, v_{f_1} *and* v_{f_2} are velocities of flow at inlet and outlet, u_2 is tangential velocity of the impeller at outlet and φ is Vane angle at outlet.

10 a. Derive an expression for the minimum speed for starting a centrifugal pump. — 8

b. Explain priming and NPSH in pumps. — 4

c. A centrifugal pump is running at 1000 rpm the outlet Vane angle of the impeller is 45° and velocity of flow at outlet is 2.5 m/s. The discharge through the pump is 200 *lt*/sec, when the pump is working against a total head of 20 m. If the manometric efficiency of the pump is 80%. Determine; — 8

i) Diameter of the impeller,

ii) Width of the impeller at the outlet.

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