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

(An Autonomous Institution affiliated to VTU, Belagavi)

Fifth Semester, B.E. - Mechanical Engineering

Semester End Examination; February / March - 2022

Turbomachines

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Missing data, if any, may suitably assume.

UNIT - I

1 a. Define turbomachines and explain any two classifications of turbomachines. 6

b. Derive Euler turbine equation as applied to a generalized rotor of a machine. 6

c. Define utilization factor and degree of reaction. Derive an expression relating utilization factor with degree of reaction. 8

2 a. Differentiate between positive displacement machine and turbomachines. 10

b. A radial outward flow turbomachines has no inlet whirl. Inlet blade angle is 45°, blade speed at exit is twice that at inlet and radial velocity is constant throughout, prove that the degree of reaction $R = \frac{2 + Cot\phi}{4}$ where ϕ is the blade angle at exit with respect to tangential direction. 10

UNIT - II

3 a. Define unit discharge, unit speed and unit power and derive the expression for the same. 9

b. Design a Pelton wheel for a head of 380 m and speed 750 rpm. The Pelton wheel develops 11772 kW. Take coefficient of velocity 0.985, speed ratio 0.45, overall efficiency 86% and jet diameter is not to exceed one-sixth of the wheel diameter. 11

4 a. Show that the maximum hydraulic efficiency of Pelton wheel is given by,

$\eta_{H\max} = \frac{1 + KCot\ \phi}{2}$, where K is bucket friction factor and ϕ is bucket angle at exit. 10

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

UNIT - III

5 a. Outline a neat sketch of Francis turbine and label the parts. Draw the velocity triangles Francis turbine. 10

b. A Kaplan turbine develops power of 30000 kW under head of 9.6 m while running at 65.2 rpm. The discharge through the turbine is 350 m^3/s. The tip diameter of the runner is 7.4 m. The hub diameter is 0.432 time the tip diameter. Calculate; 10

i) The turbine efficiency ii) The specific speed of the turbine

iii) The speed ratio iv) Flow ratio

Contd... 2

6 a. Define the following with reference to radial flow turbine: 10

i) Mechanical efficiency ii) Hydraulic efficiency iii) Flow ratio iv) Radial discharge v) Efficiency of draft tube

b. The hub diameter of a Kaplan turbine working under head of 12 m is 0.35 times the diameter of the runner. The turbine is running at 100 rpm. If the vane angle of the extreme edge of the runner at outlet is 15° and flow ratio is 0.6. Find the diameter of the runner, diameter of the boss and discharge through the runner. 10

UNIT - IV

7 a. Why compounding is done in steam turbine? With the help of schematic diagram, explain pressure compounding consisting of two steam stages. 8

b. The steam velocity leaving the nozzle to a De Laval turbine is 1000 m/s and the nozzle angle is 20°. The mean blade velocity is 400 m/s. The blades are symmetrical. Mass flow rate is 1000 kg/h, friction factor is 0.8 and nozzle efficiency is 0.95. Calculate the work done, the diagram efficiency, power developed and the stage efficiency. 12

8 a. Derive an expression for maximum diagram efficiency (blade efficiency) in a single stage impulse turbine. 10

b. The following data refers to a stage of a Parson's steam turbine.

The mean diameter of the blade is 70 cm, the steam velocity at inlet of moving blade is 160 m/s, the outlet blade angle of moving blade is 20°, the steam flow through the blades is 7 kg/s, speed 150 rpm and stage efficiency is 0.8. Draw velocity diagram and find the following: 10

i) Blade inlet angle

ii) Power developed in the stage

iii) Available isentropic enthalpy drop

UNIT - V

9 a. With a neat sketch, explain the different types of centrifugal pump casings. 10

b. A centrifugal pump with OD = 0.6 m and ID = 0.3 m runs at 900 rpm and discharges 0.2 m^3/s of water against a head of 55 m. The flow velocity remains constant along the flow. The peripheral area for flow is 0.0666 m^2. The vane angle at outlet is 25°. The entry is radial. Determine the manometric efficiency and the inlet vane angle. 10

10 a. Define the following with respect to centrifugal pump: 10

i) Static head ii) Manometric head iii) Net positive suction head iv) Manometric efficiency v) Priming

b. The following data relate to a centrifugal pump.

Diameter of the impeller at inlet and outlet 180 mm and 360 mm respectively. Width of impeller at inlet and outlet 144 mm and 72 mm respectively. Rate of flow through the pump 17.28 *lps*. Speed of the impeller 1500 rpm. Vane angle at outlet 450. Water enters the impeller radially at inlet neglecting losses through the impeller. Find the pressure rise in the impeller. 10

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