Fifth Semester B.E. Degree Examination, Dec.09-Jan.10
Turbo Machines

Time: 3 hrs. Max. Marks:100

Note: *Answer any FIVE full questions, selecting atleast TWO questions from each Part.*

PART - A

1 a. Distinguish between a turbo machine and a positive displacement machine. **(06 Marks)**

b. Using Buckingham's π theorem, show that the discharge Q consumed by an oil ring is given by $\varphi = N d^3 \varphi\left[\frac{\mu}{\rho N d^2}, \frac{\sigma}{\rho N^2 d^3}, \frac{\omega}{\rho N^2 d}\right]$; where 'd' is the internal diameter of ring, 'N' is rotational speed, 'ρ' is the density, 'μ' is viscosity, 'σ' is surface tension and 'ω' is the specific weight of oil. **(10 Marks)**

c. A hydraulic turbine has a head of 9m and average discharge of 11,200 lits/S for a generator speed of 200 rpm. What is the specific speed of the turbine? Assume efficiency = 92%. **(04 Marks)**

2 a. Define degree of reaction (R). For an inlet blade angle of 45^0, blade speed at exit as twice of that at inlet and an inlet whirl velocity of zero value, prove that $R = \frac{2+\cot\beta}{4}$ for a radial outward flow turbine, where R is the degree of reaction and β is the blade angle at exit. **(10 Marks)**

b. In an inward flow turbine, the water falls with a velocity of 30m/s on a runner with a series of curved vanes. The runner rotates at 280rpm. The vanes have inlet and outlet diameters of 1.7m and 0.85m respectively. The angle the guide vanes make with the periphery of the wheel is 30^0. The water after doing work on the runner discharges with an absolute velocity of 3m/s at an angle of 130^0 to the wheel tangent. Find the power developed by the runner if the rate of flow is 380 lits/S. Also find the vane angles at inlet and outlet. **(10 Marks)**

3 a. Define utilization factor of a turbine. Derive an expression relating utilization factor with degree of reaction. **(10 Marks)**

b. In a turbine stage with 50% reaction, the tangential blade speed is 98.5 m/s. The steam velocity at the nozzle exit is 155 m/s and the nozzle angle is 18^0. Assuming symmetric inlet and outlet velocity triangles, compute the inlet blade angle for the rotor and the power developed by the stage for a flow rate of 10kg/s. Also find the utilization factor (∈). **(10 Marks)**

4 a. Define the term 'infinitesimal' stage efficiency of a turbine. Show that the polytropic efficiency during the expansion process is given by $\eta_p = \frac{\ell n\left(\frac{T_2}{T_1}\right)}{\frac{\gamma-1}{\gamma}\ell n\left(\frac{P_2}{P_1}\right)}$. **(08 Marks)**

b. Air enters a compressor at a static pressure of 1.5bar, a static temperature of 15^0C and a flow velocity of 15m/s. At the exit, the static pressure is 3 bar, the static temperature is 100^0C and the flow velocity is 100m/s. The outlet is 1m above the inlet. Evaluate i) the isentropic change in enthalpy ii) the actual change in enthalpy and iii) efficiency of compressor. **(08 Marks)**

c. Write a note on Mach number. **(04 Marks)**

PART – B

5 a. With a neat schematic diagram, explain an axial flow compressor. Also sketch, the general velocity triangles for an axial flow compressor. (10 Marks)

b. A centrifugal compressor runs at 15,000 rpm and produces stagnation pressure ratio of 4 between the impeller inlet and outlet. The stagnation conditions of air at the compressor intake are 1 bar and 25^0C respectively. The absolute velocity at the compressor intake is axial. The compressor has radial blades at the exit, such that the relative velocity at the exit is 135m/s and the total-to-total efficiency of the compressor is 0.78. Draw the velocity triangles at the exit of the rotor and compute the slip as well as slip coefficient. Take rotor diameter at outlet as 58cm. (10 Marks)

6 a. Define the following with respect to centrifugal pumps : i) Overall efficiency ii) Static head iii) Manometric head iv) Net positive suction head v) Manometric efficiency. (10 Marks)

b. For a centrifugal pump, show that the pressure rise in the impeller neglecting the friction and other losses is given by $\frac{1}{2g}\left[V_1^2 + u_2^2 - V_{f_2}^2 \operatorname{cosec}^2\varphi\right]$ where V_{f_1} and V_{f_2} are velocities of flow at inlet and outlet, u_2 is tangential velocity of impeller at outlet and φ is vane angle at outlet. (10 Marks)

7 a. What is the necessity for compounding steam turbines? Discuss any two methods of compounding with neat sketches. (10 Marks)

b. Steam issues from the nozzle of a Delaval turbine with a velocity of 1200m/s. The nozzle angle is 20^0 and the mean blade velocity is 400m/s. Inlet and outlet angles are equal. Mass of steam flowing through the turbine is 900 kg/h. Calculate i) blade angles ii) relative velocity of steam entering the blades iii) tangential force on the blades iv) power developed v) blade efficiency. Assume K = 0.8. (10 Marks)

8 a. Draw a neat sketch of Francis Turbine. Explain the function of draft tube. Also draw the typical velocity triangles of Francis turbine. (08 Marks)

b. A pelton wheel is working under a gross head of 400m. The water is supplied through penstock of diameter 1m and length 4km from a reservoir to pelton wheel. The coefficient of friction for the penstock is given as 0.008. A jet of water of diameter 150mm strikes the buckets of the wheel and gets deflected through an angle of 165^0. The relative velocity of water at outlet is reduced by 15%, due to friction between inside surface of the bucket and water. If the velocity of the buckets is 0.45 times the jet velocity at inlet and mechanical efficiency is 85%, determine i) power given to the runner ii) shaft power iii) hydraulic efficiency and iv) overall efficiency. (12 Marks)

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