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Fifth Semester B.E. Degree Examination, Dec.2015/Jan.2016
Turbo Machines

Time: 3 hrs. Max. Marks: 100

Note: 1. *Answer any FIVE full questions, selecting atleast TWO questions from each part.*
2. *Missing data may be suitably assumed.*

PART – A

1 a. Enumerate the differences between Positive Displacement Machines and Turbomachines with reference to its action, energy conversion process and volumetric efficiency. **(06 Marks)**

b. With usual notations, derive expressions for Unit Discharge coefficient, Head coefficient and Power coefficient using Dimensional Analysis. **(08 Marks)**

c. The quantity of water available for a hydroelectric power station is 260m^3/sec. The head developed is 1.73m. If the speed of the turbines is 50 rpm and the efficiency 82.5%, find the number of turbines. Assume specific speed to be 760. **(06 Marks)**

2 a. With usual notations, derive an expression for infinitesimal stage efficiency during compression process with the aid of TS plot. **(10 Marks)**

b. A 9 stage centrifugal compressor has overall stage pressure ratio 2.82. Air enters the compressor at 1 bar and 15^{0}C. The efficiency of the compressor is 88%. Determine the following : i) Pressure ratio of each stage ii) Polytropic efficiency iii) Preheat factor. **(10 Marks)**

3 a. The velocity of the steam in a De Laval Turbine at the inlet is1200m/sec. The nozzle angle at the inlet is 22^0 and blades are equiangular. Assuming relative velocities of the fluid at inlet and exit to be equal and tangential speed of the rotor is 400m/sec. Determine the following : i) Blade angles at inlet and exit ii) Power developed in kW, if mass flow rate is 1kg/sec iii) Tangential force exerted on the rotor blade ring iv) Utilization factor. **(10 Marks)**

b. Show that for an axial flow turbine subjected under maximum utilization factor condition, the speed ratio ϕ is given by 2/3 cos α_1, where 'U' is the tangential speed of the rotor and 'V_1' is the tangential jet velocity of the fluid. Assume flow velocity to remain constant and 'α_1' is the nozzle angle. Take Degree of Reaction R = ¼. **(10 Marks)**

4 a. The total power input at a stage in an axial – flow compressor with symmetric inlet and outlet velocity triangles (R = 0.5) is 27.85 kJ/kg of air flow. If the blade speed is 180m/sec throughout the rotor, draw the velocity triangles and compute the inlet and outlet rotor blade angles. Do you recommend the use of such compressors? Comment on the results you have obtained. Assume axial velocity component to be 120m/sec. **(10 Marks)**

b. An inward flow radial reaction turbine has axial discharge at outlet. The outer blade angle is 45^0. The radial velocity of the flow remain constant. Assuming the tangential speed of the rotor at inlet to be twice the tangential speed of the rotor at exit, determine the energy transfer per unit flow depending on mass and degree of reaction. Assume $V_m = \sqrt{2g}$. If the values of degree of reaction respectively are '0' and '1', what are the corresponding values of energy transfer per unit mass of the fluid? **(10 Marks)**

PART – B

5 a. Define a steam turbine. List out the differences between Impulse and Reaction steam turbines. **(08 Marks)**

b. Briefly explain Velocity Compounding. **(04 Marks)**

c. In a reaction turbine, the inlet and outlet blade angles are 50^0 and 20^0 respectively. Steam enters at 18^0 to the plane of the rotor wheel and leaves at 40^0. The rotor speed is 200m/sec. Calculate the speed ratio, specific work and degree of reaction. **(08 Marks)**

6 a. Prove that the hydraulic efficiency of Pelton wheel is given by $\frac{1+C_b\cos\beta_2}{2}$, where '$C_b$' is Bucket velocity coefficient and β_2 is the runner tip angle. **(08 Marks)**

b. Explain the function of a draft tube. **(04 Marks)**

c. An inward flow reaction turbine with radial discharge having overall efficiency 80% when power developed is 147 kW. The head is 8m. The peripheral velocity of the fluid is $0.96\sqrt{2gH}$ and flow velocity of the fluid is $0.36\sqrt{2gH}$. The speed of the rotor is 1500 rpm and hydraulic energy losses is 22% of available energy. Determine the following :
i) Inlet guide vane and blade angles ii) Diameter of the rotor iii) Width of the rotor. **(08 Marks)**

7 a. Define a Centrifugal pump. With usual notations, derive theoretical head – capacity relationship for a centrifugal pump. **(08 Marks)**

b. What is Cavitation? What are its effects? **(04 Marks)**

c. Show that the pressure rise in the impeller of a centrifugal pump is given by $\frac{P_2 - P_1}{\rho g} = \frac{1}{2g}\left[V_{f_1}^2 + u_2^2 - V_{f_2}^2 \operatorname{cosec}^2\beta_2\right]$, where V_{f_1} & V_{f_2} are the flow velocities and β_2 is the outlet Blade angle. **(08 Marks)**

8 a. Explain Surging, Stalling and Slip factor with reference to a compressor. **(08 Marks)**

b. The impeller tip speed of a centrifugal compressor is 370m/sec, slip factor is 0.9, and the radial component at the exit is 35m/sec. If the flow area at the exit is $0.18m^2$ and compressor efficiency is 88%. Determine the mass flow rate of air and the absolute Mach number at impeller tip. Assume air density = $1.57kg/m^3$ and inlet stagnation temperature is 290K. Neglect the work input factor. Also find the overall pressure ratio of the compressor. **(12 Marks)**

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