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06ME55

Fifth Semester B.E. Degree Examination, June/July 2013
Turbo Machines

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Define turbomachines. Explain briefly with an example, the power generating, power absorbing and power transmitting turbomachines. **(08 Marks)**

b. The resisting force F of a plane during flight can be considered as dependent upon the length of aircraft 'l', velocity 'v', air viscosity 'μ', air density 'ρ' and bulk modulus of air K. Determine the three dimensionless π-terms. **(06 Marks)**

c. A $\frac{1}{25}$ model of an air plane is tested, in a pressured wind tunnel. The pressure is 15 bar, temperature is 20°C and the velocity is 100 m/sec. The total drag measured is 150 N. Estimate the velocity of the prototype and the resistance it would experience when flying in air at one bar and 20°C. **(06 Marks)**

2 a. Define degree of reaction. With the help of inlet and outlet velocity triangle, Show that the degree of reaction for an axial flow compressor is given by $R = \frac{V_a}{U}\tan\gamma_m$ where $\gamma_m = \frac{\tan\gamma_1 + \tan\gamma_2}{2}$ and γ_1 and γ_2 are inlet and outlet blade angles with respect to axial direction. **(10 Marks)**

b. Draw the velocity triangle at inlet and outlet of an axial flow compressor with the following data, R = 0.5, γ_1 = 45° (inlet blade angle with respect to axial direction), axial flow velocity is constant and is equal to 120 m/sec , radius of rotation = 0.2 mts and speed of the compressor is 6500 RPM. Determine the power required in KW to handle 15 kg of air per second. **(10 Marks)**

3 a. Define utilization factor as applied to turbines. Show that for an axial flow turbine $\epsilon = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}$ where V_1 and V_2 are absolute velocity of fluid at inlet and outlet respectively and R is the degree of reaction. **(10 Marks)**

b. The following data refers to mixed flow pump, where the fluid absolute velocity is axial at inlet and at outlet; the relative velocity is radial. Mean hub diameter is 8 cms, impeller diameter is 25 cm and speed is 3000 rpm. Assuming that the axial velocity at inlet is equal to the radial velocity at exit, determine degree of reaction and energy input to the fluid if relative velocity at exit is equal to the inlet tangential blade speed. **(10 Marks)**

4 a. Define isentropic efficiency and stage efficiency for a compression process. Show that polytropic efficiency is given by $\eta_P = \frac{n}{n-1}\cdot\frac{\gamma-1}{\gamma}$, where γ is ratio of specific heats. **(10 Marks)**

4 b. A 16 stage axial flow compressor is to have a pressure ratio of 6.3 and tests have shown that a stage efficiency of 0.895 can be obtained. The intake conditions are 15°C and 1 Bar. Determine :
i) Overall isentropic efficiency.
ii) Polytropic efficiency of compression. **(10 Marks)**

PART – B

5 a. Define slip factor and power input factor. **(04 Marks)**
b. Derive an expression for overall pressure ratio developed interms of impeller tip speed. **(08 Marks)**
c. The tip speed for a radial vane compressor is 500 m/sec. Initial temperature is 300°K, Power input factor = 1.04, Slip factor = 0.9 and Compressor efficiency = 0.8. Calculate the compressor pressure ratio. (Assume $\gamma = 1.4$ and $C_P = 1.005$ kJ/kg K). **(08 Marks)**

6 a. Define the following terms with respect to centrifugal pumps : i) Monometric efficiency ii) Hydraulic efficiency and iii) Volumetric efficiency. **(06 Marks)**
b. Derive an expression for minimum starting speed for a centrifugal pump. **(06 Marks)**
c. A centrifugal pump works against a head of 30 m and discharges 0.25 m^3/sec. While running at 1000 rpm. The velocity of flow at the outlet is 3 m/s and the vane angle at outlet is 30°. Determine the diameter and width of the impeller at outlet if the hydraulic efficiency is 0.8. **(08 Marks)**

7 a. With a neat sketch, explain the pressure-velocity compounding of steam turbine. **(08 Marks)**
b. Define stage efficiency and reheat factor. **(04 Marks)**
c. At a stage of 50% reaction turbine the mean diameter of the rotor is 1.4 m, the speed ratio is 0.7. Calculate the blade inlet angle if the blade outlet angle is 20°. The rotor speed is 3000 rpm. Also find the diagram efficiency (utilization factor). **(08 Marks)**

8 a. Show that for a Pelton turbine the maximum hydraulic efficiency is given by, $\eta_{max} = \frac{1 + K\cos\beta_2}{2}$, where K is blade velocity coefficient and β_2 is blade discharge angle. **(06 Marks)**
b. Draw the velocity diagrams for the following runner shapes of a Francis turbine, i) Slow runner, ii) Medium runner and iii) Fast runner. **(06 Marks)**
c. An inward flow reaction turbine works under a head of 110 m. The inlet and outlet diameters of the runner are 1.5 m and 1.0 m respectively. The width of the runner is constant throughout as 150 mm the blade angle at outlet is 15°. The hydraulic efficiency is 0.9. Calculate i) Speed of the turbine ii) Blade angles and iii) The power produced when the discharge velocity is 6 m/sec. **(08 Marks)**

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