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10ME56

Fifth Semester B.E. Degree Examination, June/July 2015
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. Define turbomachine. Explain the principal components of turbomachine. **(06 Marks)**

b. Define specific speed of pump. Show that specific speed of pump is given by $N_S = \frac{N\sqrt{Q}}{H^{3/4}}$. **(06 Marks)**

c. A turbine is to operate under a head of 25m at 200rpm. The discharge is 9 cumec. If the efficiency is 90%, determine the performance of the turbine under a head of 20 metres. **(08 Marks)**

2 a. What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine. **(10 Marks)**

b. The output of a three stage gas turbine is 30MW at the shaft coupling at an entry temperature of 1500K. The overall pressure ratio across the turbine is 11.0 and efficiency 88%. If the pressure ratio of each stage is the same, determine: i) pressure ratio of each stage; ii) polytropic efficiency; iii) mass flow rate; iv) efficiency and power of each stage. Assume $\gamma_{air} = 1.4$, $C_p = 1.005$ kJ/kg K, $\eta_{mech} = 91\%$. **(10 Marks)**

3 a. Define the degree of reaction and show that the relationship between utilization factor (ϵ) and degree of reaction (R) for an axial flow turbine is given by

$$\epsilon = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}.$$ **(08 Marks)**

b. Liquid water flows at the rate of 31.5 kg/s through a rotor of a radial flow turbo machine, where the inlet and outlet diameters are 125mm and 200mm respectively. The other data's relating to the turbo machine are as follows: speed = 6000 rpm, absolute velocity at inlet is 35 m/s and is axial in direction, absolute velocity at exit is 160 m/s, and its angle is 30°. Determine the relative velocities and also power required to drive the rotor in kW. Also determine the change in static and stagnation enthalpy across the rotor and change in static and stagnation pressure across the rotor and degree of reaction. **(12 Marks)**

4 a. With the help of inlet and outlet velocity triangles, show that the degree of reaction for an axial flow compressor, $R = \frac{V_a}{u}\cot\beta_m$, where V_a is axial velocity, u is blade speed and $\cot\beta_m = \frac{(\cot\beta_1 + \cot\beta_2)}{2}$, where β_1 and β_2 are inlet and outlet blade angle with respect to axial direction. **(10 Marks)**

b. A single stage axial blower with no inlet guide vanes is running at 3600 rpm. The mean diameter of the rotor is 16cm and mass flow rate of air through the blower is 0.45 kg/s. In the rotor, the air is turned such that the absolute velocity of air at exit makes an angle of 20° with respect to the axis. Assume that the axial component of fluid velocity remains constant, determine power input and degree of reaction. Assume that the density of air is constant at 1.185 kg/m^3 and area of flow is 0.02m^2. **(10 Marks)**

PART – B

5 a. What is compounding in steam turbine? Explain with neat sketch impulse-reaction turbine. **(10 Marks)**

b. In a single stage impulse steam turbine the mean diameter of the blades is 1m. It runs at 3000 rpm. The steam is supplied from a nozzle at a velocity of 350 m/s and the nozzle angle is 20°. The rotor blades are equiangular. The blade friction factor is 0.86. Draw the velocity diagram and calculate the power developed if the axial thrust is 117.72 Newton. **(10 Marks)**

6 a. Show that the maximum hydraulic efficiency of a Pelton wheel turbine is given by $(\eta_h)_{max} = \frac{(1+\cos\phi)}{2}$, where ϕ is exit blade angle. Also draw inlet and exit velocity triangles. **(10 Marks)**

b. The following data is given for a Francis turbine. Net head H = 60m; speed N = 700 rpm; shaft power = 294.3 kW, η_0 =84%, η_h = 93%, flow ratio = 0.20, breadth ratio n = 0.1, outer diameter of runner = 2 × inner diameter of runner. The thickness of vanes occupy 5% of circumferential area of the runner, velocity of flow is constant at inlet and outlet and discharge is radial at outlet. Determine:

i) Guide blade angle.
ii) Runner vane angle at inlet and outlet.
iii) Diameter of runner at inlet and outlet and
iv) Width of wheel at inlet. **(10 Marks)**

7 a. Obtain an expression for the minimum starting speed of a centrifugal pump. **(10 Marks)**

b. The outer diameter of the impeller of a centrifugal pump is 40cm, and width of impeller at outlet is 5cm. The pump is running at 800 rpm and is working against a total head of 15m. The vane angle at outlet is 40° and manometric efficiency is 75%. Determine: i) Velocity of flow at outlet; ii) Velocity of water leaving the vane; iii) Angle made by the absolute velocity at outlet with the direction of motion at outlet; iv) Discharge. **(10 Marks)**

8 a. Briefly explain the following:

i) Surging of compressors.
ii) Slip factor or slip coefficient. **(10 Marks)**

b. An air compressor has eight stages of equal pressure ratio 1.35. The flow rate through the compressor and its overall efficiency are 50kg/s and 82% respectively. If the conditions of air at entry are 1.0 bar and 40°C determine: i) The state of air at the compressor exit; ii) Polytropic efficiency; iii) Efficiency of each stage; iv) Power required to drive the compressor assuming overall efficiency of the drive as 90%. **(10 Marks)**

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