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06ME55

Fifth Semester B.E. Degree Examination, June/July 2011
Turbo Machines

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions selecting at least TWO questions from each part.***
2. Use of steam tables and Mollier chart permitted.

PART – A

1 a. Define a turbo machine. Differentiate between a turbo machine and a positive displacement machine. **(08 Marks)**

b. The pressure drop ΔP in a pipe depends on the mean velocity of flow V, length of the pipe L, diameter of the pipe D, viscosity μ, density of the fluid ρ and average height of roughness of projection on one side of the pipe surface K. By using Buckingham's π - theorem, show that $\Delta P = \rho V^2 \phi\left[\frac{1}{Re}, \frac{L}{D}, \frac{K}{D}\right]$ where Re = Reynold's number. Further prove that the head loss due to friction is given by $h_f = \frac{fLV^2}{2gD}$ where f = friction factor and g = acceleration due to gravity. **(12 Marks)**

2 a. Obtain an expression as shown below for energy transfer E and degree of reaction R as a function of discharge blade angle β_2 for a turbo machine. Make the following assumptions : i) $u_2 = 2u_1$, ii) constant radial velocity, iii) no inlet angular momentum and inlet blade angle $= 45^\circ$. Sketch the nature of variation of E and R with respect to β_2 as it varies from 0° to 180° and discuss the salient features of the graph.

$$E = 2V_{f2}^2(\cot\beta_2 - 2) \quad \text{and} \quad R = \frac{2+\cot\beta_2}{4}$$ **(12 Marks)**

b. In a mixed flow turbo machine, fluid enters such that the absolute velocity is axial at inlet and the relative velocity is radial at outlet. What is the degree of reaction and energy input to the fluid if the relative velocity at outlet is same as the tangential blade speed at inlet? The following data may be used : inlet diameter = 8cm, exit diameter = 25cm, speed = 3000rpm, blade angle at inlet = 45°. **(08 Marks)**

3 a. Show that for maximum utilization of an axial flow turbine with $R = \frac{1}{4}$, the speed ratio is given by $\phi = \frac{2}{3}\cos\alpha_1$ where α_1 = Nozzle angle at inlet with respect to tangential direction. **(06 Marks)**

b. In an axial flow turbine, the discharge blade angles are 20° each for both the stator and the rotor. The steam speed at the exit of the fixed blade is 140 m/s. The ratio $\frac{V_a}{u}$ is equal to 0.7 at the entry and 0.76 at the exit of the rotor blades. Find :i) inlet rotor blade angle; ii) power developed by the blade ring for a mass flow rate of 2.6 kg/s; iii) degree of reaction. **(08 Marks)**

c. Steam leaves the rotating blades as shown in the Fig.Q3(c). Evaluate the absolute velocity in magnitude and direction. **(06 Marks)**

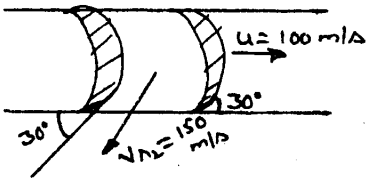

Fig.Q3(c)

4 a. For a power generating turbo machine, define :
i) total-to-total efficiency ii) total-to-static efficiency. **(04 Marks)**

b. With the help of h-s diagram, show that the preheat factor in a multi stage compressor is less than unity. **(08 Marks)**

c. Air flows through an air turbine where its stagnation pressure is reduced in the ratio 5 : 1. The total-to-total efficiency is 80%. The air flow rate is 5 kg/s. If the total power output is 500kW, find : i) inlet total temperature ; ii) actual exit total temperature; iii) actual exit static temperature if the flow velocity is 100 m/s ; iv) total-to-static efficiency. **(08 Marks)**

PART – B

5 a. Draw the velocity triangles for an axial flow compressor and show that for an axial flow compressor having no axial thrust, the degree of reaction is given by :

$$R = \frac{v_a}{2u}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \tan\beta_2}\right]$$

where v_a = axial flow velocity, u = blade speed, β_1 and β_2 = inlet and outlet blade angles. **(10 Marks)**

b. A centrifugal compressor runs at a speed of 15000 rpm and delivers 30 kg/s of air. The exit diameter is 70cm, relative velocity at exit is 100 m/s at an exit angle of 75°. Assume axial inlet and inlet total temperature = 300K, inlet total pressure = 1 bar. Determine :
i) power required to drive the compressor ii) ideal head developed
iii) work done iv) exit total pressure. **(10 Marks)**

6 a. What is cavitation? What are the causes for cavitation? Explain the steps to be taken to avoid cavitation. **(06 Marks)**

b. Derive an expression for the static pressure rise in the impeller of a centrifugal pump with velocity triangles. **(06 Marks)**

c. A 4-stage centrifugal pump has impellers each of 38cm diameter and 1.9cm wide at outlet. The outlet vane angle is 45° and the vanes occupy 10% of the outlet area. The manometric efficiency is 85% and overall efficiency is 75%. Determine the head generated by the pump when running at 1000 rpm discharging 60 litres/s. Also determine the power required. **(08 Marks)**

7 a. What is compounding of steam turbine? Explain with the help of a schematic diagram a two row velocity compounded turbine stage. **(08 Marks)**

b. Dry saturated steam at 10 bar is supplied to a single rotor axial flow impulse turbine, the condenser pressure being 0.5 bar. The nozzle efficiency is 94% and the nozzle angle at the rotor inlet is 18° to the wheel plane. The rotor blades are equiangular and move at a speed of 450 m/s. If the blade velocity coefficient for the moving blades is 0.92, find :
i) The specific power output ii) Rotor efficiency iii) Stage efficiency
iv) Axial thrust v) Direction of exit steam velocity. **(12 Marks)**

8 a. Explain the functions of a draft tube in a reaction hydraulic turbine. **(04 Marks)**

b. Draw the inlet and outlet velocity triangles for a Pelton wheel. Derive an expression for the maximum hydraulic efficiency of a Pelton wheel in terms of bucket velocity co-efficient and discharge blade angle. **(08 Marks)**

c. Two inward flow reaction turbines have the same runner diameter of 0.6m and the same hydraulic efficiency. They work under the same head and they have the same velocity of flow of 6 m/s. One of the runners 'A' revolves at 520 rpm and has an inlet vane angle of 65°. If the other runner 'B' has an inlet vane angle of 110°, at what speed should it run? Assume for both the turbines, the discharge is radial at outlet. **(08 Marks)**

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