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10ME56

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Use of Thermodynamic data hand book is permitted.

PART – A

1 a. Define turbo machines. Give at least 6 different classifications of turbomachines. **(08 Marks)**

b. Define specific speed of pumps. Show that specific speed of pump is given by,

$$N_S = \frac{N\sqrt{Q}}{H^{3/4}}.$$ **(06 Marks)**

c. A turbine model of 1 : 10 develops 2.0 kW under a head of 6 m at 500 rpm. Find the power developed by the prototype under a head of 40 m. Also find the speed of prototype and its specific speed. Assume the turbine efficiencies to remain same. **(06 Marks)**

2 a. For 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. **(06 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 in 5 kg/s. If the total power output is 500 kW, 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. **(10 Marks)**

3 a. Derive alternate form of Euler's turbine equation and explain the significance of each energy component. **(10 Marks)**

b. The velocity of fluid flow from the nozzle in an axial flow impulse turbine is 1200 m/s. The nozzle angle is 22°. If the rotor blades are equiangular and the rotor tangential speed is 400 m/s, find : (i) The rotor blade angles, (ii) The tangential force on the blade ring (iii) Power output (iv) Utilization factor. Assume $V_{r_1} = V_{r_2}$. **(10 Marks)**

4 a. Define degree of reaction for an axial flow machine. Prove that degree of reaction for an axial flow device (assuming constant velocity of flow) is given by,

$$R = \frac{V_f}{U}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \times \tan\beta_2}\right].$$ **(10 Marks)**

b. An axial flow compressor of 50% reaction design has blades with inlet and outlet angles of 44° and 13° respectively. The compressor is to produce a pressure ratio 5 : 1 with an overall isentropic efficiency of 87% when the inlet temperature is 290 K. The mean blade speed and axial velocity are constant throughout the compressor. Assume that blade velocity is 180 m/s and work input factor is 0.85, Find the number of stages required and the change of entropy. **(10 Marks)**

PART – B

5 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 1000 m/s. The nozzle angle is 20° and the mean blade velocity 400 m/s. Inlet and outlet angles are equal. Mass of steam flowing through the turbine is 1000 kg/h. Calculate (i) Blade angles (ii) Relative velocity of steam entering the blades. (iii) Axial thrust (iv) Power developed (v) Blade efficiency. Assume K = 0.8. **(10 Marks)**

6 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. A Kaplan turbine develops 10 MW under an effective head of 8 m. The overall efficiency is 0.86, the speed ratio is 2.00 and the flow ratio is 0.6. The hub diameter is 0.35 times the outside diameter of the wheel. Find the diameter and speed of the turbine. **(08 Marks)**

7 a. Explain the following, with reference to the centrifugal pump:
(i) Slip and it effects
(ii) Cavitation, its effect and remedies to it
(iii) Difference between manometric head and NPSH. **(10 Marks)**

b. The outer diameter of the impeller of a centrifugal pump is 40 cm, and width of the impeller at outlet is 5 cm. The pump is running at 800 rpm and is working against a total head of 15 m. 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. What is radial equilibrium in an axial flow compressor? Derive an expression for radial equilibrium in terms of flow velocity and whirl velocity of a fluid. **(10 Marks)**

b. A centrifugal compressor runs at a speed of 15000 rpm and delivers air at 20 kg/s. Exit radius is 0.35 m, relative velocity and vane angles at exit are 100 m/sec and 75° respectively. Assuming axial inlet and inlet stagnation temperature and stagnation pressure as 300 K and 1 bar respectively. Calculate : (i) the torque (ii) the power required to drive the compressor (iii) the ideal head developed (iv) the work done and (v) the exit total pressure. Take C_p of air = 1.005 kJ/kg-K. **(10 Marks)**

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