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10ME56

Fifth Semester B.E. Degree Examination, Dec.2013/Jan.2014
Turbomachines

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 is permitted.

PART – A

1 a. Define a turbomachine. With a neat sketch, explain the parts of a turbomachine. **(04 Marks)**

b. Define specific speed of a pump and a turbine. Explain the significance of specific speed. **(06 Marks)**

c. Tests on a turbine runner 1.25m in diameter at 30m head gave the following results, power developed = 736 kW, Speed is 180 r.p.m and the discharge is 2.7 m^3/sec. Find the diameter, speed and discharge of a similar runner to operate at 45m had and give 1472kW at the same efficiency. What is the specific speed of both the turbines? **(10 Marks)**

2 a. Define the term 'infinitesimal' stage efficiencies of a turbine. Show that the polytropic efficiency during the expansion process is given by

$$\eta_p = \frac{\log_e\left(T_2/T_1\right)}{\left(\frac{r-1}{r}\right)\log_e\left(\frac{P_2}{P_1}\right)}.$$ **(08 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 50 kg/sec and 82% respectively. If the conditions of air at the entry are 1 bar and 300K, determine:
i) The state of air at compressor exit.
ii) Polytropic efficiency.
iii) Stage efficiency.
iv) Power required to drive the compressor assuming transmission efficiency of 90%. **(12 Marks)**

3 a. With usual notations and velocity triangles derive alternate turbine equation and identify the components of energy transfer. **(10 Marks)**

b. The following data refer to a 50% degree of reaction axial flow turbomachine. Inlet fluid velocity = 230 m/sec, inlet rotor angle = 60°, inlet guide blade angle = 30°, outlet rotor angle = 25°. Find utilization factor, axial thrust and power output per unit mass flow. **(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

$$R = \frac{V_f}{2U}\left(\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 + \tan\beta_2}\right)$$

Where β_1 and β_2 are the angles made with tangent to the blades. **(10 Marks)**

b. A single stage axial blower with no inlet guide vanes is running at 3600 r.p.m. The mean diameter of the rotor is 16cm and the mass flow rate of air through the blower is 0.45 kg/sec. In the rotor the air is turned such that the absolute velocity of air at exit makes angle of 20° with respect to the axis. Assuming 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 0.02 m^2. **(10 Marks)**

PART – B

5 a. What is the necessity for compounding steam turbines? Discuss any two methods of compounding with neat sketches. Show the velocity and pressure variations across the turbine. **(10 Marks)**

b. In a single stage impulse turbine the mean diameter of the blades is 1m. It runs at 3000 r.p.m. The steam is supplied from a nozzle at a velocity of 350 m/sec and the nozzle at a velocity of 350 m/sec 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's. **(10 Marks)**

6 a. Classify hydraulic turbines with examples. **(05 Marks)**

b. Two jets strike at buckets of a Pelton wheel, which is having a shaft power as 14,715 kW. The diameter of each jet is given as 150mm. If the net head on the turbine is 500m, find the overall efficiency of the turbine, take $C_v = 1.0$ and speed ratio = 0.46. If the blade angle at outlet is 15° and reduction in relative velocity over the buckets is 5%, find the hydraulic efficiency. **(10 Marks)**

c. Draw a neat sketch of a Francis turbine and draw the velocity triangles at inlet and outlet. **(05 Marks)**

7 a. With reference to the centrifugal pump explain what do you mean by
   i) Net Positive Section Head (NPSH).
   ii) Manometric head (h_m). **(06 Marks)**

b. Explain the phenomenon of cavitation in centrifugal pump. **(04 Marks)**

c. A centrifugal pump is designed to run at 1450 r.p.m. with a maximum discharge of 1800 litres/min against a total head of 20m. The suction and delivery pipes are designed such that they are equal in size of 100mm. If the inner diameter and outer diameters of the impeller are 12cm and 24cm respectively, determine the blade angles β_1 and β_2 for radial entry. Neglect friction and other losses. **(10 Marks)**

8 a. Derive an expression for overall pressure ratio for a centrifugal compressor in terms of impeller tip speed, slip, power input factor and isentropic efficiency of compressor. **(12 Marks)**

b. An axial flow air compressor of 50% reaction design has blades with inlet and outlet angles with respect to axial direction of 45° and 10° respectively. The compressor is to produce a pressure ratio of 6:1 with an overall isentropic efficiency of 0.85 with inlet static temperature 37°C. The blade speed and axial velocity are constant throughout the compressor. Assuming a value of 200 m/sec for blade speed, find the number of stages required if work done factor is 0.87 for all stages. **(08 Marks)**

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