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10ME56

Fifth Semester B.E. Degree Examination, June/July 2018
Turbo Machines

Time: 3 hrs. Max. Marks:100

Note: *1. Answer FIVE full questions, selecting at least TWO full questions from each part.*
2. Use of steam tables and thermodynamic data handbook is permitted.

PART – A

1 a. Define a turbomachine. Explain with neat sketch construction and working of a turbomachine. **(06 Marks)**

b. Enumerate the difference between a turbomachine and a positive displacement machine. **(06 Marks)**

c. A wind mill model of 1:10 scale develops 2 kW under a head of 6m at 500rpm. A prototype work under a head of 40m. Assuming that the efficiencies of model and prototype remains same. Determine the power developed, speed of the prototype and its specific speed. **(08 Marks)**

2 a. Define the following with the help of h-s diagram for the power generating turbomachines:
i) total-to-total efficiency ii) total-to static efficiency. **(04 Marks)**

b. Derive an expression for an overall isentropic efficiency for a finite number of stages of compression interms of pressure ratio, stage efficiency, number of stages and ratio of specific heats for a compressor. **(08 Marks)**

c. A 16 stage axial flow compressor is to have a pressure ratio of 6.3 with a stage efficiency of 89.5%. The intake conditions are 15°C and 1 bar. Determine:
i) Expected overall efficiency
ii) The polytropic efficiency

Take $\gamma = \frac{C_p}{C_v} = 1.4$. **(08 Marks)**

3 a. Define utilization factor and degree of reaction of a turbine. Derive an expression for establishing relation between utilization factor and degree of reaction. **(10 Marks)**

b. An impulse turbine having mean blade diameter 0.75m runs with a speed of 2800 rpm. The absolute velocity of jet leaving a nozzle inclined at 18° to the plane of wheel is 280 m/s. If the utilization factor is 0.88 and relative velocity at the rotor exit and at the inlet remains same. Determine:
i) The inlet and outlet blade angles
ii) Work done
iii) Power output for a mass flow rate of 10 kg/s. **(10 Marks)**

4 a. Explain why turbine with reaction R > 1 and R < 0 are not in practical use? **(04 Marks)**

b. In an inward flow radial hydraulic turbine for maximum utilization factor show that,

$\alpha_1 = \cot^{-1}\sqrt{\left(\frac{(1-R)}{1-\epsilon}\right)\epsilon}$ where α_1 = Nozzle angle, R = Degree of reaction, ϵ = utilization factor. Assume radial velocity component is constant throughout and there is no tangential component of absolute velocity at outlet. **(08 Marks)**

c. Air enters in an axial flow turbine with a tangential component of absolute velocity equal to 600 m/s in the direction of rotation. At the rotor exit, the tangential component of absolute velocity is 100m/s in a direction opposite to that of rotational speed. The tangential blade speed is 250m/s. Find:
   i) Change in total enthalpy of air between the inlet and outlet of the rotor.
   ii) The power developed if the mass flow rate is 10kg/s
   iii) The change in total temperature across the rotor. **(08 Marks)**

PART – B

5 a. What are the differences between impulse and reaction steam turbine. **(06 Marks)**

b. Explain with the help of a neat sketch how an impulse steam turbine is compounded for velocity. **(06 Marks)**

c. In a stage of an impulse turbine provided with single row wheel, the mean diameter of blade is 1m rotates at 3000rpm. Steam issues from a nozzle at a velocity of 350 m/s and nozzle angle 20°. The rotor blades are equiangular, blade friction is 0.86. Determine the power developed if the axial thrust acting on the rotor bearing is 120N. **(08 Marks)**

6 a. Derive an expression for maximum hydraulic efficiency of a Pelton wheel interms of runner tip angle and bucket velocity coefficient. **(10 Marks)**

b. A Pelton wheel develops 23.11 MW under a head of 1770m while running at 750rpm. Find i) Jet diameter ii) Mean diameter of the runner iii) Number of buckets.
Assume: $C_v = 0.97$, $\phi = 0.46$, $\eta_T = 0.85$. **(10 Marks)**

7 a. Explain the following with reference to centrifugal pumps:
   i) Manometric efficiency with expression.
   ii) Cavitation in pumps
   iii) Net positive suction head
   iv) Need for priming
   v) Pumps in series. **(10 Marks)**

b. A centrifugal pump delivers 50 litres against a total head of 24m when running at 1500rpm The velocity of flow is maintained constant at 2.4 m/s and blades are curved back at 30° to the tangent at outlet. The inner diameter is half the outer diameter. If the manometric efficiency is 80%, determine:
   i) Blade angle at inlet
   ii) Power required to drive the pump. **(10 Marks)**

8 a. What is the function of a diffuser? Name the different types of diffusers and explain them with neat sketch. **(10 Marks)**

b. A centrifugal compressor delivers 20kg/s of air with a total head pressure ratio of 4:1. The speed of the compressor is 12,000rpm. Inlet total temperature is 15°C stagnation pressure at inlet is 1.0 bar, slip factor is 0.9, power input factor is 1.04. Efficiency is 80%. Calculate the outer diameter of the impeller. **(10 Marks)**

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