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10ME56

Fifth Semester B.E. Degree Examination, June/July 2019

Turbomachines

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Write a descriptive note on the classification of turbo machines. Give specific examples for each case. **(10 Marks)**

b. A Francis turbine of diameter 3m develops 6750 KW at 300 rpm under a net head of 45m. A geometrically similar model of scale ratio 1:8 is to be tested at a head of 9m. Estimate the size, speed, discharge and power developed by the model. What is the specific speed of the model? Assume overall efficiency of 0.82 for both the prototype and model. **(10 Marks)**

2 a. With the help of T-S diagram, define and very briefly explain the following efficiencies for an expansion process:
i) Total to total efficiency
ii) Static to static efficiency
iii) Polytropic efficiency
iv) Finite stage efficiency **(10 Marks)**

b. Gases from a combustion chamber inter a gas turbine at total pressure of 7 bar and a total temperature of 1100 K. The total pressure and total temperature at the turbine exit are 1.5 bar and 830 K. Assume $\gamma = 1.3$ and molecular weight of gases = 28.7. Evaluate total to total efficiency and total to static efficiency if exit velocity is 250 m/s. Assume adiabatic steady flow conditions. **(10 Marks)**

3 a. With the usual notations and velocity triangles, derive an alternative form of Euler's Turbine equation and discuss about the components of energy transfer. **(10 Marks)**

b. At a stage in 50% reaction axial flow turbine running at 3000 rpm, the mean diameter is 685 mm. If the maximum utilization for the stage is 0.915, calculate the inlet and outlet absolute velocities for the rotor. Draw the velocity triangles and find power output for a flow rate of 15 kg/s. **(10 Marks)**

4 a. Derive the degree of reaction equation for a centrifugal compressors and pumps. What conclusions can be drawn from that equation? **(10 Marks)**

b. Air flows into a stage of an axial flow compressor at 33°C and 1 bar pressure. The axial speed of air flow throughout the stage is 110 m/s. The compressor is one of 50% reaction with symmetric inlet and outlet velocity triangles, the inlet blade angle being 30° and the outlet angle of 50°. Compute the absolute velocity at the rotor inlet, the mean blade tip speed and the temperature rise of the air in passing through the stage. **(10 Marks)**

PART – B

5 a. For a Parson's turbine, show that the condition for maximum blade efficiency is $\phi_{optimum} = \cos\alpha_1$ and determine the equation for maximum blade efficiency. **(10 Marks)**

b. Steam flows from a nozzle at the rate of 0.2 kg/s and speed 900 m/s. It then enters the rotor of single stage impulse turbine with symmetric blades. The flow leaves the nozzle at an angle of 20°, the mean diameter of the blades is 240 mm and the rotor speed is 18000 rpm. Due to the frictional loss in the rotor blades, kinetic energy of relative flow at rotor exit is 85% of kinetic energy of relative flow entering the rotor. Determine:
   i) The inlet blade angle
   ii) The absolute velocity of steam leaving the rotor
   iii) Power delivered by the turbine. **(10 Marks)**

6 a. Derive an expression for maximum hydraulic efficiency of a Pelton wheel interms of discharge blade angle. **(10 Marks)**

b. The following data is given for a Francis turbine.
Net head = 70 m, speed = 600 rpm, power = 370 kW, overall efficiency = 80%, hydraulic efficiency = 95%, flow ratio = 0.25, breadth ratio = 0.1, outer diameter is twice of inner diameter of runner, the vanes occupy 10% of circumferential area of runner, velocity of flow is constant and discharge is radial at outlet. Determine:
   i) Guide blade angle
   ii) Runner vane angle of inlet and outlet
   iii) The diameter of runner at inlet and outlet
   iv) The width of wheel at inlet. **(10 Marks)**

7 a. Derive an expression for the static pressure rise in the impeller of a centrifugal pump. **(10 Marks)**

b. A 3 stage centrifugal pump is to be designed to handle 60 ltr/s of water at a speed of 900 rpm and under a manometric head of 70 m. The vanes are to be radial at inlet and are to be curved backward at exit at angle of 45°. Assume hydraulic efficiency as 84% and mechanical efficiency as 75%.Consider that vane thickness accounts for 8% of circumferential area. The velocity of flow may be assumed constant at 3 m/s. Determine:
   i) External diameter of each impeller
   ii) External width of each impeller
   iii) Total power input. **(10 Marks)**

8 a. Derive an expression for workdone and static pressure rise in the centrifugal compressor. **(10 Marks)**

b. Air enters a 3 stage axial flow compressor at 1 bar and 300 K. The energy input is 25 kJ/kg per each stage. The stage efficiency is 0.86. Calculate:
   i) The exit static temperature
   ii) The compressor efficiency
   iii) The static pressure ratio **(10 Marks)**

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