CBCS SCHEME

USN

18ME54

Fifth Semester B.E. Degree Examination, June/July 2024
Turbo Machines

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of thermodynamics data hand book and Mollier chart permitted.

Module-1

1 a. Define turbomachine. Explain the classification of turbomachines. **(06 Marks)**

b. List any six differences between turbomachines and positive displacement machines. **(06 Marks)**

c. Tests on a turbine runner 1.25 m in diameter at 30 m head gave the following results : Power developed 736 kW, Speed 180 rpm and discharge 2.7 m^3/s. Find diameter, speed and discharge 2.7 m^3/s. Find diameter, speed and discharge of a runner to operate at the same efficiency. What is the specific speed of both turbines to give 1472 kW at 45 m head. **(08 Marks)**

OR

2 a. Define Isentropic efficiency and stage efficiency for a compression process. Show that the polytropic efficiency for expansion process is given by, $\eta_P = \frac{\gamma}{(\gamma-1)}\frac{(n-1)}{n}$, where $\gamma \rightarrow$ ratio of specific heats. **(10 Marks)**

b. A 16 stage axial flow compressor is to have a pressure ratio of 6.3 and test have shown that a stage efficiency of 89.5% can be obtained. The intake conditions are 288 K and 1 bar pressure. Find (i) Overall efficiency (ii) Polytropic efficiency (iii) Preheat factor. **(10 Marks)**

Module-2

3 a. Define degree of reaction and utilization factor. Derive an expression relating utilization factor with degree of reaction. **(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 the flow rate of 1.5 kg/s. **(10 Marks)**

OR

4 a. Draw the velocity triangles for an axial flow compressor and show that for an axial flow compressor the degree of reaction is given by $R = \frac{V_a}{2u}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \times \tan\beta_2}\right]$,

Where V_a = Axial flow velocity, u = Blade Speed, β_1 and β_2 = Inlet and Outlet blade angles with respect to tangential direction. **(10 Marks)**

b. A radial flow pump having impeller diameters 5 cm and 12.5 cm runs at 1500 rpm. The inlet blade angle is 50°. The fluid enters the impeller without any whirl component while the flow component remains constant. Determine the specific work and degree of reaction at a blade outlet angle of 70°. Also find at what outlet angle the impeller becomes a zero work impeller. **(10 Marks)**

Module-3

5 a. What is necessity for compounding steam turbines? Briefly explain the different compounding methods. **(08 Marks)**

b. In a Curtis stage with two rows of moving blades, the rotor blades are equiangular. The first rotor has an angle of 29° each while second rotor has an angle of 32° each. The velocity of steam at the exit of the nozzle is 530 m/s and the blade coefficients are 0.9 in the first, 0.95 in the stator and in the second row. If the absolute velocity at the stage exit should be axial. Find : (i) Mean blade speed
(ii) The rotor efficiency
(iii) The power output for a flow rate of 32 kg/sec. **(12 Marks)**

OR

6 a. For a reaction steam turbine (Parason'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. A stage of a turbine with Parason's blading deliver dry saturated steam at 2.7 bar from the fixed blades at 90 m/s. The mean blade height is 40 mm and the moving blade exit angle is 20°. The axial velocity of steam is $\frac{3}{4}$ of the blade velocity at the mean readius. Steam is supplied to the stage at the rate of 9000 kg/hr. The effect of the blade tip thickness on the annulus area can be neglected. Calculate
(i) Wheel speed (ii) The diagram efficiency (iii) The diagram power
(iv) The enthalpy drop of the steam in this stage. **(10 Marks)**

Module-4

7 a. Draw the inlet and exit velocity triangles for a pelton wheel turbine. Show that maximum hydraulic efficiency is given by $(\eta_h)_{max} = \frac{1+\cos\beta_2}{2}$. Assume that relative velocity remains constant. **(10 Marks)**

b. In a power station, a pelton wheel produces 15,500 kW under a head of 350 m while running at 500 rpm. Assume a turbine efficiency of 0.84 coefficient of velocity for nozzle as 0.98. Speed ratio = 0.46 and Blade coefficient = 0.86. Calculate (i) Number of jets (ii) Diameter of each jet (iii) Tangential force on the buckets. If the bucket deflect the jet through 165°. **(10 Marks)**

OR

8 a. State the functions of a draft tube. Explain briefly different types of draft tubes. **(06 Marks)**

b. The inner and outer diameters of a Francis turbine are respectively 30 cm and 60 cm water enters the turbine at an angle of 20° to the wheel tangent and leaves the turbine radially. If the velocity of flow remains constant throughout at 3 m/s and speed of runner is 300 rpm. Calculate (i) Inlet and exit blade angles (ii) Theoretical power developed if the width of the wheel at inlet is 15 cm. Neglect thickness of blades. **(08 Marks)**

c. A Kaplan turbine produces 30000 kw under a head of 9.6 m while running at 65.2 rpm. The discharge through the turbine is 350 m^3/s. The tip diameter of the runner is 7.4 m. The hub diameter is 0.432 times the tip diameter. Calculate :
(i) Turbine efficiency (ii) Specific speed of turbine
(iii) Speed ratio (based on tip diameter). **(06 Marks)**

Module-5

9 a. What is priming? Why priming is required in centrifugal pump? **(03 Marks)**

b. Derive an expression for minimum starting speed of a centrifugal pump. **(05 Marks)**

c. A centrifugal pump discharges 0.15 m^3/s if water against a head of 12.5 m, the speed of the impeller being 600 rpm. The outer and inner diameters of the impeller are 500 mm and 250 mm respectively and the vanes are bent back by 35° to the tangential at the exit. If the area of flow remains 0.07 m^2 from the inlet to outlet. Calculate (i) Manometric efficiency of the pump (ii) Vane angle at inlet (iii) Loss of head of Inlet to the impeller when the discharge is reduced by 40% without changing the speed. **(12 Marks)**

OR

10 a. Define Slip actor and Power input factor. **(03 Marks)**

b. Air is compressed in a centrifugal compressor from 27° to 150°C and pressure from 1 bar to 3 bar. Find Isentropic efficiency and power developed. Take C_P = 1.005 KJ/kgK, $\dot{m} = 0.467$ kg/s, $\dot{m}$ = Mass flow rate. **(05 Marks)**

c. A centrifugal compressor running at 5950 rpm has a impeller tip diameter 100 cm, mass flow rate of air 30 kg/s, total pressure ratio 2.125, pressure at inlet 1 bar and temperature 25°C. Slip coefficient is 0.9 and mechanical efficiency 0.97. Find (i) Total efficiency (ii) Temperature of air at exit (iii) Power input (iv) Pressure coefficient. **(12 Marks)**

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