CBCS SCHEME

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18ME54

Fifth Semester B.E. Degree Examination, July/August 2022
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Steam Tables is permitted.

Module-1

1 a. Define a turbomachine. With a neat sketch, explain the parts of a turbomachine. **(06 Marks)**

b. Compare a turbomachine and a positive displacement machine. **(06 Marks)**

c. Define specific speed of pump. Derive an expression for the same in terms of discharge, speed and head. **(08 Marks)**

OR

2 a. Define Static and Stagnation States. **(04 Marks)**

b. Starting from the first law, derive an expression for the work output of a turbomachine. **(08 Marks)**

c. Show that for a turbine polytropic efficiency is given by

$$\eta_p = \left[\frac{n-1}{n}\right]\left[\frac{\gamma}{\gamma-1}\right]$$

where n is index of polytropic process, γ is ratio of specific heats. **(08 Marks)**

Module-2

3 a. With a neat sketch derive an expression for Euler's turbine equation. **(10 Marks)**

b. At a 50% reaction stage axial flow turbine the mean blade diameter is 0.6 mts. The maximum utilization factor is 0.9 and steam flow rate is 10 kg/sec. Calculate the inlet and outlet absolute velocities and power developed if the speed is 2000 rpm. **(10 Marks)**

OR

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

$$R = \frac{V_f}{2U}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \tan\beta_2}\right]$$ **(10 Marks)**

b. An inward flow reaction turbine has outer and inner diameter wheels as 1m and 0.5m respectively. The vanes are radial at inlet and discharge is radial at outlet and fluid enters the vanes at an angle of 10°. Assuming the velocity of flow to be constant and equal to 3m/s. Find (i) Speed of wheel (ii) Vane angle at outlet (iii) Degree of reaction. **(10 Marks)**

Module-3

5 a. Define Steam Turbine. List the difference between impulse and reaction steam turbines. **(06 Marks)**

b. What is the necessity for compounding steam turbines? Name the different compounding methods. **(04 Marks)**

c. A single stage impulse turbine has a diameter of 1.5m and running at 3000 rpm. The nozzle angle is 20°. Speed ratio is 0.45. Ratio of relative velocity at the outlet to that at inlet is 0.9. The outlet angle of the blade is 3° less than inlet angle. Steam flow rate is 6 kg/sec. Draw the velocity diagrams and find the following:
(i) Velocity of Whirl (ii) Axial thrust (iii) Blade angles (iv) Power developed. **(10 Marks)**

OR

6 a. Prove that the maximum blade efficiency of a reaction turbine is given by

$$\eta_{b\max} = \frac{2\cos^2 \alpha_1}{1+\cos^2 \alpha_1}$$ **(10 Marks)**

b. In a reaction turbine, the inlet and outlet blade angles are 50° and 20° respectively. Steam enters at 18° to the plane of the rotor wheel and leaves at 40°. The rotor sped is 260 m/s. Calculate the speed ratio, specific work and degree of reaction. **(10 Marks)**

Module-4

7 a. Show that the maximum hydraulic efficiency of a Pelton wheel turbine is given by $\eta_{h\max} = \frac{1+C_b \cos\beta_2}{2}$. Also draw the inlet and exit velocity triangles. **(10 Marks)**

b. A double overhung Pelton wheel unit is to produce 30000 kW of a generator under an effective head 300m at the base of the nozzle. Find the size of the Jet, mean diameter of the runner, runner speed and specific speed of each Pelton turbine. Assume generator η = 93%, Pelton wheel efficiency = 0.85, speed ratio = 0.46, Jet velocity coefficient = 0.97 and Jet ratio = 12. **(10 Marks)**

OR

8 a. Draw a neat sketch of a Francis turbine and draw the inlet and outlet velocity triangles. **(06 Marks)**

b. Explain the function of a draft tube and mention its types. **(06 Marks)**

c. A Kaplan turbine develops 10 MW under an effective head of 8m. The overall efficiency is 0.86, the speed ratio is 2 and the flow ratio 0.6. The hub diameter of the wheel is 0.33 times the outside diameter of the wheel. Find the diameter and speed of the turbine. **(08 Marks)**

Module-5

9 a. Define the following for the Centrifugal Pump:
i) Manometric head
ii) Suction head
iii) Net Positive Suction Head [NPSH] **(06 Marks)**

b. Explain with a neat sketch, multistage centrifugal pump arrangement. **(04 Marks)**

c. A centrifugal pump having outer diameter equal to 2 times inner diameter and running at 1200 rpm works against a total head of 75m. The velocity of flow through the impeller is constant and equal to 3 m/s. The vanes are setback at an angle of 30° at outlet. If the outer diameter of impeller is 60 cm and width at outlet is 5 cm, determine i) Vane angle at inlet ii) Work done iii) Monometric efficiency. **(10 Marks)**

OR

10 a. With reference to centrifugal air compressor, explain the following :
i) Choking ii) Surging iii) Slip factor iv) Pressure coefficient **(08 Marks)**

b. What are the types of diffuser used in centrifugal compressor? **(02 Marks)**

c. A centrifugal compressor runs at a speed of 15000 rpm and delivers 30 kg/s of air. The exit diameter is 70 cm relative velocity at exit is 100 m/s at an exit angle of 75°. The total temperature at inlet is 300 K and total pressure at inlet is 1 bar. Determine
i) Power required to drive the compressor ii) Ideal head developed
iii) Work done iv) Total exit pressure. **(10 Marks)**

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