CBCS SCHEME

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15ME53

Fifth Semester B.E. Degree Examination, Jan./Feb. 2023
Turbo Machine

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of steam tables and Mollier chart is permitted.***

Module-1

1 a. Define a Turbo machine. Explain the functions of different parts of a Turbo machine. **(06 Marks)**

b. Indentify the following as power generating on power absorbing Turbo machine :
i) Centrifugal compressor ii) Steam Turbine iii) Air blower. **(03 Marks)**

c. Test on a turbine runner 1.25m in diameter of 30m head gave the following results : Power developed = 736kW, Speed = 180rpm, discharge = 2.7m^3/s. Find the diameter, speed and discharge of a runner to operate at 45m head and give 1472kW at the same efficiency. What is the specific speed of both the turbines? **(07 Marks)**

OR

2 a. With h-s diagram, show that reheat factor in multi stage turbine is greater than unity. **(08 Marks)**

b. A 16-stage axial flow compressor is to have a pressure ratio of 6.3 and tests have shown that a stage efficiency of 89.5% can be obtained. The intake conditions are 288K and 1 bar. Find : i) Overall efficiency ii) Polytropic efficiency iii) Preheat factor. **(08 Marks)**

Module-2

3 a. An inward flow radial hydraulic turbine has a degree of reaction R and utilization factor E. The radial velocity is constant throughout. There is no velocity of whirl at outlet. Show that the nozzle angle is given by $\alpha_1 = \cot^{-1}\sqrt{\frac{1-R}{1-\epsilon}}\epsilon$. **(08 Marks)**

b. An inward flow reaction turbine has an inlet and outlet diameter as 1m and 0.5m respectively. The vanes are radial at inlet and the discharge is radial at outlet. The water enters the vanes at an angle of 10°. Assume the velocity of flow to be constant and equal to 3m/s. Find the following : i) Speed of the runner ii) Vane at outlet. **(08 Marks)**

OR

4 a. Draw the velocity triangles for an axial flow compressor and show that for an axial flow compressor having no axial thrust, the degree of reaction is given by $R = \frac{V_a}{2u}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \cdot \tan\beta_2}\right]$. Where V_a = Axial velocity, β_1 and β_2 = Inlet and outlet blade angles with respect to tangential direction. **(08 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 through the stage is 110m/s. The compressor is one of 50% reaction with symmetric inlet and outlet velocity triangles, the inlet blade angle being 30° and outlet angle 50° with respect to tangential direction. Compute the absolute velocity at the rotor inlet, the mean blade tip speed and the temperature rise of the air is passing through the stage. **(08 Marks)**

Module-3

5 a. Derive the condition for maximum blade efficiency of a single stage impulse steam turbine. Further, show that $(\eta_b)_{max} = \cos^2\alpha_1$ for symmetrical blades with no friction in the blade channels where α_1 = Nozzle angle. **(08 Marks)**

b. A single stage impulse turbine rotor has a diameter of 1.2m running at 3000rpm. The nozzle angle is 18°. Blade speed ratio is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3° less than the inlet angle. Steam flow rate is 5Kg/s. Draw the velocity triangles and find :

i) Blade angles
ii) Tower developed
iii) Blade efficiency. **(08 Marks)**

OR

6 a. What do you mean by compounding of steam turbine? Explain with the help of a schematic diagram, a two row pressure compounded impulse turbine stage. **(06 Marks)**

b. Dry saturated steam at 10bar is supplied to a single rotor axial flow impulse turbine, the condenser pressure being 0.5 bar. The nozzle efficiency is 94% and the nozzle angle at rotor inlet is 18° to the wheel plane. The rotor blades are equiangular and move at a speed of 450m/s. If the blade velocity coefficient for the moving blades is 0.91, determine: i) Power output for a mass flow rate of 1Kg/s ii) Rotor efficiency iii) Stage efficiency. **(10 Marks)**

Module-4

7 a. Show that for a Pelton wheel, the maximum hydraulic efficiency is given by

$$(\eta_b)_{max} = \frac{1 + K\cos\beta_2}{2}.$$

Where K = blade velocity coefficient, β_2 = Blade angle at exit. **(08 Marks)**

b. A three jet Pelton wheel is required to generate 10,000 kW under a net head of 400m. The blade angle at outlet is 15° and the reduction in relative velocity over the buckets is 5%. If the overall efficiency is 80%, $C_v = 0.98$ and speed ratio = 0.46, find :

i) Diameter of each jet
ii) total flow rate in m^3/s
iii) Tangential force exerted by a jet on the buckets. **(08 Marks)**

OR

8 a. Mention the functions of a Draft tube in a reaction hydraulic turbine using Bernoulli's equation, show that the pressure head at the inlet of the draft tube is less than the atmospheric pressure. **(06 Marks)**

b. Following data refers to an inward radial flow Francis turbine : Output = 15000kW, Speed = 300rpm, Net Head = 120m, Inner diameter of the runner = 0.6 × outer diameter of the runner, axial length of the blade at inlet = 0.1 × corresponding diameter, flow ratio = 0.15, hydraulic efficiency = 80%, overall efficiency = 85%, area blocked by the blade thickness = 5% of area of flow at inlet. Assume radial discharge at outlet and velocity of flow is constant throughout. Calculate :

i) Diameter of the runner at inlet and outlet
ii) Guide vane angle
iii) Moving vane angle at inlet and outlet. **(10 Marks)**

Module-5

9 a. Write a note on cavitations in centrifugal pumps. (04 Marks)

b. Derive an expression for the static pressure rise in the impeller of a centrifugal pump with velocity triangles. (06 Marks)

c. A centrifugal pump is running at 1500rpm. The outlet angle of the impeller is 45° and the velocity of flow at the outlet is 2.5m/s. The discharge through the pump is $0.2m^3/s$ when the pump is working against a head of 20m. If the manometric efficiency is 80%, draw the outlet velocity triangle and calculate :

i) The diameter of the impeller at the outlet
ii) Width of the impeller at outlet. (06 Marks)

OR

10 a. Explain the following with appropriate sketches :
i) surging ii) chocking iii) pre-rotation. (09 Marks)

b. An axial flow compressor has the following data :
Entry conditions = 1 bar and 20°C, Degree of reaction = 50%
Mean blade ring diameter = 36cm
rotational speed = 18000 rpm
blade height at entry = 6cm,
Blade angle at rotor exit = 65°
Axial velocity = 180m/s, mechanical efficiency = 0.967. Find :

i) Blade angle at rotor inlet
ii) Power required to drive the compressor. (07 Marks)

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