CBCS SCHEME

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18MR55

Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define a turbo machine. With a neat sketch explain the parts of a turbo machine. Also classify turbo machine. **(10 Marks)**

b. A model of a water turbine 1m diameter develops 15kW running at 800rpm under a head of 20m. The prototype has to work under a head of 200m at 200rpm. If the efficiencies are same, find i) Diameter of the prototype ii) Specific speed iii) Power developed and name of the turbine runner. **(10 Marks)**

OR

2 a. Derive the relation between isentropic efficiency and polytropic efficiency for an expansion process with usual rotations. **(10 Marks)**

b. A two stage gas turbine develops 22MW at the shaft. The inlet temperature is 1500K. The pressure ratio of each stage is same, and the P_2/P_1 equal to 8. Take the isentropic expansion efficiency is 0.9 calculate: i) The pressure ratio of each stage, if it has 2 – stages ii) Polytropic efficiency iii) The mass flow rate iv) The efficiency and power of each stage, assume $\gamma = 1.4$, $C_p = 1.005$kJ/kg K, overall drive efficiency = 0.90. **(10 Marks)**

Module-2

3 a. With usual notation and velocity triangles derive alternative Euler turbine equation and identify the components of energy transfer. **(10 Marks)**

b. Following data refers to a 50% reaction turbine blade speed 250ms^{-1}, $\alpha_1 = 18°$ the velocity of flow is constant and is equal to blade speed. Determine: i) Blade angles ii) Energy transfer iii) Utilization factor such that the inlet and outlet velocity triangle are symmetry. **(10 Marks)**

OR

4 a. Show that the degree of reaction for axial flow compressor is constant velocity of flow is given by

$$R = \frac{Va}{2u}\left[\frac{\tan\beta_2 + \tan\beta_1}{\tan\beta_1 \tan\beta_2}\right] = \frac{Va}{2u}\cot\beta_n$$ **(10 Marks)**

b. The following data refers to an axial flow compressor degree of reaction 0.5, inlet blade angle 45°. Axial velocity of flow is constant $V_f = V_{f_1} = V_{f_2} = 100$ms^{-1} speed of the blade 6000rpm. Diameter of the blade 0.5m. The blade speed is same at inlet and outlet $u_1 = u_2 = u$ mass of air flowing is 2kgs^{-1}. Determine, the fluid angles at inlet and outlet the power required. **(10 Marks)**

Module-3

5 a. Prove that for maximum blading efficiency for a single stage impulse steam turbine is given by $(\eta_b)_{max} = \cos^2\alpha_1$. **(08 Marks)**

b. A single stage impulse steam turbine has a diameter of 1.5m and running at 300rpm. 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 at inlet angle, steam flow rate is 6kg/s. Draw the velocity diagrams and find the following:
i) Velocity of whirl
ii) Axial thrust
iii) Blade angles
iv) Power developed. **(12 Marks)**

OR

6 a. Briefly explain velocity compounding. **(06 Marks)**

b. Steam leaves the nozzles of a two row velocity compounded impulse turbine stage at 900m/s. The nozzle angle is 20° to the plane of rotation. The first row blades have an inlet angle of 25° and outlet angle of 27° and a blade velocity coefficient of 0.95. The fixed blades are symmetrical, and have a velocity coefficient of 0.98. In the second moving row, the blade velocity coefficient is 0.95. The absolute velocity of the steam leaving the second row is axial, the mass flow rate is 10kg/s. Determine : i) U ii) $\alpha_1, \alpha_2, \alpha_3$ iii) β_3 and β_4 iv) Fa v) Power (P). **(14 Marks)**

Module-4

7 a. Briefly classify hydraulic turbines. **(05 Marks)**

b. Show that the maximum hydraulic efficiency of a pelton wheel turbine is given by $(\eta_h)_{max} = \dfrac{1+K\cos\beta_2}{2}$. **(06 Marks)**

c. The penstock supplies water from a reservoir to the pelton wheel with a gross head of 500m. One third of the gross head is lost in friction in the penstock. The rate of flow of water through the nozzle fitted at the end of penstock is $2m^3/s$. The angle of deflection of the jet is 165°. Determine the power given by the water to the runner and also hydraulic efficiency of the pelton wheel. Take speed ratio 0.45 $C_v = 1$. **(09 Marks)**

OR

8 a. With a neat sketch explain the principle and working of Francis turbine. **(08 Marks)**

b. Classify draft tube and mention the function of draft tube. **(04 Marks)**

c. A Kaplan turbine develops 1500KW under a head of 6m. The turbine is set 2.5m above the tail race level. A vacuum gauge inserted at the turbine outlet records a suction head of 3.2m. If the efficiency is 85%. What will be the efficiency of the draft tube having inlet diameter of 3m. **(08 Marks)**

Module-5

9 a. With a neat sketch, briefly explain the principle parts of a centrifugal pump. **(08 Marks)**

b. Derive an expression for minimum starting speed of a centrifugal pump. **(06 Marks)**

c. Find the power required to drive the CF pump which delivers $0.04m^3/s$ of water to a height of 20m, through a 15cm diameter of pipe and 100m long. The overall efficiency of the pump is 70% and the friction factor is assumed to be 0.015. **(06 Marks)**

OR

10 a. Write a note on C.F. pump for the following:
i) NPSH ii) Cavitation iii) Need for priming. **(09 Marks)**

b. A C.F. pump having outer diameter equal to 2 times the inner diameter and running at 1000rpm, working under a head of 30m. The velocity of flow through the impeller is constant and equal to 2.5m/s. The vanes are set back at an angle of 40° at the outlet. If the outer diameter = 50cm and width at outlet 56m, calculate: i) vane angle at the inlet ii) work done by the impeller on water/second iii) manometric efficiency. **(11 Marks)**

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