CBCS SCHEME

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15ME53

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Turbo Machines

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Enumerate the difference between positive displacement machine and turbo machine. **(04 Marks)**

b. Define static and stagnation states. **(04 Marks)**

c. Air flows through an air turbine where its stagnation pressure is reduced in the ratio 5:1. The total to total efficiency is 80%. The air flow is 5 kg/s. If the total power output is 500 KW. Find:
(i) Inlet total temperature
(ii) Actual exit total temperature
(iii) Actual exit static temperature if the velocity is 100 m/s
(iv) Total to static efficiency **(08 Marks)**

OR

2 a. 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)**

b. A turbine is to operate under a head of 25m at 200 rpm. The discharge is 9 m^3/s. If the efficiency is 90%, determine the performance of the turbine under a head of 20 m. **(08 Marks)**

Module-2

3 a. Show that the alternate form of Euler's turbine equation can be expressed as follows

$$W = \frac{(v_1^2 - v_2^2) + (u_1^2 - u_2^2) + (v_{r_2}^2 - v_{r_1}^2)}{2}$$

Draw the relevant velocity triangles. **(08 Marks)**

b. Show that for maximum utilization factor of an axial flow machine with $R = \frac{1}{4}$. The speed ration $\phi = \frac{2}{3}\cos\alpha$, where R is degree of reaction and α_1 is nozzle angle with respect to tangential direction at inlet. **(08 Marks)**

OR

4 a. A radial outward flow turbo machine has no whirl at inlet. The blade speed at exit is twice that at inlet. The radial velocity remains constant. Inlet blade angle is 45°. Show that the degree of reaction for this machine is given by $R = \frac{2 + \cot\beta_2}{4}$ where R is degree of reaction and β_2 is blade angle at exit. **(08 Marks)**

b. A single stage air blower with no inlet guide vanes is running at 3600 rpm. The mean diameter of rotor is 16 cm and mass flow rate of air through the blower is 0.45 kg/s. In the rotor the air is turned through an angle of 20° towards the axial direction during the passage through the rotor at mean diameter. Assume that the axial component of fluid velocity remain constant. Determine the power input and degree of reaction. Assume that the density of air is constant at 1.185 kg/m^3 and area of flow is 0.02 m^2. **(08 Marks)**

Module-3

5 a. What is need for compounding in stream turbines? Explain velocity compounding. **(04 Marks)**

b. For a 50% reaction turbine show that $\alpha_1 = \beta_2$ and $\alpha_2 = \beta_1$ where α_1 and α_2 are inlet and outlet angles of fixed blades and β_1 and β_2 are inlet and outlet angles of moving blades. **(04 Marks)**

c. In a single stage impulse turbine the nozzle angle is 25°. The absolute velocity of stream at exit is 300 m/s in a direction 120° to the direction of motion of blades assuming no axial thrust. Determine: (i) the blade angles and (ii) power developed. **(08 Marks)**

OR

6 a. Show that the maximum utilization factor of blade efficiency with equiangular blades is given by $\eta_{b\max} = \cos^2 \alpha_1$ where α_1 is the nozzle angle. **(08 Marks)**

b. The following data refers to a stage of a reaction turbine. Rotor diameter 1.5 m, speed ratio 0.72, outer blade angle 20° rotor speed 3000 rpm. Determine:
(i) Diagram efficiency
(ii) Percentage increase in diagram efficiency and rotor speed. If the rotor is designed to run at the best theoretical speed. Assume symmetric velocity triangles. **(08 Marks)**

Module-4

7 a. Show that the maximum hydraulic efficiency of pelton wheel turbine is given by

$$\eta_{h\max} = \frac{1 + K\cos\beta_2}{2}$$

where K is blade velocity coefficient, β_2 is blade discharge angle. **(08 Marks)**

b. The following data refers to a Francis turbine:
Net head = 60 m, speed = 700 rpm, shaft power = 294.3 KW, overall efficiency = 84%, hydraulic efficiency = 93%, flow ratio = 0.20, breadth ratio = 0.1, outer diameter of runner equal twice the inner diameter. The thickness of the vane occupy 5% of circumferential area of the runner, velocity of flow is constant at inlet and outlet and the discharge is radial at outlet. Determine :
(i) Guide blade angle
(ii) Runner vane angle at inlet and outlet
(iii) Diameter of runner at inlet and outlet
(iv) Width of the wheel at inlet **(08 Marks)**

OR

8 a. Explain with neat sketch working of Francis turbine. Mention the functions of draft tube. **(08 Marks)**

b. A pelton wheel is to be designed for a head of 60 m when running at 200 rpm. The pelton wheel develops 95.65 KW shaft power. The velocity of buckets = 0.45 times the velocity of jet, overall efficiency = 0.85 and coefficient of velocity = 0.98. Find:
(i) The diameter of jet
(ii) Diameter of wheel
(iii) Size of buckets
(iv) Number of buckets **(08 Marks)**

Module-5

9 a. When the pumps are arranged in series and in parallel? Explain any one arrangement. **(04 Marks)**

b. Explain the phenomenon of surging in centrifugal compressors. **(04 Marks)**

c. An air compressor has eight stages of equal pressure ratio 1.35. the flow rate through the compressor and its overall efficiency are 50 kg/s and 82% respectively. If the conditions of air at entry are 1.0 bar and 40°C. Determine:

(i) State of air at exit of compressor
(ii) Polytropic efficiency
(iii) Efficiency of each stage
(iv) Power required to drive the compressor, assume overall efficiency of drive as 90%. **(08 Marks)**

OR

10 a. Define slip and slip coefficient with respect to centrifugal compressor. **(02 Marks)**

b. Draw the velocity diagrams at exit of a centrifugal pump for forward, radial and backward curved vanes. **(06 Marks)**

c. A centrifugal pump impeller has radial vanes from inner radius of 8 cm to outer radius of 24 cm. The width of the impeller is constant and is 6 cm between the shrouds. If the speed of the pump is 1500 rpm and discharge is 250 lit/s. Find:

(i) Change in enthalpy
(ii) The outlet pressure if the inlet pressure is 0.8 kPa and water flow is outward. **(08 Marks)**

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