CBCS SCHEME

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15ME53

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Turbomachines

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Define a turbomachine. With a neat sketch, explain the parts of a turbomachine. **(04 Marks)**

b. Define and explain the significance of dimensionless parameters flow coefficient and power coefficient. **(04 Marks)**

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

OR

2 a. Explain static and stagnation states of a fluid. **(04 Marks)**

b. Discuss in detail, the application of first and second law of thermodynamics to a turbomachine. **(06 Marks)**

c. Air enters a blower at a total pressure of 1 atm, a total temperature of 30°C and a flow velocity of 55 m/s. At the exit, total temperature is 41.2°C and the flow velocity is 150 m/s. Calculate: (i) The change in total pressure between inlet and exit of the blower.
(ii) Change in static pressure in metres of water. **(06 Marks)**

Module-2

3 a. Derive alternate form of Euler's turbine equation and explain the significance of each energy component. **(06 Marks)**

b. Define the terms Degree of Reaction (R) and utilization factor ($\in$). **(04 Marks)**

c. With the help of inlet and exit velocity triangles, show that the degree of reaction for an axial flow compressor is given as $R = \frac{V_f}{U}.\cot\beta_m$ where V_f is axial velocity, U is blade speed and $\text{Cot}\,\beta_m = \frac{\text{Cot}\,\beta_1 + \text{Cot}\,\beta_2}{2}$, β_1 and β_2 are inlet and outlet blade angles with respect to axial direction. **(06 Marks)**

OR

4 a. Draw the inlet and exit velocity triangles for an axial flow machine for the following cases:
(i) R < 0 (ii) R = 1 (iii) R > 1 **(06 Marks)**

b. A radial outward flow turbomachine has no inlet whirl. The blade speed at exit is twice as that of the inlet. Radial velocity is constant throughout. Taking the inlet blade angle as 45°, show that degree of reaction is given as $E = \frac{2 + \cot\beta_2}{4}$ where β_2 is the blade angle at exit. **(10 Marks)**

Module-3

5 a. Define compounding in steam turbines. Explain its necessity. With neat sketches, explain the methods of compounding. **(08 Marks)**

b. In a reaction turbine, the fixed and moving blades are of the same shape but reversed in direction. The angle of receiving tips are 35° and discharging tips are 20°. Find the power developed per pair of blades for a steam consumption of 1 kg/s when the blade speed is 50 m/s. Find also the efficiency of the pair if the heat drop in the pair is 10 kJ/kg. **(06 Marks)**

c. Define the terms Blade efficiency and stage efficiency of a steam turbine. **(02 Marks)**

OR

6 a. The following particulars relate to a two row velocity compounded impulse wheel. Steam velocity at nozzle outlet = 650 m/s; Mean blade speed = 125 m/s ; Nozzle outlet angle = 16° ; Outlet angle of first row moving blades = 18° ; Outlet angle of fixed and second row of moving blades = 22° and 36° ; Steam flow rate = 2.5 kg/s ; Ratio of relative velocities at outlet to inlet = 0.84 for all the blades. Determine:
(i) Axial thrust on blade (ii) Power developed (iii) Efficiency of wheel **(10 Marks)**

b. In a simple impulse turbine, the nozzles are inclined at 20° to the direction of motion of moving blades. Steam leaves the nozzle at 375 m/s. Blade velocity is 165 m/s. Calculate the suitable inlet and outlet angles for the blades in order that axial thrust is zero. The relative velocity is reduced by 15% due to friction. Determine the power developed for a flow rate of 10 kg/s. **(06 Marks)**

Module-4

7 a. Classify hydraulic turbines in detail. **(04 Marks)**

b. Define the following terms associated with hydraulic turbines:
(i) Hydraulic efficiency (ii) Mechanical efficiency (iii) Overall efficiency **(04 Marks)**

c. Three Francis turbines A, B, C have the following same data:
Inlet diameter = 0.5 m, Inlet velocity of flow = 5 m/s, Hydraulic efficiency is same. The speed, inlet blade angle for turbine 'A' are 500 rpm, 60°. For turbines 'B' and 'C', the inlet blade angles are 90° and 110° respectively. Calculate the speed of two turbines 'B' and 'C'. **(08 Marks)**

OR

8 a. A propeller turbine has a outer diameter of 4.5 m and inner diameter 2m. It develops 20,605 KW under a head of 20 m at 137 rpm. Hydraulic efficiency is 0.94, overall efficiency is 0.88. Find the Runner blade angles and discharge through the runner. **(08 Marks)**

b. Show that the specific speed of a Pelton wheel is given by $N_s = 240 \frac{\sqrt{n}}{m}$ where 'n' is the number of jets used for flow, 'm' is wheel diameter to jet diameter ratio. Assume $C_V = 0.97$, $\phi = 0.45$ and overall efficiency of turbine = 0.89. **(08 Marks)**

Module-5

9 a. Define priming and explain the phenomenon of cavitation in centrifugal pumps. **(04 Marks)**

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

c. A centrifugal pump lifts water under a static head of 36 m of which 4m is suction lift. Suction and delivery pipes are of 150 mm in diameter. The head loss in suction pipe is 1.8 m and 7 m in delivery pipe. Impeller is 380 mm in diameter and 25 mm wide at mouth and revolves at 1200 rpm. Its exit blade angle is 35°. If the manometric efficiency of pump is 82%, find the discharge and pressure at the suction and delivery branches of pump. **(07 Marks)**

OR

10 a. Explain surging and stalling with reference to a centrifugal compressor. **(08 Marks)**

b. The following data refers to a centrifugal compressor. Free air delivered = 1200 kg/hr, suction conditions are 1 bar and 290 K. Velocity of air at entry = 60 m/s, $\eta_{i_{sen}} = 70\%$, $\eta_{mech} = 95\%$. Total head pressure ratio = 3. Find total head, temperature of air at exit and power required. **(08 Marks)**

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