CBCS SCHEME

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15ME53

Fifth Semester B.E. Degree Examination, July/August 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. Describe the parts of a turbomachine with neat sketch. **(08 Marks)**

b. Explain the effect of Reynolds Number in turbomachines. **(04 Marks)**

c. From the performance curves of turbines, its seen that a turbine of one motor diameter acting under a head of one meter, develops a speed of 25 rpm. What diameter should be a prototype have if it is develop 10,000 kW working under a head of 200 m with a specific speed of 150. **(04 Marks)**

OR

2 a. Explain the application of 1st and 2nd law of Thermodynamics to Turbomachines. **(08 Marks)**

b. Explain total to total efficiency and total to static efficiency. **(08 Marks)**

Module-2

3 a. Derive Euler's turbine equation with usual notation. **(08 Marks)**

b. In a radial inward flow turbine, the runner outer diameter is 75 cm and the inner is 50cm. The runner speed is 400rpm. Water enters runner at a velocity of 15 m/s at an angle of 15° to the wheel tangent at inlet. The flow is radial at exit with a velocity of 5 m/s. Find blade angles at inlet and exit. Also find power output for a mass flow rate of 1.5 m^3/s, degree of reaction and utilization factor. **(08 Marks)**

OR

4 a. Define degree of reaction. For an inlet blade angle of 45°, blade speed at exit as twice of that at inlet and a inlet whirl velocity of zero value, prove that $R = \frac{(2+\cot\beta_2)}{4}$

For a radial outward flow turbine where, β = Blade angle at exit, R = Degree of reaction. **(08 Marks)**

b. Show that for maximum utilization of an axial flow turbine with R = ¼ , the speed ratio is given by $\phi = \frac{2}{3}\cos\alpha_1$, where α_1 = Nozzle angle at inlet with respect to tangential direction. **(08 Marks)**

Module-3

5 a. What is compounding? Explain pressure compounding with sketch. **(06 Marks)**

b. A single stage impulse turbine rotor has a diameter of 1.2m running at 3000 rpm. The nozzle angle is 18°, Blade speed is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The steam flow rate is 5 kg/s. Draw the velocity diagram and find the following: (i) Velocity of whirl (ii) Axial Thrust (iii) Blade angles (iv) Power developed. Take $\beta_2 = \beta_1 - 3°$. **(10 Marks)**

OR

6 a. What is meant by reaction staging? Prove that the maximum stage efficiency of Parson's (50% Reaction) turbine is given by

$$\eta_{smax} = \frac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}$$ **(08 Marks)**

b. The following data refers to a particular stage of a Parson's reaction turbine. Speed of turbine = 1500 rpm, Mean diameter of rotor = 1m, State efficiency = 0.8, Blade outlet angle = 20°, Speed ratio = 0.7. Determine the available isentropic enthalpy drop in the stage. **(08 Marks)**

Module-4

7 a. Explain the working of Francis turbine with neat sketch. Also draw velocity triangles. **(08 Marks)**

b. A Kaplan turbine working under a head of 20 m develops 11772 kW of shaft power, the outer diameter of runner is 3.5m and hub diameter is 1.75 m. The guide blade angle at the extreme edge of the runner is 35°. The hydraulic and overall efficiency of the turbine are 88% and 84% respectively. If the velocity of whirl at outlet is zero. Determine:
i) Runner vane angles
ii) Speed of the turbine. **(08 Marks)**

OR

8 a. Briefly explain the different type of draft tubes with neat sketches. **(08 Marks)**

b. A three jet Pelton turbine is required to generate 10,000 kW under a head of 400m. The blade angle at outlet is 15° and the reduction in relative velocity while passing over the blades is 5%. If overall efficiency of wheel is 80%, $C_v = 0.98$ and speed ratio = 0.46, find (i) Total flow in m^3/s (ii) Discharge through each jet (iii) Diameter of jet (iv) Force exerted by jet on wheel. **(08 Marks)**

Module-5

9 a. For a centrifugal pump, show that the pressure rise in impeller neglecting friction and other losses is

$$(P_1 - P_2) = \frac{1}{2}\left[V_{f_1}^2 + u_{f_2}^2 - V_{f_2}^2 \ \text{cosec}^2\beta_2\right]$$

where V_{f_1} and V_{f_2} = Velocity of flow at inlet and exit

u_2 = Tangential velocity of Impeller at exit

β_2 = Blade discharge angle. **(08 Marks)**

b. A 4-stage centrifugal pump has impeller each of 38 cm diameter and 1.9 cm wide at outlet. The outlet vane angle is 45° and the vanes occupy 10% of the outlet area. The manometric efficiency is 85% and overall efficiency is 75%. Determine the head generated by the pump when running at 1000 rpm discharging 60 lit/s. Also determine the power required. **(08 Marks)**

OR

10 a. With a neat sketch explain an axial flow compressor. Also sketch the velocity triangles at inlet and exit. **(08 Marks)**

b. A centrifugal compressor runs at 15,000 rpm and produces stagnation pressure ratio of 4 between the impeller inlet and outlet. The stagnation conditions of air at compressor intake are 1 bar, 25°C respectively. The absolute velocity at compressor intake is axial. The compressor has radial blades at exit, such that relative velocity at exit is 135 m/s and total to total efficiency of compressor is 0.78. Draw velocity triangles and compute slip and slip coefficient. Assume rotor diameter of 58 cm. **(08 Marks)**

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