CBCS SCHEME

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18ME54

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

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Differentiate between turbo machine and positive displacement machine under the following aspects (i) Action (ii) Operation (iii) Mechanical features (iv) Efficiency of energy conversion (v) Volumetric efficiency **(10 Marks)**

b. A ¼ scale turbine model is tested under a head of 10 meters. The prototype is required to work under a head of 30 meters and to run at 425 rpm. Estimate the speed of the model if it develops 125 kW and uses 1.1 m^3/sec of water at this speed. Also calculate the power output, discharge of prototype and suggest the type of turbine. **(10 Marks)**

OR

2 a. Explain static and stagnation state for a fluid. **(04 Marks)**

b. Show that polytropic efficiency for compressor is given by $\eta_P = \left(\frac{r-1}{r}\right) \times \left(\frac{n}{n-1}\right)$. **(08 Marks)**

c. A turbine has four stages and each stage pressure ratio is 2. The inlet static temperature is 630°C. The mass flow rate is 30 kg/sec. The overall efficiency is 0.8. Calculate

(i) Polytropic efficiency (ii) The stage efficiency
(iii) The power developed (iv) Reheat factor. **(08 Marks)**

Module-2

3 a. Define degree of reaction and utilization factor. Derive relation between degree of reaction and utilization factor. **(10 Marks)**

b. In an axial flow machine (turbine), the discharge blade angles are 20° each for both stator and rotor. The steam speed at the exit of the fixed blade is 140 m/sec. The ratio $\frac{V_f}{U} = 0.7$ at the entry and 0.76 at the exit of the rotor blade. Find the inlet rotor angle, the power developed by the blade ring for a mass flow rate of 2.6 kg/sec and the degree of reaction. **(10 Marks)**

OR

4 a. A radial outward flow turbo machine has no inlet whirl. The blade speed at the exit is twice that at inlet. Radial velocity is constant throughout. Taking the inlet blade angle as 45°. Show that the degree of reaction is given by $R = \frac{2 + \cot\beta_2}{4}$, where β_2 is the blade angle at exit with respect to tangential direction. **(10 Marks)**

b. An inward flow turbine has water inlet angle of 20°, the water leaves radially, speed of wheel = 350 rpm. Velocity of flow is 4 m/sec. The inner and outer diameter of the turbine are 30 cm and 60 cm respectively. Width of the wheel at inlet is 12 cm. Find the blade angle of power developed. Also what will be the value of R. **(10 Marks)**

Module-3

5 a. What is compounding? Explain (i) Velocity compounding and (ii) Pressure compounding with neat sketches. **(10 Marks)**

b. A single stage impulse turbine has a diameter of 1.5 m and running at 3000 rpm. The nozzle angle is 20°. Speed ratio is 0.45. The ratio of relative velocity at outlet to that at inlet is 0.9. The outlet angle of the blade is 3° less than inlet angle. Steam flow rate is 6 kg/sec. Draw the velocity diagram and find the following : (i) Velocity of whirl (ii) Axial thrust (iii) Blade angles (iv) Power developed. **(10 Marks)**

OR

6 a. Derive condition for maximum efficiency of reaction steam turbine and hence prove that $n_{b_{max}} = \frac{2\cos^2 \alpha_1}{1+\cos^2 \alpha_1}$. **(10 Marks)**

b. In a Parson's turbine the axial velocity of flow of steam is 0.5 times the mean blade speed. The outlet angle of blade is 20°, the diameter of the blade ring is 1.3 m and the rotational speed is 3000 rpm. Determine inlet blade angles, power developed for the steam flow of 65 kg/sec and the isentropic enthalpy drop, if the stage efficiency is 80%. **(10 Marks)**

Module-4

7 a. With a mathematical expression, define the following : (i) Hydraulic efficiency (ii) Mechanical efficiency (iii) Overall efficiency (iv) Volumetric efficiency. **(08 Marks)**

b. Show that the maximum efficiency of Pelton wheel is given by $\eta_{b,max} = \frac{1+C_b \cos\beta_2}{2}$, where C_b = Blade velocity coefficient, β_2 = Bucket angle at its outlet. **(12 Marks)**

OR

8 a. Explain the functioning of a Kaplan turbine, with help of a sectional arrangement diagram. Draw the velocity triangles of Kaplan turbine. **(08 Marks)**

b. The following data is given for a Francis turbine, net head = 70 m, Speed = 600 rpm, Shaft power = 370 kW, $\eta_O = 0.80$, $\eta_h = 0.95$, flow ratio = 0.25, breadth ratio is equal to 0.1, outer diameter of runner is equal to two times inner diameter of the runner. The thickness of vanes occupy 10% circumferential area of the runner. Velocity of flow is constant and discharge is radial at outlet. Determine (i) Guide blade angle (ii) Runner angle at inlet and outlet (iii) Diameter of the runner at inlet and outlet (iv) Width of the wheel at inlet. **(12 Marks)**

Module-5

9 a. Define the following with respect to centrifugal pump, (i) Static head (ii) Cavitation (iii) Priming (iv) Multistage centrifugal pumps. **(08 Marks)**

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

c. A centrifugal pump discharges 0.15 m^3/s of water against a head of 12.5 m, speed of impeller is 600 rpm. The outer and inner diameter of impeller are 500 mm and 250 mm respectively and the vanes are bent back at 35° to the wheel tangent at exit. If the area of flow remains 0.07 m^2 from inlet to, outlet, find
(i) Manometric efficiency (ii) Vane angle at inlet **(06 Marks)**

OR

10 a. Explain the following with respect centrifugal compressor: (i) Pressure coefficient (ii) Slip factor (iii) Power factor (iv) Surging **(08 Marks)**

b. A centrifugal compressor runs at a speed of 15000 rpm and delivers air at 30 kg/sec. Exit radius is 0.35 m, relative velocity and vane angles at exit are 100 m/s and 75°. Assuming axial inlet, inlet stagnation temperature and pressure as 300 K and 1 bar. Calculate (i) The torque (ii) The power required to drive the compressor. (iii) The ideal head developed (iv) The work done (v) The exit total pressure. Take $C_{P_{air}} = 1.005$ kJ/kg. **(12 Marks)**

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