CBCS SCHEME

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15ME53

Fifth Semester B.E. Degree Examination, June/July 2023
Turbo Machines

Time: 3 hrs. Max. Marks: 80

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

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. List the difference between Positive Displacement Machines and Turbo Machines. **(05 Marks)**

b. Define Specific Speed of a Turbine. Derive an expression for Specific speed. **(05 Marks)**

c. A one fourth 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 r.p.m. Estimate the speed of the model if it develops 125kW and uses $1.1 m^3/S$ of water at this speed. Also calculate the power output of the prototype and suggest the type of the turbine. **(06 Marks)**

OR

2 a. Define the term Infinitesimal Stage efficiencies of a turbine. Show that the polytropic efficiency during the expansion process is given by

$$\eta_p = \frac{\log_e \frac{T_2}{T_1}}{\left(\frac{r-1}{r}\right)\log_\ell \frac{P_2}{P_1}}.$$ **(08 Marks)**

b. A sixteen (16) stage, axial flow compressor is to have a pressure ratio of 6.3 and tests have shown that a stage efficiency of 89.5% can be obtained. The intake conditions are 288K and 1 bar pressure. Find i) Overall efficiency ii) Polytropic efficiency iii) Preheat factor. **(08 Marks)**

Module-2

3 a. Derive an alternative form of Euler's turbine equation and explain the significance of each energy components. **(08 Marks)**

b. In an axial flow turbine, the discharge blade angles 20º each for both the stator and the rotor. The steam speed at the exit of the fixed blade is 140m/s. The ratio of $\frac{V_a}{u} = 0.7$ at the entry and 0.76 at the exit of the rotor blade. Find i) the inlet rotor blade angle ii) the power developed by the blade ring for a mass flow rate of 2.6 kg/s iii) Degree of reaction. **(08 Marks)**

OR

4 a. Draw the velocity diagram for a power absorbing radial flow turbo machine and show that $R = \frac{1}{2}\left[1 + \frac{Vm_2 \cot \beta_2}{U_2}\right]$. Where R = Degree of reaction , Vm_2 = Flow velocity at outlet β_2 = Blade Angle at outlet , U_2 = Tangential speed at outlet. **(08 Marks)**

b. An Inward flow reaction turbine has outer diameter and inner wheel as 1m and 0.5m respectively. The vanes are radial at inlet and discharge is radial at outlet and fluid enters vanes at an angle of 10º. Assuming the velocity of flow to be constant and equal to 3m/s. Find i) Speed of the wheel ii) Vane angle at outlet iii) Degree of reaction. **(08 Marks)**

Module-3

5 a. Draw the Inlet and exit velocity triangles for a Single Stage Impulse Steam turbine. Further prove that maximum blade efficiency is given by $\eta_{b\,max} = \cos^2 \alpha_1$. Assume $Vr_1 = Vr_2$ and $\beta_2 = \beta_1$. **(08 Marks)**

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b. Steam issues from the nozzle of a Delaval turbine with a velocity of 1000m/s. The nozzle angle is 20º and the mean blade speed is 400m/s. Inlet and outlet angles are equal , Mass of steam flowing through the turbine is 1000 kg/hr. Calculate
i) Blade Angles ii) Relative velocity of steam entering the blades iii) Axial thrust
iv) Power Developed v) Blade efficiency. Assume friction factor = 0.8. **(08 Marks)**

OR

6 a. What is the necessity of Compounding Steam Turbines? Discuss any one methods compounding with neat sketches. Show velocity and pressure variations across the turbine. **(08 Marks)**

b. The following data refers to a 50% degree of reaction axial flow turbo machine. Inlet fluid velocity = 230 m/s , Inlet rotor angle = 60º . Outlet rotor angle = 250. Find utilization factor, Axial thrust and Power output per unit mass flow. **(08 Marks)**

Module-4

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

b. The following data are given for Francis turbine Net head = 70m , Speed = 600 rpm , Power at the shaft = 367.5 kW , overall efficiency = 85% , Hydraulic efficiency = 95% , Flow ratio = 0.25 , Width ratio = 0.1 , Outer diameter to inner diameter ratio = 2.0. The thickness of vanes occupy 10% of circumferential area of the runner velocity of flow is constant at inlet and outlet and discharge is radial at outlet. Determine
i) Guide Blade Angle ii) Runner Blade Angles iii) Diameters of the runner at inlet and outlet iv) Width of wheel at inlet. **(08 Marks)**

OR

8 a. Draw a neat sketch of a Francis turbine and explain working principle with velocity triangles. **(08 Marks)**

b. The penstock supplies water from a reservoir to the Pelton wheel with a gross head of 500m. One third of 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 165º. Determine the power given by the water to the runner and also hydraulic efficiency of the Pelton wheel. Take speed ratio 0.45 and $C_V = 1.0$. **(08 Marks)**

Module-5

9 a. Explain the following refers to centrifugal pump :
i) Manometric efficiency with expression ii) Cavitations in pumps
iii) Need for priming iv) Pumps in series. **(08 Marks)**

b. A centrifugal pump with 1.2m diameter runs at 200 rpm and pumps $1.88m^3/s$. The average lift being 6m. The angle which the vane makes at exit with the tangent to the impeller is 26º and the radial velocity of flow is 2.5m/s. Find manometric efficiency and the least pump to start pump of the inner diameter being 0.6m. **(08 Marks)**

OR

10 a. With neat sketch, explain Slip ; Slip coefficient. **(05 Marks)**

b. Explain the Phenomenon of Surging. **(03 Marks)**

c. A centrifugal compressor delivers 18.2 kg/s of air with a total pressure ratio of 4 : 1 speed is 1500 rpm. Inlet total temperature is 15ºC slip coefficient is 0.9. Power Input factor 1.04, Efficiency is 0.8. Calculate overall diameter of impeller. **(08 Marks)**

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