CBCS SCHEME

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17ME53

Fifth Semester B.E. Degree Examination, July/August 2022
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of steam table is permitted.***

Module-1

1 a. Distinguish the difference between turbomachines and positive displacement machines. **(10 Marks)**

b. A model of centrifugal pump absorbs 5 kW at a speed of 1500 rpm, pumping water against head of 6 m. The large prototype pump is required to pump water to a head of 30 m. The scale ratio of diameter is 4. Assume same efficiency and similarities. Find (i) Speed (ii) Power of prototype and (iii) ratio of discharge of prototype and model. **(10 Marks)**

OR

2 a. What is Reheat Factor? Show that the Reheat Factor for a turbine is greater than unity. **(10 Marks)**

b. A turbine has three stages and each stage pressure ratio is 2. The inlet static temperature is 600°C. Determine the overall efficiency if the stage efficiency is 75%. Also determine polytropic efficiency power developed and Reheat factor. The mass flow rate is 25 kg/s. **(10 Marks)**

Module-2

3 a. Derive an expression for an Alternate form Euler Turbine equation and explain the different components of energy equation. **(10 Marks)**

b. Define utilization factor and derive an equation establishing a relationship between utilization factor and degree of reaction. **(10 Marks)**

OR

4 a. By analyzing the velocity triangles of an axial flow turbine, show that the maximum utilization factor is given by, $\in_{max} = \dfrac{2\phi\cos\alpha_1}{1+2\phi R\cos\alpha_1}$

where ϕ is ratio of blade velocity at inlet to the absolute velocity of fluid at inlet and α_1 is nozzle angle and R is degree of reaction. **(10 Marks)**

b. In an axial flow 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/s. The ratio of axial velocity and blade speed is 0.7 at entry and 0.76 at the exit of the rotor blades. Find
(i) The inlet rotor blade angles.
(ii) The degree of reaction.
(iii) Power developed by the blade ring at a mass flow rate of 2.6 kg/s. **(10 Marks)**

Module-3

5 a. What is the necessity of compounding of steam turbine? With a neat schematic sketch, explain any two methods of compounding of steam turbine. **(10 Marks)**

b. The following data refers to Delaval turbine velocity of steam at the exit of the nozzle is 1000 m/s wit a nozzle angle of 20°. The blade velocity is 400 m/s and the blades are equiangular. Assume a mass flow rate of 1080 kg/hour, the friction coefficient is 0.8 and the nozzle efficiency is 95%. Construct the velocity triangle and determine (i) Blade angles (ii) Work done per kg of steam (iii) Power developed (iv) Blade efficiency and (v) Stage efficiency. **(10 Marks)**

OR

6 a. The following data refers to a stage of a reaction turbine. Rotor diameter = 1.5 m, Speed ratio = 0.72, Outlet blade angle = 20°, Rotor speed = 3000 rpm. Determine (i) Diagram efficiency (ii) Percentage increase in diagram efficiency, if the rotor is designed to run at the best theoretical speed. **(10 Marks)**

b. Following particulars referes to Parson's turbine consisting of one ring of fixed blades and one ring of moving blades. The mean diameter of the blade ring is 90 cm and its speed is 3000 rpm. The inlet velocity to blade is 300 m/s, the blade outlet angle is 20° and the steam flow rate is 7.6 kg/s. Calculate (i) Blade inlet angle (ii) Tangential force and (iii) Power developed. **(10 Marks)**

Module-4

7 a. Show that the absolute velocity of Jet is equal to twice the peripheral velocity of vane is the condition required for maximum hydraulic efficiency. Using this condition derive an equation for maximum hydraulic efficiency. **(10 Marks)**

b. Design a Pelton wheel which is required to develop 1500 kW working under a head of 160 m at a speed of 420 rpm. The overall efficiency is 89%. Assume other suitable data. **(10 Marks)**

OR

8 a. The internal and external diameter of an inward flow reaction turbine are 0.6 m and 1.2 m. The head on turbine is 22 m. The velocity of flow is constant throughout and is equal to 2.5 m/s. The guide blade angle is 10° and the runner vanes are radial at inlet. If the discharge at outlet is radial, find (i) Speed of turbine (ii) Vane angle at outlet (iii) Hydraulic efficiency. If the turbine develops 225 kW power, find its specific speed. **(10 Marks)**

b. A Kaplan turbine has outer and hub diameter 4 m and 2 m respectively. It develops 25 MW power when working under a head of 20 m with an overall efficiency of 85% and running at 150 rpm. Find the discharge through the turbine and the runner blade angles at inlet and outlet. Assume hydraulic efficiency of 90%. **(10 Marks)**

Module-5

9 a. With reference to a centrifugal pump, explain briefly the following. Write a schematic sketch, wherever applicable.
   (i) Manometric efficiency with expression.
   (ii) Cavitation in pumps.
   (iii) Pumps connected in series.
   (iv) Pumps connected in parallel.
   (v) NPSH. **(10 Marks)**

b. Outer diameter of pump is 500 mm and inner diameter is 250 mm. The centrifugal pump is running at 1000 rpm working against a head of 40 m. Velocity of flow is constant and is equal to 2.5 m/s. Vanes are set back at an angle of 40° at outlet and the width at outlet is 50 mm. Find (i) Vane angle at inlet (ii) Work done by the impeller (iii) Manometric efficiency. **(10 Marks)**

OR

10 a. What is the role of a diffuser in a centrifugal compressor? With a neat schematic diagram, explain the 3 different types of diffusers employed in a compressor. **(10 Marks)**

b. A centrifugal compressor runs at a speed of 15000 rpm and delivers 30 kg/s of air. The exit diameter is 70 cm, relative velocity at exit is 100 m/s at an exit angle of 75°. Assume axial entry and inlet total temperature is 300 K, inlet total pressure is 1 bar. Determine
   (i) Power required to drive the pump. (ii) Total exit pressure. **(10 Marks)**

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