CBCS SCHEME

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18ME54

Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Thermodynamic data Handbooks are allowed.***

Module-1

1 a. Define a turbomachine. List any six differences between a turbo-machine and a positive displacement machine. **(08 Marks)**

b. Indentify the following as power generating or power absorbing turbo-machines. :
i) Kaplan Turbine
ii) Centrifugal blower
iii) De-Laval turbine
iv) Axial compressor **(04 Marks)**

c. A $1/4^{th}$ scale turbine model is tested under a head of 10m. A full scale turbine is required to work under a head of 28.5m and turns at 415rpm. At what speed must the model be run if it develops 94kW and uses $0.96m^3/s$ of water at this speed? What power will be developed from the full scale turbine? Name the type of turbine. **(08 Marks)**

OR

2 a. With h-s diagram, show that reheat factor in a multi-stage turbine is greater than unity. **(08 Marks)**

b. Define :
i) Total to total efficiency
ii) Total to static efficiency for a power
Generating turbomachine with h-s diagram. **(04 Marks)**

c. A 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. Find :
i) Overall efficiency
ii) Polytropic efficiency
iii) Pre-heat factor **(08 Marks)**

Module-2

3 a. With usual notations and velocity triangles derive alternate form of Euler turbine equation and identify the components of energy transfer. **(10 Marks)**

b. Define utilization factor for a turbine. Derive an expression relating utilization factor with the degree of reaction. **(10 Marks)**

OR

4 a. A radial outward flow turbomachine has no inlet whirl. The blade speed at exit is twice that at inlet. The radial velocity is constant throughout. Taking the inlet blade angels as 45°, show that the degree of reaction $R = \frac{2+\text{Cot}\beta_2}{4}$, where β_2 = Blade angle at exit with respect to tangential direction. **(12 Marks)**

b. At a stage of an axial flow impulse turbine, the mean blade diameter is 80cm and the speed is 3000rpm. The absolute velocity of the fluid is 300m/s and is inclined at 20° to plane of wheel. If the utilization factor is 0.85 and relative velocity at rotor exit is equal to that at inlet, determine :
   i) inlet and exit blade angles
   ii) power output in kW for a mass flow rate of 1Kg/s
   iii) Sketch the inlet and outlet velocity triangle. **(08 Marks)**

Module-3

5 a. What do you mean by compounding of stream turbine? Explain with the help of a schematic diagram, the following methods of compounding
   i) Velocity compounding
   ii) Pressure compounding **(10 Marks)**

b. In a de-Laval turbine, steam flow from a nozzle with a velocity of 1200m/s. the nozzle angle is 22°. The mean blade speed is 400m/s and inlet and outlet angle of blades are equal. The mass of steam flowing through the turbine is 0.25Kg/s. Calculate :
   i) Blade angle at inlet and outlet
   ii) Tangential force on blades
   iii) Power developed
   iv) Blade efficiency

   Take blade coefficient as 0.8. **(10 Marks)**

OR

6 a. Derive an expression for maximum blade efficiency of a single stage impulse turbine in terms of nozzle angles assuming identical blades and relative velocities are same at inlet and exit. **(10 Marks)**

b. The following particulars refer to a Parson's reaction turbine consisting of one ring of fixed blades and one ring of moving blades. The mean diameter of the blade ring is 90cm and its speed is 300rpm. The inlet absolute velocity to the blade is 300m/s. The blade outlet angle is 20°. The stream flow rate is 7.6Kg/s. Calculate :
   i) Blade inlet angle
   ii) Tangential force
   iii) Power developed **(10 Marks)**

Module-4

7 a. Show that for a Pelton wheel, the maximum hydraulic efficiency is given by $(\eta)_{max} = \frac{1+k\,Cos\beta_2}{2}$. Where K = Blade velocity coefficient β_2 = Blade angle at exit. **(10 Marks)**

b. A three jet Pelton wheel is required to generate 10000kW under a head of 400m. The blade angle at outlet is 15° and reduction in relative velocity over the blade (buckets) is 5%. If overall efficiency is 80%, $C_v = 0.98$ and speed ratio = 0.46.
   Find : i) Diameter of jet
   ii) Total flow in m^3/s
   iii) Force exerted by jet on the buckets **(10 Marks)**

OR

8 a. Explain the functioning of a Kaplan turbine with the help of a sectional arrangement diagram. Draw the velocity triangle of Kaplan turbine. **(10 Marks)**

b. Define the following efficiencies of a hydraulic turbine :
   i) Hydraulic efficiency
   ii) Mechanical efficiency
   iii) Overall efficiency **(06 Marks)**

c. Explain the functions of a draft tube in a reaction turbine. **(04 Marks)**

Module-5

9 a. What a primary? Why it is required? Explain how primary is achieved in centrifugal pump. **(04 Marks)**

b. With sketches, explain the principal of multi stage centrifugal pumps in i) series ii) parallel. **(08 Marks)**

c. A centrifugal pump is running at 1000rpm. The outer vane angle of the impeller is 45 and the velocity of flow at the outlet is 2.5m/s. The discharge through the pump is $0.2m^3/s$, when pump is working against a head of 20m. If the manometric efficiency is 80%, draw the outlet velocity diagram and calculate :
   i) Diameter of impeller at outlet
   ii) Width of impeller at outlet **(08 Marks)**

OR

10 a. Explain the phenomenon of surging as applied to a centrifugal compressor. **(06 Marks)**

b. What is slip and slip factor in a centrifugal compressor? Derive an expression for the same. **(06 Marks)**

c. A centrifugal compressor running at 5950rpm having an impeller tip diameter of 100cm has a mass flow rate of air as 30Kg/s. The total pressure ratio is 2.125. The pressure at the inlet is 1 bar and temperature is 0.9 and the mechanical efficiency is 97%. Find :
   i) Total efficiency
   ii) Temperature of air at exit
   iii) Power input needed
   iv) Pressure coefficient **(08 Marks)**

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