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06ME55

Fifth Semester B.E. Degree Examination, December 2012
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: *1. Answer FIVE full questions, selecting at least TWO questions from each part.*
2. All notations have their usual meanings.
3. Thermodynamics data hand book and charts are permitted.

PART – A

1 a. Define a turbomahcine. Write a schematic diagram showing principal parts of a turbomachine. **(06 Marks)**

b. Compare a turbomachine and a positive displacement machine. **(06 Marks)**

c. Define:
i) Adiabatic efficiency
ii) Mechanical efficiency.
For power generating and power absorbing turbomachines. **(08 Marks)**

2 a. Derive Euler turbine equation, state the assumptions made. **(10 Marks)**

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

3 a. Define utilization factor. Obtain a relation between degree of reaction and the utilization factor. **(08 Marks)**

b. Sketch velocity diagrams for R = 0 and R = 0.5 and label. **(06 Marks)**

c. The velocity of steam out flow from a nozzle in a Delaval turbine is 1200 m/s. The nozzle angle being 22°. If the rotor blades are equiangular and the rotor tangential speed is 400 m/s. Compute:
i) Power output assuming $V_{r_1} = V_{r_2}$.
ii) Utilization factor. **(06 Marks)**

4 a. Define static and stagnation states. **(06 Marks)**

b. Give classification of fluid flow based on Mach number and explain in brief. **(06 Marks)**

c. Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15°C and a flow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is 100°C and the flow velocity is 100 m/s. The outlet is 1m above the inlet. Evaluate:
i) The isentropic change in enthalpy.
ii) The actual change in enthalpy.
iii) Efficiency of the compressor.
Take $C_p = 1005$ J/kg K. **(08 Marks)**

PART – B

5 a. Discuss the following for a centrifugal compressor:
   i) Compressibility and prewhirl.
   ii) Diffuser design. **(10 Marks)**

b. The following data refer to a centrifugal compressor: Impeller tip diameter = 100cm, speed = 5950 rpm, mass rate of air flow 30 kg/s, static pressure ratio $\frac{P_3}{P_1} = 2.125$, atmospheric pressure and temperature 1 atm and 25°C, slip coefficient = 0.90 and mechanical efficiency = 0.97, C_p = 1004 J/kg K. Find: i) the adiabatic efficiency of the impeller; ii) the temperature of the air at the exit; iii) the shaft power input and iv) the pressure coefficient. **(10 Marks)**

6 a. Define the following for a centrifugal pump:
   i) Static head
   ii) Suction head
   iii) Delivery head
   iv) Total head and
   v) Manometric head (with the help of a schematic diagram). **(10 Marks)**

b. A centrifugal pump with an impeller outer diameter of 1.05 m runs at 1000 rpm. The blades are backward curved and they make an angle of 20° with the wheel tangent at the blade tip β_2. If the radial velocity of flow at the tip is 8 m/s and the slip coefficient is 0.86, find:
   i) The actual work input/kg of water flow.
   ii) The absolute velocity of fluid at the impeller tip.
   iii) The hydraulic efficiency, considering the kinetic energy at the outlet as wasted.
   If the pump is fitted with a diffusion chamber with an efficiency of 0.75 so that the exit velocity is reduced to 5 m/s, find the new hydraulic efficiency. **(10 Marks)**

7 a. With sketches explain velocity and pressure compounding. **(08 Marks)**

b. Define: i) rotor efficiency and ii) stage efficiency of a steam turbine. **(04 Marks)**

c. Steam issues from a single stage steam turbine with a velocity of 1200 m/s, the nozzle angle is 22°. If the rotor blades are equiangular and the rotor tangential speed in 400 m/s compute, assume $V_{r_1} = V_{r_2}$.
   i) Rotor blade angles.
   ii) Power developed for a flow rate of 900 kg/hr. **(08 Marks)**

8 a. Mention the general characteristic features of Pelton, Francis and Kalpan turbines. **(06 Marks)**

b. Explain the function of a draft tube and mention its types. **(06 Marks)**

c. A Pelton wheel is to be designed for a head of 60m when running at 200 rpm. The Pelton wheel develops 95.65 kW shaft power. The velocity of the buckets = 0.45 times the velocity of the jet, overall efficiency = 0.85 and coefficient of velocity is equal to 0.98. Find diameter of jet, diameter of wheel, size of buckets and number of buckets. **(08 Marks)**

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