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10ME/MR56

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

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of steam table and thermodynamic data handbook is permitted.

PART – A

1 a. Distinguish between positive displacement machine and turbomachine based on its action, operation and efficiency. **(06 Marks)**

b. Define turbomachine. How do you classify turbomachines? **(06 Marks)**

c. 1:4 scale model of Francis turbine working under a head of 10m. The full scale turbine is required work at 30m head and at 430 RPM. At what speed must be the model develop 96 kW and gives 1.07 m^3/s of water. What power will be developed from the full scale turbine assuming its efficiency is 3% better than of its model. Also determine the discharge of prototype. **(08 Marks)**

2 a. Define the polytropic efficiency of a turbine. Show that the polytropic efficiency is given by

$$\eta_p = \left[\frac{n-1}{n}\right]\left[\frac{\gamma}{\gamma-1}\right]$$

Draw the T - s diagram. **(10 Marks)**

b. 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 1 m above the inlet. Evaluate (i) The isentropic change in enthalpy (ii) The actual change in enthalpy (iii) Efficiency of the compressor. **(10 Marks)**

3 a. Show that the alternative form of Euler's turbine equation can be expressed as follows:

$$W = \frac{\left(V_1^2 - V_2^2\right) + \left(u_1^2 - u_2^2\right) + \left(Vr_2^2 - Vr_1^2\right)}{2}$$

Draw the relevant velocity triangles. **(10 Marks)**

b. Air enters an axial flow turbine with a tangential component of the absolute velocity equal to 600 m/s in the direction of rotation. At the exit, the tangential component of absolute velocity is 100 m/s in a direction opposite to that of rotational speed. The tangential blade speed is 250 m/s. Evaluate
i) The change in total Enthalpy.
ii) The power in kW.
iii) The total change in temperature, if the mass flow rate is 10 kg/s. **(10 Marks)**

4 a. Define Degree of reaction for an axial flow machine. Prove that degree of reaction for an axial flow device is given by

$$R = \frac{V_f}{2U}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \tan\beta_2}\right]$$

Assuming constant velocity of flow. **(10 Marks)**

b. A centrifugal pump of 1.5m diameter at 210 rpm, and pumps 1800 lts of water per sec. The vanes are set back with an angle of 25° at exit. Assuming radial entry and velocity of flow throughout is 2.5 m/s. Determine the power required to drive the pump. If the manometric efficiency of the pump is 65%, find the average lift of the pump. **(10 Marks)**

PART – B

5 a. Distinguish between Impulse and Reaction steam turbine. **(06 Marks)**

b. What are the types of forces occurring on rotor blades and shaft? Explain the types in simple terms. **(04 Marks)**

c. In a stage of an impulse turbine provided with single row wheel, the mean diameter of the blades is 1m. It rotates at 3000 rpm. The steam velocity at nozzle is 350 m/s and the nozzle is 20°. The rotor blades are equiangular. The blade friction is 0.86. Determine the power developed if the axial thrust on the end of bearing of rotor is 120 N. **(10 Marks)**

6 a. Show that for a Pelton wheel turbine the maximum hydraulic efficiency is given by $\eta_{max} = \frac{1+C_b \cos\beta_2}{2}$, where C_b = Blade velocity coefficient, β_2 = Blade discharge angle. **(08 Marks)**

b. Classify the hydraulic turbines. **(04 Marks)**

c. A Pelton wheel is to be designed for a head of 6m, when running at 200 rpm. The Pelton wheel developed 95.55 kW. The velocity of buckets is 0.45 times the velocity of the jet, overall efficiency is 0.85 and coefficient of velocity is equal to 0.98. Find
(i) Diameter of jet (ii) Diameter of the wheel (iii) Number of buckets on the wheel **(08 Marks)**

7 a. List the types of pump losses. Write atleast two examples for each. **(06 Marks)**

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

c. A centrifugal pump delivers water against a head of 20 m at the rate of 50 lit/s. The radial velocity of flow is constant and equal to 3 m/s. The blades are radial and the pump runs at 1440 RPM. Compute the diameter at the tip and corresponding width of the impeller. **(08 Marks)**

8 a. With the help of a characteristic curve, explain surging and choking of a centrifugal compressor. **(08 Marks)**

b. An air compressor has eight stages of equal pressure ratio 1.35. The flow rate through the compressor and its overall efficiency are 50kg/s and 82% respectively. If the conditions of air at entry are 1.0 bar and 40°C, determine:
i) The state of air at the compressor exit
ii) Polytropic efficiency
iii) Efficiency of each stage
iv) Power required to drive the compressor assuming overall efficiency of the drive as 90%. **(12 Marks)**

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