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10ME56

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Compare the Turbomachines and positive Displacement machines. **(05 Marks)**

b. Define Specific speed of the Turbine. Derive an expression for specific speed of the turbine. **(06 Marks)**

c. Define and explain following Specific Quantities :
i) Flow coefficient ii) Head coefficient iii) Power coefficient. **(09 Marks)**

2 a. Define Polytropic efficiency for expansion process and show that polytropic for expansion process is given by

$$\eta_p = \frac{\ln \frac{T_2}{T_1}}{\frac{r-1}{r}\ln \frac{P_2}{P_1}}$$, where r is the ratio of Specific heat , T_2 and T_1 are the initial and final temperature respectively P_1 and P_2 are the pressure at inlet and outlet respectively. **(10 Marks)**

b. In a multistage axial flow compressor, the air is taken in at 1 bar and 15°C and compressed to final pressure of 6.4 bars and final true temperature of 300°C during compression process. Determine Polytropic efficiency and overall efficiency. **(10 Marks)**

3 a. Show that maximum utilization of an axial flow turbine with degree of reaction = $\frac{1}{4}$, the relationship of blade speed U to the absolute velocity at the rotor inlet V_1 should be $\frac{U}{V_1} = \frac{2}{3}\cos\alpha_1$, where α_1 is the nozzle angle. Assume flow velocity is constant from inlet to outlet. **(10 Marks)**

b. In a radial inward flow turbine the degree of reaction is 0.8 and the utilization factor for the runner is 0.9. The tangential speeds of the wheel at the inlet and outlet respectively. 11m/s and 5.5m/s. Draw the velocity triangle at inlet and outlet assuming radial velocity is constant and equal to 5m/s. Flow is radial at exit. Find the power output for a volumetric flow rate $2m^3$ of water/sec. **(10 Marks)**

4 a. Derive an equation $H = k_1 - k_2Q$ for Radial outward flow devices (centrifugal pump), where $k_1 = \frac{V_2^2}{g}$ $k_2 = \frac{U_2 \cot\beta_2}{\pi D_2 B_2 g}$, where H is pressure head , Q is discharge , V_2 = tangential speed at outlet , D_2, B_2 and β_2 are diameter, width of the blade and β_2 vane angle at outlet respectively. Also draw H – Q curve for centrifugal pump using above equation. **(10 Marks)**

b. In a mixed flow compressor handling air at 16000 RPM, the stagnation temperature of the air at the compressor inlet and outlet are respectively 27°C and 215°C. The absolute velocity of air at the rotor inlet is axial while at the exit the tangential component of the absolute velocity is 0.93 times the tangential impeller speed. If the mass flow rate of air through the impeller is 15kg/S and the specific heat of air assumed to be constant. Find the impeller diameter and total power input. C_p for air = 1.005 kJ/kg K. **(10 Marks)**

PART – B

5 a. Explain the term "Compounding" in Steam Turbine and also explain necessities of Compounding. **(06 Marks)**

b. In a Curtis stage of Turbine Steam enters the first row of moving blades at 700m/s. The outlet angles of the nozzle, the first rotor blade, the stator blade and the last rotor respectively 17°, 23° , 19° , 37°. If the mean blade speed is 160m/s and the blade coefficient is 0.93 for all the stages and steam flow rate is 162 kg/min. Estimate i) Power developed in the stage ii) Rotor efficiency iii) Axial thrust iv) Tangential force on the blades. **(14 Marks)**

6 a. Show that for maximum efficiency, the speed ratio is 0.5 for a Pelton wheel. Further derive an expression for maximum efficiency for a Pelton wheel. **(10 Marks)**

b. A Francis turbine is required to develop a power of 330kW under a head of 30m while operating at 350 r.p.m. If overall efficiency = 80% ; Hydraulic efficiency = 88% ; Speed ratio = 0.75 ; Flow ratio = 0.25 and Ratio of outer to inner diameters = 2. Calculate the stator and rotor angles and dimensions of the runner. **(10 Marks)**

7 a. Define and derive an expression for Minimum starting speed. **(06 Marks)**

b. Explain the phenomenon of Cavitation. **(04 Marks)**

c. Find the pressure rise in the impellor of centrifugal pump through which the water is flowing at the rate of 15lit/s. The inner and outer diameters of the impeller are 20cm and 40cm respectively. The widths of the impeller at the inlet and outlet are 1.6cm and 0.8cm. The pump is running at 1200 r.p.m. The water enters the impeller radically at the inlet and impeller vane angle at outlet is 30°. Neglect the losses through the impeller. **(10 Marks)**

8 a. Explain the term slip and slip coefficient with velocity diagram in centrifugal compressor. **(06 Marks)**

b. Explain the phenomenon of Surging in Centrifugal compressor. **(04 Marks)**

c. The first stage of an axial flow compressor develops a pressure ratio 1.2:1. The inlet pressure and temperature are 1bar and 31°C respectively. The stage efficiency of the compressor is 83%. The flow coefficient $\frac{V_f}{U} = 0.47$. The velocity diagram is symmetrical and at mean radius. The ratio of change in whirl velocity to axial velocity $\frac{\Delta V_u}{V_f} = 0.5$. Determine the compressor speed if the mean diameter is 50cm. **(10 Marks)**

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