CBCS SCHEME

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18MR55

Fifth Semester B.E. Degree Examination, July/August 2021
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. Differentiate between Turbo machine and Positive displacement machine. **(06 Marks)**

b. Define Specific speed of turbine. Obtain and expression for the same in terms of power, speed and head. **(08 Marks)**

c. A turbine model of 1:10 develops 2kw under a head of 6m at 500rpm. Find the power developed by the prototype under a head of 40m. Also find the speed of prototype and its specific speed. Assume the turbine efficiency to remain the same. **(06 Marks)**

2 a. Show that the stage efficiency of compression is

$$\eta_{st} = \frac{P_r^{\left(\frac{\gamma-1}{\gamma}\right)} - 1}{P_r^{\frac{1}{\eta_p}\left(\frac{\gamma-1}{\gamma}\right)} - 1}$$

where P_r is pressure , ratio and η_p is polytropic efficiency of compressor. **(10 Marks)**

b. A nine stage centrifugal compressor has an overall pressure ratio of 2.82. Air enters the compressor at a pressure of 1bar and 17 °C. The stage efficiency is 0.9. Determine
i) Pre – heat factor ii) Overall efficiency and iii) Polytropic efficiency. **(10 Marks)**

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

b. The velocity of steam outflow from a nozzle in a Delaval turbine is 1200m/s. The nozzle angle being 22 degree. If the rotor blades are equiangular and rotor tangential speed is 400m/s. Compute i) The rotor angles ii) Tangential force on the blade ring iii) Power output assuming $Vr_1 = Vr_2$ and mass flow rate is 1kg/s. **(10 Marks)**

4 a. Show that the degree of reaction for axial flow compressor is

$$R = \frac{Va}{2U}\left(\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \quad \tan\beta_2}\right)$$

, where Va is axial flow velocity , β_1 & β_2 are blade angles at inlet and exit respectively. **(12 Marks)**

b. Air flows into a stage of an axial flow compressor at 33 °C and 1 atm pressure. The axial speed of air flow through out the stage is 110m/s. The compressor is one of the 50% reaction with symmetric inlet and outlet velocity triangles. The inlet angle being 33° and outlet angle is 50°. i) Compute absolute velocity at the rotor inlet, the mean blade speed and the temperature rise of the air in passing through the stage ii) Power input per unit mass flow rate. **(08 Marks)**

5 a. What is Compounding in turbines? With neat sketch, explain velocity compounding and pressure compounding. **(09 Marks)**

b. A single stage impulse turbine has a diameter of 1.5m and running at 3000 rpm. The nozzle angle is 20°. Speed ratio is 0.45. Ratio of relative velocity at the outlet to that at inlet is 0.9. The outlet angle of the blade is 3° less that inlet angle. Steam flow rate is 6kg/s. Draw the velocity diagrams and find the following : i) Velocity of whirl ii) Axial thrust iii) Blade angles iv) Power developed v) Stage efficiency. **(11 Marks)**

6 a. Show that the maximum blade efficiency for a single stage impulse turbine is given by $(\eta_b)_{max} = \text{Cos}^2 \alpha_1$. **(07 Marks)**

b. In a Curtis stage with two rows of moving blades, the rotor are equiangular. The first rotor has angle of 29° each while second rotor has angle of 32° each. The velocity of steam at the exit of nozzle is 530m/s and the blade coefficients are 0.9 in the first, 0.95 in the stator and in the second rotor. If the absolute velocity at the stage exit should be axial , find i) Mean blade speed ii) The rotor efficiency iii) The power output for a flow rate of 32kg/s. **(13 Marks)**

7 a. Show that for a Pelton wheel turbine the maximum efficiency is given by $\eta_{max} = \frac{1+C_b \cos \beta_2}{2}$, where β_2 is runner tip angle. **(10 Marks)**

b. A double Jet Pelton – wheel is required to generate 7500 kw when the available head at the base of the nozzle is 400m. The Jet is deflected through 165° and relative velocity of the Jet is reduced by 15% in passing over the buckets. Determine i) diameter of each Jet ii) Total flow iii) Force exerted by the jets in the tangential direction. Assume Generator efficiency is 95% , $\eta_o = 80\%$, Speed ratio = 0.47. **(10 Marks)**

8 a. Define the following terms with respect to Hydraulic turbine : i) Gross head and effective head ii) Hydraulic efficiency iii) Volumetric efficiency iv) Mechanical efficiency v) Overall efficiency. **(10 Marks)**

b. An inward flow reaction turbine with radial discharge with an overall efficiency of 80% is required to develop 147 kw. The head is 8m. Peripheral velocity of the wheel is $0.96\sqrt{2gH}$, the radial velocity of the flow is $0.36\sqrt{2gH}$. The wheel is to make 150 RPM and the hydraulic losses in the turbine are 22% of the available energy. Determine i) The angle of the guide blade at inlet ii) The wheel vane angle at inlet iii) The diameter of the wheel iv) The width of the wheel at inlet. **(10 Marks)**

9 a. What is Minimum Starting Speed? Derive an expression for minimum starting speed of a centrifugal pump. **(07 Marks)**

b. With neat sketch, explain Centrifugal pumps in i) Series ii) Parallel. **(05 Marks)**

c. A centrifugal pump has its impeller diameter 30cm and a constant area of flow 210cm^2. The pump runs at 1440 RPM and delivers 90 LPS against a head of 25m. If there is no whirl velocity at entry, compute the rise in pressure head across the impeller and hydraulic efficiency of pump. The vanes at exit are bent back at 22° with respect to tangential speed. **(08 Marks)**

10 a. Derive an expression for H-Q characteristics curve for a centrifugal pump. Discuss the H-Q curve for the forward, radial and backward curved vanes. **(10 Marks)**

b. A centrifugal pump delivers 1800 ℓpm against a total head of 20m. Its speed is 1450 RPM, inner and outer diameter of the impeller are 120mm and 240mm respectively and diameter of suction and delivery pipe are both 120mm. Determine the blade angles β_1 & β_2 if the water enters radically. Also find the power required to drive the pump. **(10 Marks)**

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