CBCS SCHEME

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18MR55

Fifth Semester B.E. Degree Examination, June/July 2023
Turbo Machines

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. Define Specific speed of turbine and derive an expression for specific speed of turbine. **(07 Marks)**

b. Differentiate the turbomachine and positive displacement machine. **(06 Marks)**

c. A turbine model of 1 : 10 develops 2kW under a head of 6m at 500 rpm. Find the power developed by the prototype under a head of 40mt. Also find the speed of prototype and its specific speed. Assume turbine efficiency remain same for model and prototype. **(07 Marks)**

OR

2 a. Show that the stage efficiency of expansion process in multistage turbine is

$$\eta_{st} = \frac{1 - P_r^{-\eta_p\left(\frac{\gamma-1}{\gamma}\right)}}{1 - P_r^{-\left(\frac{\gamma-1}{\gamma}\right)}}.$$ **(10 Marks)**

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

Module-2

3 a. Derive the Euler's turbine equation in terms of velocity components and state the assumptions. **(10 Marks)**

b. At a stage of an impulse the mean blade diameter is 0.75m, its rotational speed being 3500rpm. The absolute velocity of fluid discharging from nozzle inclined at 20° to the plane of the wheel is 275 m/s. If the utilization factor is 0.9 and the relative velocity at rotor exit is 0.9 times that at the inlet, find the inlet and exit rotor angle. **(10 Marks)**

OR

4 a. With usual notation shown that the degree of reaction for an axial flow compressor is given by $R = \frac{V_a}{2U}(\cot\beta_1 + \cot\beta_2)$. Draw the velocity triangles at inlet and outlet. V_a = axial flow velocity, β_1 & β_2 are the blade angles at inlet and exit respectively and U is the blade velocity. **(12 Marks)**

b. A centrifugal pump of 1.5m diameter runs at 210 rpm and pumps 1800 lit of water per second. The vanes are set back with an angle of 25° at exit. Assuming radial entry and velocity of flow throughout is 2.5m/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. **(08 Marks)**

Module-3

5 a. What is Compounding of steam turbines? Explain i) Velocity compounding ii) Pressure compounding. **(10 Marks)**

b. Steam issuing from a nozzle to a Delaval turbine with a velocity of 1000 m/s. The nozzle is 20° , the mean blade speed is 400m/s. The blades are symmetrical , the mass flow rate = 1000kg/hr , friction factor = 0.8 , Nozzle efficiency = 0.95. Calculate
i) Blade angle ii) Axial thrust iii) Power developed iii) Blade efficiency
iv) Stage efficiency. **(10 Marks)**

OR

6 a. Differentiate the Impulse and reaction steam turbine. **(06 Marks)**

b. In a Curtis stage with two rows of moving blades, the rotor angles are equal. The first rotor has angle of 29° each while the second rotor has angle of 32° each. The velocity of steam at the exit of the nozzle is 530 m/s and the blade coefficient 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) Power output if flow rate of water is 32kg/s. **(14 Marks)**

Module-4

7 a. Show that for a Pelton wheel turbine maximum hydraulic efficiency is given by $\eta_{max} = \frac{1+C_b \cos\beta_2}{2}$, where $C_b = V_r / V_H$ and β_2 is exit blade 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 1650 and the 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 directions. Assume generator efficiency is 95% and overall efficiency is 80% and speed ratio is 0.47. **(10 Marks)**

OR

8 a. With a mathematical expression define the following related to turbine :
i) Hydraulic efficiency ii) Mechanical efficiency iii) Overall efficiency
iv) Volumetric efficiency v) Gross and effective head. **(10 Marks)**

b. In a Francis turbine , the discharge is radial , the blade speed at inlet = 25 m/s. At the inlet tangential component of velocity = 18m/s. The radial velocity of flow is constant and equal to 2.5m/s. Water flows at the rate of $0.8 m^3/s$. The utilization factor is 0.82. Find
i) Euler's head ii) Power developed iii) Inlet blade angle iv) Degree of reaction
v) Draw the velocity triangles. **(10 Marks)**

Module-5

9 a. What is Minimum Starting Speed? Derive an expression for minimum starting speed. **(06 Marks)**

b. Explain the following with respect to centrifugal pump : i) Cavitation ii) NpSH iii) Slip and slip coefficient. **(06 Marks)**

c. A centrifugal pump has an impeller diameter of 25cm and width of 7.5cm at exit. It delivers 120 lit/s of water against a head of 24m at 1440 rpm. Assuming the vane blocks the area of flow by 5% and hydraulic efficiency of 0.85, estimate the vane angle at exit. Also calculate the torque exerted by the driving shaft if the mechanical efficiency is 95%. **(08 Marks)**

OR

10 a. Show that the pressure rise in the impeller of a centrifugal pump when the frictional and other losses in the impeller are neglected is, where
V_{f_1} and V_{f_2} are flow velocities , β_2 is exit blade angle. **(10 Marks)**

b. A CF 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 section and delivery pipe are both 120mm. Determine the blade angels β_1 and β_2 if the water enters radically. Also find the power required to drive the pump. **(10 Marks)**

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