CBCS SCHEME

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17ME53

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

Time: 3 hrs. Max. Marks: 100

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



### Module-1

1 a. Differentiate between a turbomachine and positive displacement machine. **(05 Marks)**

b. Briefly explain the significance of specific speed related to fluid machines. **(05 Marks)**

c. A pelton wheel is running at a speed of 200 rpm and develops 5200 KW when working under a head of 220 m with an overall efficiency of 80%. Determine its unit quantities and specific speed. Find the speed, flow and power when operating point changes to a head of 140 m. Take the density of water = 1000 kg/m$^3$. **(10 Marks)**

**OR**

2 a. Define "infinitesimal stage efficiency of a turbine. Show that the polytropic efficiency during the expansion process is given by $\eta_p = \dfrac{\ell n\left(\frac{T_2}{T_1}\right)}{\frac{\gamma-1}{\gamma}\ell n\left(\frac{P_2}{P_1}\right)}$. **(10 Marks)**

b. For a multistage compressor, show that the overall efficiency is less than the stage efficiency using h-s diagram. **(10 Marks)**

### Module-2

3 a. Define utilization factor and degree of reaction. Derive the expression relating utilization and degree of reaction. **(10 Marks)**

b. In a turbine stage with 50% reaction. The tangential speed is 98.5 m/s. The steam velocity at nozzle exit is 155 m/s and the nozzle angle is 18°. Assuming symmetric inlet and outlet velocity triangles, compute inlet blade angle of the rotor, and power developed by the stage, assume steam flow 10 kg/s. Also find utilization factor. **(10 Marks)**

**OR**

4 a. For an inlet blade angle of 45°, blade speed at exit as twice of that at inlet and inlet whirl velocity of zero, prove that $R = \dfrac{2+\cot\beta_2}{4}$ for a radial outward flow turbine, where R is degree of reaction and $\beta_2$ blade exit angle. **(10 Marks)**

b. With the help of velocity triangle, show that the degree of reaction for an axial flow compressor is $R = \dfrac{Va}{2u}(\tan\beta_1 + \tan\beta_2)$ where $\beta_1$ and $\beta_2$ are blade angles. **(10 Marks)**

### Module-3

5 a. What is compounding of steam turbines? Explain any two of them with P-V curves. **(10 Marks)**

b. In a Curtis stage with two rows of moving blades, the rotor blades are equiangular. The first rotor has an 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 coefficients are 0.9 in first, 0.95 in stator and in second rotor. If absolute velocity at stage exit is axial, find:(i)Mean blade speed (ii) Rotor efficiency (iii) Power output for flow rate of 32 kg/s **(10 Marks)**

**OR**

6 a. Show that the maximum efficiency of a Parson's reaction turbine is

$$\eta_{max} = \frac{2\cos^2 \alpha_1}{1+\cos^2 \alpha_1} \quad \text{where } \alpha_1 = \text{Nozzle angle} \qquad \textbf{(10 Marks)}$$

b. In a single stage impulse steam turbine the mean diameter of blades is 1m. It runs at 3000 rpm. The steam is supplied from a nozzle at a velocity of 350 m/s and nozzle angle is 20°. The rotor blades are equiangular. The blade fraction factor is 0.86. Draw velocity diagram and calculate power developed if the axial thrust is 117.72 Newton. **(10 Marks)**

## Module-4

7 a. Draw velocity triangles for pelton wheel. Derive an expression for maximum hydraulic efficiency of pelton wheel in terms of bucket velocity coefficient and discharge blade angle. **(10 Marks)**

b. A pelton wheel is to be designed for a head of 60 m, when running at 200 rpm. The pelton wheel developed 95.55 KW. The velocity of buckets is 0.45 times the velocity of jet. Overall efficiency is 0.85 and coefficient of velocity is 0.98. Find diameter of jet, diameter of wheel and number of buckets on wheel. **(10 Marks)**

**OR**

8 a. Explain the functioning Kaplan turbine with the help of sectional arrangement diagram. Draw the velocity triangles for it. **(10 Marks)**

b. A Kaplan turbine produces 30,000 KW under a head of 9.6 m. While running at 65.2 rpm discharge is 350 $m^3/s$, tip diameter of runner is 7.4 m, hub diameter 0.432 times tip diameter. Determine: (i) Turbine efficiency (ii) Specific speed (iii) Speed ratio (iv) Flow ratio **(10 Marks)**

## Module-5

9 a. Derive an expression for the static pressure rise in the impeller of a centrifugal pump with velocity triangles. **(10 Marks)**

b. The outer diameter of impeller of a centrifugal pump is 40 cm and width of impeller at outlet is 5 cm. The pump is running at 800 rpm and is working against a head of 15 m. The vane angle at outlet is 40° and manometric efficiency is 75%. Determine:

(i) Velocity of flow at outlet
(ii) Velocity of water leaving the vane
(iii) Angle made by absolute velocity at outlet with direction of motion at outlet
(iv) Discharge **(10 Marks)**



**OR**

10 a. With neat sketch and velocity triangles, explain different vane shapes of the centrifugal compressor. **(10 Marks)**

b. A centrifugal compressor running at 6000 rpm having an impeller tip diameter of 101 cm has the following data:
Mass flow rate = 25 kg/s, static pressure ratio = 2.12, pressure at inlet is = 100 kPa, temperature = 28°C, mechanical efficiency = 0.97
Find: (i) Slip coefficient (ii) Temperature of air at exit (iii) Power input
(iv) Power coefficient **(10 Marks)**

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