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## Fifth Semester B.E. Degree Examination, Dec.2024/Jan.2025

### 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. Compare turbo machines and positive displacement machines. (06 Marks)
- b. Define the following for a turbomachine.
  - i) Flow coefficient      ii) Power coefficient      iii) Capacity coefficient (06 Marks)
- c. A turbine model working under a head of 2m runs at 170 rpm and has a diameter of 1m. A prototype turbine develops 22 MW under a head of 250 m with a specific speed of 100. Calculate: i) Scale ratio      ii) Power development by the model. (08 Marks)

#### OR

- 2 a. Define total to total, total-to-static, static-to-static and static-total efficiencies for power generator and power absorbing turbo machine with the help of T-S diagram. (10 Marks)
- b. Air flows through an air turbine where its stagnation pressure is decreasing in the ratio 5:1. Total to total efficiency is 0.8 and air flow rate is 5 Kg/s. The inlet total temperature is 280K. Calculate :
  - i) Actual power output
  - ii) Actual exit total temperature
  - iii) Actual exit static temperature if the exit flow velocity is 100 m/s and
  - iv) Total-to-static efficiency of the device. (10 Marks)

#### Module-2

- 3 a. Derive an expression for maximum utilization factor in an axial flow type :
  - i) Impulse turbine and      ii) 50% Reaction turbine. Draw also the velocity triangles. (10 Marks)
- b. In an radial inward flow turbine, the degree of reaction is 0.8 and utilization factor is 0.9. The tangential speeds of wheel at the inlet and outlet are 11m/s and 5.5 m/s. Draw the velocity triangle at inlet and outlet assuming radial velocity is constant and equal to 5 m/s. Flow is radial at exit. Find the power output for a volumetric flow rate 2 m<sup>3</sup> of water per second. (10 Marks)

#### OR

- 4 a. A radial outward flow machine has no inlet whirl. The blade speed at the exit is twice that at inlet. Radial velocity is constant throughout. Taking the inlet blade angle as 45 degree show that degree of action,  $R = \frac{2 + \cot \beta_2}{4}$ . Where  $\beta_2$  is the blade angle at exit with respect to tangential direction. (10 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.  
2. Any revealing of identification, appeal to evaluator and/or equations written e.g. 42-8=50, will be treated as malpractice.

- b. The mean rotor blade speed of an axial flow turbine with 50% reaction is 210 m/s. Steam emerges from the nozzle inclined at  $28^\circ$  to the plane of wheel with axial component equal to blade speed. Assuming symmetrical inlet and outlet velocity triangle, find :
- Rotor blade angles
  - Utilization factor. Find also
  - Degree of reaction to make the utilization factor maximum, if the axial velocity blade speeds as well as nozzle angle remains constant. (10 Marks)

### Module-3

- 5 a. Define compounding. Explain any two types of compounding with a neat sketch, showing variations of pressure and velocity of the stream. (10 Marks)
- b. Steam emerges from a nozzle to an impulse De-Laval turbine with a velocity of 1000m/s. The nozzle angle is  $20^\circ$ . The mean blade speed is 400 m/s. The blades are symmetrical. The mass flow rate of steam is 1000 Kg/hr. Friction factor is 0.8. Calculate the following
- Blade angles
  - Axial thrust
  - Work done per Kg of steam
  - Power developed. (10 Marks)

OR

- 6 a. Derive the expression for maximum efficiency of impulse steam turbine and show that maximum efficiency is  $[\cos^2 \alpha_1]$ . (10 Marks)
- b. The following data refers to a particular stage of a Parson's reaction turbine.  
Speed of the turbine = 1500 rpm. Mean diameter of rotor = 1m, Stage efficiency = 0.8, blade outlet angle =  $20^\circ$ . Speed ratio = 0.7. Determine the available isentropic enthalpy drop in the stage. (10 Marks)

### Module-4

- 7 a. Derive an expression for maximum hydraulic efficiency of pelton wheel. (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 400 m. The jet is deflected through  $165^\circ$  and the relative velocity of the jet is reduced by 15% in passing over the buckets. Determine the
- Diameter of each jet
  - Total flow
  - Force exerted by the jets in the tangential direction. Assume generator efficiency is 95%, overall efficiency = 80% and speed ratio = 0.47. (10 Marks)

OR

- 8 a. Define the following :
- |                            |                           |                         |
|----------------------------|---------------------------|-------------------------|
| i) Functions of draft tube | ii) Hydraulic efficiency  | iii) Overall efficiency |
| iv) Mechanical efficiency  | v) Volumetric efficiency. | (10 Marks)              |
- b. Following data are given for a Francis turbine net head = 60m, speed = 700 rpm. Power at the shaft = 294.3 KW, Overall efficiency = 84%, hydraulic efficiency = 93%, flow ratio 0.2, width ratio = 0.1, outer diameter to inner diameter ratio = 2. Thickness of vane occupy 5% of circumference area of runner velocity of flow is constant at inlet and outlet and discharge is radial at outlet. Determine :
- Guide blade angle
  - Runner vane angles
  - diameter of runner at inlet and outlet
  - width of wheel at inlet. (10 Marks)



**Module-5**

- 9 a. Define :  
 i) Manometric efficiency  
 ii) Manometric head (04 Marks)
- b. Derive an expression for minimum starting speed of pump. (06 Marks)
- c. A centrifugal pump runs 950 rpm. its outer and inner diameter are 500 mm and 250 mm. The vanes are set back at  $35^\circ$  to the wheel rim. If the radial velocity of water through the impeller is constant at 4 m/s, find  
 i) vane angle at inlet ii) velocity of water at outlet iii) Direction of water at outlet and iv) work done per kg of water. Entry of water at inlet is radial. (10 Marks)

**OR**

- 10 a. Define :  
 i) Slip factor ii) Power input factor. (04 Marks)
- b. Explain: i) Surging ii) Choking iii) Pre notation. (06 Marks)
- c. A centrifugal compressor running at 6000 rpm having an impeller tip diameter of 101 cm has the following test data :  
 i) Mass flow rate = 25 Kg/s  
 ii) Static pressure ratio = 2.12  
 iii) Pressure at inlet = 100 KPa, temperature at inlet =  $28^\circ\text{C}$   
 iv) 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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