CBCS SCHEME

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17ME53

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

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Define and give the significance of the specific speed, head coefficient and power coefficient with respect to turbomachines. **(08 Marks)**

b. Explain the effect of Reynold number on the performance analysis of turbomachines. **(04 Marks)**

c. A quarter scale turbine model is tested under a head of 10m. The full scale turbine is required to work under a head of 28.5 m and 415 rpm:
(i) At what speed must the model be run if it develops 94 KW and uses 0.96 m^3/sec at this speed.
(ii) What power will be obtained from the full scale turbine?
(iii) Name the type of turbine. **(08 Marks)**

OR

2 a. Define: (i) Polytropic efficiency (ii) Stage efficiency (iii) Overall efficiency related to compression process. Obtain expressions relating the above efficiencies. **(10 Marks)**

b. A multistage axial flow compressor has equal pressure ratio for each of its stages and is equal to 1.35. The slow rate through the compressor and its overall efficiency are 50 kg/sec and 0.82 respectively. If the conditions of air at the entry are 1.0 bar and 300 K and temperature at the exit of the compressor is 660 K, determine:
(i) The number of stages
(ii) Polytropic efficiency
(iii) Efficiency of each stage
(iv) Power required to drive the compressor assuming the transmission efficiency of 90%. **(10 Marks)**

Module-2

3 a. With the help of inlet and outlet velocity triangles of a general turbomachine, derive the alternate form of Euler turbine equation and identify the components of energy transfer. **(10 Marks)**

b. The steam issues from the nozzle inclined at 28° to the wheel plane with a velocity of 450 m/sec. The mean rotor blade speed of an axial flow turbine stage with a degree of reaction of 50% is 200 m/sec. Ascending symmetrical inlet and outlet velocity triangles, find: (i) rotor blade angle (ii) utilization factor (iii) energy transfer per kg. **(10 Marks)**

OR

4 a. A radial outward flow turbomachine has no inlet whirl. The blade speed at exit is twice that at inlet. The radial velocity is constant throughout, taking the blade angle as 45°, show that degree of reaction is $R = \frac{2+\cot\beta_2}{4}$ where β_2 = blade angle at exit with respect to tangential direction. Discuss the effect of blade discharge angle. **(10 Marks)**

b. Water enters the mixed flow pump axially and leaves radially so that radial component at inlet and axial component at outlet both are zero. At the inlet, the tangential and axial component each are 16 units and 17 units. At the rotor exit, the radial and tangential components of the absolute velocity are 13 m/sec and 25 m/sec respectively. The tangential blade speed at inlet and exit are 12 m/sec and 47 m/sec respectively. Calculate:
(i) Change in enthalpy across rotor.
(ii) Changes in total pressure
(iii) Change in static pressure
(iv) Degree of reaction R **(10 Marks)**

Module-3

5 a. What is need for compounding in steam turbines? Explain with the help of schematic diagram, the velocity compounding of steam turbine. **(08 Marks)**

b. Steam flows through the nozzle with a velocity of 450 m/s at a direction which is inclined at an angle of 16° to wheel tangent. Steam comes out of the moving blades with a velocity of 100 m/sec in the direction of 110° with the direction of blade motion. The blades are equiangular and the steam flow rate is 10 kg/sec, find:
(i) Power developed (ii) The power loss due to friction (iii) Axial thrust
(iv) Blade efficiency (v) Blade coefficient **(12 Marks)**

OR

6 a. For a 50% reaction steam turbine, show that $\alpha_1 = \beta_2$ and $\alpha_2 = \beta_1$, where β_1 and β_2 are the inlet and outlet blade angles, α_1 and α_2 are the angles with respect to fixed blades. **(08 Marks)**

b. A stage of a turbine with persons blading delivers dry saturated steam at 2.7 bar ($V_s = 0.67\ m^3/kg$) from the fixed blades at 90 m/sec. The mean blade height is 40 mm and the moving blade exit angle is 20°. The axial velocity of steam is ¾ of the blade velocity at the mean radius. Steam is supplied to the stage at the rate of 9000 kg/hr. The effect of blade thickness on the annular area can be neglected. Calculate:
(i) Wheel speed
(ii) The diagram efficiency
(iii) The diagram power
(iv) Enthalpy drop of the steam in this stage **(12 Marks)**

Module-4

7 a. Derive an expression for the hydraulic efficiency of a pelton wheel turbine in terms of jet velocity v_1, blade velocity, u and blade angles. **(10 Marks)**

b. A pelton wheel has a tangential velocity of buckets as 40 m/sec. The water is supplied under a head of 400 m at the rate of $0.675\ m^3$/sec. The jet of water is deflected through 165° in the bucket with 15% reduction. If the coefficient of velocity for the nozzle is 0.97. Find the power developed by the turbine wheel. **(10 Marks)**

OR

8 a. With a neat sketch, explain the working of a Kaplan turbine. Draw the velocity triangles at inlet and outlet of a turbine. Also explain the function of draft tube. **(10 Marks)**

b. A Kaplan turbine develops 9000 KW under a head of 10 m, overall efficiency of the turbine is 85%. The speed ratio based on the outer diameter is 2.2 and flow ratio is 0.66. The diameter of the boss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner, base diameter and specific speed of the wheel. **(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. A single stage centrifugal pump delivers 1800 litres of water per minute against a total head of 20 m. Its speed is 1450 rpm, inner and outer diameter of the impeller are 120 mm and 240 mm respectively and diameter of suction end and delivery pipes are both 100 mm. Determine the blade angles $\beta 1$ and $\beta 2$ if the water enters radially. Also find the power required to drive the pump if the manometric efficiency of the pump is 85% and mechanical efficiency is equal to 88%. **(10 Marks)**

OR

10 a. What do you mean by slip coefficient and power input factor? Obtain an expression for the overall pressure ratio across a centrifugal compressor stage considering ship coefficient and power input factor. **(12 Marks)**

b. An axial flow compressor of 50% reaction design has blades with inlet and outlet angles with respect to axial direction as 45° and 10° respectively. The compressor is to produce a pressure ratio of 6:1 with an overall isentropic efficiency of 0.85 when inlet static temperature is 37°C. The blade speed and axial velocity are constant throughout the compressor. Assuming a value of 200 m/sec for blade speed, find the number of stages required if the work done factor is 0.87 for all the stages. **(08 Marks)**

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