CBCS Scheme

USN | | | | | | | | | | 15MR54

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Turbo Machines

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing one full question from each module.
2. Use of steam tables and Mollier chart is permitted.

Module-1

1 a. Define a turbo machine. With a neat sketch explain the parts of a turbomachine. **(06 Marks)**

b. 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%.
i) Determine its unit speed, unit flow, unit power and specific speed.
ii) Find the speed, flow and power when its operating point changes to a head of 140 m.
Take $\rho_{water} = 1000\ kg/m^3$. **(10 Marks)**

OR

2 a. Define the term 'infinitesimal' stage efficiencies of a turbine. Show that the polytropic efficiency during the expansion process is given by

$$\eta_P = \frac{\log_e(T_2/T_1)}{\left(\frac{\gamma-1}{r}\right)\log_e\left(\frac{P_2}{P_1}\right)}$$ **(10 Marks)**

b. Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15°C and a flow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is 100°C and flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate:
i) Isentropic charge in enthalpy
ii) Actual change in enthalpy
iii) Efficiency of compressor (isentropic efficiency) **(06 Marks)**

Module-2

3 a. Define the degree of reaction and show that the relationship between utilization factor (ϵ) and degree of reaction (R) for an axial flow turbine is given by

$$\epsilon = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}$$ **(08 Marks)**

b. At nozzle exit of a steam turbine, the absolute steam velocity is 300 m/s. The rotor speed is 150 m/s at a point where nozzle is 18° If outlet rotor blade angle is 3.5 less than the inlet blade angle, find the power output from the stage for a steam flow rate of 8.5 kg/s. Assuming $V_{r_1} = V_{r_2}$ find the utilization factor. Specify how you would alter the blade design so that the utilization may become maximum under the given circumstances. **(08 Marks)**

OR

4 a. With the help of inlet and outlet velocity triangles, show that the degree of reaction for an axial flow compressor, $R = \frac{V_a}{u}\cot\beta_m$, where '$V_a$' is axial velocity, 'u' is blade speed and $\cot\beta_m = \frac{\cot\beta_1 + \cot\beta_2}{\alpha}$ where β_1 and β_2 are inlet and outlet blade angles. **(08 Marks)**

b. The total power input at a stage in an axial flow compressor with symmetric inlet and outlet velocity triangles (R = 0.5) is 27.85 kJ/kg of air flow. If the blade speed is 180 m/s throughout the rotor, draw the velocity triangles compute inlet and outlet rotor blade angles. Assume axial velocity component to be 120 m/s. Would you recommend this type of compressor? **(08 Marks)**

Module-3

5 a. Briefly explain pressure-velocity compounding. **(06 Marks)**

b. One stage of an impulse turbine consists of nozzle and one ring of moving blades. The nozzle is inclined at 22° to the tangential speed of blades and blade tip angles are equiangular and equal to 35°. Using graphical method, or otherwise:

i) Find the blade speed, diagram efficiency by neglecting losses. If the velocity of steam at the exit of nozzle is 660 m/s.

ii) If relative velocity of steam is reduced by 15% in passing through the blade ring, find the diagram efficiency and end thrust on shaft when blade ring develops 1745 KW. **(10 Marks)**

OR

6 a. Show that maximum blade efficiency ($\eta_{blade\ max.}$) is $\eta_{(blade\ max)} = \frac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}$ for 50% reaction parson's steam turbine. **(08 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 530 m/s and blade coefficients are 0.9 in the first and 0.95 in the stator and in 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 32 kg/s. **(08 Marks)**

Module-4

7 a. Show that for a pelton turbine the maximum hydraulic efficiency is given by $\eta_{max} = \frac{1+C_b\cos\beta_2}{2}$ **(08 Marks)**

b. A propeller turbine gas an outer diameter of 4.5 m and inner diameter of 2m. It develops 20580 kW, when running at 140 rpm under a head of 20 m. The hydraulic efficiency is 94% and overall efficiency is 88%. Find the discharge through the turbine and guide blade angle at inlet. **(08 Marks)**

OR

8 a. Draw neat sketch of different types of draft tubes used in hydel power station and explain the function of a draft tube. **(08 Marks)**

b. An inward flow reaction turbine works under a total head of 20 m. The inner diameter is 0.6 m and outer diameter is double that of inner diameter. The water enters at an angle of 16° and the vane tip is radial at entry. The water leaves the draft tube with a velocity of 3.65 m/s. Calculate the speed of wheel and vane exit angle. Assume water leaves radially. What will be the power developed if width at inlet is 7.5 cm? **(08 Marks)**

Module-5

9 a. With neat sketch explain centrifugal pumps in series and parallel. **(06 Marks)**

b. Explain the phenomenon of cavitations in centrifugal pumps. **(03 Marks)**

c. A centrifugal pump having outer diameter equal to two times the inner diameter and running at 1000 rpm, working under a head of 30 m. The velocity of flow through the impeller is constant and is equal to 2.5 m/s. The vanes are set back at an angle of 40° at outlet. If outer diameter = 50 cm and width at outlet = 5 cm, calculate:

i) Vane angle at inlet,

ii) Work done by impeller on water/second and

iii) Manometric efficiency. **(07 Marks)**

OR

10 a. Define the following terms of centrifugal compressor:

i) Slip factor

ii) Power factor

iii) Pressure coefficient

iv) Surging **(08 Marks)**

b. A centrifugal compressor running at 6000 rpm having an impeller tip diameter of 101 cm has the following test data.

Mass flow rate = 25 kg/s

Static pressure ratio = 2.12

Pressure at inlet = 100 kPa

Temperature = 28°C

Mechanical efficiency = 0.97

Find: i) Slip coefficient ii) Temperature of air at exit

iii) Power output iv) Power coefficient **(08 Marks)**

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