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17ME53

Fifth Semester B.E. Degree Examination, Aug./Sept. 2020
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 a turbo machine. List any six differences between turbo machines and positive displacement machines. **(08 Marks)**

b. Identify the following as power generating or power absorbing turbo machines:
(i) Centrifugal compressor (ii) Steam turbine
(iii) Air blower (iv) Kaplan turbine. **(04 Marks)**

c. Tests on a turbine runner 1.25 m in diameter at 30 m head gave the following results : Power developed = 736 kW, Speed = 180 rpm, Discharge = 2.7 m^3/s. Find the diameter, speed and discharge of a runner to operate at 45 m head and give 1472 kW at the same efficiency. What is the specific speed of both turbines? **(08 Marks)**

OR

2 a. Define the following for an expansion process:
(i) Total-to-Total efficiency (ii) Total-to-static efficiency. **(04 Marks)**

b. Show that the polytropic efficiency for a compression process is given by $\eta_P = \frac{n}{n-1} \times \frac{r-1}{r}$ where r is the ratio of specific heats, n is the index of compression. **(08 Marks)**

c. Air flows through an air turbine where its stagnation pressure is decreased in the ratio 5 : 1. Total-to-Total efficiency is 0.8. The air flow rate is 5 kg/s. If the total power output is 500 kW, find : (i) Inlet total temperature (ii) Actual exit static temperature if the flow velocity is 100 m/s. (iii) Actual exit total temperature (iv) Total-to-static efficiency. **(08 Marks)**

Module-2

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

b. At a stage in a 50% degree of reaction axial flow turbine running at 3000 rpm, the blade mean diameter is 68.5 cm. If the maximum utilization factor for the stage is 0.915, calculate the inlet and outlet absolute velocities for the rotor. Find also the power output for a flow rate of 15 kg/s. **(10 Marks)**

OR

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

b. In a mixed flow compressor handling air at 16000 rpm, the stagnation temperature of air at compressor inlet and outlet are respectively 27°C and 215°C. The absolute velocity of air at rotor inlet is axial while at the exit, the tangential component of absolute velocity is 0.93 times the tangential impeller speed. If the mass flow rate is 15 kg/s, find the impeller diameter and total power input. **(10 Marks)**

Module-3

5 a. Derive the condition for maximum blade efficiency of a single stage impulse steam turbine. For symmetric blades with no friction in the blade channels, further show that $(\eta_{rotor})_{max} = \cos^2 \alpha_1$ where α_1 = nozzle angle at inlet. **(10 Marks)**

b. For a De-Laval turbine, the following data are given – Jet velocity of steam = 450 m/s, Nozzle angle = 25°, Moving blade exit angle = 20°, Blade speed = 180 m/s, Mass of steam = 2 kg/s, velocity coefficient of blades = 0.8. Determine with velocity triangles : (i) Power developed (ii) axial thrust (iii) blade efficiency **(10 Marks)**

OR

6 a. What do you mean by compounding of steam turbine? Explain with the help of schematic diagram, the following methods of compounding :
(i) Velocity compounding (ii) Pressure compounding. **(10 Marks)**

b. The following particulars refer to a Parson's reaction turbine :
Mean diameter of the blade ring = 90 cm, Speed = 3000 rpm,
Inlet absolute velocity = 350 m/s, Blade outlet angle = 20°,
Steam flow rate = 7.2 kg/s. Calculate :- (i) Blade inlet angle (ii) Tangential force (iii) Power developed. **(10 Marks)**

Module-4

7 a. Define the following heads of hydraulic turbine : (i) Gross head (i) Net head. **(04 Marks)**

b. Define the following efficiencies of hydraulic turbine :
(i) Hydraulic efficiency (ii) Mechanical efficiency (iii) Overall efficiency **(06 Marks)**

c. 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° 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 rate (iii) Tangential force on the buckets. Assume overall efficiency = 80%, Speed ratio = 0.47, $C_V = 0.97$ **(10 Marks)**

OR

8 a. Draw a neat sketch of Francis turbine and explain the functions of main parts. Draw the velocity triangles of a Francis turbine. **(10 Marks)**

b. The following data is given for a Francis turbine : Net head = 70 m, Speed = 600 rpm, Shaft power = 368 kW, Overall efficiency = 85%, Hydraulic efficiency = 95%, Flew ratio = 0.25, Breadth ratio = 0.1, Outer diameter of the runner = $2 \times$ inner diameter of the runner. Velocity of flow is constant throughout. The thickness of the vanes occupies 10% of the circumferential area of the runner and discharge is radial at outlet. Determine :
(i) Guide blade angle (ii) Runner vane angles at inlet and outlet
(iii) Diameter of the runner at inlet and outlet (iv) Width of the runner at inlet. **(10 Marks)**

Module-5

9 a. What is cavitation in centrifugal pumps? What are the effects of cavitation? **(04 Marks)**

b. Derive an expression for static pressure rise in the impeller of a centrifugal pump with velocity triangles. **(08 Marks)**

c. A 4 stage centrifugal pump has impellers each 38 cm diameter and 1.9 cm wide at outlet. The outlet vane angle is 45° and the vanes occupy 8% of outlet area. The manometric efficiency is 84% and overall efficiency is 75%. Determine the head generated by the pump when running at 900 rpm and discharging 0.059 kg/s. Also find the shaft power. **(08 Marks)**

OR

10 a. Derive an expression for overall pressure ratio for a centrifugal compressor in terms of impeller tip speed, slip, power input factor and isentropic efficiency of compressor. **(10 Marks)**

b. An axial flow compressor has the following data:
Entry condition = 1 bar, 20°C, Degree of reaction = 50%,
Mean blade ring diameter = 36 cm, Blade height at entry = 6 cm,
Rotational speed = 18000 rpm, Blade angle at rotor exit = 65°,
Axial velocity = 180 m/s, Mechanical efficiency = 0.967.
Calculate : (i) Blade angle at rotor inlet (ii) Power required to drive the compressor. **(10 Marks)**

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