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06ME55

Fifth Semester B.E. Degree Examination, December 2010
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Are vane compressors and gear pumps turbomachines? Why? **(02 Marks)**

b. Explain the physical significance of following non – dimensional numbers used in turbomachines : i) Specific capacity ; ii) Specific speed. **(04 Marks)**

c. A blower develops 750 mm W.G. (Water Gauge) at a speed of 1480 rpm and a flow rate of 38 m^3/s. Determine the specific speed of the air blower. **(04 Marks)**

d. Using Rayleigh's method of dimensional analysis, show that the performance of a turbocompressor is given by $\frac{P_{O_2}}{P_{O_1}} = f\left(\frac{m^\circ\sqrt{T_{O_1}}}{P_{O_1}}, \frac{N}{\sqrt{T_{O_1}}}\right)$ where the symbs have usual meanings. **(10 Marks)**

2 a. Explain the procedure to draw velocity triangles. Why velocity triangles are of utmost importance in the study of turbomachines? **(05 Marks)**

b. Why the discharge blade angle has considerable effect in the analysis of a turbomachine? Give reasons. **(05 Marks)**

c. In a certain turbomachine, the inlet whirl velocity is 15 m/s; inlet flow velocity is 10 m/s; blade speeds are 30 m/s and 8 m/s respectively. Discharge is radial with an absolute velocity of 15 m/s. If water is the working fluid, flowing at the rate of 1500 litres/s, calculate : i) Power in kW ; ii) the change in total pressure in bar ; iii) the degree of reaction ; iv) Utilization factor. **(10 Marks)**

3 a. Explain why turbines with reaction R > 1 and R < 0 are not in practical use? **(04 Marks)**

b. Steam leaves the rotating blades as shown in the sketch. Evaluate the absolute velocity in magnitude and direction. **(04 Marks)**

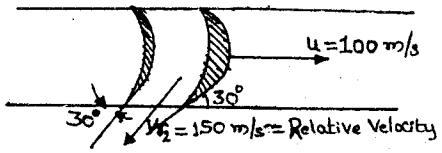

Fig.Q.3(b).

c. A hydraulic reaction turbine of the radial inward flow type, works under a head of 160 m of water. At the point of fluid entry, the rotor blade angle is 119° and the diameter of the runner 3.65 m. At the exit, the runner diameter is 2.45m. If the absolute velocity at the wheel outlet is radially directed with a magnitude of 15.5 m/s and the radial component of velocity at the inlet is 10.3 m/s. Determine : i) the power developed by the machine, for a flow rate of 110 m^3/s ; ii) the degree of reaction and iii) the utilization factor. **(12 Marks)**

4 a. Define the following, with the help of a h – s diagram, for the power generating turbomachines :
total – to – total efficiency
total – to – static efficiency
static – to – total efficiency

b. static – to – static efficiency. **(06 Marks)**

Define infinitesimal stage efficiency of a turbine. Show that the index 'n' of polytropic expansion in a turbine of infinitesimal stage efficiency η_p is given by

$n = \frac{\gamma}{\gamma - (\gamma - 1)\eta_p}$, where '$\gamma$' is a ratio of specific heats. **(08 Marks)**

c. A low pressure air compressor develops a pressure of 120mm W.G. If the initial and final states of air are P_1 = 1.02 bar, T_1 = 27°C and T_2 = 42°C, determine the compressor and infinitesimal stage efficiencies. **(06 Marks)**

PART – B

5 a. What is radial equilibrium in an axial flow compressor? Derive an expression for radial equilibrium in terms if flow velocity and whirl velocity of a fluid. **(10 Marks)**

b. A centrifugal compressor runs at a speed of 15000 rpm and delivers air at 20 kg/s. Exit radius is 0.35m, relative velocity and vane angles at exit are 100 m/s and 75° respectively. Assuming axial inlet and inlet stagnation temperature and stagnation pressure as 300 K and 1 bar respectively, calculate : i) the torque ; ii) the power required to drive the compressor; iii) the ideal head developed ; iv) the work done and v) the exit total pressure. Take $(c_p)_{air}$ = 1.005 kJ/kg. **(10 Marks)**

6 a. Explain the following, with reference to the centrifugal pump :
i) Slip and its effect.
ii) Cavitation, its effect and remedies to it.
iii) Difference between manometric head and NPSH. **(08 Marks)**

b. Why does a centrifugal pump always comes with a motor unit, not a single unit? **(02 Marks)**

c. A three stage centrifugal pump has impeller of 40 cm diameter and 2.5 cm wide at the outlet. The vanes are curved back at the outlet at 30° and reduce the circumferential area by 15%. The manomatric efficiency is 85% and overall efficiency is 75%. Determine the head generated by the pump when running at 12000 rpm, and discharging the water at 0.06 m^3/s. Find the shaft power also. **(10 Marks)**

7 a. Why is compounding of steam turbine necessary? Describe the velocity compounding of steam turbines. **(04 Marks)**

b. Prove that the maximum blade efficiency for a single stage impulse turbine with equiangular rotor blades is given by $(\eta_b)_{max} = (1+c_b)\frac{\cos^2\alpha_1}{2}$, where α_1 is the nozzle angle and c_b is blade velocity coefficient. **(08 Marks)**

c. In a Parson's turbine, the axial velocity of flow of steam is 0.5 times the mean blade speed. The outlet angle of the blade is 20°, diameter of the blade ring is 1.30m and the rotational speed is 3000 rpm. Determine inlet blade angles, power developed for steam flow of 65 kg/s and the isentropic enthalpy drop, if the stage efficiency is 80%. **(08 Marks)**

8 a. Show that the specific speed of a Pelton wheel is given by $N_s = 240\frac{\sqrt{n}}{m}$,
where n = number of jets used for the flow.
m = wheel diameter to jet diameter ratio.
Assume the jet velocity coefficient as 0.97, speed ratio as 0.45 and efficiency of the turbine as 0.89. **(06 Marks)**

b. A conical draft tube has top diameter of 2.0 m and total height of 5m. The pressure head at the inlet is 6m vacuum, while the atmospheric pressure head is 10m. Discharge velocity of flow is 1.5 m/s and the discharge of water is 24 m^3/s. Neglecting the losses, calculate the height of the draft tube immersed. **(06 Marks)**

c. A Kaplan turbine develops 10 MW under an effective head of 8m. The overall efficiency is 0.86, the speed ratio is 2.0 and the flow ratio 0.60. The Hub diameter of the wheel is 0.35 times the outside diameter of the wheel. Find the diameter and speed of the turbine. **(08 Marks)**

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