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06ME55

Fifth Semester B.E. Degree Examination, December 2011
Turbomachines

Time: 3 hrs. Max. Marks:100

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

PART - A

1 a. Explain with a neat sketch, the principal components of a turbomachine. **(06 Marks)**

b. Define specific speed of a turbine and derive it. **(06 Marks)**

c. Using Buckingham's method, prove that the wave resistance of a ship is given by $V = \sqrt{gH}\ \phi\ [\ d/H,\ \mu/\rho VH\ ]$, where H = head of liquid over the orifice, d = diameter of the orifice, μ = viscosity of the liquid, L = linear dimension, V = velocity of the ship, ρ = density of the liquid, ϕ = a functional relation. **(08 Marks)**

2 a. An inward flow radial reaction turbine has axial discharge at the outlet, with an outlet blade angle of 45^0. The radial velocity of flow is constant. The blade speed at the inlet is twice that at the exit. Express the energy transfer per unit mass and degree of reaction in terms of inlet nozzle angle α_1. Assume $V_m = \sqrt{2g_c}$. At what values of α_1 will the degree of reaction be zero and unity? What are the corresponding values of energy per unit mass? **(10 Marks)**

b. In a mixed flow compressor, handling air at 16000 RPM, the stagnation temperatures of air at the compressor inlet and outlet are respectively 27^0C and 215^0C. The absolute velocity of the air at the rotor inlet is axial while at the exit the tangential component of the absolute velocity is 0.93 times the tangential impellor speed. If the mass flow rate of air through the impeller is 15kg/s and specific heat assumed to be constant, find the impellor diameter and total power input. **(10 Marks)**

3 a. In a turbomachine, prove that the maximum utilization factor is given by **(10 Marks)**

$\epsilon_{max} = \dfrac{2\phi.\cos\alpha_1}{1+2\phi R\ \cos\alpha_1}$, where ϕ = speed ratio , R = degree of reaction , α_1 = nozzle angle.

b. At a stage of an impulse turbine, the mean blade dia is 0.75m, its rotational speed being 3500 RPM. The absolute velocity of the fluid discharging from a nozzle inclined at 20^0 to the plane of wheel, is 275m/sec. If the utilization factor is 0.9 and the relative velocity of the fluid at the rotor exit is 0.9 times that at the inlet, find the inlet and exit rotor angles. Also find the power output from the stage for a mass flow rate of 2kg/s and axial thrust on the shaft. **(10 Marks)**

4 a. Define and explain i) static state ii) stagnation state for a fluid. **(04 Marks)**

b. What is a reheat factor? Show that the reheat factor is greater than unity. **(06 Marks)**

c. Compressor A has total pressure ratio of 4, a total head adiabatic efficiency of 86% and an exit velocity of 130m/s at the point of measurement. Compressor B has static pressure of 6 bar, a static temperature of 245^0C and a velocity of 100m/s at the point of measurement. Which compressor has the best polytropic efficiency? Assume the ambient temperature and pressure are 15^0C and 1 bar respectively. **(10 Marks)**

PART - B

5 a. Explain the phenomenon of i) surging ii) choking in the centrifugal compressor. **(06 Marks)**

b. What is the necessity of providing the pre – whirl at the inlet of the centrifugal compressor? **(02 Marks)**

c. Find the number of stages of axial flow compressor with symmetric blades $\beta_1 = 40°C$ and $\beta_2 = 60°C$ needed to produce a total pressure rise from 1 bar to 4 bar. The blade height is 3 cm and the rotor mass diameter 10cm. The speed of the machine is 24000 rpm. The stage efficiency is 82%. Assume the air enters at 30^0C. What will be the actual pressure rise? **(12 Marks)**

6 a. Derive an expression for H – Q characteristic curve for a centrifugal pump. Discuss the H – Q curve for the forward, radial and backward curved vanes. **(08 Marks)**

b. What is meant by cavitation in centrifugal pumps? What are the causes of cavitation? **(04 Marks)**

c. A centrifugal pump has straight (radial) vanes from inner radius 8cm to outer radius 24cm. The width of the impeller is constant and 6cm between the shrouds. The speed is 1500 RPM and the discharge is 250 lit/s. Find the outlet pressure if the inlet pressure = 0.8kPa and water flow is outward. **(08 Marks)**

7 a. Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines. **(08 Marks)**

b. In a curtis stage turbine, steam enters the first row of moving blades at 700m/s. The outlet angles of the nozzle, the first rotor blade, the stator blade and the last rotor blade respectively are 17^0, 23^0, 19^0 and 37^0. The mean blade speed is 160m/sec, the blade coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on the blades. **(12 Marks)**

8 a. Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet. **(08 Marks)**

b. Explain the functions of a draft tube. **(04 Marks)**

c. A single jet pelton wheel produces 20MW, operating against a head of 500m. If the overall efficiency is 0.85 and specific speed (SI units) is 12, estimate the jet and wheel diameter. Assume speed ratio $\phi = 0.46$. **(08 Marks)**

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