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06ME55

Fifth Semester B.E. Degree Examination, June 2012
Turbomachines

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Explain any six major differences between turbomachines and positive displacement machines. **(06 Marks)**

b. Define specific speed of a pump. Derive the expression for specific speed for a pump. **(06 Marks)**

c. Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump has an impeller diameter of 0.3 m and lifts water at rate of 20 ℓ/s against a head of 15 m. Determine the head and impeller diameter of other pump to deliver half the discharge. **(08 Marks)**

2 a. Draw the inlet and exit velocity triangles for a turbine. Derive an expression for alternate form of Euler's turbine equation. **(06 Marks)**

b. In a radial inward flow turbomachine the radii and tangential velocity components at the inlet and outlet are 15 cm and 7.5 cm ad 350 m/s and 60 m/s respectively. Find the torque due to 1 kg/s of mass flow. **(06 Marks)**

c. In an axial flow machine discharge blade angles are 20° each for both stator and rotor. The steam speed at the exit of fixed blade in 140 m/s. The ratio $\frac{V_{ax}}{U} = 0.7$ at entry and 0.76 at exit. Find the inlet blade rotor angle, power developed by the blade ring and degree of reaction for a mass flow rate of 2.6 kg/s. **(08 Marks)**

3 a. Draw inlet and exit velocity triangles for an axial flow compressors. Show that degree of reaction for axial flow compressor is given by, $R = \frac{V_a}{2U}(\tan\gamma_1 + \tan\gamma_2)$. Assume axial velocity $V_{a_1} = V_{a_2} = V_a$ is constant. γ's are air angles. **(10 Marks)**

b. For a 50% degree of reaction axial flow turbomachine, inlet fluid velocity is 230 m/s, outlet angle of inlet guide blade is 30°, inlet rotor angle is 60° and outlet rotor angle is 25°. Find utilization factor, axial thrust and power output per unit mass flow. Axial velocity at inlet is different from axial velocity at exit. **(10 Marks)**

4 a. Show that polytropic efficiency of a turbine is given by, $\eta_P = \frac{\frac{\gamma}{\gamma-1}\log_e\frac{T_2}{T_1}}{\log_e\frac{P_2}{P_1}}$, further show that stage efficiency is given by, $\eta_{st} = \frac{1-\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}\eta_P}}{1-\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}}$

Draw the corresponding T-S or h-s diagram. **(10 Marks)**

4 b. An air compressor has 8 stages of equal pressure ratio of 1.3. The flow rate through the compressor and its overall efficiency are 45 kg/s and 80% respectively. If the conditions of air at entry are 1 bar and 35°C, determine i) state of compressed air at exit, ii) Polytropic efficiency, iii) stage efficiency. **(10 Marks)**

PART – B

5 a. Air at a temperature of 300 K flows in a centrifugal compressor running at 18000 rpm. Isentropic efficiency in 0.76, outer blade tip diameter is 550 mm, slip factor is 0.82, calculate i) temperature rise of air passing through compressor ii) static pressure ratio. Assume that the absolute velocity of air at inlet and exit of compressor is same. Take C_p = 1005 J/kgK. **(10 Marks)**

b. Briefly explain the following :
   i) Surging of compressors.
   ii) Slip factor or slip coefficient. **(10 Marks)**

6 a. The impeller of a centrifugal pump is 30 cm in diameter and 5 cm wide at outlet, vanes are curved backwards at 35°. Thickness of vanes occupy 20% of peripheral area and velocity of flow is constant. The discharge is 75 ℓ/s when rotating at 800 rpm. Calculate pressure rise in impeller and percentage of total work converted to kinetic energy. **(10 Marks)**

b. Explain the following with mathematical expression:
   i) Manometric efficiency
   ii) Mechanical efficiency
   iii) Volumetric efficiency
   iv) Overall efficiency
   v) Static head **(10 Marks)**

7 a. An axial flow single stage steam turbine has a mean rotor diameter of 55 cm and runs at 3300 rpm. The speed ratio is 0.45 and blade velocity co-efficient is 0.91. If the nozzle angle at the rotor inlet is 20°. Find
   i) Rotor blade angles assuming axial exit.
   ii) Draw the inlet and exit velocity triangles.
   iii) Power output per unit mass flow rate.
   Assume absolute velocity at inlet to be 211 m/s. **(10 Marks)**

b. Show that for a 50% degree of reaction axial flow reaction turbine, the blade speed is given by $U = V_f(\cot\beta_2 - \cot\beta_1)$. Assume velocity of flow or axial velocity to be constant. β_2 is exit rotor blade angle and β_1 is inlet rotor blade angle. **(10 Marks)**

8 a. Show that the maximum hydraulic efficiency of a Pelton wheel turbine is given by,

$$(\eta_h)_{max} = \frac{1 + C_b \cos\beta_2}{2}$$

Also, draw the inlet and exit velocity triangles C_b is bucket velocity coefficient and β_2 in exit blade angle. **(10 Marks)**

b. The external and internal diameters of inward flow reaction turbine are 1.2 m and 0.6 m respectively. The head on turbine is 22 m, and velocity of flow through the turbine is constant and equal to 2.5 m/s. The guide blade angle is 10° and runner vanes are radial at inlet. If the discharge at outlet is radial, determine i) speed of turbine ii) vane angle at outlet of runner iii) velocity triangles at inlet and exit iv) hydraulic efficiency. **(10 Marks)**

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