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06ME55

Fifth Semester B.E. Degree Examination, June/July 2014
Turbomachines

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. How turbomachines are classified? Give at least one example of each. **(06 Marks)**

b. The resistance R experienced by a partially submerged body depends upon the velocity V, the length of the body L, the viscosity of the fluid μ, the density of the fluid ρ, and the gravitational acceleration g. Obtain a dimension expression for R. **(08 Marks)**

c. A hydraulic turbine has a scale ratio of 1:10. Following data refers to model and prototype,
Model: P = 25kW, N = 500rpm, H = 10m, $\eta_0 = 0.8$.
Prototype: H = 130m
Calculate the discharge, speed power and overall efficiency of the prototype. **(06 Marks)**

2 a. Explain the effect of blade discharge angle on energy transfer and the degree of reaction in a turbomachine. Also show the variations along the graphs. **(06 Marks)**

b. Define the following: i) Degree of reaction; ii) Utilization factor. **(04 Marks)**

c. Show that for maximum utilization, the work output per stage of an axial flow impulse machine with equiangular blades is double that of a 50% reaction stage which has the same speed. Assume that the axial velocity remains constant of a 50% reaction machine. **(10 Marks)**

3 a. With the help of inlet and outlet velocity diagrams, show that the degree of reaction for an axial flow compressor is given by

$$R = \frac{Va}{2u}[\cot\beta_1 + \cot\beta_2] \text{ where,}$$

v_a = axial flow velocity.
u = blade velocity.
β_1 and β_2 are the vane angles of inlet and outlet. **(08 Marks)**

b. Combustion products approach an axial flow turbine rotor with an absolute velocity of 600m/s and 70° to the axial direction. The tangential component of this absolute velocity is in the same direction as the wheel velocity. The mass flow rate is 30kg/s. The blade speed is 250m/s and the absolute velocity is exited axially. Draw the velocity triangles at inlet and outlet and determine,
i) The power output; ii) Utilization factor; iii) Degree of reaction. **(12 Marks)**

4 a. Show that the polytropic efficiency (infinite signal stage efficiency) is given by. [Draw the T-S diagram].

$$\eta_p = \left[\frac{n-1}{n}\right]\left[\frac{\gamma}{\gamma-1}\right]$$

where, n = polytropic process of index, γ = ratio of specific heats. **(10 Marks)**

b. An air compressor has six stages of equal pressure ratio 1.4. The mass flow rate is 45kg/s. The overall isentropic compression efficiency is 84%. Entry pressure is 1 bar and $T_1 = 40°C$. Calculate: i) The state of air at the exit; ii) Polytropic efficiency; iii) Each stage efficiency; iv) Power required to drive the compressor (overall efficiency of drive is 0.9).
Assume r = 1.4, R = 0.287 kJ/kg-K, c_p = 1.005 kJ/kg-K. **(10 Marks)**

PART – B

5 a. Write a short note on the surging of centrifugal compressor. **(04 Marks)**

b. A centrifugal compressor runs at a speed of 550m/s with no prewhirl. Suppose the slip is 0.95 and isentropic efficiency of compressor is 0.85. Calculate the following for standard sea level. i) Pressure ratio; ii) The work required and iii) The power required. Assume mass flow rate = 25 kg/s, c_p = 1.005 kJ/kg-K ambient temperature = 15°C. **(06 Marks)**

c. With a neat schematic diagram, explain the working principle of an axial flow compressor. Also draw velocity diagrams. **(10 Marks)**

6 a. With the help of velocity diagrams of inlet and exit, obtain the expression for pressure rise in a centrifugal pump. **(08 Marks)**

b. A centrifugal pump discharges 0.15 m^3/s of water against a head of 12.5m. Speed of impeller is 600rpm. The outer and inner diameters of impeller are 500mm and 250mm respectively. The vanes are bent back at 35° to the tangent at exit. If the area of flow remains $0.07m^2$ from inlet to outlet, find:

i) Manometric efficiency.
ii) Vane angles at inlet.
iii) Loss of head at inlet to impeller when the discharge is reduced by 40% without changing the speed. **(12 Marks)**

7 a. For an impulse steam turbine, prove that the blade efficiency is given by,
$\eta_b = 2\phi (\cos\alpha_1 - \phi)(1 + kc)$
where, ϕ = speed ratio
k = blade velocity co-efficient and
$c = \frac{\cos\beta_2}{\cos\beta_1}$. **(08 Marks)**

b. In an impulse steam turbine (with single row wheel), the mean diameter of the blades is 1.05m and the speed is 3000 rpm. The nozzle angle is 1.05m and the speed is 3000rpm. The nozzle angle is 20° and the ratio of blade speed to steam speed is 0.45 and the ratio of relative from outlet to inlet is 0.85. The outlet angle of the blade is 3° less than the blade angle at inlet. If the steam flow is 10kg/s determine:

i) Tangential thrust on the blades.
ii) Axial thrust on the blades.
iii) Resultant thrust on blade.
iv) Power developed in the blades and
v) Blading efficiency.

Also draw the velocity triangles at the inlet and outlet of the blades. **(12 Marks)**

8 a. Draw the velocity diagrams of the inlet and outlet for a Pelton wheel and obtain the expressions for torque on the wheel, power developed by the runner and hydraulic efficiency. **(10 Marks)**

b. A Francis turbine working under a head of 230m runs at 800rpm. The velocity of water of entry is 32m/s. The outer and inner diameters of the runner bare 1.5m and 0.75m respectively. The inlet angle of the guide blades is 12°. Calculate the runner blade angles of the inlet and outlet and the hydraulic efficiency, if the discharge is axial and the velocity of flow is constant through the runner. **(10 Marks)**

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