USN | | | | | | | | | | |

06ME55

Fifth Semester B.E. Degree Examination, Dec.2013/Jan.2014
Turbo Machines

Time: 3 hrs. Max. Marks: 100

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

PART – A

1 a. The performance of a turbo machine, for incompressed flow, like water turbines, pumps, fans and blowers depends on density of the fluid ρ, speed of machine N, characteristic diameter D, gravity head (gH), discharge q, Power developed P and viscosity μ of fluid. Taking ρ, N, D as repeating variables. Using Buckingham π theorem. Obtain non dimensional coefficients and explain their significance. **(12 Marks)**

b. Define specific speed of a water turbines used practically. **(03 Marks)**

c. A hydraulic turbine working under a head of 100 meters develops 16.5 MW while running at 300 rpm. What is the specific speed of the turbine? Name the type of turbine. **(05 Marks)**

2 a. An outward flow turbo machine, radial in shape, has the outer diameter twice the inner diameter. Fluid enters without whirl at inlet and the inlet vane angle is 45°. With the help of the velocity diagrams at inlet and outlet show that the entropy transfer per unit mass $E = 2(\cot\beta_2 - 2)$ and degree of reaction $R = \left[\frac{2+\cot\beta_2}{4}\right]$ where β_2 is the vane angle at outlet to the rotational direction. **(10 Marks)**

b. In an inward flow water turbine, the water enters the runner through a guide vane at an angle of 30° and at velocity of 30 m/s. The inlet diameter is 1.8 m and the outlet diameter is half the inlet diameter. The water leaves the runner at an absolute velocity of 3 m/s at an angle of 130° to the wheel tangent, with a slight positive whirl. Find the power developed by the turbine if the discharge is 0.4 m^3/s and also the blade angles at inlet and outlet. If the speed of the turbine is 300 rpm. **(10 Marks)**

3 a. Define utilization factor ∈ and degree of reaction R of an axial flow turbine and give its mathematical expression. **(06 Marks)**

b. Show for an axial turbine, $\in = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}$. **(06 Marks)**

c. The following data refer to 50% reaction axial flow steam turbine, with steam rate 10 kgs/sec Inlet velocity = 250 m/s, Inlet guide vane angle = 30°, Outlet angle of blade = 26°, Rotor velocity, tangential = 180 m/s. Find i) Utilisation factor ∈ ii) Axial thrust iii) Power output **(08 Marks)**

4 a. With the help of TS diagram, obtain the expression for total to total efficiency of a compressor as,

$$\eta_{C\,tt} = \frac{T_{01}\left[P_{r_0}^{\frac{\gamma-1}{\gamma}} - 1\right]}{T_{02} - T_{01}} \text{ where } P_{r_0} = \frac{P_{02}}{P_{01}} \text{ and } \gamma = \text{ratio of specific heats}$$ **(08 Marks)**

4 b. An air compressor has the following data:
Inlet total pressure = 1.02 bar
Exit total pressure = 1.5 bar
Inlet total temperature = 300 K
Total Exit temperature = 340 K
Calculate i) Isentropic efficiency ii) Polytropic efficiency. **(08 Marks)**

c. If the degree of reaction is zero for an axial turbine , what will be the shape of turbine rotor blade and the theoretical relative velocity at inlet and outlet of rotor passage. **(04 Marks)**

PART – B

5 a. Using continuity equation and energy equation for a circular flow passage show that,

$$\frac{dA}{A} = \frac{dP}{P}\left[\frac{1-M^2}{\gamma M^2}\right]$$

For isentropic flow of a perfect gas for compressible flow with usual notations and show that shape of a subsonic to supersonic steam nozzle shape. **(10 Marks)**

b. Explain the phenomena of surging in compressors. **(05 Marks)**

c. Explain slip factor in compressors. **(05 Marks)**

6 a. Explain : i) Priming ii) Cavitation iii) NPSH as applicable to centrifugal pumps. **(08 Marks)**

b. A centrifugal pump has the following data:
i) Suction head h_s = 5 m
ii) Delivery head h_d = 35 m
iii) Head lost in suction pipe = 1 m
iv) Head lost in delivery pipe = 4 m
v) Diameter of suction pipe = 11 cm
vi) Diameter of delivery pipe = 10 cm
vii) Manometric head = 50 m
viii)Manometric efficiency = 80%
ix) Overall efficiency = 75%
Find i) Power at discharge end ii) Power available to impeller
iii) Power required for the motor drive iv) Total suction head
v) Total delivery head. **(12 Marks)**

7 a. Show for an axial flow steam turbine with degree of reaction 0.5, like a Parson reaction turbine, the maximum efficiency is $\left[\frac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}\right]$ where α_1 is the nozzle angle to the directions of rotation. **(10 Marks)**

b. A single stage impulse turbine has a diameter of 1.5 m and running at 3000 rpm. The nozzle angle is 20°. Speed ratio is 0.45, ratio of velocity at outlet to inlet is 0.9. The outlet angle of the blade is 3° less than inlet angle. Steam flow rate is 10 kgs/sec. Draw the velocity diagrams and find the following : i) Velocity of whirl ii) Axial thrust iii) Blade angles iv) Power developed. **(10 Marks)**

8 With neat sketches, explain any four of the following:
a. Runner shape of Kaplan turbine from hub to tip.
b. Purpose of Draft tube in reaction water turbines.
c. Semi-ellipsoidal pelton turbine shape for best efficiency.
d. Classification of hydraulic turbines based on specific speed.
e Various efficiencies of a water turbine. **(20 Marks)**

* * * * *