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

10ME56

Fifth Semester B.E. Degree Examination, June/July 2013
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. Explain at least six differences between turbomachines and positive displacement machines. **(06 Marks)**

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

c. Define specific speed of a turbine. Obtain an expression for the same in terms of P shaft power, speed and head. **(06 Marks)**

2 a. Air enters a compressor at a static pressure of 15 bar and static temperature of 15°C and a flow velocity of 50 m/s. At exit, the static pressure is 30 bar, static temperature is 100°C and flow velocity is 100 m/s. The outlet is 1 m above the inlet. Find i) Isentropic change in total enthalpy ii) Actual change in total enthalpy. Take C_P for air as 1005 J/kgK. **(10 Marks)**

b. Obtain an expression for polytropic efficiency for a compressor in terms of pressure ratio and temperature ration. Further express stage efficiency in terms of polytropic efficiency and pressure ratio. Also draw the relevant T-S diagram. **(10 Marks)**

3 a. Show that the alternate form of Euler's turbine equation can be expressed as follows:

$$W = \frac{\left(V_1^2 - V_2^2\right) + \left(U_1^2 - U_2^2\right) - \left(V_{r_1}^2 - V_{r_2}^2\right)}{2}$$

Draw the relevant velocity triangles. **(10 Marks)**

b. In an axial flow turbine dischange blade angles are 20° each for both stator and rotor. The steam speed at the exit of fixed blade is 140 m/s. The ratio $\frac{V_{ax}}{U} = 0.7$ at entry and 0.76 at exit of rotor. Find the inlet blade rotor angle, power developed for a flow rate of 2.6 kg/s and degree of reaction. **(10 Marks)**

4 a. Draw the velocity triangles for axial flow compressor. From the triangles show that degree of reaction for axial flow compressor is given by, $R = \frac{V_{ax}}{2U}\left(\tan\gamma_1 + \tan\gamma_2\right)$. Assume axial velocity to remain constant. γ_1 and γ_2 are angles made by relative velocities with the axial direction. **(10 Marks)**

b. A radial outward flow turbomachine has no inlet whirl. The blade speed at exit is twice that at the inlet. The radial velocity remains constant. Inlet blade angle is 45°. Show that the degree of reaction for this machine is given by, $R = \frac{2 + \cot\beta_2}{4}$. **(10 Marks)**

PART – B

5 a. Draw the inlet and exit velocity triangles for a pelton wheel turbine. Show that maximum hydraulic efficiency is given by, $(\eta_{hyd})_{max} = \frac{1+\cos\beta_2}{2}$. Assume that relative velocity remains constant. **(10 Marks)**

b. The internal and external diameters of an 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 runner is constant and is equal to 2.5 m/s. The guide blade angle is 10° and the runner vanes are radial at inlet. If the discharge at outlet is radial. Find i) Speed of turbine ii) Vane angle at outlet iii) Hydraulic efficiency iv) Draw velocity triangles. **(10 Marks)**

6 a. Explain the following with reference to centrifugal pump:
i) Manometric efficiency with expression.
ii) Cavitation in pumps.
iii) Need for priming.
iv) Pumps in series. **(10 Marks)**

b. Outer diameter of a pump is 50 cm and inner diameter is 25 cm and runs at 1000 rpm, against a head of 40 m. Velocity of flow is constant and is equal to 2.5 m/s. Vanes are set back at an angle of 40° at the outlet. Width at outlet is 5 cm. Find, i) Vane angle at inlet ii) Work done by impeller iii) Manometric efficiency. **(10 Marks)**

7 a. Draw the inlet and exit velocity triangles for a single stage steam turbine. Further prove that maximum blade efficiency is given by,
$(\eta_b)_{max} = \cos^2\alpha_1$
Assume $V_{r_1} = V_{r_2}$ and $\beta_2 = \beta_1$ **(10 Marks)**

b. The following data refer to a 50% reaction turbine. D = 1.5 m, $\rho\left(\frac{U}{V_1}\right) = 0.72$, $\beta_2 = 20^0$, N = 3000 rpm, find i) Blade efficiency ii) Determine percentage increase in blade efficiency and rotor speed if the rotor is designed to run at its best theoretical the rotor is designed to run at its best theoretical speed, the exit angle (α_1) is 20°. Blade efficiency for best speed is given by, $\eta_b = \frac{z\cos^2\alpha_1}{1+\cos^2\alpha_1}$ **(10 Marks)**

8 a. With the help of H-Q plot explain the phenomena of surging in centrifugal compressors. **(10 Marks)**

b. A centrifugal compressor delivers 18.2 kg/s of air with a total pressure ratio of 4 : 1. Speed is 15000 rpm. Inlet total temperature is 15°C. Slip coefficient is 0.9, power input factor is 1.04. Efficiency is 0.8. Calculate overall diameter of impeller. **(10 Marks)**

* * * * *