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

10ME56

Fifth Semester B.E. Degree Examination, June/July 2016
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting atleast TWO questions from each part.*
2. Use of Steam table and thermodynamic data handbook is permitted.

PART – A

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

b. What are unit quantities? Derive the expressions to each of them. **(06 Marks)**

c. The following data were obtained from the main characteristics of a Kaplan turbine of runner diameter 1 m. $P_u = 30.695$, $Q_u = 108.6$, $N_u = 63.6$. Estimate (i) The runner diameter (ii) The discharge (iii) The speed of a similar runner working under a head of 30 m and developing 2000 kW. Also (iv) determine the specific speed of the runner. **(08 Marks)**

2 a. Define the polytropic efficiency of a turbine. Draw the T-S diagram and show that the polytropic efficiency is given by

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

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

b. Air flows through an air turbine where its stagnation pressure is reduced in the ratio 5:1. The total-to-total efficiency is 80%. The air flow is 5 kg/s. If the total power output is 500 kW, find (i) inlet total temperature (ii) actual exit total temperature (iii) actual exit static temperature if the flow velocity is 100 m/s (iv) total-to-static efficiency. **(10 Marks)**

3 a. Obtain an expression as shown below for energy transfer and degree of reaction as a function of discharge blade angle β_2 for a turbomachine. Make the following assumptions: (i) $u_2 = 2u_1$, (ii) Constant radial velocity, (iii) No whirl velocity at inlet and inlet blade angle 45°.

$$R = \frac{2+\cot\beta_2}{4}$$

(10 Marks)

b. In an axial flow turbine, the discharge blade angles are 20° each, for both the stator and the rotor. The steam speed at the exit of the fixed blade is 140 m/s. The ration of $\frac{V_a}{u} = 0.7$ at the entry and 0.76 at the exit of the rotor blade. Find (i) the inlet rotor blade angle, (ii) the power developed by the blade ring for a mass flow rate of 2.6 kg/s, (iii) Degree of reaction. **(10 Marks)**

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

$$R = \frac{V_a}{2U}[\cot\beta_1 + \cot\beta_2]$$

where, V_a = axial flow velocity, u = blade velocity, β_1 and β_2 are the vanes angles of inlet and outlet. **(10 Marks)**

b. A centrifugal pump delivers water against a head of 25 m. The radial velocity of flow is 3.5 m/s and is constant, the flow rate of water is 0.05 m^3/s. The blades are radial at tip and pump runs at 1500 rpm. Determine (i) Diameter at tip, (ii) Width of blade at tip, (iii) Inlet diffuser angle at impeller exit. **(10 Marks)**

PART – B

5 a. With a neat sketch, explain the pressure-velocity compounding of steam turbine. **(08 Marks)**

b. In a Curtis stage with two rows of moving blades the rotor are equiangular. The first rotor has angle of 29° each while second rotor has angle of 32° each. The velocity of steam at the exit of nozzle is 530 m/s and the blade coefficients are 0.9 in the first, 0.95 in the stator and in the second rotor. If the absolute velocity at the stage exit should be axial, find (i) Mean blade speed (ii) The rotor efficiency (iii) The power output for a flow rate of 32 kg/s. **(12 Marks)**

6 a. Show that for a Pelton turbine the maximum hydraulic efficiency is given by

$$\eta_{max} = \frac{1 + C_b \cos\beta_2}{2}$$

where C_b is blade velocity co-efficient and β_2 is blade discharge angle. **(08 Marks)**

b. Explain the function of a draft tube and mention its types. **(04 Marks)**

c. In a Francis turbine, the discharge is radial, the blade speed at inlet is 25 m/s. At the inlet tangential component of velocity is 18 m/s. The radial velocity of flow is constant and equal to 2.5 m/s. Water flows at the rate of 0.8 m^3/s. The utilization factor is 0.82. Find (i) Euler's head (ii) Power developed (iii) Inlet blade angle (iv) Degree of reaction (R). Draw the velocity triangles. **(08 Marks)**

7 a. What are the applications of multi-stage centrifugal pumps? With a neat sketch, explain centrifugal pumps in series and parallel. **(08 Marks)**

b. Explain the phenomenon of cavitation in centrifugal pump. **(04 Marks)**

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

8 a. Define the following terms of centrifugal compressor:
(i) Slip factor (ii) Power factor (iii) Pressure coefficient. **(06 Marks)**

b. Explain the phenomenon of surging in centrifugal compressor. **(04 Marks)**

c. The speed of an axial flow compressor is 15,000 rpm. The mean diameter is 0.6 m. The axial velocity is constant and is 225 m/s. The velocity of whirl at inlet is 85 m/s. The work done is 45 kJ/kg of air. The inlet conditions are 1 bar and 300 K. Assume a stage efficiency of 0.89. Calculate (i) Fluid deflection angle, (ii) Pressure ratio, (iii) Degree of reaction, (iv) Mass flow rate of air. Power developed is 425 kW. **(10 Marks)**

* * * * *