B. E. MECHANICAL ENGINEERING THIRD YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2024

Ref. No.: Ex/ME(M2)/PC/B/T/311/2024(S)

FLUID MACHINERY- II

Time:-Three Hours Full Marks:-100

Answer any **five** Questions

Assume any data relevant to the questions if not provided

1. By using the dimensional analysis for the incompressible flow through the turbo-machinery find the flow coefficient, head coefficient and power coefficient and explain why they are so important? (20)

2. a) What are the main components of a centrifugal Compressor and briefly explain the function of them. (05)

   b) The following data pertains to a Centrifugal Compressor:
   Total pressure ratio = 3.25:1
   Diameter of the inlet eye of the compressor impeller = 35 cm.
   Axial velocity at inlet = 140 m/s
   Mass flow rate = 12.8 Kg/s
   The velocity in the delivery duct = 123 m/s
   The tip speed of the impeller = 470 m/s
   Speed of the impeller = 16500 r.p.m.
   Total head isentropic efficiency = 82%
   Pressure coefficient = 0.75
   Ambient conditions: 1.013 bar and 16° C

   Calculate:
   1) The static pressure and temperature at inlet and outlet of the Compressor.
   2) The static pressure ratio
   3) Work of the Compressor per Kg of Air
   4) The theoretical power required. (15)

3. a) What do you understand by Multistaging of Centrifugal pump? Explain with neat diagram the following:
   Centrifugal Pumps in Series connection. (08)

b) Two Centrifugal Pumps A and B are available for use in a pipe flow system having their characteristics as given below:

Pump A		Pump B	
Discharge Q (m^3/s)	Head H (m)	Discharge Q (m^3/s)	Head H (m)
0	41.05	0	46.00
0.13	36.05	0.135	41.50
0.135	31.00	0.225	36.05
0.29	23.00	0.305	29.05
0.35	17.00	0.36	19.05

Determine the head-capacity curves when these pumps are in parallel connection using a graph paper. (12)

4. (a) Discuss analytically and graphically how the shaft torque depends on the ratio of U/V_a for a turbomachine considering the blade angles to remain constant at varying rotor speeds. (10)

   (b) A Francis turbine works under a head of 32 m and produces 11880 kW while running at 120 rpm. The turbine has been installed at a station where atmospheric pressure is 10 m of water and vapour pressure is 0.225 m of water. Calculate the maximum height of the straight draft tube for the turbine. Critical cavitation factor for a Francis runner in terms of specific speed is given by the expression $\sigma_c = 0.045\ (N_s/100)^2$. (10)

5. (a) Show that the tangential component of the flow in the pump casing is free vortex flow. (8)

   (b) A Francis turbine produces 6760 kW at 310 rpm under a net head of 46 m with an overall efficiency of 86%. What would be the rpm, discharge and power output of the same turbine under a net head of 62 m? (8)

   (c) Explain how the expression for specific speed of hydraulic turbines is used to select the type of turbine for a particular site? (4)

6.

(a) A Pelton wheel turbine in a hydro-electric power plant has a mean bucket diameter of 1.25 m and it is running at a speed of 1050 r.p.m. The turbine is working under a net head of 850 m. The side clearance angle of the turbine is 15° and discharge through the nozzle is 0.128 m^3/s. The Co-efficient of velocity of the turbine is 0.97 and the speed ratio is 0.45 respectively.

Draw the velocity triangles and determine the followings:

i) The Jet velocity
ii) The velocity of wheel
iii) The power available at the nozzle
iv) The hydraulic Efficiency of the turbine (10)

b) A reaction turbine works at 500 r. p. m. under a head of 122 m. Its diameter at the inlet is 1.2 m and the flow area is 0.42 m^2. The angles made by absolute and relative velocities at the inlet are 20° and 60° respectively with the tangential velocity. If the velocity of whirl at the outlet is zero determine 1) volume flow rate ii) power developed and iii) hydraulic efficiency. (10)

7.

(a)

Define cavitation and Thomas cavitation parameter and draw the efficiency or the total head vs Thomas. (10)

(b) The external and internal diameters of the impeller of a centrifugal pump are 0.4 m and 0.2 m, respectively. The centrifugal pump runs at 1200 r. p. m. and its vanes at the exit are set back at an angle of 25°. If a constant radial flow through the impeller is maintained at 2.5 m/s, then determine (i) the inlet vane angle (ii) angle made by the absolute velocity at the outlet. (10)

8.

(a) Draw a neat sketch of the Kaplan turbine and explain the working principle of the same. (10)

(b) A Kaplan turbine develops 50000 kW of power under a net head of 30 m with an overall efficiency of 85%. The speed ratio of the Kaplan Turbine is 2.0 and the flow ratio is 6.0 respectively. The diameter of the boss of the turbine is 0.35 times the diameter of the runner. Draw the velocity diagrams of the Kaplan Turbine and calculate the diameter, speed and specific speeds (Both dimensional and non-dimensional) of the turbine.

(10)

9. The experimental data for the performance test of a double entry Centrifugal Pump is as given below:

Run No.	1	2	3	4	5	6
Test Speed (in r.p.m.)	1400	1420	1440	1460	1480	1500
Discharge (Lit./min.)	631	663	645	582	448	0
Suction Gauge Reading (in m of water)	3.98	3.85	3.46	3.36	0.66	0.42
Delivery Gauge Reading (in m of water)	25.0	20.0	18.1	16	24	26.0
Power input to the pump (in KW)	4.82	4.62	3.83	2.9	2.72	2.0

The suction and delivery pipes attached to the pump are of same diameter and the centers of the suction and delivery gauges are located on the same horizontal plane. Plot the following curves using the above test-data at a rated speed of 1550 r.p.m.

i) Total Head (H) Vs. Discharge (Q)
ii) Pump input Power (P) Vs. Discharge (Q)
iii) Overall Efficiency (η_o) Vs. Discharge (Q).

Find from these curves the rated head, rated discharge and rated power input of the pump using graph paper. (20)