

Performance Analysis and Design of Fluid Machinery

Time:-Three Hours

Full Marks:-100

Answer any **five** Questions

Assume any data relevant to the questions if not provided

1. a) Define the non-dimensional “Specific Speed” and “unit Speed” of an incompressible-flow Turbo-machine. Explain the importance of the “Specific Speed”. (12)
b) Explain the “Affinity Law” in connection with the performance of a Turbo-Pump. (8)
2. By using Dimensional analysis obtain non-dimensional functional relationship between the variables of an incompressible turbo-machinery. (20)
3. a) Explain the terms ‘Flow Co-efficient’, ‘Head Co-efficient’ and ‘Power Co-efficient’. Why they are important? (8)
b) A Pelton wheel is rotating at a speed of 1000 r. p .m. and develops 10000 KW, working under a head of 300 m with an overall efficiency of 75 %. Determine “Unit Speed”, “Unit Discharge” and “Unit Power” of the Turbine. (12)
4. The experimental data for the performance test of a double entry Centrifugal Pump are 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.)	630	660	640	580	445	0
Suction Gauge Reading (in m of water)	3.9	3.8	3.4	3.3	0.60	0.4
Delivery Gauge Reading (in m of water)	25.0	20.0	18	16	24	26.0
Power input to the pump (in KW)	4.8	4.6	3.8	2.9	2.7	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 1500 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. (20)

5. a) Show that the ideal head (H_i) developed by a radial-flow pump impeller varies linearly with the volume flow rate (Q) of the pump. Explain why the actual head (H) vs. discharge rate (Q) curve differs from the ideal one. (10)

b) An eight bladed Centrifugal pump has an outlet diameter of 300 mm and the width of the impeller at the inlet is 18 mm. The blades are curved backward making an angle of 45° with the tangential direction and the impeller rotates at a speed of 3000 r.p.m. Neglecting blockage effects and all losses, find the relationship between the ideal head (H_i) in m and volume of flow rate (Q) in m^3/s through the impeller. (10)

6. a) Explain the system curve, design point and operating point in connection with a centrifugal pump and pipeline assembly. (8)

b) A 1200 m long pipeline having a diameter of 185 mm is used to pump water from a reservoir to storage tank, where the water levels stands at a height of 80 m above the water level in the reservoir. The Darcy's friction factor for the pipeline is 0.03. The pump connected to this pipeline has the Head-Discharge characteristics as tabulated below:

Total Head (H) in meter	45	71	75	95
Discharge (Q) in lit/min	2100	2000	1500	900

Plot the Head vs. Discharge Curve for this pump as well as the System Head curve for the pipeline system and thus obtain the point of operation. (12)

7. a) Distinguish between the 'available NPSH' and required 'NPSH' of a turbo pump. (6)

b) A Centrifugal pump running at 250 r.p.m. has an outlet vane angle of 63° . The velocity of flow through the impeller is constant at 2.5 m/s. The manometric head is 24 m and the manometric efficiency is 75 %. The outer diameter is twice the inlet diameter. Assuming that the water enters without whirl, find (i) the inlet and outlet diameter of the impeller (ii) Inlet vane angle. (14)

8. a) explain the function of wicket gates and draft tube in a reaction type hydro turbine. (8)

b) A vertical shaft Francis turbine has an overall efficiency of 80 % and runs at 12 revolutions per second with a water discharge of $16 m^3/s$. The velocity at the inlet of the spiral casing is 8.5 m/s and pressure head at this point is 300 m, the centerline of the casing inlet being 4.0 m above the tailrace level. The diameter of the runner at inlet is 1.5 m and width at inlet is 300 mm. The hydraulic efficiency 70%, determine:

- i) Output power
- II) The dimensionless specific speed
- III) The guide vane angle
- iv) The runner blade angle at inlet. (12)

9. Write short notes on any two of the followings: (10 X 2 =20)

- a)Wicket gate b) Priming of a Centrifugal Pump c) Cavitation d)Characteristics of a Centrifugal pump e)Draft tube