

Hydraulics Machines

P. Pages : 4

Time : Three Hours



NIR/KW/18/3370/3396

Max. Marks : 80

- Notes :
1. All questions carry marks as indicated.
 2. Solve Question 1 OR Questions No. 2.
 3. Solve Question 3 OR Questions No. 4.
 4. Solve Question 5 OR Questions No. 6.
 5. Solve Question 7 OR Questions No. 8.
 6. Solve Question 9 OR Questions No. 10.
 7. Solve Question 11 OR Questions No. 12.
 8. Due credit will be given to neatness and adequate dimensions.
 9. Assume suitable data whenever necessary.
 10. Illustrate your answers whenever necessary with the help of neat sketches.
 11. Use of non programmable calculator is permitted.

1. a) Calculate the Mach number at a point on a jet propelled aircraft, which is flying at 1100km/hr at sea level where air temperature is 20°C. Take $K = 1.4$ and $R = 287 \text{ J/kg k}$. 3
 b) Prove that the velocity of sound wave in a compressible fluid is given by 5

$$C = \sqrt{\frac{k}{\rho}}$$
 c) Find the velocity of air flowing at the outlet of the nozzle, fitted to a large vessel which contains air at a pressure of $294.3 \text{ N/cm}^2 (\text{abs})$ and at a temperature of 20°C the pressure at the outlet of the nozzle is $206 \text{ N/cm}^2 (\text{abs})$. Take $k = 1.4$ & $R = 287 \text{ J/kg k}$. 5

OR

2. a) Prove that the work done per second on a series of moving curved vanes by a jet of water striking at one of the tips of the vane is given by 6

$$\text{work done/sec} = \rho_a v_1 [v_{w1} \pm v_{w2}] \times u$$
 where v_1 = absolute velocity of jet at inlet
 v_{w1} = velocity of whirl at Inlet
 v_{w2} = velocity of whirl at outlet
 u = velocity of vane
 b) A jet of water having a velocity of 35m/s impinges on a series of vanes moving with a velocity of 20m/s. The jet makes an angle of 30° to the direction of motion of vanes when entering and leaves at an angle of 120°. Draw the triangles of velocities at inlet and outlet and find. 7
 - a) The angles of vanes tips so that water enters and leaves without shock.
 - b) The work done per unit weight of water entering the vanes, and
 - c) The efficiency.

3. a) What are the elements of hydro-electric power plant? 5
- b) What are turbo machines? How are they classified. 4
- c) A Pelton wheel is having a mean bucket diameter of 1m and is running at 1000rpm. The net head on the Pelton wheel is 700m. If the side clearance angle is 15° and discharge through nozzle is $0.1\text{m}^3/\text{s}$, find 4
- i) Power available at the nozzle head. ii) Hydraulic efficiency of turbine.

OR

4. a) A Pelton wheel is to be designed for a head of 60m when running at 200rpm. The Pelton wheel develops 95.6475kW shaft power. The velocity of the bucket = 0.45 times the velocity of the jet ; overall efficiency = 0.85 and coefficient of velocity = 0.98 7
- Find :-
- i) Diameter of jet (d) ii) Diameter of wheel (D)
- iii) Width & depth of buckets iv) Number of buckets on the wheel.
- b) Derive a equation to prove that the maximum efficiency of a Pelton wheel is 6
- $$\text{Max } \eta_n = \frac{(1 + \cos \phi)}{2}.$$
- where
- η_n = hydraulic efficiency
- ϕ = angle of deflection or vane angle at the outlet
5. a) The external & internal diameters of an inward flow reaction turbines are 1.20m & 0.6m respectively. The head on the turbine is 22m and velocity of flow through the runner is constant and equal to 2.5m/s. The guide blade angle is given as 10° and the runner vanes are radial at inlet. If the discharge at outlet is radial, determine : 5
- i) The speed of turbine
- ii) Vane angle at outlet of the runner,
- iii) Hydraulic efficiency.
- b) Explain the terms. 4
- i) Speed ratio. ii) Flow ratio. iii) Jet ratio.
- c) Explain the governing of reaction turbine with neat sketch. 5

OR

6. a) A Kaplan turbine runner is to be designed to develop 7357.5 kW shaft power. The net available head is 5.50m. Assume that the speed ratio is 2.09 and the flow ratio is 0.68, and the overall efficiency is 60%. The diameter of boss is $\frac{1}{3}^{\text{rd}}$ of the diameter of runner. Find the diameter of the runner, its speed and its specific speed. 7
- b) Write short notes on 7
- i) Draft tube
- ii) Significance of specific speed for selection of turbines.
- iii) Operating characteristics curves & Muschel curve.

7. a) Draw and discuss the operating characteristics of a centrifugal pump. 6
- b) How will you obtain an expression for minimum speed for starting a centrifugal pump? 7
 From this find out the minimum starting speed (N) of a pump based on the following data:-
- i) Diameter of impeller at inlet $D_1 = 30\text{cm}$
 - ii) Diameter of impeller at outlet $D_2 = 60\text{cm}$.
 - iii) Head, $H_m = 30\text{cm}$.

OR

8. a) Define specific speed of a centrifugal pump. How does the specific speed of a centrifugal pump differ that from a turbine. 5
- b) Briefly state the significance of similarity parameters in hydraulic pumps. 4
- c) What is cavitation? What are its causes? How will you prevent cavitation in hydraulic machines. 4
9. a) Draw an Indicator Diagram, considering the effect of acceleration and friction in suction & delivery pipes. Find an expression for the work done per second in case of single acting reciprocating pump. 6
- b) A cylinder bore diameter of a single acting reciprocating pump is 150mm and its stroke is 300mm. The pump runs at 50 rpm and lifts water through a height of 25m. The delivery pipe is 22m long and 100mm in diameter find the theoretical discharge and theoretical power required to run the pump. If the actual discharge is 4.2 Litres/s, find the percentage slip. Also determine the acceleration head at the beginning and middle of the delivery stroke. 7

OR

10. a) Show from first principle that the work saved, against friction in the delivery pipe of a single acting reciprocating pump, by fitting an air vessel is 84.8% while for double acting reciprocating pump the work saved is only 39.20%. 6
- b) What is air vessel? Describe the function of the air vessel for reciprocating pumps. 4
- c) Define slip, percentage slip and negative slip of a reciprocating pump. 3
11. a) What is meant by Geometric, Kinematic and dynamic similarities? Are these similarities truly attainable? If not why? 4
- b) Define the following non dimensional numbers; 4
- i) Reynold's number
 - ii) Froude's number &
 - iii) Mach's number.
- What are their significance for fluid flow problems.

- c) A hydraulic turbine is to develop 1015 kW when running at 120r.p.m. under a net head of 12m. Work out the maximum flow rate and specific speed for the turbine if the overall efficiency at the best operating point is 92%. In order to predict its performance, a 1:10 scale model is tested under a head of 7.2m. What would be the speed, power output and water consumption of the model if it runs under the conditions similar to the prototype. **6**

OR

12. Write in details about **any three**. **14**

- i) Air lift pump.
- ii) Hydraulic Ram.
- iii) Submersible Pump.
- iv) Regenerative pump.
