2013
TURBO MACHINERY

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Which among the following is not a rotodynamic machine ?

a) Axial pump b) Gear pump

c) Steam turbine d) Gas turbine.

ii) Chocked flow through a nozzle refers to the condition when

a) Normal shock occurs

b) Sonic velocity occurs at the exit

c) Mass flow rate through the nozzle is maximum

d) Enthalpy drop is maximum.

iii) The diffuser of a turbo-machine converts

a) mechanical energy to pressure

b) mechanical energy to velocity

c) pressure to velocity

d) velocity to pressure.

iv) Efficiencies of most hydraulic turbines are of the ord of

a) 75% b) 82%

c) 94% d) 98%.

v) The draft tube of reaction turbine serves the purpose of

a) increasing the effective head of the turbine

b) reducing cavitation damage of the turbine

c) increasing the kinetic energy of water leaving th runner

d) uniformly supplying water to the runner vanes.

vi) Kaplan turbine is a turbine of

a) impulse and axial flow type

b) reaction and radial flow type

c) impulse and mixed flow type

d) reaction and axial flow type.

vii) When the speed of a centrifugal pump is doubled, th power required to drive the pump will

a) double b) increase four times

c) increase eight times d) remains the same.

vii) Head coefficient is

a) $\frac{gH}{N^2D^2}$ b) $\frac{gH}{N^2D^3}$

c) $\frac{\rho H}{N^2D^2}$ d) $\frac{\rho H}{N^2D^3}$.

ix) Mach number is defined as the ratio of

a) inertia force to viscous force

b) inertia force to gravity force

c) inertia force to elastic force

d) inertia force to pressure force.

x) Cavitation in centrifugal pump can be prevented by

a) suitably designing the impeller

b) maintaining suction head sufficiently greater than the vapour pressure

c) maintaining suction head sufficiently lower than the vapour pressure.

xi) The impeller of a centrifugal machine converts

a) mechanical energy into pressure energy

b) mechanical energy into kinetic energy

c) heat energy into pressure energy.

xii) In centrifugal pump, the discharge Q, head H and power P vary with speed N as

a) $Q \propto N^2$, $H \propto N^2$, $P \propto N^3$

b) $Q \propto N^2$, $H \propto N^3$, $P \propto N$

c) $Q \propto N^3$, $H \propto N^3$, $P \propto N^2$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Derive the minimum speed for starting a centrifugal pump and also derive its specific speed. 3 + 2

3. With a neat sketch, define 'Draft Tube' with theory and efficiency.

4. Draw the performance characteristic curve of centrifugal pump, mixed flow pump and axial flow pump.

5. Show that the maximum efficiency of the Pelton wheel is

$Max.\ \eta_h = (1 + \cos\varphi)/2$.

6. Show that the work done per second per unit weight of water in a reaction turbine can be given as :

$(U_1 Vu_1 \pm U_2 Vu_2)/g$

where, U_1 and U_2 = peripheral velocities at inlet and outlet respectively.

Vu_1 and Vu_2 = velocities of whirl at inlet and outlet respectively.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

a) What is draft tube ? Why is it used in a reaction turbine ? Describe with sketch two different types of draft tube. 2 + 2 + 3

b) A pelton wheel having a mean bucket diameter of 1·2 m is running at 1000 rpm. The net head of the pelton wheel is 840 m. If the side clearance angle is 15° and he discharge through the nozzle is 0·1 m^3/s, determine —

(i) the power available at the nozzle

(ii) hydraulic efficiency of the turbine. 4 + 4

a) A hydraulic turbine is to develop 1015 kW when running at 120 rpm under a net head of 12m. Work out the maximum flow rate, 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 7·2 m. What would be the speed, power output and water consumption of the model if it runs under the conditions similar to the prototype ? 7

b) The impeller of a centrifugal pump is 0·6 m in diameter and runs at 1500 r.p.m. The pressure gauges on suction and delivery sides show the difference 30 m. The blades are curved to an angle of 30°. The velocity of flow through impeller, being equal to 2·8 m/s, find manometric efficiency of the pump. If the frictional losses in impeller amount to 2·2 m, find the fraction of total energy which is converted into pressure energy by impeller. Also find the pressure rise in pump casing. 8

9. a) A 1/5 scale model of a centrifugal pump absorbs 20 kW when pumping against a test head of 8 m at its best speed of 400 r.p.m. If the actual pump works against 32m head, find the speed and power required for the actual pump. Determine also the quantity of water discharged by the two pumps.

b) A reaction turbine works at 450 rpm under a head of 120 m. Its diameter at inlet is 1·2 m and flow area is 0·4 m^2. The angle made by absolute and relative velocities at inlet are 20° and 60° respectively with the tangential velocity.

Determine :

(i) the volume flow rate

(ii) the power developed

(iii) the hydraulic efficiency.

10. a) What is meant by Net Positive Suction Head (NPSH) ? 2

b) What is an axial thrust in centrifugal pump ? State its causes. 3

c) A centrifugal pump lifts water under a static head of 40 m of water of which 4·2 m is suction lift. Suction and delivery pipes are both 160 mm in diameter. The head loss in suction pipe is 1·8 m and in delivery pipe 8 m. The impeller is 380 mm in diameter and 35 mm wide at mouth and revolves at 1200 r.p.m. Its exit blade angle is 35°. If the manometric efficiency of the pump is 85%, determine the discharge and the pressure at the suction and delivery branches of the pump. 10

11. a) Draw the velocity triangles of a stage of an axial flow compressor with stator guide vane. 2

b) State the fan laws. 3

c) A centrifugal fan running at 1500 rpm has inner and outer diameters of the impeller as 0·24 m and 0·30 m respectively. The absolute and relative velocities of air at entry are 23 m/s and 21 m/s respectively and those at exit are 28 m/s and 19 m/s respectively. The flow rate is 0·8 kg/s and the motor efficiency is 85 %.

Determine —

(i) the stage pressure rise

(ii) the degree of reaction

(iii) the power required to drive the fan.

Assuming the flow to be incompressible with the density of air as 1·2 kg/m^3. 10

12. Write short notes on any *five* of the following : 5 × 3

a) Penstock of a turbine

b) Stationary and moving blade

c) Causes of cavitations and its parameter

d) Nozzle and diffuser

e) Static and stagnation state for compressible flow

f) Surge and choking

g) Ventilation and propulsion.