2014

Turbo Machinery

Time Alloted : 3 Hours *Full Marks : 70*

The figure 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 the following: 10x1=10

i) The degree of reaction of a turbine is define as the ration of

a) static pressure drop to total energy transfer

b) total energy transfer to static pressure drop

c) change of velocity energy across the turbine to the total energy transfer

d) velocity energy to pressure energy

ii) The movable wicket gates of a reaction turbine are used to

a) control the flow of water passing through the turbine

b) control the pressure under which the turbine is

working

c) strengthen the casting of the turbine

d) reduce the size of the turbine

iii) Water hammer in pipe lines takes place when

a) fluid is flowing with high velocity

b) fluid is flowing with high pressure

c) flowing fluid is suddenly brought to rest by closing a valve

d) flowing fluid is brought to rest by gradully closing valve

iv) A turbine is called impulse if at the inlet of the turbine:

a) Total energy is only kinetic energy.

b) Total energy is only pressure energy

c) Total energy is sum of kinetic energy and potential energy.

d) None of above.

v) Francis turbine is :

a) An impulse turbine

b) Radial flow impulse turbine

c) An axial flow reaction turbine

d) A radial flow reaction turbine.

vi) Kaplan turbine is :

a) An impulse turbine

b) Radial flow impulse turbine

c) An axial flow reaction turbine

d) A radial flow reaction turbine

vii) Draft tube is used for discharging water from the exit of:

a) An impulse turbine b) A Francis turbine

c) A Kaplan turbine d) A Peltron wheel

viii) The relation between Thoma's cavitation factor σ and NPSH is

a) $\sigma = \frac{NPSH}{H_{net}}$ b) $\sigma = \frac{NPSH}{Hgross}$

c) $\sigma = \frac{H_{net}}{NPSH}$ d) $\sigma = \frac{H_{gross}}{NPSH}$

ix) The difference between a fan and blower is

a) Fan is of axial type but blower is of radial type

b) Fans deal with cold air but blowers deal with hot air

c) Fans deal with air but blowers deal with water

d) Total pressure rise across a fan is much compared to blower

x) In a compressible flow situation,Mach number is 0.931 and temperature is -5° C. Calculate the stagnation temperature if $\gamma = 1.4$

a) 40°C b) 44°C

c) 41.44°C d) 44.41°C

GROUP - B

(Short Answer Type Questions)

Answer any *three* of the following.

3x5=15

2. The velocity of water at the outlet of a conical draft tube attached to a Francis turbine is 1.4m/s.The velocity of water at the inlet of the draft tube, which is 4.5m above the tail race level, is 5m/s. If the loss of head due to friction in the draft tube is 40% of the velocity head at oultet of the tube, find pressure head at inlet to the draft tube.

3. Draw the performance characteristic curve of Pelton turbine, Francis turbine and Kaplan turbine.

4. Explain the specific speed of turbine.

5. An air compressor has eight stages of equal pressure ratio 1.35. The flow rate through the compressor and its overall efficiency are 50 kg/s and 82%, respectively. If the conditions of air at entry are 1.0 bar and t_1 = 40°C, determine, the state of air at the compressor exit. (take γ = 1.4)

6. What is an air vessel? Describe the function of the air vessel for reciprocating pump.

7. Define and explain hydraulic efficiency, mechanical effi ciency, and overall efficiency of a turbine.

GROUP - C
(Long Answer Type Questions)
Answer any *three* of the following.

3x15=45

8. (a) Determine: Head coefficient, Capacity coefficient, Power coefficient, Reynolds number and specific speed of an incompressible flow machine where head (gH), power (P) and efficiency (η) are the function of rotor speed (N), rotor diameter (D), discharge (Q), characteristic length ratio $\left(\frac{s}{l}, \frac{h}{l}, etc\right)$, fluid density (ρ), fluid viscosity (μ).

(b) Show that the maximum hydraulic efficiency of the Pelton wheel is $\eta_h(\max) = \frac{1 + k\cos\varphi}{2}$ (9+6)

9. (a) A hydro-turbine is required to give 25 MW at 50 m. head and 90 rpm runner speed. The laboratory facilities available, permit testing of 20 KW model at 5 m. head. What should be the model runner speed and model to prototype cscale ratio?

(b) A centrifugal pump is to discharge 0.118 m³/s at a speed of 1450 rpm against a head of 25 m. The impeller diameter is 250 mm., its width at outlet is 50 mm., and manometric efficiency is 75 percent. Determine the vane angle at the outer periphery of the impeller. (7+8)

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

(b) State the fan laws.

(c) A centrifugal fan running at 1500 rpm has inner and

outer diameter of the impeller as 0.24 m and 0.30 m. 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 and

(iii) the power required to drive the fan.

Assuming the flow to be incompressible with the density of air as 1.2 kg/ m³ (2+3+10)

11. A Pelton wheel has a mean bucket speed of 10 m /sec with a jet of water flowing at the rate of 700 liters/sec. Under a head of 30 m. The bucket deflects the jet through an angle of 160° Calculate the power given by water to the runner and the hydraulic efficiency. Assume coefficient of velocity as 0.98.

12. (a) For Isentropic flow through nozzle derives the relation $\frac{dA}{A} = [M^2 - 1]\frac{dV}{V}$, where the symbols have their usual meanings. 8

(b) A nozzle expand air from p_1 =8.0 bar, T_1 = 540 K to a pressure of 5.8 bar with an efficiency of 95% The air is than passed through a diffuser of area ratio 4.0. The total pressure loss across the diffuser is 367 mm Hg.

Determine the efficiency of the diffuser and the velocities of air at its entry and exit. What is the static pressure at the diffuser exit? 7

13. (a) The diameter of the runner of a vertical shaft Francis Turbine is 450 mm at inlet. The width of the runner at the inlet is 50mm. The diameter and width at the outlet are 300 mm and 75mm respectively.The blades occupy 8% of the circumference. The guide vane angle is 24°, the inlet angle of the runner blade is 95° and the outlet angle is 30°. The fluid leaves the runner without whirl. The pressure head at the inlet is 55m above that at the exit from the runner. The fluid friction losses account for 18% of the pressure head at inlet. Calculate the speed of the runner and output power. (Given, hydraulic efficiency as 95%). 8

(b) A radial flow hydraulic turbine is required to be designed to produce 20MW under a head of 16m at a speed of 90 r.p.m A geometrically similar model with an output of 30kW and a head of 4m is to be tested under dynamically similar conditions. At what speed must the model run? What is the required runner diameter ratio between the model and the prototype and what is the discharge through the model, if its efficiency is assumed to be 90%? 7