UNIVERSITY OF PUNE

[4363]-118

T. E. Mechanical/Mech SW Examination –2013

TURBO MACHINES

(2008 Course)

[Total No. of Questions:12] **[Total No. Printed Pages:7]**

[Time : 3 Hours] **[Max. Marks : 100]**

Instructions :

1) *Attempt q. No. 1 or q. no2, Q. No. 2, Q. No. 3 or Q. No. 4, Q. No. 5 or Q. No. 6 from Section I and Q No. 7 or Q. No. 8, Q. No. 9 or Q. No. 10. Q. No. 11 or Q No. 12 from section II.*
2) *Answer **any three** questions from each I and three questions from section II*
3) *Answers to the **two sections** should be written in **separate answer-books**.*
4) *Neat diagrams must be drawn wherever necessary.*
5) *Black figures to the right indicate full marks.*
6) *Use of electronic pocket calculator is allowed.*

SECTION – I

Q.1 a) Show that, in case of jet striking the flat plate mounted on wheel, efficiency shall be maximum when the tangential velocity of wheel is half that of the jet. [8]

b) A jet of water having a velocity of 30 m/s, strikes a series of radial curved vanes mounted on a wheel which is rotating at 300 r.p.m. The jet makes an angle of 30^0 with the tangent to the wheel at inlet and leaves the wheel with a velocity of 5m/s at an angle of 130^0 to the tangent to the wheel at outlet. Water is flowing from outward in a radial direction. The outer and inner radii of the wheel are 0.5m and 0.25m respectively. [8]

Determine :

i) Vane angles at inlet and outlet
ii) Work done per unit weight of water
iii) Efficiency of wheel

OR

Q.2 a) Obtain an expression for the work done per second by water on the runner of Pelton wheel and also find the relation between jet speed and bucket speed for maximum efficiency. [8]

b) A Pelton wheel is working under a gross lead of 400m. The water is supplied through penstock of diameter 1 m and length 4 km from reservoir to the Pelton wheel. The coefficient of friction for the penstock is given as 0.008. The jet of water of diameter 150 mm strikes the buckets of the wheel and gets deflected through an angle of 165^{o}. The relative velocity of water at outlet is reduced by 15% due to friction between inside surface of the bucket and water. If the velocity of the buckets is 0.45 times the jet velocity at inlet and mechanical efficiency as 85% [8]

Determine :

i) Power given to the runner
ii) Shaft power
iii) Hydraulic efficiency and overall efficiency

Q.3 a) The following data is given for a Francis Turbine Net heat H = 70m ; Speed N = 600 r.p.m.; Shaft power = 367.875 kW ; η_0 =85% η_h = 95% ; flow ratio = 0.25; breadth ratio = 0.1 ; outer diameter of the runner = 2 x inner diameter of the runner. The thickness of vanes occupy 10% of circumferential area of the runner. Velocity of flow is constant at inlet and outlet and discharge is radial at outlet. [10]

Determine :

i) Guide blade angle
ii) Runner vane angles at inlet and outlet
iii) Diameters of runner at inlet and outlet
iv) Width of wheel at inlet

b) What is specific speed of a turbine? State its significance and derive an [8] expression for the same.

OR

Q.4 a) A Propeller reaction turbine of runner diameter 4.5 m is running at 40 r.p.m [10]

The guide blade angle at inlet is 145° and runner blade angle at outlet is 25° to the direction of vane. The axial flow area of water through runner is $25m^{2.}$

If the runner blade angle at inlet is radial, determine:

i) Hydraulic efficiency of the turbine
ii) Discharge through turbine
iii) Power developed by the turbine
iv) Specific speed of the turbine

b) A conical type draft tube, attached to Francis turbine has an inlet diameter [8] of 3 m and its area at outlet is 20 m^2. The velocity of water in inlet, which is set 5 m above tail race level, is 5 m/s. Assuming the loss in draft tube equal to 5% of velocity head at outlet, find:

i) The pressure head at top
ii) Total head at top taking tail race level as datum
iii) Power of water at runner outlet
iv) Power of water at turbine outlet
v) Power lost in draft tube.

Q.5 a) An impulse turbine has 3 similar stages of the same mean diameter an [10] geometry; each stage develops 500 kW. The peripheral speed of the rotor blades at the mean diameter is 100 m/s; the whirl components of the absolute velocities at entry and exit of the rotor are c_{y2} = 200 m/s and c_{y3} = 0 respectively. The nozzle angles at exit are equal to $\alpha_2 = 65^{o}$.

The steam at the exit of the first stage has P_2 = 8.0 bar, t_2 = 200°C. Determine for the first stage

i) mean diameter of the stage for a speed of 3000 r.p.m
ii) mass flow rate of steam
iii) isentropic enthalpy drop for an efficiency of 69%

iv) rotor blade angles
v) the blade height of the nozzle and rotor blade at exit.

b) How are steam turbines classified? Give a list of types of steam turbines used in various applications. [6]

OR

Q.6 a) A 50% reaction stage of a gas turbine has the following data : [10]

Entry pressure and temperature P_1 = 10 bar, T_1 = 1500 K

Speed = 1200 r.p.m., mass flow rate of the gas = 70 kg/S,

Stage pressure ratio and efficiency $\rho_r = 2.0$, efficiency $\eta_{st} = 87\%$

Fixed and moving blade exit angles = 60^o

Assume optimum blade to gas speed ratio. Take $\gamma = 1.4$, $C_p = 1.005$ KJ/Kg K for the gas

Determine:

i) Flow coefficient
ii) Mean diameter of the stage
iii) Power developed
iv) Pressure ratio across fixed and rotor blade rings
v) Hub tip ratio of the rotor
vi) Degrees of reaction at hub in tip

b) Explain briefly four method which can be employed for improving thermal efficiency of steam turbine power plant. [6]

SECTION – II

Q.7 a) The stagnation pressure ratio across a gas turbine stage is 2.0 and the initial and final stagnation temperatures of the gas are 600^oC and 500^oC respectively. The absolute velocity of the gas both at entry and exit is 120 m/S. Determine [10]

i) Total to total efficiency
ii) Total to static efficiency
iii) Work done per kg of gas
iv) Mass flow rate of gas to develop 10 MW

b) What are the advantages of closed circuit gas turbine power plant over open [6] circuit gas turbine power plant? Give three practical examples where closed circuit gas turbine plants are used.

OR

Q.8 a) A small gas turbine plant has a output of 1 MW at a maximum to minimum temperature ratio of 5 and pressure ratio of 25. The overall turbine and compressor efficiencies are 85% and 82% respectively. The compressor draws air at 300 K; the properties of gas may be assumed to be the same as that of air. Determine : [10]

i) The mass flow through the turbine
ii) Thermal efficiency of the plant
iii) Efficiencies of reversible Joule cycle and Carnot cycle between the same temperatures.

b) What are the various methods employed for improving the efficiency and output of a constant pressure gas turbine power plant? [6]

Q.9 a) What do you man by manometric head, manometric efficiency, mechanical efficiency and overall efficiency of a centrifugal pump? [8]

b) A centrifugal pump having outer diameter equal to two times inner diameter. and running at 1200 r.p.m. works against a total head of 75 m. The velocity of flow through the impeller is constant and equal to 3 m/s. The vanes are set back at width at an angle of 30^{o} at outlet. If the outer diameter of the impeller is 600 mm and width at outlet is 50 mm, determine : [10]

i) Vane angle at inlet
ii) Work done per second by impller
iii) Manometric efficiency

OR

Q10 a) What is priming of centrifugal pump and why it is necessary? [4]

b) Draw and discuss the operating characteristics of a centrifugal pump. [6]

c) The outer diameter of an impeller of a centrifugal pump is 400 mm and [8] outlet width is 50 mm. the pump is running at 800 r.p.m. and is working against a total head of 15 m. The vane angle at outlet is 40^o and manometric efficiency is 75% Determine :

i) Velocity of the flow at outlet
ii) Velocity of water leaving the vane
iii) Angle made by the absolute velocity at outlet with the direction of motion.
iv) Discharge

Q.11 a) An axial compressor stage has following data [10]

Temperature and pressure at entry ------ 300K, 1 bar

Degree of reaction-------------------------- 50%

Mean blade ring diameter------------------ 36 cm

Rotational speed---------------------------- 18000r.p.m.

Blade height at entry----------------------- 6 cm

Air angles at rotor and stator exit--------- 25^o

Axial velocity-------------------------------- 180 m/s

Work done factor---------------------------- 0.88

Stage efficiency------------------------------ 85%

Mechanical efficiency----------------------- 96.7%

Determine:

i) Air angles at the rotor and stator entry
ii) The mass flow rate of air
iii) The power required to drive the compressor
iv) The loading coefficient
v) The pressure ratio developed the stage
vi) The Mach number at the rotor entry

b) How do stalling and surging take place in centrifugal compressor stages? [6]
How does it affect the performance of compressor? Suggest methods to minimize.

OR

Q.12 a) Derive the following relation for efficiencies and degree of reaction of axial compressor [8]

$$\eta_{st} = R\,\eta_R + (1-R)\,\eta_D$$

Calculate the value of the stage efficiency of 50% reaction compressor stage with the following efficiencies of the blade rows.

$$\eta_R = 0.849 \text{ and } \eta_D = 0.849$$

b) Draw velocity triangles at entry and exit for following axial compressor stages. [8]

i) $R = 1/2$

ii) $R = 1$

iii) $R > 1$