Total No. of Questions : 12]

SEAT No. :

P2260

[Total No. of Pages :5

[4758] - 17
T.E. (Mech. & Mech-SW)
TURBO MACHINES
(2008 Course) (Semester - II) (302049)

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

Instructions to the candidates:

1) ***Answer Q1 or Q2, Q3 or Q4, Q5 or Q6, Q7 or Q8, Q9 or Q10, Q11 or Q12.***
2) ***Answers to the two sections should be written in separate books.***
3) ***Neat diagrams must be drawn wherever necessary.***
4) ***Figures to the right side indicate full marks.***
5) ***Use of electronic pocket calculator is allowed.***
6) ***Assume suitable data, if necessary.***

SECTION - I

Q1) a) How do you classify water turbines? What is the difference between the Reaction and Impulse turbines? **[6]**

b) A jet of oil having sp. gravity 0.8 of 40mm diameter strikes a stationary plate inclined at an angle 30° with the axis of jet at a velocity of 30m/s. Find the force exerted by the jet on the plate in the direction: **[6]**

i) Normal to plate

ii) Along the X-axis and Y-axis

Also, find the ratio of discharge which is divided into two streams.

c) Prove that the theoretical number of buckets required on a runner of impulse turbine is given as: $Z = 360°/\psi$ where, $\psi = \cos^{-1}((m+1)/(m+1.2))$ in which m represents the jet ratio. **[4]**

OR

Q2) a) A jet of water having velocity of 30 m/s enters on a series of moving vanes having velocity of 15 m/s. The jet makes 30° to the direction of motion of the vanes at inlet and leaves the vanes at 10° and 5 m/s. Draw the velocity triangles and find: **[8]**

i) Vane tip angles at inlet and outlet for a shock less flow.

ii) Work done per kg of water

iii) Efficiency

b) Show that, the maximum efficiency of the Pelton Wheel turbine is given by $(1+k\cos\beta)/2$. Where, k is bucket friction factor and β is bucket outlet angle. **[8]**

Q3) a) What is draft tube? Why it is used in a reaction turbine? Describe with neat sketch two different types of draft tubes. **[6]**

b) A Francis turbine with an overall efficiency of 75% is required to produce 148.25 kW power. It is working under a head of 7.62m. The peripheral velocity is $0.26\sqrt{2gH}$ and the radial velocity of flow at inlet is $0.96\sqrt{2gH}$. The wheel runs at 150rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine: **[10]**

i) The guide blade angle,

ii) The wheel vane angle at inlet,

iii) Diameter of the wheel at inlet,

iv) Width of the wheel at inlet.

OR

Q4) a) A Kaplan turbine working under a head of 20m develops 11772kW shaft power. The outer diameter of the runner is 3.5m and hub diameter 1.75m. The guide blade angle at the extreme edge of the runner is 35°. The hydraulic and overall efficiencies of the turbine are 88% and 84% respectively. If the velocity of whirl is zero at outlet, determine: **[10]**

i) Runner vane angles at inlet and outlet at the extreme edge of the runner, and

ii) Speed of the turbine.

b) A turbine is to operate under a head of 25m at 200 rpm. The discharge is $9m^3/s$. If the efficiency is 90%, determine: **[6]**

i) Specific speed of the machine,

ii) Power generated, and

iii) Type of turbine.

Q5) a) Explain, with the help of h-s diagram, the effect of friction on flow through a steam nozzle. **[4]**

b) Define nozzle efficiency and state the factors on which it depends. **[4]**

c) The mean diameter of the blades of an impulse turbine with a single row turbine is 1.05m and the speed is 3000 rpm. The nozzle angle is 18°, the ratio of blade velocity to steam velocity is 0.42 and ratio of relative velocity at outlet from the blades to that at inlet is 0.84. The outlet angle of the blade is to be made 3° less than the inlet blade angle. The Steam flow is 8kg/s. Draw velocity diagram and find the resultant thrust on blades, tangential thrust, axial thrust, power developed and blade efficiency. **[10]**

OR

Q6) a) Show that in a 50% reaction turbine, the maximum stage efficiency is $\frac{2\cos^2\alpha}{1+\cos^2\alpha}$ where, α is the nozzle angle. **[8]**

b) A 50% reaction turbine runs at 3000 rpm. The angles at exit of fixed bladings and inlet of moving bladings are 20° and 30° respectively. The mean ring diameter is 0.7m and steam condition is 1.5 bar and 0.96 dry. Calculate: **[10]**

i) Required height of blades to pass 50kg/s of steam and

ii) Power developed by the stage.

SECTION - II

Q7) a) Show that the optimum pressure ratio for maximum work output between fixed temperature limits of the Joule cycle is given as: **[6]**

$$r_p = \left\{\frac{T_{max}}{T_{min}}\right\}^{\frac{\gamma}{2(\gamma-1)}}$$

b) In an oil gas turbine, air is compressed from a pressure of 1 bar and temperature of 300K up to a pressure of 5 bar. The oil used has a calorific value of 42500 kJ/kg and the combustor efficiency is 95%. The hot gases leave the combustor at 1000K. The isentropic efficiency of the turbine and compressor are 90% and 85% respectively. Assuming a mass flow rate of air at 1kg/s, find: **[10]**

i) Air-Fuel Ratio

ii) Power output of the plant

iii) Thermal efficiency of power plant.

Assume $C_{pa} = 1.005 \frac{kJ}{kgK}, C_{pg} = 1.1 \frac{kJ}{kgK}$ and $\gamma = 1.4$ for air and gases. Neglect pressure losses in combustor. Assume that the gases expand in the gas turbine from 5 bar pressure to 1 bar pressure.

OR

Q8) a) For an actual Brayton cycle without any pressure drops, derive the condition for maximum plant output in terms of isentropic temperature ratio and compressor and turbine efficiencies. **[6]**

b) A gas turbine plant of 800 kW capacities takes the air at 1.01 bar and 15°C. The pressure ratio of the cycle is 6 and maximum temperature is limited to 700°C. A regenerator of 75% effectiveness is added in the plant to increase the overall efficiency of the plant. The pressure drop in the combustion chamber is 0.15 bars as well as in the regenerator is also 0.15 bars. Assuming the isentropic efficiency of the compressor 80% and of the turbine 85%, determine the plant thermal efficiency. Neglect the mass of the fuel. **[10]**

Q9) a) Derive an expression for the minimum speed for starting a centrifugal pump and minimum diameter of impeller for this condition. **[6]**

b) A centrifugal pump is to deliver water from a tank against a static head of 40m. The suction pipe is 50m long and 25cm diameter. The delivery pipe is 20cm diameter and 1600m long. The pump characteristics cane be defined as $H = 100\text{-}6000Q^2$ where, H is the head in meters and Q is discharge in m^3/s. Calculate the net head and discharge of the pump. The coefficient of friction f = 0.02 for both the pipes. Calculate power required to drive the pump if overall efficiency of the pump is 85%. **[10]**

OR

Q10) a) Explain various efficiencies related to centrifugal pumps. **[6]**

b) A centrifugal pump impeller whose external diameter and width at the outlet are 0.8 and 0.1m respectively is running at 550 rpm. The angle of impeller vanes at outlet is 40°. The pump delivers 0.98m^3 of water per second under an effective head of 35m. If the pump is driven by a 500 kW motor. Determine: **[10]**

i) The Manometric efficiency

ii) The overall efficiency

iii) The Mechanical efficiency

Q11) a) Explain the terms slip factor and power input factor in a centrifugal compressor. **[6]**

b) A single sided centrifugal compressor for a gas turbine is required to deliver 10 kg/s of air while operating with a total pressure ratio of 4.5 while turning 18000 rev/min. Initial conditions of air are 1.013 bar pressure and 300K temperature. The air enters the inlet eye axially with a velocity of 140 m/s with no pre-whirl. Assuming isentropic efficiency for the compressor as 80% and slip factor as 0.92, make calculations for: **[12]**

i) Rise in total temperature

ii) Tip speed of the impeller and tip diameter

iii) Annulus area of inlet eye, and

iv) Power required to drive the compressor.

OR

Q12) a) Explain the term degree of reaction for an axial flow compressor. Why is the degree of reaction generally 50%? **[6]**

b) A axial flow compressor having eight stages and 50% reaction design compresses air in the pressure ratio of 4:1. The air enters the compressor at 20°C and flows through it with a constant speed of 90 m/s. The rotating blades of the compressor rotates with a mean speed of 180 m/s. Isentropic efficiency of the compressor may be taken as 82%. **[12]**

Calculate:

i) Work done by the machine

ii) Balde angles

Assume, $\gamma = 1.4, C_p = 1.005 \frac{kJ}{kgK}$.

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