

Total No. of Questions : 12]

SEAT No. :

**P2395**

**[5153]- 18**

[Total No. of Pages : 5

**T.E. (Mechanical)**

**TURBO MACHINES**

**(2008 Pattern) (Semester - II) (302049)**

*Time :3 Hours]*

*[Max. Marks :100*

*Instructions to candidates:*

- 1) *Answer Q1 or Q2, Q3 or Q4, Q5 or Q6, Q7 or Q8, Q9 or Q10, Q11 or Q12.*
- 2) *Answer to the two sections should be written in separate books.*
- 3) *Neat diagram 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**

**UNIT - I**

**Q1) a)** Show that the ratio of flow rate,  $\frac{Q_1}{Q_2} = \frac{1+\cos\theta}{1-\cos\theta}$  for the impact of jet on stationary flat plate inclines at to the direction of horizontal jet. Where  $Q_1$  = Upward directed flow rate and  $Q_2$  = Downward directed flow rate. **[8]**

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  $\beta$  is bucket outlet angle. **[8]**

OR

**Q2) a)** A jet of oil having sp.gravity 0.8 of 40 mm diameter strikes a stationary plate inclined at an angle  $30^\circ$  with the axis of jet at a velocity of 30 m/s. Find the force exerted by the jet on the plate in the direction: **[8]**

- i) Normal to plate
- ii) Along the X-axis and Y-axis

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

b) 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  $30^\circ$  to the direction of motion of the vanes at inlet and leaves the vanes at  $10^\circ$  and 5 m/s. Draw

**P.T.O.**

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

### UNIT - II

**Q3) a)** A Kaplan turbine working under a head of 20m develops 11772kW shaft power. The outer diameter of the runner is 3.5 m and hub diameter 1.75m. The guide blade angle at the extreme edge of the runner is  $35^\circ$ . 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) What is draft tube? Why it is used in a reaction turbine? Describe with neat sketch two different types of draft tubes. **[6]**

OR

**Q4) a)** 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 150 rpm 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,  
Width of the wheel at inlet.
- b) A turbine is to operate under a head of 25m at 200 rpm. The discharge is  $9 \text{ m}^3/\text{s}$ . If the efficiency is 90%, determine: **[6]**
- i) Power generated,
  - ii) Specific speed of the machine
  - iii) Type of turbine.

### Unit -III

- Q5) a)** 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  $18^\circ$ , 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  $3^\circ$  less than the inlet blade angle. The steam flow is 8 kg/s. Draw velocity diagram and find the resultant thrust on blades, tangential thrust, axial thrust, power developed and blade efficiency. **[10]**
- b)** Derive an expression for maximum blade efficiency of a single stage impulse turbine in terms of nozzle angle. **[8]**

OR

- Q6) a)** A 50% reaction turbine runs at 3000 rpm. The angles at exit of fixed blading's and inlet of moving blading's are  $20^\circ$  and  $30^\circ$  respectively. The mean ring diameter is 0.7 m and steam condition is 1.5 bar and 0.96 dry. Calculate: **[10]**
- i) Required height of blades to pass 50 kg/s of steam and
  - ii) Power developed by the stage.
- b)** Show that in a 50% reaction turbine, the maximum stage efficiency is  $\frac{2\cos^2\alpha}{1+\cos^2\alpha}$  where,  $\alpha$  is the nozzle angle. **[8]**

### SECTION - II

#### UNIT - IV

- Q7) a)** 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 1 kg/s, find: **[10]**
- i) Air-Fuel Ratio
  - ii) Power output of the plant
  - iii) Thermal efficiency of power plant.

Assume  $C_{pa} = 1.005 \frac{\text{kJ}}{\text{kgK}}$ ,  $C_{pg} = 1.1 \frac{\text{kJ}}{\text{kgK}}$  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.

- b) 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]

OR

- Q8) a)** 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]

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

$$r_{\text{opt}} = \sqrt{\left\{ \frac{T_{\text{max}}}{T_{\text{min}}} \right\}^{\frac{\gamma}{(\gamma-1)}}$$

### UNIT - V

- Q9) a)** A centrifugal pump impeller whose external diameter and width at the outlet are 0.8 and 0.1 m respectively is running at 550 rpm. The angle of impeller vanes at outlet is 40°. The pump delivers 0.98 m³ of water per second under an effective head of 35m. If the pump is driven by a 500kW motor. Determine: [10]

- i) The Manometric efficiency
- ii) The overall efficiency
- iii) The Mechanical efficiency

- b) Draw and explain characteristic curves for multistage centrifugal pumps in series and parallel [6]

OR

- Q10)a)** 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 characteristic can be defined as  $H = 100 - 6000 Q^2$  where, H is the head in meters and Q is discharge in m<sup>3</sup>/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]
- b) Discuss the typical layout of centrifugal pump with the help of a neat sketch. Name the main parts and accessories. Discuss its working. [6]

### UNIT -VI

- Q11)a)** An 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 rotate 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) Blade angles.

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

- b) Define polytropic efficiency of axial flow compressor with help of T-s diagram and obtain an expression for polytropic efficiency. [6]

OR

- Q12)a)** A single sided centrifugal compressor for a gas turbine is required to deliver 10kg/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.
- b) Define degree of reaction as applied to axial flow compressors and show that the blades are symmetrical for 50% reaction. [6]

