

Total No. of Questions : 10]

SEAT No. :

P3481

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[Total No. of Pages : 4

T.E. (Mechanical)
TURBOMACHINES
(2012 Course) (Semester-II)

Time : 2½ Hours]

[Max. Marks : 70

Instructions to the candidates:

- 1) *Answer Q1 or Q2, Q3 or Q4, Q5 or Q6, Q7 or Q8, Q9 or Q10.*
- 2) *Figures to the right indicate full marks.*
- 3) *Use of scientific calculator is allowed.*
- 4) *Use of steam table is permitted.*
- 5) *Assume data whenever necessary.*
- 6) *Due credit will be given to neat figures wherever necessary.*

Q1) a) Derive the expression for maximum blade efficiency in a single stage impulse steam turbine. **[4]**

b) A jet of water discharges 140 N per second at 40 m/s in a direction making 30° to the direction of series of curved vanes moving at 17.50 m/s. If the outlet angle of the vanes is 20°, determine **[6]**

- i) Inlet vane angle of the vane so that there is no shock at entry
- ii) The direction of flow at outlet and
- iii) The work done per second.

OR

Q2) a) Show that the hydraulic efficiency of a pelton wheel is given by

$$\eta_h = (1 + \cos \phi) \frac{2u(V - u)}{V^2}$$

Where all symbols have their usual meaning. **[4]**

b) A Kaplan turbine is having hydraulic efficiency of 90% and the mechanical efficiency of 93%, with the runner diameter of 6 m and a boss diameter of 1.80 m. If the discharge of the turbine is 180 m³/sec, calculate the head on the turbine and the shaft power of the turbine. Assume that there is no whirl at outlet and the discharge is free. Neglect the losses in the turbine. **[6]**

P.T.O.

Q3) a) What methods are used in reducing the speed of the rotor? Explain any one. [4]

b) A reaction turbine works under a head of 120 m and runs at 450 rpm. Its diameter at inlet is 1.20 m and the flow area is 0.4 m^2 . The angle made by absolute velocity and relative velocity at inlet is 20° and 60° respectively with the tangential velocity. Determine [6]

- i) The volume flow rate
- ii) The power developed
- iii) Hydraulic efficiency.

Assume no whirl at outlet.

OR

Q4) a) What is the basis of selection of turbine at a particular site? [4]

b) The velocity of steam exiting from the nozzle of the impulse stage of a turbine is 400 m/sec. The blades operate close to maximum efficiency. The nozzle angle is 20° . Considering equiangular blades and neglecting blade friction calculate for a steam flow of 0.6 kg/s, the diagram power and diagram efficiency. [6]

Q5) a) What do you mean by manometric head? How it is different from head generated by the impeller? What are the various expressions for the manometric head. [8]

b) A centrifugal pump running at 1000 rpm has an impeller 350 mm diameter. The outlet vane angle is 30° . The velocity of flow through impeller is constant at 2.5 m/s. The static suction lift is 3.25 m. The following losses of head takes place. The loss of head in the suction pipe = 0.75 m, The loss of head in impeller = 0.6 m, Loss of head in volute casing = 0.95 m. Find the pressure heads [10]

- i) At the inlet to the impeller
- ii) At the outlet to the impeller
- iii) At the inlet to the delivery pipe.

Take the suction and delivery pipes as 1.50 m/s.

OR

Q6) a) How can you determine minimum starting speed of a centrifugal pump? [6]

- b) A centrifugal pump has an external diameter of 450 mm and discharge area of 0.11 m^2 . The vanes are set backwards so that the direction of the relative velocity at the outlet makes an angle of 145° with the tangent to the outer periphery drawn in the direction of impeller rotation. The diameter of suction and delivery pipes is 300 mm and 230 mm respectively. Pressure gauges at the points on the suction and delivery pipes close to the pump; each gauge 1.50 metre above the level in the supply sump showed a gauge pressure heads of 3.70 metres below and 19 metres above atmospheric head respectively, when the pump was delivering 200 litre per second of water at 800 rpm. It requires 70 kW to drive the pump. Determine: [12]
- The loss of head in the suction pipe
 - Manometric efficiency
 - Overall efficiency.
- Q7) a)** Describe surging and choking in a centrifugal compressor. How do these phenomena affect the working of a compressor? [6]
- b) A single inlet type centrifugal compressor handles 528 kg/min of air. The ambient air conditions are 1 bar and 20°C . The compressor runs at 20000 rpm with isentropic efficiency of 80%. The air is compressed in the compressor from 1 bar static pressure to 4 bar total pressure. The air enters the impeller eye with a velocity of 145 m/s with no prewhirl. Assuming that the ration of whirl speed to the tip speed is 0.9, calculate
- Rise in total temperature during compression if the change in the K.E. is negligible. [10]
 - The tip diameter of the impeller
 - Power required
 - Eye diameter if the hub diameter is 12 cm.

OR

- Q8) a)** What is centrifugal compressor? How it differs from axial flow compressor? [6]
- b) A centrifugal compressor running at 10000 rpm delivers $660 \text{ m}^3/\text{min}$ of free air. The air is compressed from 1 bar and 20°C to a pressure ratio of 4 with an isentropic efficiency of 82%. Blades are radial at outlet of the impeller and the flow velocity of 62 m/s may be assumed throughout constant. The outer radius of the impeller is twice the inner and the slip factor may be assumed as 0.9. The blade area coefficient is 0.9 at inlet. Calculate: [10]

- i) Final Temperature of the air
- ii) Theoretical power
- iii) Impeller diameter at inlet and outlet
- iv) Impeller blade angle at inlet
- v) Diffuser blade angle at inlet

Q9) a) Explain various losses in axial flow compressor stage. **[8]**

- b) An axial flow compressor with an overall isentropic efficiency of 85% draws air at 20°C and compresses it in the pressure ratio of 4:1. The mean blade speed and flow velocity are constant throughout the compressor. Assuming 50% reaction blading and taking blade velocity as 180 m/s, work input factor as 0.82, angle made by absolute velocity at inlet as 12° and that of relative velocity in axial direction to blade velocity as 42°. Calculate: **[8]**

- i) Flow velocity
- ii) Number of stages

OR

Q10) a) What do you understand by slip factor and pressure coefficient in a compressor. **[6]**

- b) In an axial flow compressor, the overall stagnation pressure ratio achieved is 4 with overall stagnation isentropic efficiency of 85%. The inlet stagnation pressure and temperature are 1 bar and 300 K. The mean blade speed is 180 m/s. The degree of reaction is 0.5 at the mean radius with relative air angles of 12° and 32° at the rotor inlet and outlet respectively. The work done factor is 0.9. Calculate **[10]**

- i) Stagnation polytropic efficiency.
- ii) Number of stages
- iii) Inlet temperature and pressure
- iv) Blade height in first stage if hub-tip ratio is 0.42

Take mass flow rate = 19.5 kg/s.

