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Paper Code : ME-605C

TURBOMACHINERY

Time Allotted : 3 Hours | *Full Marks* : 70

The figures 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 : 10 × 1 = 10

i) The difference between a fan and a blower is

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

b) fan deals with cold air but blower deals with hot air

c) fan deals with air but blower deals with water

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

ii) The specific speed of Kaplan Turbine is 700 and it works under a head of 6 metres. If the power generated by the turbine is 8600 kW, the turbine is running at

a) 70 rpm b) 75 rpm

c) 72 rpm d) 68 rpm.

iii) By using draft tube in a reaction turbine, the efficiency of the turbine

a) increases along with the net head on the turbine

b) decreases but the net head on the turbine increases

c) decreases along with the net head on the turbine

d) does not change but the net head on the turbine increases

iv) To produce a high head by multistage centrifugal pumps, the impellers are connected in

a) parallel

b) series

c) in parallel and series both

d) none of these.

v) Kaplan turbine is

a) an impulse turbine

b) radial flow impulse turbine

c) an axial flow reaction turbine

d) a radial flow reaction turbine.

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

a) Kaplan turbine

b) Reciprocating pump

c) Pelton turbine

d) Centrifugal pump.

vii) Muschel curve means

a) constant entropy curve

b) constant head curve

c) constant efficiency curve

d) constant discharge curve.

viii) In a compressible flow situation, Mach number is 0·931 and temperature is 5°C. Calculate stagnation temperature if $\gamma = 1{\cdot}4$:

a) 41·44°C b) 40°C

c) 44°C d) 44·41°C.

ix) A Kaplan turbine works under a head of 40 metres and its speed ratio is equal to 2 : 1. If the outer diameter of its runner is 2·8 metres, the speed of the turbine is nearly

a) 400 rpm b) 800 rpm

c) 600 rpm d) 1000 rpm.

x) A centrifugal pump delivers water at the rate of 50 litres/s against a total head of 40 metres. Then the power required to drive the pump is

a) 2 kW b) 15·2 kW

c) 19·6 kW d) 25·8 kW.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

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

3. Derive the maximum efficiency of the Pelton wheel.

4. Draw the performance characteristic curve of centrifugal pump, mixed flow pump and axial flow pump.

5. Steam at the rate of 7·5 kg/s flows through a set of nozzles. The inlet pressure is 14 bar and superheat is 55°C. The exit pressure is 6 bar. Neglect the velocity of approach and assume the expansion of steam is isentropic. Find the number of nozzles used if the outlet area of each nozzle is approximately 2·3 cm^2. What should be the correct exit area ?

6. With a neat sketch; define 'Draft Tube' with theory and efficiency.

GROUP - C
(Long Answer Type Questions)

Answer any three of the following. 3 × 15 = 45

7. a) Draw the velocity triangle diagram of an inward flow reaction turbine and derive the work done per unit weight of water.

   b) Derive expression of specific speed of turbine.

   c) The velocity of water at the outlet of a conical draft tube attached to a Francis turbine is 1·4 m/s. The velocity of water at the inlet of the draft tube, which is 4·5 m above the tail race level, is 5 m/s. If the loss of head due to the friction of the draft tube is 40% of the velocity head at outlet of the tube, find pressure head at inlet to the draft tube. 5 + 4 + 6

8. a) What is draft tube ? Why is it used in a reaction turbine ? Describe with sketch, different types of draft tube.

   b) A Pelton wheel is to be designed for a head of 60 m when running at 200 r.p.m. The Pelton wheel develops 95.6475 kW shaft power. The velocity of the buckets = 0·45 times the velocity of the jet, overall efficiency = 0·85 and co-efficient of the velocity is equal to 0·98. 6 + 9

9. a) For isentropic flow through the nozzle derive the relation

   $$d A/A = \{ M^2 - 1 \} d V/V$$

   b) Carbon dioxide flows through a diffuser. The pressure, velocity and temperature at a section where the area of section is 50 sq. cm are 85 kPa, 250 m/s and − 5°C respectively. What should be the area at another downstream section to give a pressure of 120 kPa ? What is the temperature at this section ? Calculate the Mach number at the two sections. Assume isentropic flow with R = 287 J/kg-K and γ = 1·4. 8 + 7

10. a) Write the Thoma's cavitation parameter and explain the significance of it in case of cavitation.

b) An outward radial flow impulse turbine has nozzles with a total area of 10 cm^2. The guide vanes make an angle of 20° to the wheel tangent at exit. The inner and outer diameters are 0·5 m and 0·7 m respectively. The moving vanes have an outlet angle of 20° to the wheel tangent. The turbine develops 11·75 kW at the shaft running at 620 rpm under a head of 60 m, at a discharge of 0·03 m^3/s. The water at discharge leaves the runner in a forward direction and is inclined at 15° to the radius.

Calculate :

i) the head lost in the nozzle

ii) the head lost in the moving vanes

iii) the head lost in the bearing. 5 + 10

11. a) What is meant by Net Positive Suction Head ?

b) A nozzle expands air p_1 = 8·0 bar, T = 540 K to a pressure of 5·8 bar with an efficiency of 95%. The air is then 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. 6 + 9

12. a) Explain the term 'Dynamic Similarity'. Mention the significance and composition of the dimensionless parameters Reynolds number and Mach number. 3 + 5

b) The efficiency (η) of a fan depends on density ρ, dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rotor and discharge Q. Express (η) in terms of dimensionless parameters. 7