WEST BENGAL UNIVERSITY OF TECHNOLOGY

ME-605C

TURBO MACHINERY

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. $10 \times 1 = 10$

(i) At the stagnation point of a flow field, the value is zero for

(A) pressure (B) velocity

(C) temperature (D) none of these

(ii) In all reaction turbines, for maximum efficiency

(A) the velocity of swirl at entrance must be zero

(B) the velocity of flow at outlet must be zero

(C) the velocity of swirl at outlet must be zero

(D) the velocity of flow at entrance must be zero

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(iii) A fast centrifugal pump impeller will have

(A) forward facing blades (B) backward facing blades

(C) radial blades (D) propeller type blades

(iv) The mechanical efficiency takes into account the losses in

(A) pump impeller (B) bearings and windages

(C) pipes (D) all of the above

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

(A) Kaplan Turbine (B) Francis Turbine

(C) Pelton Turbine (D) both (A) and (B)

(vi) The ratio of total useful heat drop to the total isentropic heat drop, is called

(A) stage efficiency (B) internal efficiency

(C) rankine efficiency (D) none of these

(vii) Axial flow compressors have

(A) purely impulse stage

(B) impulse and reaction stages

(C) purely reaction stage

(D) alternate stages of impulse and reaction

(viii) Stalling of the blade means

(A) loss of drag (B) separation of flow

(C) loss of lift (D) loss of performance

(ix) Fluid is flowing through a duct with a Mach number equal to 1.2. An increase in cross-sectional area in the downstream will cause an

(A) decrease in velocity (B) chocked flow situation

(C) increase in static pressure (D) increase in velocity

(x) Pelton turbine is used for

(A) low head high discharge (B) high head low discharge

(C) medium head medium discharge (D) high head medium discharge

(xi) Muschel curve means

(A) constant entropy curve (B) constant head curve

(C) constant efficiency curve (D) constant discharge curve

(xii) Generally the efficiency of the prototype is _____ the efficiency of model of a turbomachine.

(A) less than (B) greater than

(C) equal (D) none of these

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. Differentiate between isentropic and adiabatic process. 5

3. Explain terms flow co-efficient; head co-efficient and power co-efficient. 5

4. Explain the functional differences between nozzle and diffuser for compressible flow. 5

5. Air flows from a large tank (P = 650 kPa(abs), T = 550°C) through converging nozzle, with a throat area of 600 mm^2 and discharge to the atmosphere. Determine the rate of mass flow under isentropic condition in the nozzle. 5

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6. Explain the hydraulic functions of spiral casing, guide vanes and the draft tube. 5

7. Differentiate between impulse turbine and a reaction turbine. Why does efficiency of pump is less than that of a turbine? 3+2

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

8. A centrifugal pump lifts water against a static head of 40 m of water. Suction and delivery pipes are both 150 mm in diameter. Head losses in the suction and delivery pipes are 2.5 m and 7 m of water respectively. The impeller is 400 mm in diameter, 25 mm wide and rotating at 1200 r.p.m. The impeller blade angle at exit is 30°. Assume radial entry at the impeller inlet, if the manometric efficiency is 85% and overall efficiency is 75%, determine the discharge and power required to drive the pump. 15

9. (a) A hydraulic turbine is to develop 1015 kW when running at 120 rpm under a net head of 12 m. Work out the maximum flow rate specific speed for the turbine if the overall efficiency at the best operating point is 92%. In order to predict its performance, a 1:10 scale model is tested under a head of 7.2 m. What would be the speed, power output and water consumption of the model if it runs under the conditions similar to the prototype? 7

(b) Show that the pressure head rise in the impeller of a centrifugal pump with no swirl at inlet, and frictional and other losses in the impeller are neglected, is given by 8

$$\frac{1}{2g}\left[C_{r1}^2 + U_2^2 - C_{r2}^2 \operatorname{cosec}^2 \beta_2\right]$$

where C_{r1} and C_{r2} are velocity of flow at inlet.

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10.(a) A Francis turbine is to be designed to develop 370 kW of power under a head of 70 m while running at a speed of 750 rpm. Following are some pertinent data of the turbine: 10+5

(i) Ratio of width of runner to outer diameter of runner = 0.1
(ii) Ratio of inner diameter of runner to outer diameter of runner = 0.5
(iii) Flow ratio = 0.15
(iv) Hydraulic efficiency = 95%
(v) Mechanical efficiency = 84%
(vi) Circumferential area occupied by thickness of vanes = 5%

Assuming constant flow velocity calculate (a) guide vane angle (b) runner blade angle at inlet and (c) blade angle at outlet.

(b) The following data refer to an elbow type draft tube:
Area of circular inlet = 25 m^2. Area of rectangular outlet = 11 m^2. Velocity of water at inlet to draft tube = 10 m/s
The frictional head loss in draft tube equals to 10% of the inlet velocity head.
Elevation of inlet plane above tail race level = 0.6 m
Determine:
(i) Vacuum or negative head at inlet
(ii) Power loss in tail race

11.(a) The mean bucket speed of a pelton turbine is 14 m/s. It is supplied with water at the rate of 0.8 m^3/s under a head of 45 m. If the water jet is deflected by the buckets, through an angle of 165°, find the power and efficiency of the turbine. Assume coefficient of velocity as 0.985. 7+8

(b) A compressor cascade has the following data:
Velocity of air at entry = 75 m/s, air angle at entry = 48°, air angle at exit = 25°, pitch chord = 1.1, stagnation pressure loss = 11 mm W.G., density of air = 1.25 kg/m^3.
Determine loss coefficient, drag and lift coefficients, ideal and actual pressure recovery coefficients, diffuser efficiency and maximum diffuser efficiency.

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12.(a) A pelton wheel is to be designed for the specifications. Power = 735.75 kW, s.p head = 200 m, speed = 800 r.p.m., η_0 = 0.86 and the jet diameter is not to exceed one-tenth of the wheel diameter. Determine 7+6+2

(i) Wheel diameter
(ii) Number of jets required
(iii) Diameter of the jet.

Take C_v = 0.98 and speed ratio = 0.45.

(b) Find the mach number when an Aeroplane is flying at 900 km/hour through still air having a pressure of 8.0 N/cm^2 and temperature –15°c. take K = 287 J/kgK. Calculate the pressure, Temperature and Density of air at the stagnation point on the nose of the plane.

(c) What do you mean by dimensional homogeneity?

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