Sridevi Institute of Engineering and Technology, Tumkur – 06

V Semester : I Internal Test : Nov 2022

18ME54 – Turbo Machines

Time: 90 Minutes] [Max Marks: 40

Note: Answer Any TWO Full Questions

Question Nos		Descriptions of Questions	Max Marks
Q1	a.	Define Turbo machine. With a neat sketch explain the principal parts of general turbo machine.	06
	b	Explain the following with appropriate equation: (v) Flow coefficient (vi) Head coefficient (vii) Power Coefficient (viii) Specific speed of a turbine	10
	c	List the difference between positive displacement machine with turbo machine	04
Q2.	a	Define unit quantities. Explain their uses and derive expressions to each of them.	06
	b	The performance of the lubricating of oil ring defends on the diameter (D) shaft speed (N), oil discharge (Q), density (ρ), Viscosity (μ), Surface tension (σ) and specific weight (W) of the fluid. Find the functional relationship in terms of dimensionless parameters.	10
	c	Discuss the importance of the specific speed in selection of turbo machine.	04
Q3.	a	Derive an expression for Euler's energy for turbo machine	06
	b	The Pelton wheel is running at a speed of 200rpm and develops 5200 KW when working under a head of 220m with an overall efficiency of 80%.Determine its unit speed, unit flow, unit power and specific speed. Find the speed, flow, and power when it's operating point changes to a head of 140m.take density of water =1000kg/m^3.	10
	c	Define specific speed of a pump. Obtain an expression for the same in terms of discharge, speed and head	04

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Sem:- 5th Subject:- Turbo Machines - 18ME54

I Internal

1) a) Turbo Machine - 2M

Sketch - 2M

Explaination - 2M

Total:- 6 Marks

b) i) Flow Co-Efficient - 2M

ii) Head Co-Efficient - 2M

iii) Power Co-Efficient - 2M

iv) Specific Speed of a turbine - 2M + 2M

Total:- 10 Marks

c) The difference between positive displacement machine with turbomachine,

* positive displacement machine - 2M

* Turbo machine. - 2M

Total:- 4 Marks

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2. a) Unit quantities - 1M

i) Unit flow - 1M

ii) Unit speed - 2M

iii) Unit power - 2M

Total :- 6 Marks

b) The general relationship is,

$f[D, N, \theta, S, \mu, \sigma, W]$ = Constant - 1M

π_1 - term :-

$$\pi_1 = \frac{\theta}{ND^3} \quad - 2M$$

π_2 - term :-

$$\pi_2 = \frac{\mu}{SND^2} \quad - 2M$$

π_3 - term :-

$$\pi_3 = \frac{\sigma}{SN^2D^3} \quad - 2M$$

π_4 - term :-

$$\pi_4 = \frac{W}{SN^2D} \quad - 2M$$

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General relationship,

$$\therefore f\left[\frac{\theta}{ND^3}, \frac{\mu}{SND^2}, \frac{\sigma}{SN^2D^3}, \frac{W}{SN^2D}\right] = \text{Constant} \quad - 1M$$

Total :- 10 Marks

c) Specific speed of turbomachine:-

Defn - 1M

Power Co-eff - $\frac{P}{\rho N^3 D^5}$

$$P \propto \left\{ \frac{N^3 H^{5/2}}{N^5} \right\}$$

$$P \propto \left\{ \frac{H^{5/2}}{N^5} \right\}$$

$$P = G \left[\frac{H^{5/2}}{N^5} \right] - 1M$$

$P = 1KW_g$, $H = 1m$, $N = N_s$

$$P = \frac{N_s^2 [H]^{5/2}}{N^2} - 1M$$

$$\therefore P = \frac{N P^{1/2}}{H^{5/4}}$$

$$P = \frac{N\sqrt{P}}{H^{5/4}} - 1M$$

Total:- 04 Marks

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3. a) Euler's Energy for turbo machine :-

Velocity Δle - 1M

$$F = \frac{M_1}{g_c t} V_{u_1} - \frac{M_2}{g_c t} V_{u_2}$$

Now, $\frac{M_1}{t} = \frac{M_2}{t} = \dot{m}$

$$F = \frac{\dot{m}}{g_c} [V_{u_1} - V_{u_2}] - 1M$$

Applied Torque, $T = F * r$

$$T = \frac{\dot{m}}{g_c} [V_{u_1} r_1 - V_{u_2} r_2] - 1M$$

$$E_0 = \omega T - 1M$$

$$\omega * r = U$$

$$E_0 = \frac{\dot{m}}{g_c} [U_1 V_{u_1} - U_2 V_{u_2}] - 1M$$

$$E = gH = \frac{1}{g_c} [U_1 V_{u_1} - U_2 V_{u_2}]$$

$$E = \frac{U_2 V_{u_2} - U_1 V_{u_1}}{g_c} - 1M$$

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Total :- 6 Marks

b) Data:- N = 200 rpm, P = 5200 KW, Head, H = 220 m.

$\eta_0 = 80\%$, H = 140 m, $\rho = 1000 kg/m^3$

i) Unit speed = 2M

ii) Unit flow = 2M

iii) Unit power = 2M

iv) Specific speed = $\frac{NP^{1/2}}{H^{5/4}}$ – 4M

Total:- 10 Marks

c) Specific speed of a pump – 1M

Discharge, $Q - Q_u = Q/\sqrt{H}$

Speed, $N - N_u = N/\sqrt{H}$

Head, H –

$$\pi_5 = \frac{\pi_1^{1/2}}{\pi_2^{3/4}} = \frac{Q^{1/2}}{(ND^3)^{1/2}} * \frac{(D^2N^2)^{3/4}}{(gH)^{3/4}}$$

↳ 2M

$$\pi_5 = \frac{NQ^{1/2}}{(gH)^{3/4}} - 1M$$

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$$N_s = \frac{NQ^{1/2}}{H^{3/4}} - 1M$$

Total:- 4 Marks

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Vth Semester: II Internal Test: DEC 2021

18ME54 – Turbo Machines

Time: 90 Minutes] [Max Marks: 40

Note: Answer Any TWO Full Questions

Question Nos		Description of Questions	Max Marks
Q1	a.	Define the following (i) Hydraulic efficiency (ii) Vane efficiency	04
	b	Define Utilization factor and Degree of reaction. Also derive the relation between utilization factor and degree of reaction.	08
	c	At a stage in a 50% Reaction axial flow machine running at 3000RPM, the blade mean diameter is 685mm.If the maximum utilization for the stage is 0.915.Calculate the absolute velocity at inlet and draw velocity triangles. Also find power output for flow rate of 15Kg/s.	08
Q2.	a	Derive Euler's equation for power absorbing turbo machine.	04
	b	With a necessary velocity triangles and assumption derive the expression for effect of blade discharge, angle on energy transfer and degree of reaction for radial flow machines.	08
	c	At the stage of an impulse turbine, the mean blade diameter is 0.75m and its rotational speed is 3500rpm.The absolute velocity of the fluid discharging from a nozzle inclined at 20° to the plane of the wheel is 275m/s. If the utilization factor is 0.9 and the relative velocity of the fluid at the rotor exit is 0.9times that of the inlet, find the inlet rotor angles. Also find the power output from the stage for a mass of 2kg/s and the axial thrust on the shaft.	08
Q3.	a	What is the effect of blade friction in a steam turbine? Explain	04
	b	What is velocity compounded turbine? Draw a two stage impulse steam turbine (Curtis turbine) indicating the pressure and velocity variations across it.	08
	c	A single stage impulse turbine has a diameter of 1.6m and running at 3500 rpm. The nozzle angle is 22°, the speed ratio is 0.55, Ratio of relative velocity at the outlet to that at inlet is 0.95.The outlet angle of the blade is 4° less than inlet angle. Steam flow rate is 8kg/s. Draw velocity diagrams and find the following : (i) Velocity of whirl (ii) Axial thrust (iii) Blade angles (iv) Power developed	08

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5th Sem Subject:- Turbo Machines - 18ME54

II Internal

1.

a) i) Hydraulic Efficiency - 2M

ii) Vane Efficiency - 2M

Total:- 4 Marks

b) Defn Utilisation factor - 1/2M

Degree of Reaction - 1/2M.

$$R = \frac{[(V_1^2 - V_2^2) + (V_{R_2}^2 - V_{R_1}^2)]}{[(V_1^2 - V_2^2) + (U_1^2 - U_2^2) + (V_{R_2}^2 - V_{R_1}^2)]} - 1M$$

$$\varepsilon = \frac{[(V_1^2 - V_2^2) + (U_1^2 - U_2^2) + (V_{R_2}^2 - V_{R_1}^2)]}{[V_1^2 + (U_1^2 - U_2^2) + (V_{R_2}^2 - V_{R_1}^2)]} - 2M$$

$$\varepsilon = \frac{(1-R)[(V_1^2 - V_2^2)] + R[V_1^2 - V_2^2]}{(1-R)V_1^2 + R(V_1^2 - V_2^2)} - 2M$$

$$\varepsilon = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2} - 1M$$

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Total:- 8 Marks

c) Data:- 50% Reaction axial flow machine

$N = 3000$ rpm

$D = 685mm$

$\varepsilon_{max} = 0.915$

$\dot{m} = 15 Kg/sec$

$$\varepsilon_{max} = \frac{V_1^2 - V_2^2}{V_1^2 - 2V_2^2} \quad - 2M$$

$$V_1^2 = 5.6 V_2^2 - 1M$$

inlet velocity Δ^{le}, $V_1^2 = V_2^2 + U^2 - 1M$

Velocity $\Delta^{les} = 1M$, $V_1 - 1M$

power, $P = \dot{m} U V_{u_1} - 2M$

Total:- 8 Marks

2. a) Eulers Equation

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$E = \omega T - 1M$

Torque, $T = \frac{\dot{m}}{g_c} [V_{u_1} R_1 - V_{u_2} R_2] - 1M$

$U = \omega * R$

$$E_0 = \omega \frac{\dot{m}}{g_c} [V_{u_1} R_1 - V_{u_2} R_2] - 1M$$

$E = U_2 V_{u_2} - U_1 V_{u_1} - 1M$ Total:- 4 Marks

b) Velocity triangles - 1M

Assumption - 1M

Expression for effect of blade discharge, - 2M

Angle on Energy transfer - 2M

Degree of reaction for

Radial flow machines - 2M.

Total:- 8 Marks

c) Velocity Δ^{le} - 1M

Tangential speed, $U = \frac{\pi D m N}{60} = 137.44 m/sec$ - 1M

Utilisation factor, $\varepsilon = \frac{V_1^2 - V_2^2}{V_1^2 - 2V_2^2}$

$V_2 = 86.96 m/sec$ - 1M

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$V_{f_1} = V_1 \sin\alpha_1 = 94.06 m/sec$

$V_{r_1} = 153.24 m/sec$ } - 1M

$\beta_1 = 37.86°$

$\beta_2 = 36.82°$

$\tan\beta_1 = \frac{V_{f1}}{X}$, $\beta_1 = 37.86°$ - 1M

$V_{r_2} = 137.92 m/sec$

$\beta_2 = 36.82°$ } 1M

$P = \dot{m} U [V_{u1} - V_{u2}]$

$P = 63.6 KW$

$F_a = \dot{m} [V_{f1} - V_{f2}]$

$F_a = 22.80 N$ - 1M

$V_{u_2} = -27.03 m/sec$

Total:- 8 Marks

3. a) The Effect of blade friction in a steam turbine,

Explaination - 4 Marks

b) Velocity compounded turbine - 2M

Curtis turbine

Sketch - 4 M

Explaination - 2M

Total :- 8 Marks

c) Single stage turbine :-

Velocity Δ^gs - 1M.

i) Velocity of whirl - 2M

ii) Axial thrust - 1M

iii) Blade Angles - 2M

iv) power developed - 2M

Total :- 8 Marks

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Vth Semester: III Internal Test: Jan' 2023

18ME54 – Turbo Machines

Time: 90 Minutes] [Max Marks: 40

Note: Answer Any TWO Full Questions

Question Nos		Description of Questions	Max Marks
Q1	a.	Explain the working principle of compressor with a neat sketch.	04
	b	Derive an expression for work done by a Pelton wheel with necessary velocity triangles.	08
	c	A kaplan turbine develops 24647Kw at an Average head of 39m.Assuming a speed ratio of 2,flow ratio of 0.6,diameter of boss equal to 0.35times the diameter of runner and an overall efficiency of 90%, Calculate the diameter, speed and specific speed of turbine.	08
Q2	a	Derive an expression for pressure rise in the centrifugal pump.	04
	b	Explain the working of Francis Turbine with the help of sectional arrangement diagram. Also draw the velocity triangles of Francis Turbine.	08
	c	A centrifugal compressor compresses 30kg of air per second at a rotational speed of 15000rpm.The air enters the compressor axially and the conditions at exit section are: radius=0.3m, relative velocity at the air the tip is 100m/s at an exit angle of 80^0.Find the torque and power required to drive the compressor and also the ideal head developed. Take P_{01}=1Bar and T_{01}=300K	08
Q3	a	With a neat sketch, explain the functions of draft tubes.	04
	b	The impellor of a centrifugal pump has outer diameter 1.2m is used to lift water at a rate of 1800Kg/s. The blade is making an angle of 150^0 with the direction of the motion at outlet and speed is being 2000rpm.If the radial velocity of flow is 2.5m/s. Find impeller Power.	08
	c	A Pelton Wheel is to be designed for the following specifications: Shaft Power=11772Kw,Head=300m,Overall efficiency=86%,Jet diameter not to exceed 1/6 of Wheel Diameter: Determine(i) Wheel Diameter,(ii) Jet Diameter (iii) Number of jets required, Take C_v=0.98 Φ=0.46	08

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5th Sem Subject:- Turbo Machines - 18MES4

3rd Internal

1. a) The working principle of Compelletor,

Sketch - 2M

Explaination - 2M

Total:- 4 Marks

b) Pelton Turbine:-

Sketch - 2M

$V_{u_2} = V_{r_2}\cos\beta_2 - U$

$V_{u_2} = [V_1 - U]\cos\beta_2 - U$ - 1M

Workdone/kg of water by the runner,

$W = U[V_{u_1} \pm V_{u_2}]/g_c$ - 1M

$W = U[V_{u_1} + (V_1 - U)\cos\beta_2 - U]/g_c$

$W = U[(V_1 - U)(1 + \cos\beta_2)]/g_c$ - 2M

If bucket velocity co-efficient $C_b = V_{r_2}/V_{r_1}$

$\therefore W = U[(V_1 - U)(1 + C_b\cos\beta_2)]/g_c$ - 2M.

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Total:- 8 Marks

c) Data:- power, $P = 24647\,KW$

Head, $H = 39\,m$.

Speed ratio, $\phi = 2$

Flow ratio, $\psi = 0.6$

$D = 0.35d$.

$\eta_0 = 90\,\%$ – 1M – Velocity Δ^{le}

i) Diameter of turbine – 2M

ii) Specific Speed – 3M

iii) Speed of turbine – 2M

Total:- 8 Marks

2. a) pressure rise in the centrifugal pump,

The pressure rise in the impeller neglecting the friction and other is given by,

$$= \frac{1}{2g}\left\{V_{f_1}^2 + U_2^2 - V_{f_2}^2 \operatorname{Cosec}^2\phi\right\} - 2M$$

where, V_{f_2} and V_{f_1} are velocities of flow at inlet & outlet

U_2 – Tangential velocity. – 2M

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Total:- 4 Marks

b) Francis Turbine,

Sketch - 3M

Explaination - 3M

Velocity triangles - 2M

Total :- 8 Marks

c) Centrifugal compressor, Velocity Δ - 1M.

Speed = 15,000 rpm

Radius = 0.3m

Relative Velocity = 100 m/sec - 1M

i) Torque, T — 2M

ii) power, P - 2M

iii) Ideal head developed, H - 2M

Total :- 8 Marks

3. a) Draft tubes,

Sketch - 2M

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Explaination - functions - 2M

Total :- 4 Marks

b) Centrifugal pump, Velocity Δs - 2M.

$D_0 = 1.2m$

Flow rate of Water = 1800 Kg/Sec

Blade angle = 150°

Speed = 2000 Rpm

Velocity of flow = 2.5m/sec - 2M

i) Impeller power - 4M.

Total :- 8 Marks

c)

pelton wheel, Velocity Δs - 1M

Shaft power = 11772KW

Head = 300m

$\eta_0 = 86\%$ 1M.

$\frac{d}{D} = \frac{1}{6}$

i) wheel diameter - 2M

ii) Jet diameter - 2M

iii) Number of jets - 2M

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Total :- 8 Marks