KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 2024

Marks Scored:

Level : B.E.
Year : III

Course : MEEG 309
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 13 DEC 2024

SECTION "A"
[20 Q. × 1 = 20 marks]

Choose and mark [X] in the most appropriate option from each set of choices

1. How can cavitation be mitigated in a pump system?
   [ ] increasing pump speed
   [ ] decreasing fluid temperature
   [ ] decreasing fluid pressure
   [ ] decreasing pump suction head

2. How does the efficiency of a pump or turbine typically change with increasing flow rate?
   [ ] efficiency increases with flow rate
   [ ] efficiency decreases with flow rate
   [ ] efficiency remains constant with flow rate
   [ ] efficiency first increases, then decreases with flow rate

3. In a turbine performance curve, what does the term "runaway speed" signify?
   [ ] the maximum operating speed of the turbine
   [ ] the minimum operating speed of the turbine
   [ ] the speed at which the turbine becomes inefficient
   [ ] the speed at which the turbine self-destructs

4. Which parameter primarily influences the efficiency of a draft tube?
   [ ] length of the draft tube
   [ ] diameter of the draft tube
   [ ] shape of the draft tube
   [ ] material of construction

5. The efficiency of a jet impinging on a surface can be increased by:
   [ ] decreasing the velocity of the jet
   [ ] increasing the density of the fluid
   [ ] decreasing the angle of impact
   [ ] increasing the viscosity of the fluid

6. What type of flow does a Pelton turbine utilize to generate energy?
   [ ] laminar
   [ ] turbulent
   [ ] transitional
   [ ] pulsating

7. In which application are Francis turbines commonly used?
   [ ] high-altitude regions
   [ ] low-flow rivers
   [ ] tidal energy extraction
   [ ] pumped-storage hydroelectricity

8. In a Kaplan/Propeller turbine, what is the function of the hub?
   [ ] increase turbine efficiency
   [ ] regulate water flow
   [ ] prevent cavitation
   [ ] connect the runner to the shaft

9. A centrifugal pump running at 500 rpm and at its maximum efficiency is delivering a head of 30 m and a flow rate of 60 liters/minute. If the rpm of the pump is changed to 1000 rpm then the head H in meters and the flow Q in liters/minute can be estimated to be
   [ ] 60,120
   [ ] 120,120
   [ ] 60,480
   [ ] 120, 30

10. A centrifugal pump with an impeller having inlet diameter of 0.3 m and outlet diameter of 0.6 m is to be pump water to a head of 25 m. The minimum speed (in rpm) at which this pump would start pumping is

[ ] 667 [ ] 705 [ ] 814 [ ] 1410

11. In a two jets Pelton wheel working at full load, each of the nozzles are issuing 10 cm diameter jets. The nozzles are so shaped as to avoid any further contraction of the jet. If the load is suddenly reduced to 36 % of full load, the altered jet diameter will be

[ ] 1.8 cm [ ] 3 cm [ ] 3.6 cm [ ] 6 cm

12. Two geometrically similar pumps A and B have the same speed of 1500 rpm. Pump A has a diameter of 0.35 m and discharge of 36 L/s against a head of 25 m. Pump B gives a discharge of 18 L/s. What is the total head and impeller diameter of pump B?

[ ] 15.86 m, 0.278 m [ ] 86.15 m, 0.872 m
[ ] 158.6 m, 2.78 m [ ] 58.16 m, 8.72 m

13. At a site on a river, the power potential is 225 MW under a net head of 15 m. It is desired to operate the turbines at a speed of 60 rpm. The atmospheric pressure is 9.9 m (abs), and vapour pressure head is 0.30 m. What is the maximum draft tube head in each case (Francis and Kaplan) if the critical Thoma cavitation number can be taken as 0.36 for Francis and 0.73 for Kaplan turbine?

[ ] 4.2 m and -1.35 m [ ] - 4.2 m and 1.35 m
[ ] - 4.2 m and -1.35 m [ ] 4.2 m and 1.35 m

14. For a given conditions, Pelton turbines have a wide range of speed. If the speed of the turbine made higher, then, ______________

[ ] the jet diameter will decrease [ ] the jet diameter will increase
[ ] the jet diameter will remains same [ ] decrease the runner efficiency

15. The optimum speed ratio of Pelton turbine is obtained only when the β_2 is equal to ________

[ ] 0° [ ] 15° [ ] 90° [ ] 180°

16. The range of speed number for Kaplan turbine is ____________

[ ] 1.2 - 3.2 [ ] 2.1 - 4.3 [ ] 0.19 - 1.5 [ ] 0.06 - 0.19

17. The runway speed of Francis turbine is ______________

[ ] 100 - 125 % [ ] 125 -175 % [ ] 155 - 190 % [ ] 200 - 300 %

18. What does the head vs. discharge curve of a centrifugal pump typically show?

[ ] head decreases with increasing discharge
[ ] head increases with increasing discharge
[ ] head remains constant with increasing discharge
[ ] head fluctuates randomly with discharge

19. Which parameter is typically held constant to obtain the main characteristics curves of hydraulic turbines?

[ ] speed [ ] head [ ] discharge [ ] efficiency

20. It is recommended to use ______________________ kind of impeller if the working fluid in centrifugal pump is cloggy in nature

[ ] enclosed [ ] semi-open [ ] open [ ] any of the above

KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 2024

Level : B.E.
Year : III
Time : 2 hrs. 30mins.

13 DEC 2024

Course : MEEG 309
Semester : II
F. M. : 55

SECTION "B"
[5 Q. × 11 = 55 marks]

Attempt *ALL* questions. *Formula sheet is supplied in this exam along with the question. Assume suitable data if missing/necessary.*

1.

a. Sate the function of distributor and injectors in a Pelton turbine. [3]
b. Justify for the same type of turbine: "If speed number is less, the size of the runner is more". Derive that maximum speed number for Pelton turbine is 0.22. [3]
c. A jet of water having a velocity of 45 m/s impinges without shock on a series of vanes moving at 15 m/s. The direction of motion of the vanes in inclined at 20^0 to that of the jet, the relative velocity at outlet is 0.9 of that at inlet, and the absolute velocity of the water at exit is to be normal to the motion of vanes, find (i) vanes angles at entrance and exit; (ii) work done on vanes per kg of water supplied by the jet; and (iii) hydraulic efficiency. [5]

2.

a. Why does it become necessary to install a water turbine bellow the tail race level? What do you mean by 'net positive suction head' (NPSH)? [3]
b. Differentiate between inward and outward flow turbines. Which of the above turbines has better control of speed and why? [3]
c. A three jet Pelton turbine is required to generate 10 MW under a net head of 400 m. The bucket angle at the outlet is 165^0 and the decrease in the relative velocity while passing over the bucket is 5 %. Given that: $\eta_o = 80\ \%$, $\varphi = 0.46$, $C_D = 0.98$. Determine: (i) diameter of jet, (ii) the force exerted by the jet on the buckets, (iii) if the jet ratio is not to be less than 10, calculate the highest speed of the wheel for a frequency of 50 Hz and the corresponding wheel diameter. [5]

3.

a. How the models testing of centrifugal pump are made? [3]
b. What is the influence of exit blade angle on performance and efficiency of a centrifugal pump? Assume radial flow at entrance. [3]
c. The axis of a centrifugal pump is 2.5 m above the water level in the sump and the static lift from the pump center is 32.5 m. The friction losses in the suction and delivery pipes are 1 m and 8 m respectively. The suction and delivery pipes are each 12 cm diameter. At outlet, the diameter and width of the impeller are 30 cm and 1.8 cm respectively and the vanes are set back at an angle of 30^0 with tangent to the wheel. For a speed of 1800 rpm, mechanical efficiency 0.75 and manometric efficiency 0.8, make calculations or the discharge and the power required to drive the pump. Assume radial entry. [5]

P.T.O.

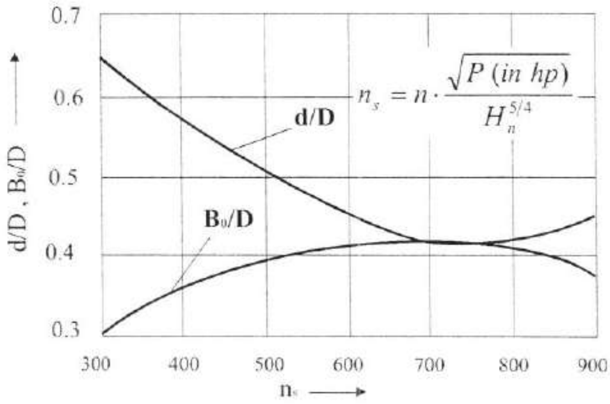
4.

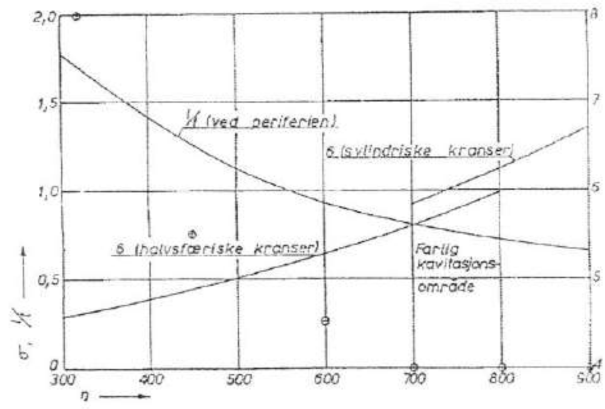
a. Write a brief note on the cavitation problem in centrifugal pump. [3]
b. Draw and discuss the main characteristics of a hydraulic turbine. Why discharge curve of Kaplan and Francis turbines is not same. [3]
c. A single stage centrifugal pump has a specific speed of 30 and pump water against a total head of 40 m. Calculate the height of the pump above the sump so that the NPSHA has a margin of 2 m. The atmospheric pressure and vapor pressure head can be taken as 10.3 m and 0.33 m respectively. The head loss in the suction pipe can be taken as 10 % of the suction lift. [5]

5.

a. Compare the efficiency characteristics of a Propeller turbine and a Kaplan turbine. [2]
b. Describe the variation of the following velocities in a Kaplan turbine runner: (a) velocity of flow, (b) tangential velocity and (c) whirl velocity. [3]
c. An elbow-type draft tube of a Francis turbine has an inlet diameter of 2.5 m and its area at outlet is 18 m^2. The inlet to draft tube is situated 5 m above the tail water level and the velocity of flow at the inlet is 5 m/s. Assume the loss of head due to friction in the draft tube to be 80 % of the velocity head at the draft tube outlet. Calculate (a) the pressure head at the entrance to the draft tube, (b) power lost due to friction in the draft tube, (c) power wasted to the tailrace, and (d) the efficiency of the draft tube. [6]

$\eta = \frac{u_1 \cdot v_{u1} - u_2 \cdot v_{u2}}{g \cdot H_n}$	$13^0 < \beta_2 < 22^0$ (lowest value for highest head) $35 < U_2 < 43$ m/s (highest value for highest head)	$H_m = h_s + h_d + h_{fs} + h_{fd} + \frac{v_d^2}{2}$
$h_f = f \cdot \frac{L}{D} \cdot \frac{v^2}{2 \cdot g}$	$v_{m2} = 1.1 \cdot v_{m1}$ $H_m = \left[\frac{p_o}{\rho \cdot g} + \frac{v_o^2}{2 \cdot g} + z_o\right] - \left[\frac{p_i}{\rho \cdot g} + \frac{v_i^2}{2 \cdot g} + z_i\right]$	$n_q = n \cdot \frac{\sqrt{Q}}{H^{3/4}}$ $n_{s,turbine} = 2.97 \cdot n_{q,pump}$
$N_s = \frac{N \cdot \sqrt{p}}{H^{5/4}}$ (P in kW) Pelton, 1 jet: 12 - 30 Pelton, 2 jet: 17 - 50 Pelton , 4 jet: 24 - 70 High head Francis: 80 - 150 Medium head Francis: 150 - 250 Low head Francis: 250 - 400 Propeller/ Kaplan:300 - 1000 Bulb or Tubular: 1000 - 2000	$H_s = 10 - NPSH_R$ $NPSH_R = a \cdot \frac{v_{m2}^2}{2 \cdot g} + b \cdot \frac{u_2^2}{2 \cdot g}$ *Turbines* *Pumps* a $1.05 < a < 1.15$ $1.6 < a < 2.0$ b $0.05 < b < 0.15$ $0.2 < b < 0.25$ $d_s = \sqrt{\frac{4 \cdot Q}{z \cdot \pi \cdot v_1}}$	Affinity Law 1: $\frac{Q_1}{Q_2} = \frac{n_1}{n_2}$ $\frac{H_1}{H_2} = \left(\frac{u_1}{u_2}\right)^2 = \left(\frac{n_1}{n_2}\right)^2$ $\frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^3$
$n_q = n \cdot \frac{\sqrt{Q}}{H^{0.75}}$	$\underline{Q}_n = \frac{\pi \cdot (D^2 - d^2)}{4} \cdot \underline{c}_{1m}$	Affinity Law 2: $\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\right)^3$
$^*\Omega = {^*\underline{\omega}} \cdot \sqrt{^*\underline{Q}}$ $^*\underline{\Omega} \leq 0.22$ (Pelton) $0.2 < {^*\underline{\Omega}} < 1.25$ (Francis) $^*\underline{\Omega} > 1.0$ (Kaplan/Bulb)	$D = \sqrt{\frac{\underline{Q}_n \cdot 4}{\pi \cdot \underline{c}_{1m}}}$ $n = \frac{3000}{z_p}$ $\sigma = \frac{10 - H_S}{H}$	$\frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\right)^2$ $\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\right)^5$
$H_e = \frac{u_2 \cdot v_{u2}}{g} = \frac{u_2}{g}[u_2 - v_{f2} \cdot \cot \beta_2]$	$\underline{c}_{1m} = 0.12 + 0.18\ {^o\Omega}$	$P = \rho \cdot Q \cdot g \cdot H_t$
$v_1 = C_d \cdot \sqrt{2 \cdot g \cdot H_n}$ [C_d= 0.97 to 0.98]	$\frac{P_2}{\gamma} = \frac{P_a}{\gamma} - h_s - (\frac{v_2^2 - v_3^2}{2g} - h_f)$	$H_t = \frac{u_2 \cdot v_{u2} - u_1 \cdot v_{u1}}{g}$ $H_t = \frac{u_2^2 - u_1^2}{2 \cdot g} + \frac{v_2^2 - v_1^2}{2 \cdot g} - \frac{w_2^2 - w_1^2}{2 \cdot g}$
$\phi = \frac{u}{v} = 0.45 - 0.48$ Pelton $\phi = \frac{u}{v} = 0.62 - 0.82$ Francis	$\frac{1 - \eta_M}{1 - \eta_P} = \left(\frac{D_P}{D_M}\right)^{1/5}$ $\frac{0.94 - \eta_v}{0.94 - \eta_r} = \left(\frac{Q_r}{Q_u}\right)^{0.32}$	$\eta_{man} = \frac{g \cdot H_m}{v_{u2} \cdot u_2}$
$3.1 > \frac{B}{d_s} \geq 3.4$ $D = 10 \cdot d_s$, for $H_n \leq 500$ m $D = 15 \cdot d_s$, for $H_n = 1300$ m	$\eta_d = \frac{\frac{v_2^2 - v_3^2}{2g} - h_f}{\frac{v_2^2}{2g}}$	$n_{min} = \frac{120.\eta_{man}.v_{u2}.D_2}{\pi(D_2^2 - D_1^2)}$ $D_{Housing} = D + K \cdot B$
$Pr.rise = \frac{P_2 - P_1}{\rho g} = \frac{1}{2g}\left[v_1^2 - v_2^2 + 2v_{u2}u_2\right]$	head or lift co-efficient: $\frac{\sqrt{H}}{D.n}$	$\varphi = \frac{v_{m2}}{\sqrt{2.g.H_m}}[0.1 - 0.25]$
$I = \frac{p}{\rho \cdot g} + \frac{w^2}{2 \cdot g} - \frac{(\omega \cdot r)^2}{2 \cdot g} = const$	flow co-efficient: $\frac{Q}{D^3 n}$	power co-efficient: $\frac{P}{D^5.n^3}$





$$(\sigma_c)_{Francis} = 0.625 \cdot \left(\frac{n_s}{380.78}\right)^2 \equiv 431 \cdot 10^{-8} \cdot n_s^{\ 2}$$

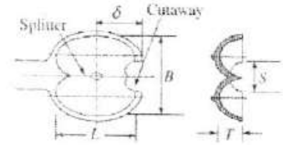
$$(\sigma_c)_{Kaplan} = 0.28 + \left(\frac{1}{7.5}\left(\frac{n_s}{380.78}\right)^3\right)$$

$$(\sigma_c)_{CP} = 1.03 \cdot 10^{-3} \cdot n_s^{\frac{4}{3}}$$

$$\sigma \geq \sigma_c \quad Or \quad NPSH \geq \sigma_c H \quad \Rightarrow no\ cavitation$$

$$NPSH_{min} = \sigma_c H$$

Basic geometrical dimensions of the Pelton bucket



Radial length = L	Axial width = B	Depth of bucket = T	Axial width of cutaway = S	Radial length of cutaway = δ	Inlet bucket angle = β_1	Outlet bucket angle = β_2
L/d	B/d	T/d	S/d	δ/d	β_1	β_2
2.0 to 3.0	3.0 to 5.0	0.8 to 1.2	1.1 to 1.2	0.18 to 0.20	5° to 8°	165° to 170°