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Note: Attempt all Questions & Draw diagrams where necessary.

Question No 1 **20**

A. With the help of a diagram show different Elements of a Hydropower Plant? CLO 1
B. Water for a small hydroelectric station is to be made available from a pondage with a volume of $5 \times 10^5 m^3$ located at a height uphill to provide water at a head of 100m at a hydraulic efficiency of 85% If the electrical efficiency is 94% and the water supply is available for 8 hours daily, determine the capacity of the generator to be installed at the power station. CLO 2

Question No 2 **20**

A. Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines? CLO1
B. Select a suitable turbine for a hydropower scheme with available head height of 190m and rated discharge of 2.2 m^3/s with overall efficiency of 85%? Also determine turbine diameter and jet diameter? Specific speed $Ns = 85.49/(h)^{0.243}$. $Diameter = 38.56\sqrt{h}/n$. *Jet Diameter* $q = (\pi dj^2)Vj/4$ where $Vj = \sqrt{2gh}$ CLO 2

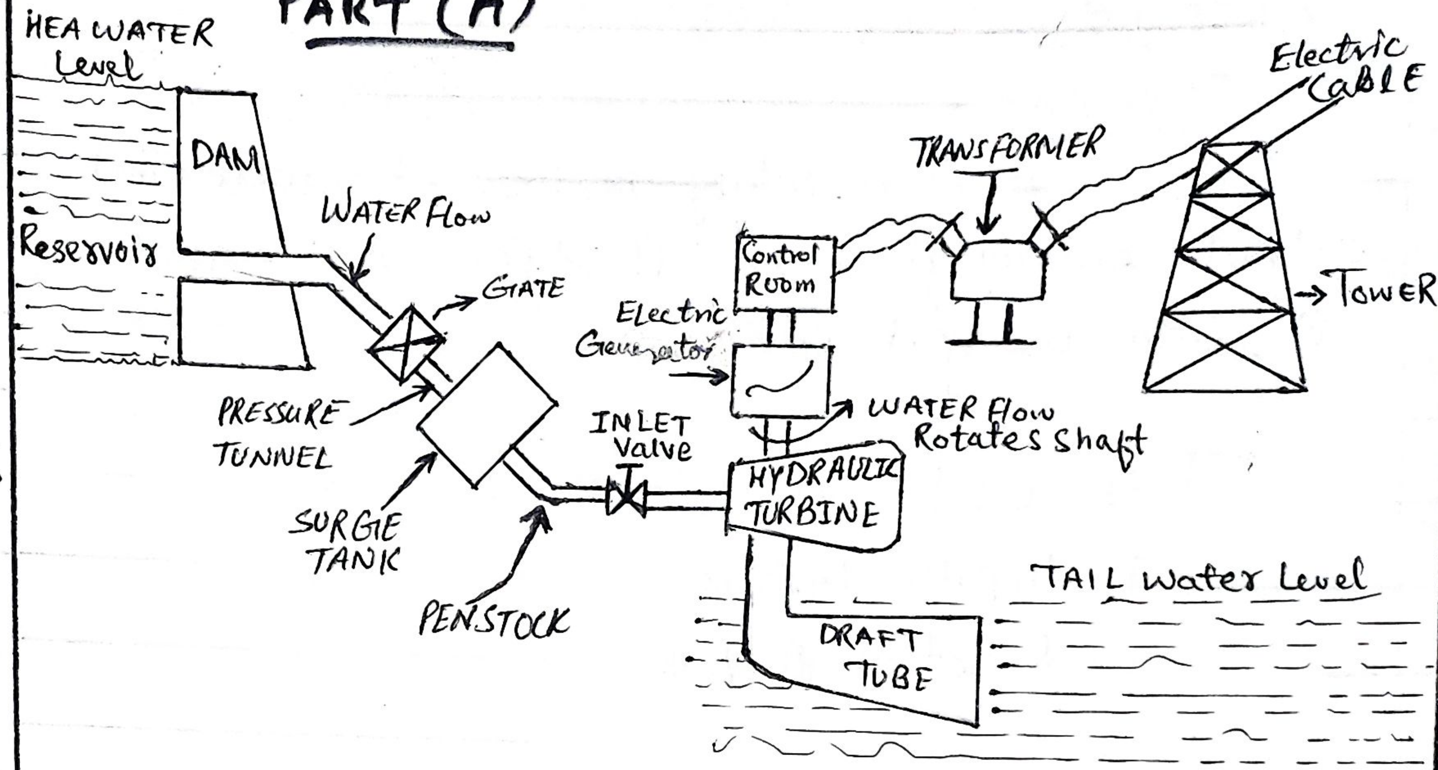
Question No 3 **10**

Explain different stages of Nuclear Fuel Cycle? CLO 1

GOOD LUCK

Q1/ANSWER/

PART (A)



PART (B)

Given DATA:

Available Volume at pondage: $V = 5 \times 10^5\ m^3$

Available head: $h = 100\ m$

Hydralic efficiency: 85% 0.85

Electrical efficiency: 0.94

Therefore: Overall efficiency: $0.85 \times 0.94 = 0.80$

Using $E = \eta\rho g h V = 0.8 \times 1000 \times 9.81 \times 100 \times 5 \times 10^5$

$E = 3.92 \times 10^{11}$ W-s

Q 2 / ANSWER /

PART (A)

Turbine :

It is a rotary mechanical device that extracts energy from a "fluid flow" and convert it into use ful work.

TYPES OF HYDROTURBINES :

1. Impulse Turbine
2. Reaction Turbine

1. IMPULSE TURBINE :

The steam velocity is very high & Therefore turbine speed is very high.

→ Moving buckets
→ Fixed nozzle

2. REACTION TURBINE :

The steam velocity as well as pressure is utilized.

→ Moving buckets
→ Rotating nozzle

NEXT

Q / ANSWER /

TYPE OF TURBINE SELECTED FOR PROJECT IS BASED ON:

- → Height of Standing Water "head" → Flow of water
- → Volume of water
- → How deep the turbine must be set
- → Efficiency → Cost

TYPES OF IMPULSE TURBINES:

i. Pelton Turbine ii. Cross-flow Turbine

i. PELTON TURBINES:

A pelton wheel has one or more free jets, discharging water on the bukets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum tail water to permit operation at atmospheric pressure.

A Turgo wheel, resembles a fan blade that is closed on the outer edges. The water stream is applied on one side, goes across the blades & exist on the other side.

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Q.2 / ANSWER / CONTINUE

ii. CROSS-FLOW TURBINES:

It resembles a "squirrel cage" blower. The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the inside; the second pass is form the inside back out. A guide vane at the entrance to the turbine directs the flow to a limited portion of the runner. The cross-flow was developed to accommodate larger water flows & lower heads than the pelton.

2) REACTION TURBINE:

Reaction turbines are generally used for sites with lower head & higher flows than compared with the impulse turbines.

TYPES OF REACTION TURBINE:

i. Propeller Turbine
ii. Francis Turbine
iii. Kinetic Turbine

NEXT

Q 2 / ANSWER / CONTINUES /

i. PROPELLER TURBINE:

→ A propeller turbine generally has a runner with three to six blades in which the water contacts all of the blades constantly. Picture a boat propeller running in a pipe.

→ The pitch of the blades may be fixed or adjustable.

TYPES OF PROPELLER TURBINES:

i. Bulb Turbine
ii. Straflo Turbine
iii. Tube Turbine
iv. Kaplan Turbine

i. BULB TURBINES:

→ The turbine & generator are a sealed unit placed directly in the water stream.

ii. STRAFLO TURBINES:

→ The generator is attached directly to the perimeters of the turbine.

NEXT

Q2/ANSWER/CONTINUES/

iii) TUBE TURBINES:

→ The penstock bends just before or after the runner.

iv) Kaplan Turbines:

→ Both the blades & the wicket gates are adjustable, allowing for a wider range of operation.

(II) FRANCIS TURBINE (Reaction Turbine):

→ A francis turbine has a runner with fixed buckets (vanes), usually nine or more. Water is introduced just above the runner & all around it & then falls through, causing it to spin. Besides the runner, the other major components are the scroll case, wicket gates & draft tube.

III) KINETIC TURBINES (REACTION TURBINE):

→ Kinetic turbines, also called free-flow turbine, generate electricity from the kinetic energy present in flowing water. The system may operate in rivers,

NEXT

man-made channels, tidal waters, or ocean currents. Kinetic systems utilize the water stream's natural pathway. Kintic systems do not require large civil works; however, they can use existing structures such as bridges, and channels.

TURBINE PROPERTIES & SELECTION:

Head Classification	Turbine TYPES: Impulse	Turbine TYPES: Reaction
High (>50 m)	→ Pelton → Turgo	
Medium (10 – 50m)	→ Cross flow → Turgo → Multi-Jet Pelton	→ Francis (Spiral case)
Low (<10 m)	→ Cross flow → Under Shot water Wheel	→ Propeller → Kaplan → Francis (open – flume)

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Q2/ANSWER/CONTINUES/

Operational Range Of Different Turbines (ESHA, 2004)			
TYPES Of Turbines	Head Range (m)	Acceptance Of flow Variation	Acceptance Of head Variation
Kalplan/Propeller	2 — 40	High	Low
francis	25 — 350	Medium	Low
Pelton	50 - 1.300	High	High
Cross-flow	2 - 200	High	Medium
Turgo	50 - 250	Low	Low

Maximum efficiency (%)
91 – 93
94
90
86
85

NEXT

Q 2 / ANSWER / CONTINUES /

Selection of Turbines:

→ Net Head → Ra ge of Discharge through turbine
→ Rotational speed → Cost

→ Francis is slow runner will be used in high head schemes, where Kaplan, propeller & bulb are used in low head schemes with high speeds.
→ The available energy therefore depends on the head of the water above the turbine & volume of water flowing through it.
→ Turbines can be selected on the basis of their output power & rated discharge.

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NEXT

Q2/ANSWER/

PART (b)

Given that:

Head : $h = 190\ m$

Discharge : $q = 2.2\ m^3/s$

Overall efficiency : $\eta = 85\%$ or 0.85

At a head of 190 meters, a single jet pelton wheel turbine seems most suitable. Therefore from table 11.3, the specific speed can be calculated by using:

$$n_\% = 85.49/(h)^{0.243}$$

or

$$n_\% = 85.49/(190)^{0.243} = 23.88\ rpm$$

The output power can be obtained by using:

$$P = \eta \rho q g h \quad \text{watts}$$

$$P = 0.85 \times 1000 \times 2.2 \times 9.81 \times 190 = 3485.5\ Kw$$

or

Using equation 11.39, we have:

$$n = n_s \frac{h}{\sqrt{P}} = 23.88 \times \frac{(190)}{\sqrt{3485.5}} = 285.32\ rpm$$

An alternator rated at 50 Hz frequency with synchronous speed approaching 285.32 rpm but not greater is to be selected. The number of poles

Q 2 / ANSWER / C.ONTINUES /

required are computed by using :

$N_s = 120f/p$

Or

$P = 120 \times 50 / 285.32 = 21.02$ Poles

Now To find
Diameter = ?
JET Diameter = ?

Solution: At 250 rpm at 50Hz

$D = 38.56\sqrt{h/n}$

$= 38.56\sqrt{190/250}$

$= 2.12$ m

OR

$N_s = 23.88$ rpm

$D = 38.56 \times \sqrt{190/23.88}$

$= 38.56 \times 0.577$

$D = 22.25$

JET Diameter: $q = (\pi d_j^2) v_j / 4$

$d_j = \sqrt{4q / \pi v_j}$

Where

$v_j = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 190} = 61.05$ m/s

$d_j = \sqrt{4q / \pi v_j} = \sqrt{4 \times 2.2 / 3.14 \times 61.05}$

$d_j = 0.214$ m OR 21.4 cm

Q 3 / ANSWER /

Nuclear fuel Cycle:

Mining & Milling:

→ Uranium is usually mined by either surface (open cut) or underground mining techniques, depending on the deth at which the ore body is found.

→ from these, the mined uranium ore is sent to a mill which is usually located close to the mine.

→ At the mill the ore is crushed & ground to a fine slurry which is leached in sulfuric acid to allow the separation of uranium oxide (U_3O_8) concentrate.

— Sometimes this is known as "Yellow Cake"

Conversion:

→ Because uranium needs to be in the form of a gas before it can be enriched, the U_3O_8 is converted into the gas Uranium hexafluoride (UF_6) at a conversion plant.

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Q3 / ANSWER / CONTINUES /

Enriching:

→ Need to enrich uranium to at 3% for a power plant

→ Two Methods of Enriching

→ **Gaseous Diffusion Method:**

- UF_6 (hexafluoride) gas heated
- U-238 is heavier than U-235
- Hexafluoride Gas can be separated into two streams:
  - i - Low velocity U-238
  - ii - High " U-235

→ **Centrifuge Method**

- Gas spun in centrifuge
- Lighter U-235 will separate from heavier U-238

Fuel Conversion:

→ Enriched Uranium transported to a fuel fabrication plant where it is converted to uranium dioxide (UO_2) powder & pressed into small pellets.

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Q3/ANSWER/CONTINUES

→ These pellets are inserted into thin tubes, usually of a zirconium alloy or stainless steel, to form fuel rods.

→ The rods are then sealed & assembled in clusters to form fuel assemblies for use in the nuclear reactor.

FUEL Packaging In The Core:

→ Rods contain Uranium enriched

→ Need roughly 100 tons per year for a 1000 MW plant.

The Reactor Core:

→ The reactor core consists of fuel rods & control rods:

- Fuel rods contain enriched uranium.
- Control rods are inserted b/w the fuel rods to absorb neutrons &
- slow the chain reaction.

→ Control rods are made of Cadmium, which absorb neutrons effectively.

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Moderators:

→ Neutrons produced during fission in the core are moving too fast to cause a chine reaction.

— Note: This is not an issue with a bomb, where fissile uranium is so tightly packe that fast moving neutrons can still do the job.

→ A moderator is required to slow down the neutrons.

→ In Nuclear Power Plants water or graphite acts as the moderator.

END