IQRA National University, Peshawar
Department of Electrical Engineering
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Power Generation

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Terminal Examination   *course Instructor: Engr.Sanaullah Ahmad*

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^2/s with overall efficiency of 85%? Also determine turbine diameter and jet diameter? Specific speed $Ns = 85.49/(h)^{0.243}$. *Diameter* $= 38.56\, \overline{h}/n$. *Jet Diameter* $q = (\prod dj^2)Vj/4$ *where* $Vj = 2gh$ CLO 2

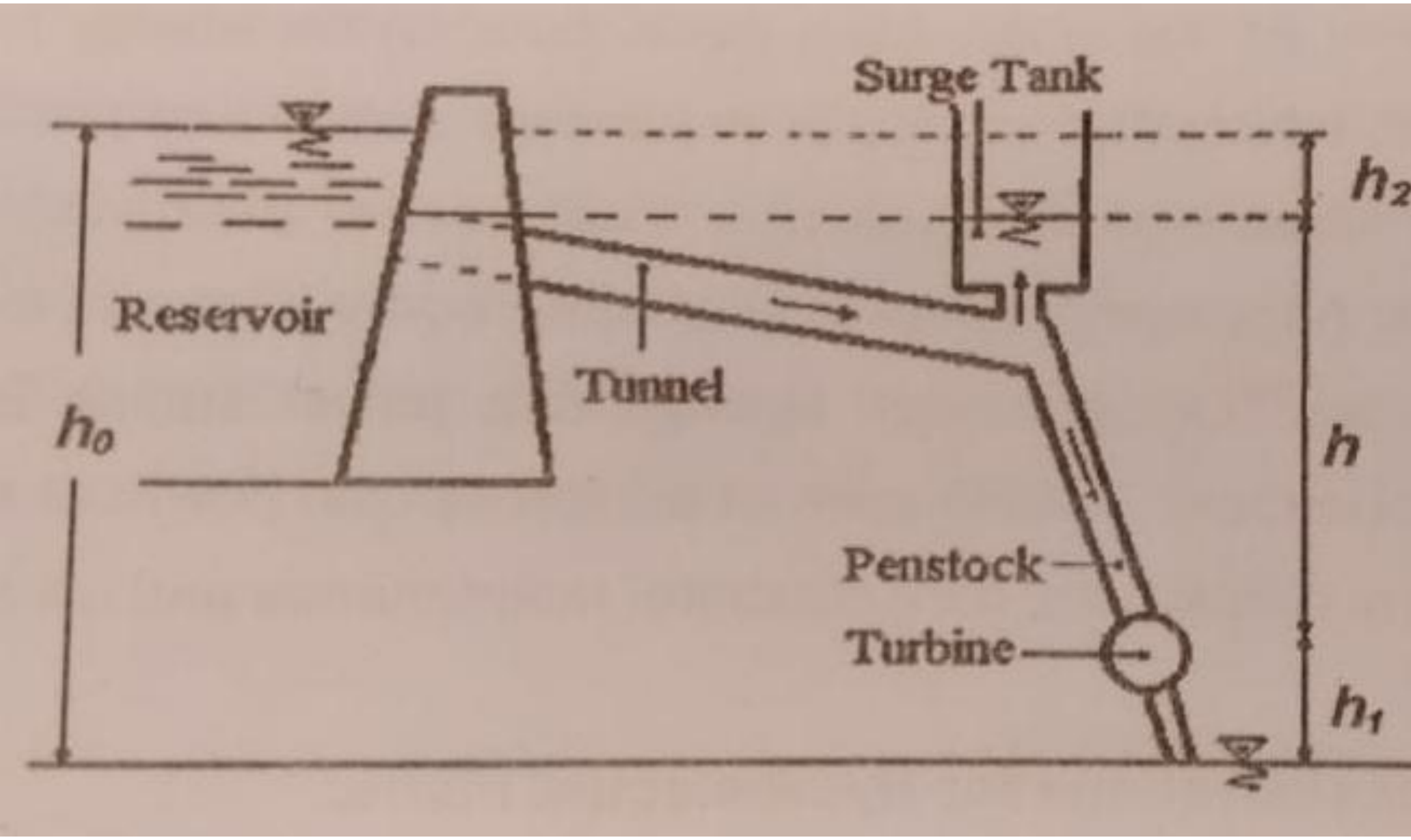
Question No 3 ***10***

Explain different stages of Nuclear Fuel Cycle? CLO 1

☺ GOOD LUCK ☺

Q1)a With the help of a diagram show different Elements of a Hydropower Plant?

Answer:



A hydroelectric plant consists of a reservoir for storage of water, a diversion dam, an intake structure for controlling and regulating the flow of water, a conduit system to carry the water from the intake to the waterwheel, the turbines coupled with generators, the draft tube for conveying water from waterwheel to the tailrace, the tailrace and a power house i.e., the building to contain the turbines, generators, the accessories and other miscellaneous items.

The size, location, and type of each of these essential elements depend upon the topography and geological conditions and the amount of water to be used. The height to which the dam may be built is usually limited by the extent of flowage damage. Pondage may have great value, particularly for peak load power plants, warranting the purchase of extensive flowage rights. The spillway section of the dam must be long enough to pass safely the maximum amount of water to be expected. Likewise the abutments and other short structures must be built to withstand successfully the greatest freshet conceivable on the river.

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Question No 1 (b)

Given data:-

Available volume at pondage = $V = 5\times10^5 m^3$

Available head $h = 100m$

Hydraulic efficiency = 85% = 0.85

Electrical efficiency = 0.94.

Required

$E = ?$

Sol

Overall efficiency $0.8\times0.94 = 0.80$

Using

$E = \eta\rho g h V = 0.8\times1000\times9.81\times100\times5\times10^8$

$E = 3.92\times10^{11}$ W-s

Q2) A Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines?

Answer:

Types of hydropower turbines:

1. Impulse Turbine
2. Reaction Turbine

Impulse Turbine:

- The impulse turbine generally uses the **velocity** of the water to move the runner. The water stream hits each bucket on the runner.
- An impulse turbine is generally suitable for high head, low flow applications.
- In impulse turbine, at inlet , only kinetic energy available. But in reaction turbine, at inlet kinetic energy as well as pressure energy both are available.

Types of impulse turbine:

1. Pelton turbine
2. Cross flow turbine

Reaction turbine:

- A reaction turbine develops power from the combined action of **pressure and moving water.** The runner is placed directly in the water stream flowing over the blades rather than striking each individually.
- Reaction turbines are generally used for sites with lower head and higher flows than compared with the impulse turbines.

Type of reaction turbine:

- Propeller Turbine

- Francis Turbine
- Kinetic Turbine

The parameters required for the selection of hydropower turbines:

- Height of standing water “head”
- Flow of water
- Volume of water
- How deep the turbine must be set
- Efficiency
- Cost

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Question 2(b)

Given that

Head = h = 190m

Discharge q = 2.2 m^2/s

Overall efficiency n = 85% or 0.85

Solution:-

Required:-

$N_s = 8.549/(h)^{0.243}$

$N_s = ?$

Diameter = ?

Jet diameter = ?

Sol

$$N_s = \frac{85.49}{(h)^{0.243}}$$

$$N_s = \frac{85.49}{(190)^{0.243}}$$

$N_s = 23.88$ rpm.

At 250 rpm at 50Hz

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

$$= \frac{38.56 \times \sqrt{190}}{250}$$

$= 2.12$m

OR

$N_s = 23.88$ rpm

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

$$D = \frac{38.56 \times 13.78}{23.88}$$

$D = 38.56 \times 0.577$

$D = 22.25$.

* Jet diameter

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

$$d_j = \sqrt{\frac{4q}{\pi V_j}}$$

where

$$V_j = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 190} = 61.05 \, m/s.$$

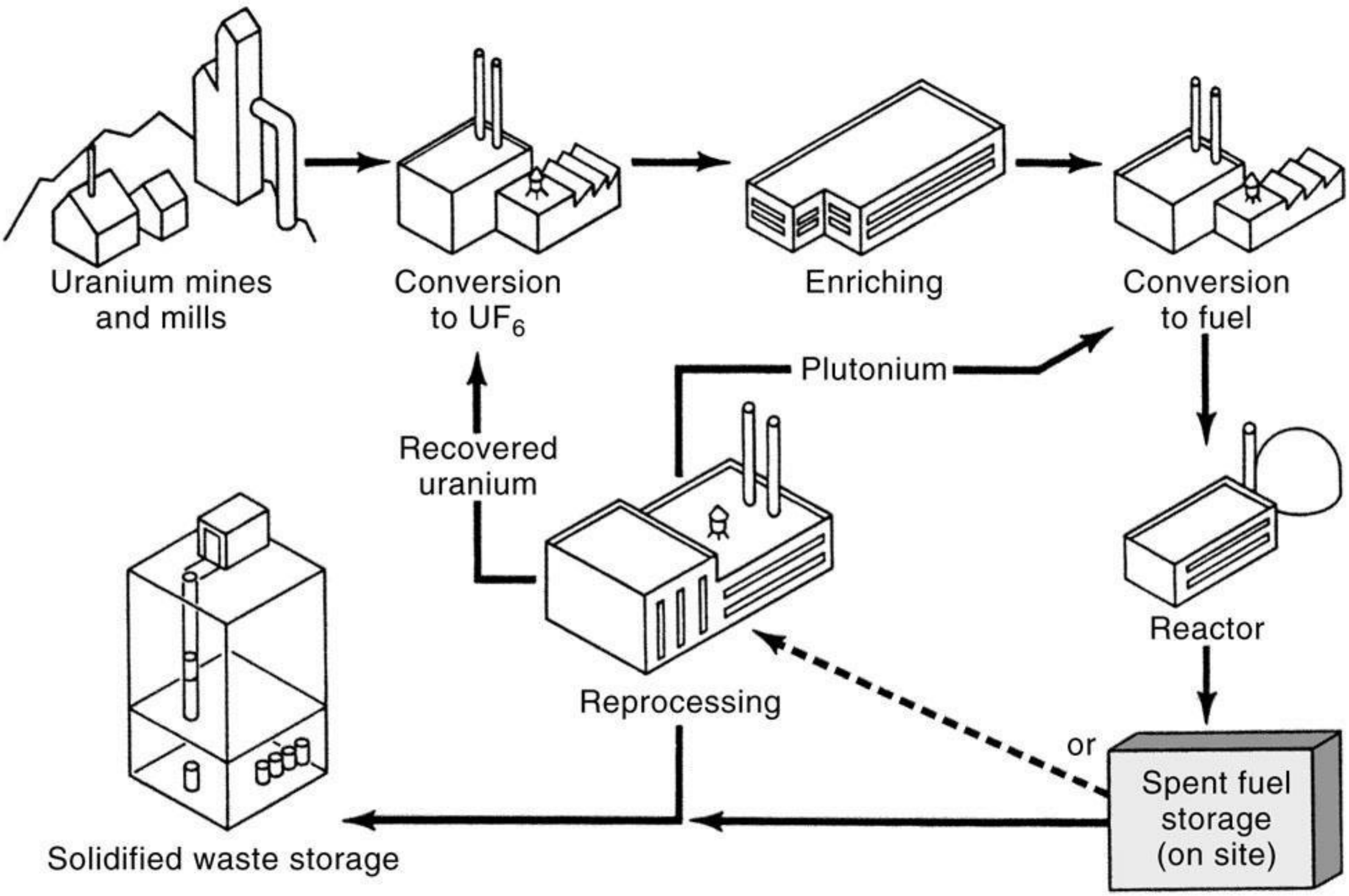
$$d_j = \sqrt{\frac{4q}{\pi V_j}} = \sqrt{\frac{4 \times 2.2}{3.14 \times 61.05}}$$

$$= 0.214 m \text{ or } 21.4 cm.$$

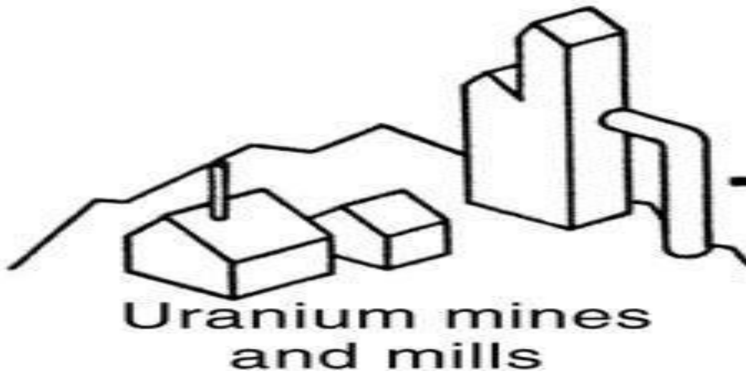
Q3) Explain different stages of Nuclear Fuel Cycle?

Answer:

Nuclear Fuel Cycle



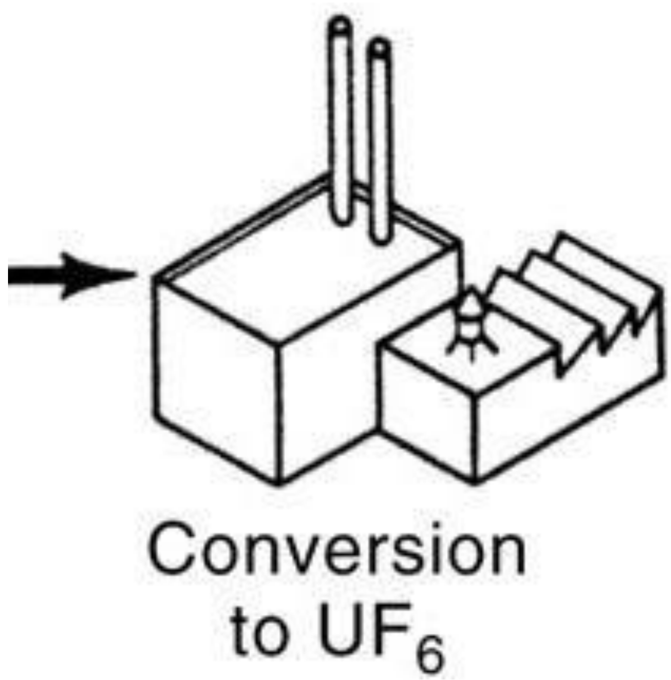
Mining milling:



- Uranium is usually mined by either surface (open cut) or underground mining techniques, depending on the depth 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 and ground to a fine slurry which is leached in sulfuric acid to allow the separation of uranium from the waste rock.
- It is then recovered from solution as uranium oxide (U_30_8) concentrate.
  - Sometimes this is known as "yellowcake"

Conversion:

- Because uranium **needs** to be in the form of a **gas** before it can be enriched, the U_30_8 is converted into the **gas uranium hexafluoride** (UF_6) at a conversion plant.



Enriching:

- Need to enrich uranium to at least 3% for a power plant
- **Two** Methods of Enriching
- **Gaseous Diffusion Method**
  - UF_6 (hexafluoride) gasheated
  - U-238 is heavier than U-235
  - Hexafluoride Gas can be separated into two streams
    - Low velocity U-238
    - High Velocity 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 and pressed into small pellets.
- These pellets are inserted into thin tubes, usually of a zirconium alloy or stainless steel, to form **fuel rods**.
- The rods are then sealed and assembled in clusters to form fuel assemblies for use in the core of the nuclear reactor.

Fuel packaging in the core:

Rods contain uranium enriched

Need roughly 100 tons **per year** for a 1000MW plant

The reactor core:

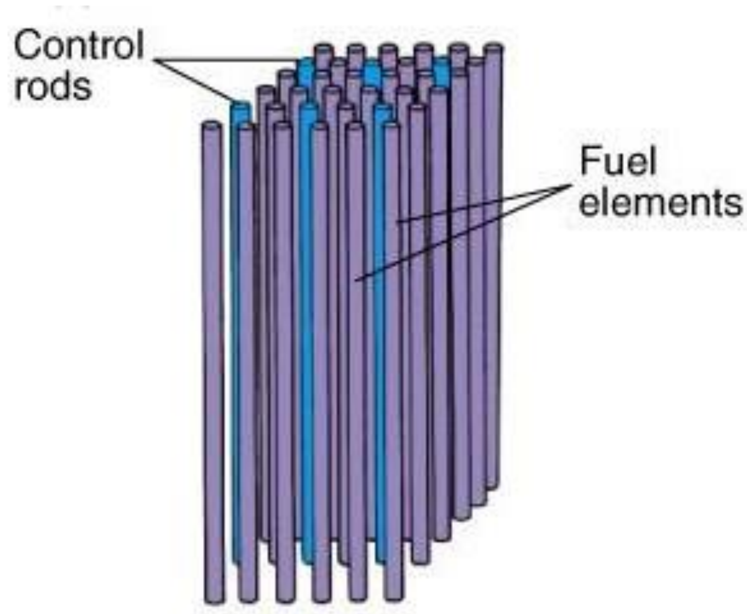
The reactor *core* consists of

fuel rods and *control rods*

Fuel rods contain enriched uranium

Control rods are inserted between the fuel rods to absorb neutrons and slow the chain reaction

Control rods are made of cadmium, which absorb neutrons effectively



Moderator:

- Neutrons produced during fission in the core are moving too fast to cause a chain reaction
  - Note: This is not an issue with a bomb, where fissile uranium is so tightly packed 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**

Uranium Reprocessing:

- Spent fuel still contains approximately 96% of its original uranium, of which the fissionable U- 235 content has been reduced to less than 1%.
- Spent fuel comprises waste products and the remaining 1% is plutonium produced while the fuel was in the reactor
- Reprocessing extracts useable fissile U-238
- Most of the spent fuel <u>can be reprocessed.</u>
- Federal law prohibits commercial reprocessing because it will produce plutonium (which can be used both as a fuel *and* in constructing bombs)'

Nuclear waste disposal:

- In the U.S., *no high-level nuclear waste is ever disposed of*--it sits in specially designed pools resembling large swimming pools (water cools the fuel and acts as a radiation shield) or in specially designed dry storage containers.
- Spent nuclear fuel must be isolated for thousands of years
- After 10,000 years of radioactive decay, according to EPA standards, the spent nuclear fuel will no longer pose a threat to public health and