IQRA National University, Peshawar
Department of Electrical Engineering
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Power Generation

Name: **Hamza**
ID: **16469**

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 $Ns = 85.49/(h)^{0.243}$. *Diametar* $= 38.56\ \sqrt{h}/n$. *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 ☺

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Name Hamza
ID 16469

Q1
(A)
Sol:-

Main Elements of Hydro power plant:

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, building to contain the turbines, generators, the accessories and other miscellaneous items.

Element # 1. Storage Reservoir.

It is the basic requirement of a hydroelectric plant. its purpose is to store water during excess flow periods (i.e., rainy season) and supply the same during lean flow periods (i.e., dry season) and thus it helps in supplying water to the turbines according to the load on the power plant.

A reservoir can be either natural or artificial. A natural reaservoir is a lake in high mountains and an artifical reservoir is made by constructing a dam across the river. Low head plants require very large storage reservoir.

Element # 2. ~~[illegible]~~ Forebay:

A forebay is a basin area of hydropower plant where water is temporarily stored before going into intake chamber. The

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Storage of water in forebay is decided based on required water demand in that area. This is also used when the local requirement in intake is less.

We know that reservoirs are built across the rivers to store the water, the water stored on upstream side of dam can be carried by penstocks to the power house. In this case, the reservoir itself acts as forebay.

Element # 3. Intake:

The intake includes the head-works which are the structures at the intake of conduits, tunnels, or flumes. These structures include booms, screens or trash racks, sluices to divert and prevent entry of debris and ice into the turbines.

intake structure is a structure which collects the water from the forbay and directs it into the penstocks. There are different types of intake structures are available and selection of type of intake structure depends on various local conditions.

Element # 4 : Penstock:

Penstocks are like large pipes laid with some slope which carries water from intake structure or reservoir to the turbines. They run with some pressure so, sudden closing or openning of penstock gates can cause water hammer effect to the penstocks. So these are designed to resist the water hammer effect apart from this Penstock is similar to normal pipe.

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Element # 5. surge chamber:

A surge chamber or surge tank is a cylindrical tank which is open at the top to control the pressure in penstock. it is connected to the penstock and as close as possible to the power house.

whenever the power house rejected the water load coming from penstock the water level in the surge tank rises and control the pressure in penstock.

similarly, when the huge demand is needed in power house surge tank, accelerates the water flow into the power house.

Element # 6. Hydraulic Turbines:

Hydraulic turbine, a device which can convert the hydraulic energy into the mechanical energy which again converted into the electrical energy by coupling the shaft of turbine to the Generator.

The mechanism in this case is, whenever the water coming from penstock strick the circular blades or runner with high pressure it will rotate the shaft provided at the center and it causes generator to produce electrical power.

Element # 7: power House:

power house is a building provided to protect the hydraulic and electrical equipment. Generally, the whole equipment is supported by the foundations or substructure laid for the power house. ~~In case of Reaction~~

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Element # 7. Draft tube:

If reaction turbines are used, then draft tube is a necessary component which connects turbine outlet to the tailrace. The draft tube contains gradually increasing diameter so that the water discharged into the tailrace with safe velocity. At the end of draft tube, outlet gates are provided which can be closed during repair work.

Element # 8. Tailrace:

Tailrace is the flow of water from turbines to the stream. It is good if the power house is located nearer to the steam. But, if it is located far away from the stream then it is necessary to build a channel for carrying water into the stream.

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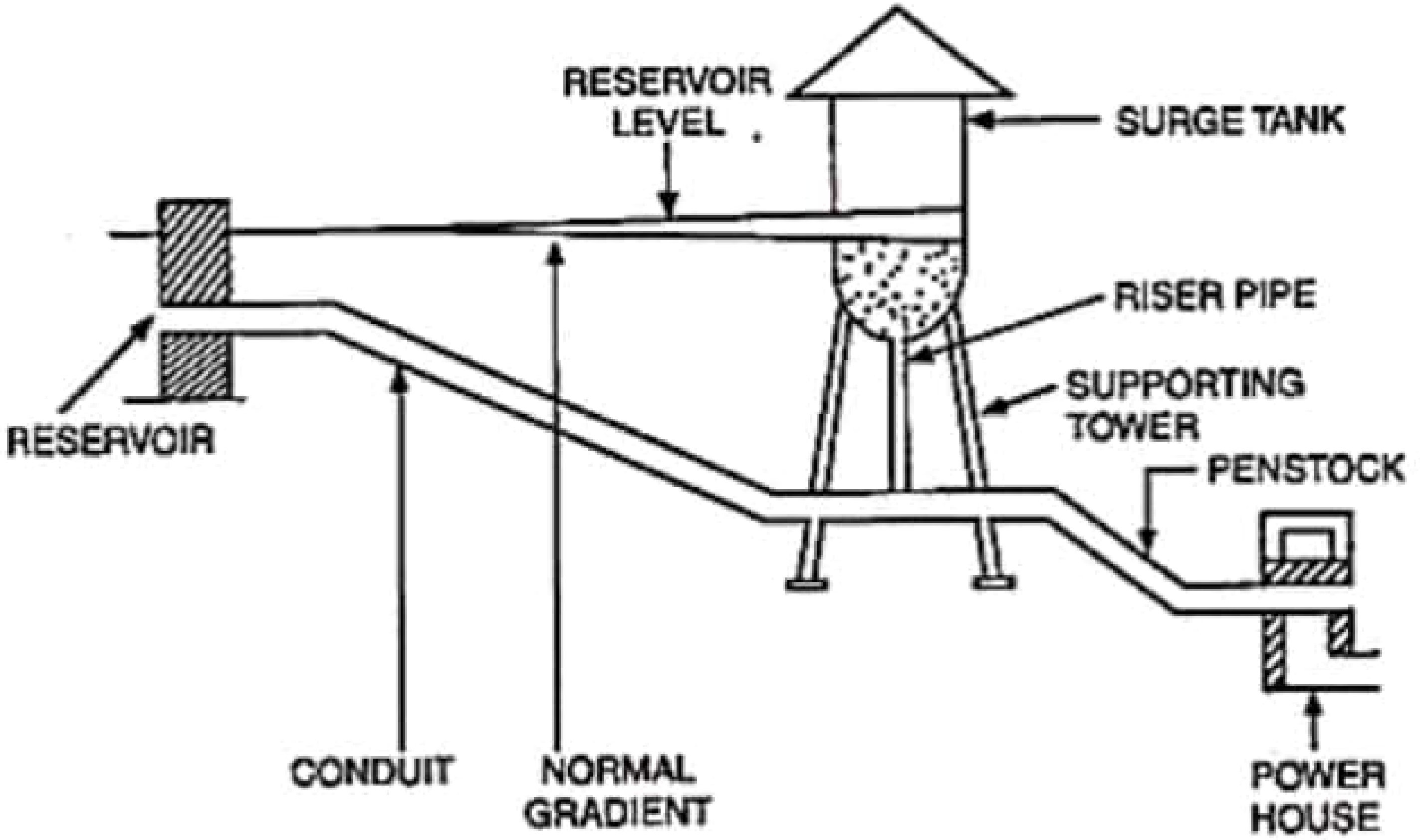

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Q 1
(B)
Sol:-

Given data

Available volume at pondage : $V = 5 \times 10^5 \, m^2$
Available ~~height~~ head : $h = 100 m$
Hydraulic efficiency : 85% = 0.85
Electrical efficiency : 0.94

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

Formula

$$E = \eta \rho g h V$$

solution

puts values in formula

$$E = 0.8 \times 1000 \times 9.81 \times 100 \times 5 \times 10^5$$

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

Ans

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Q 2
(A)
sol:-

Turbine:

Turbine is a rotary mechanical device that extracts energy from a "fluid flow" and converts it into useful work.

There are two main types of hydro turbines

- impulse
- Reaction

① Impulse Turbine

→ The impulse turbine generally uses the velocity of the water to move the runner. The water stream hits each buckets on the runner.

→ An impulse turbine is generally suitable for high head, low flow application.

→ In implust turbine, at inlet, only kinetic energy available.

There are two types of Implulse Turbines

- pelton Turbine
- cross-flow Turbine

pelton Turbines

→ A pelton wheel has one or more free jets, discharging water on the buckets 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.

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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 from the inside back out. A guide vane at the entrance to the turbine directs the flow to a limited postition of the runner. The cross-flow was developed to accomodate larger water flows and lower heads that the pelton.

2 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 flow than compared with the impulse turbines.

There are three main types of reaction turbines.

- Propeller Turbine
- Francis Turbine
- Kinetic Turbine

(a) propeller turbine

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

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

There are also four types of propeller turbine

- Bulb Turbine
- straflo Turbine
- Tube Turbine
- Kaplan Turbine

(a)(i) Bulb Turbines

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

(a)(ii) Straflow Turbines

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

(a)(iii) Tube Turbines

The penstock bends just before or after the runner.

(a)(iv) Kaplan Turbines

Both the blades and the wicket gates are adjustable, allowing for a wider range of operation

(b) Francis Turbines

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

(c) Kinetic Turbines:

Kinetic turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water. The system may operate in rivers, man-made channels, tidal waters, or ocean currents. Kinetic systems utilize the water stream's natural pathway. Kinetic systems do not require large civil works; however, they can use existing structures such as bridges, and channels.

Parameters required for selections of turbines

The type of hydropower turbine selected for a project is based on the height of standing water — reffered to as "head" — and the flow, or volume of water, at the site. Other deciding factors include how deep the turbine must be set, efficiency, and cost.

Q2
(B)
Sol/u

Given data

Head: $h = 190$
Discharge: $q = 2.2\ m^2/s$
Overall efficiency $= \eta = 85\% = 0.85$

specific speed can be calculated by using given formula

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

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

$$\boxed{n_s = 23.88\ rpm}$$

By using "$P = \eta P q g h$" to obtain output power

$P = \eta P q g h$ watt

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

$$\boxed{P = 3485.5\ KW.}$$

$$n = n_s = 23.88 \times \frac{(190)^{3/4}}{\sqrt{3485.5}}$$

$$= \boxed{285.32\ rpm}$$

The number of poles required are computed by

$$N_s = \frac{120f}{P}$$

$$P = \frac{120 \times f}{N_s}$$

$$= \frac{120 \times 50}{285.32}$$

$$\boxed{P = 21.02 \text{ poles}}$$

we will select 24 poles which will rotates at 250 rpm at 50 Hz. So the turbine will have a diameter which can be ~~att~~ determine by given formula.

$$D = 38.56\frac{\sqrt{h}}{n} = 38.567\frac{\sqrt{190}}{250}$$

$$\boxed{D = 2.12 \text{ m}}$$

To calculate Jet diameter use $q = \frac{(\pi d_j^2) v_j}{4}$ and jet velocity by $v_j = \sqrt{2gh}$

$$\text{Jet velocity} = v_j = \sqrt{2gh} = \sqrt{2 \cdot 9.81 \times 190}$$

$$\boxed{v_j = 61.05 \text{ m/s}}$$

Now jet diameter is

$$d_j = \sqrt{\frac{4q}{\pi v_j}} = \sqrt{\frac{4 \times 2.2}{3.14 \times 61.05}} = 0.214 \text{ m}$$

$$\boxed{d_j = 21.4 \text{ cm}}$$

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Q3

Mining and 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_3O_8) concentrate.

"sometime 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 hexaflueride (UF_6) at a conversion plant.

Enriching

→ Need to enrich uranium to at least 3% for a power Plant.

→ There are two methods of Enriching.

→ Gasous Diffusion method:

- UF_6 (hexaflouride) gas heated
- 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.

Reactor core

→ The reactor core consists of fuel rods and control rods.

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

→ Control rods are made of cadmium, which absorb newtrons effectively.

Moderators

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

→ A moderator is required to slow down the neutrons

→ In nuclear power plants water or graphite acts as modulator.

Light VS Heavy Water

→ 99.99% of water molecles contain normal hydrogen (with a sigle proton in the nucleus).

→ water can be specially prepared so that the molecules contain deuterium (hydrogen with a proton and a neutron in the nucles)

→ Normal water is called light water while water containning deuterium is called heavy water.

→ Heavy water is a much better moderator but is very expensive to make.

Boiling water Reactor

→ Heat generated in the core is used to generated steam through a heat exchanger.

→ The steam runs a turbine just like a normal power plant.

Pressurized water Reactor

→ water is the core heated top 315°C but is not turned into steam due to high pressure in the primary loop

→ Heat exchanger used to transfer heat into secondry loop where water is turned to steam to power turbine.

→ Steam used to power turbine never comes directly in contact with radioactive materials.

Uranium Reprocessing

→ Spent fuel still contain 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 production while the fuel was in the reactor

→ Reprocessing extracts useable fissile U-238

→ most of the spent fuel can be reprocessed.

→ 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 .

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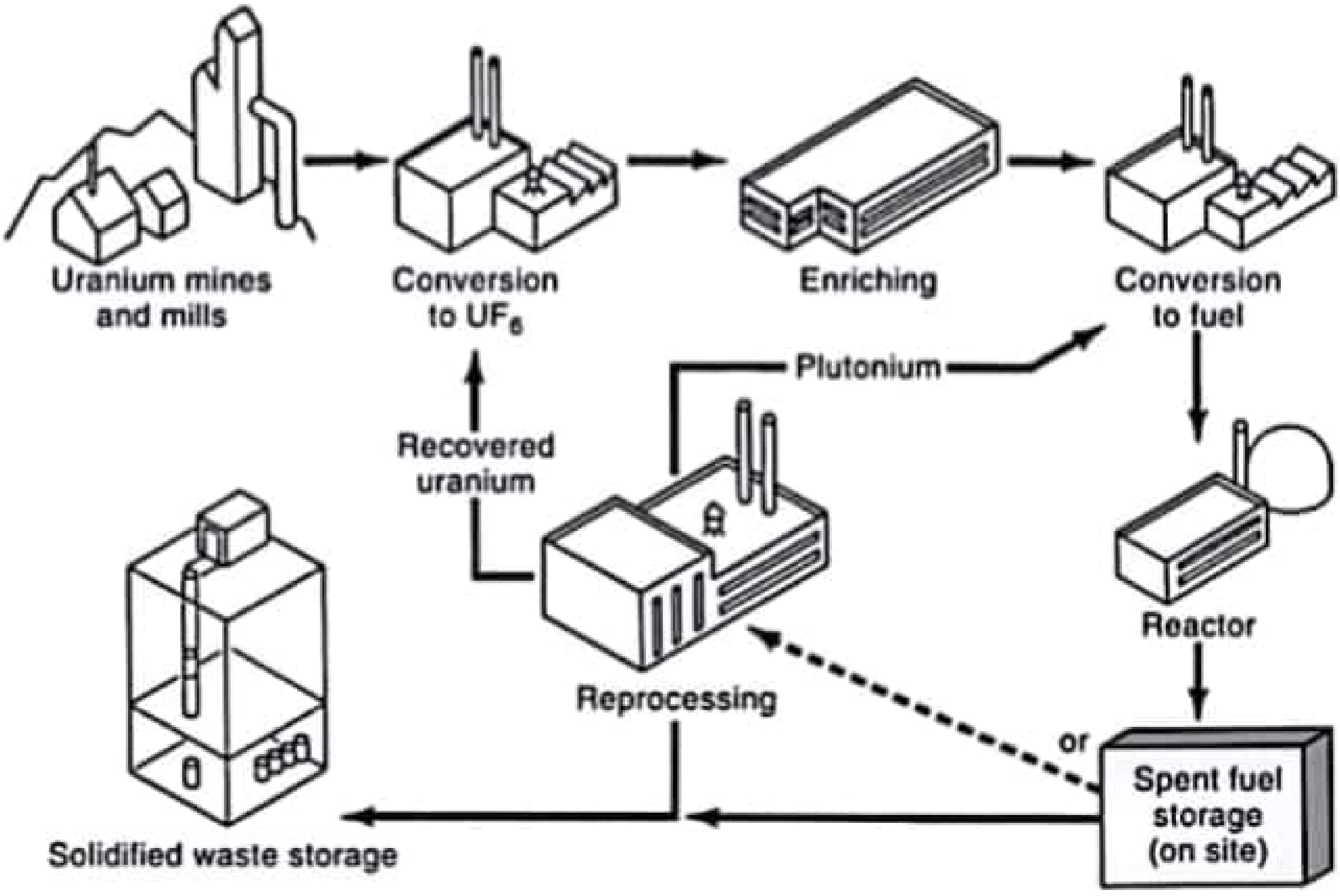
Nuclear Fuel Cycle



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