IQRA National University, Peshawar
Department of Electrical Engineering

Name: Irshad Khan

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Power Generation

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 $Ns = 85.49/(h)^{0.243}$. $Diameter = 38.56\sqrt{h}/n$. *Jet Diameter* $q = (\prod dj^2)Vj/4$ *where* $Vj = \sqrt{2gh}$ CLO 2

Question No 3 ***10***

Explain different stages of Nuclear Fuel Cycle? CLO 1

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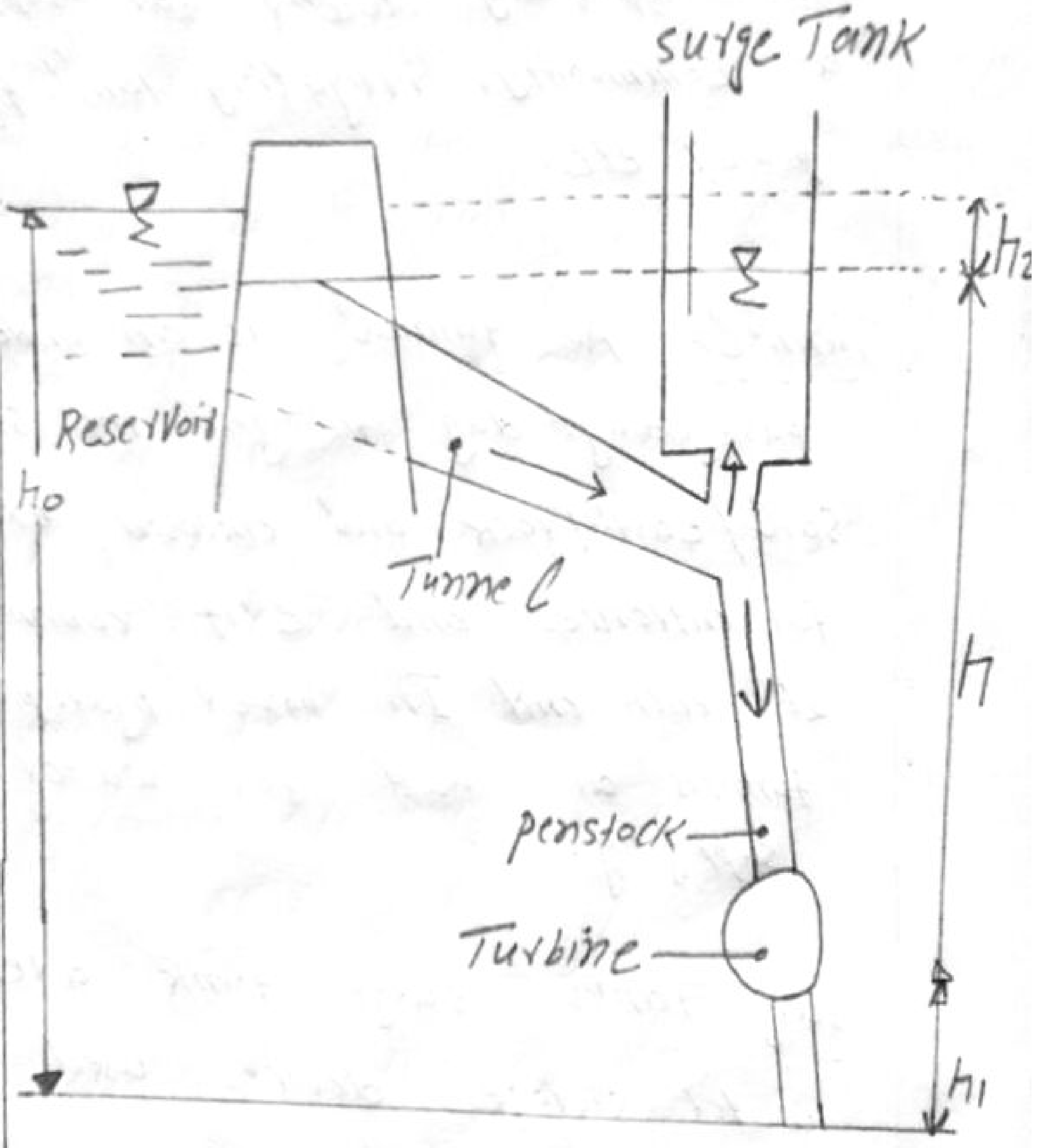
Q1 (A) with the help of diagram show different elements of a hydropower plant?

Ans:-



There are different elements of hydropower plants such as.

Reservoir
surge Tank
Tunnel
penstock
Turbine.

Reservoir:
A natural or artificial place where water is collected and stored for use. especially water for supplying a community, irrigating land, furnishing power etc.

Tunnel: A tunnel is an underground passageway, dug through the surrounding soil/earth/rock and enclosed except for entrance and exit, commonly at each end. In power hydroplants tunnels are used for water supplying.

Surge Tank: surge tank are water storage device used as pressure neutralizer in hydropower water conveyance system to resists excess penstock:

penstocks are pipes or long channels that carry water down from the hydroelectric reservoir to turbines inside the actual power station. Generally they are made of steel and water under high pressure flows through the penstock.

Turbine:

The turbine is the heart of a powerplant that produces electric current. A gas turbine is a combustion engine that can convert natural gas or other liquid fuels to mechanical energy. This energy than drives a generator that produces electrical energy.

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Q1 (B) water for a small hydroelectric station is to be made available from a pondage volume of $5 \times 10^3\ m^3$ located at a height up hill to provide water at a head of 100m at a hydraulic efficiency of 85%. If the electrical ~~of~~ ~~85%~~ efficiency ~~of~~ is 94% and the water supply is available for 8 hours daily. determine the capacity of generator to be installed at the power station.

Soln: Available volume at pondage

$V = 5 \times 10^5\ m^3$

Available head $h = 100\,m$.

Hydraulic efficiency: 85%

$$\frac{85\%}{100} \Rightarrow \boxed{0.85}$$

Electrical ~~e~~ efficiency = 94%

$$\frac{94\%}{100} \Rightarrow \boxed{0.94}$$

overall efficiency:

Hydraulic efficiency X Electrical efficiency

$0.85 \times 0.94 = 0.799$

or $\boxed{80\%}$

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

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

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

$E = 3.924 \times 10^{11}$ w-s

Q2 (A) Classify different hydropower turbines and their selections?

Ans: Types of hydropower Turbines:

① Impulse Turbine

② Reaction Turbine.

Impulse: The steam velocity is very high and therefore turbine speed is very high.

Reaction: The steam velocity as well as pressure is utilized.

① 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.

Types of Impulse Turbine:

I: pelton Turbines

II: Cross flow Turbine.

(g) 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 imulse turbines.

Types of Reaction Turbines:

- propeller Turbine
- Francis Turbine
- Kinetic Turbine.

(1) 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.

(2) Crossflow Turbine:-

Low to medium heads (2- 40 meters)
Low to medium flows (0.1 – 5 m^3/s).

(3) Kaplan Turbine:-

Low to medium heads (1.5 – 20 meters)
medium to high flows (3 m^3/s – 30 m^3/s).
For higher flows multiple turbines can be used.

(4) pelton / Turgo Turbine:

High heads (greater than 25 meters)
Lower flows (0.01 m^3/s – 0.5 m^3/s)

(5) water wheels:

Low heads (1– 5 meters) - though turbines often more appropriate for higher heads. Medium flows (0.3 – 1.5 m^3/s).

(6) Francis Turbine:-

No longer commonly used except in very large storage hydropower systems, smaller turbines are in existence and can be restored.
Low to medium heads (1.5–20 meters)
medium flows (0.5 – 4 m^3/s).

(7) 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 system utilize the water stream's natural path way. Kinetic system do not require large civil works, however they can use existing structures such as bridges, and channels.

Selection of Turbines:

- Net head
- Range of discharge through turbine
- Rotational speed.
- cost

The available energy therefore depends on the head of the water above the turbine and volume of water flowing through it.

- Turbines can also be selected on the basis of their output power and rated discharge.

Q 9 (B) select a suitable turbine for hydropower scheme with available head height of 190m and rated discharge of 9.9 m^3/s with overall efficiency of 85%.

- - - - - - - - - - - - - - $Q = (\pi d^2) V_j / 4$ where $V_j = \sqrt{2gh}$.

Soln:

Head $h = 190m$

Discharge $Q = 9.9 m^3/s$

over all efficiency $\eta = \frac{85\%}{100}$ or $\boxed{0.85}$

At a head of 190m a single Jet pelton wheel turbines the specific speed can be calculates as

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

or

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

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

The output power can be obtained by using.

$P = \eta \rho Q g h$ watts

$P = 0.85 \times 1000 \times 9.9 \times 9.81 \times 190$

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

we have

$$n = n_s \frac{h^{3/4}}{\sqrt{P}}$$

$$= 23.88 \times \frac{(190)^{3/4}}{\sqrt{34855}}$$

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

At 50 HZ frequency with synchronous speed approaching 285.32 rpm.

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

or

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

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

Note: selecting 24 poles will remain at 250 rpm at 50 HZ frequency.

$$D = 38.567 \frac{\sqrt{h}}{n}$$

$$D = 38.567 \frac{\sqrt{190}}{250}$$

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

The jet diametter can be calculated as.

$$Q = \frac{(\pi dj^2) vj}{4}$$

The jet velocity is

$$vj = \sqrt{2gh}$$

$$vj = \sqrt{2 \times 9.81 \times 190}$$

$$\boxed{vj = 61.05\ m/s}$$

Now to find jet diameter value.

$$dj = \sqrt{\frac{4Q}{\pi vi}}$$

$$dj = \sqrt{\frac{4 \times 2.2}{3.14 \times 61.05}}$$

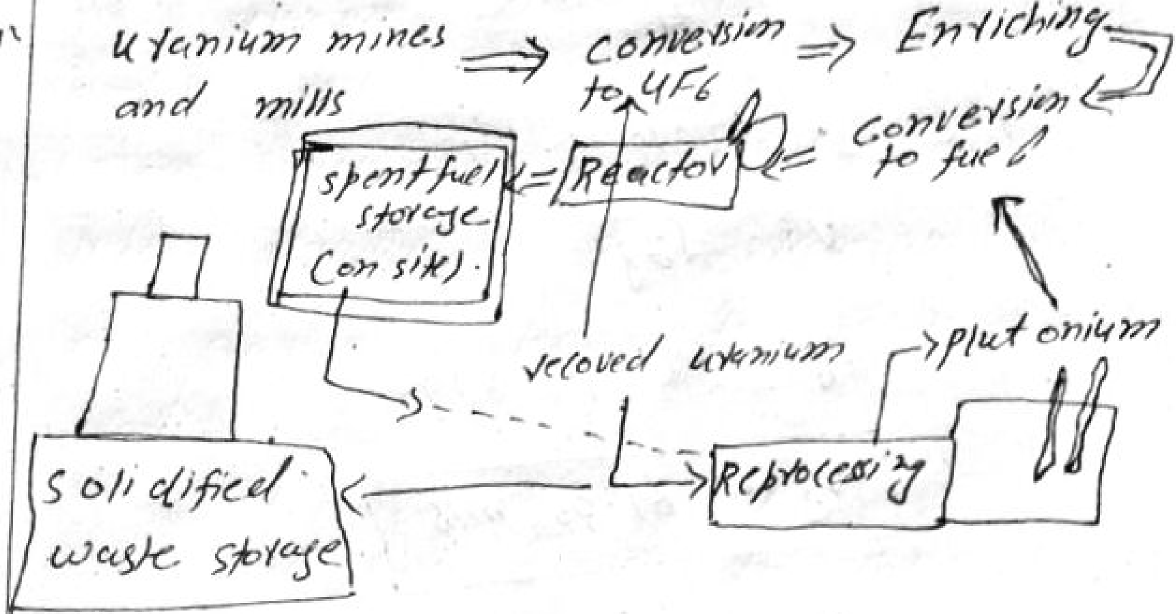
$$dj = 0.214m$$

$$\boxed{\text{or } dj = 21.4cm}$$

The turbines will have a standard diameter of 2 meters and the centre line diameter of the jet 20cm.

Q3 Explain different stages of nuclear fuel cycle?

sol:



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

Conversion

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

Enriching

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

Two methods for Enriching

- Gaseous Diffusion Method
  - UF_6 gas heated.
  - U-238 is heavier than U-235
    - Low velocity U-238
    - High velocity U-235
- Centrifuge Method.
  - Gas spun in centrifuge
  - Lighter U-235 will separate from heaviour 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 assampbled in clusters to form fuel assemblies for use in the core of the nuclear reactor.

Uranium Reprocessing:-

- spent fuel still contains approxiametely 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

Nuclear waste Disposal:

- In the U.S. no high-level nuclear waste is ever disposed of it sits in especially 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~~.