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

☺ GOOD LUCK ☺

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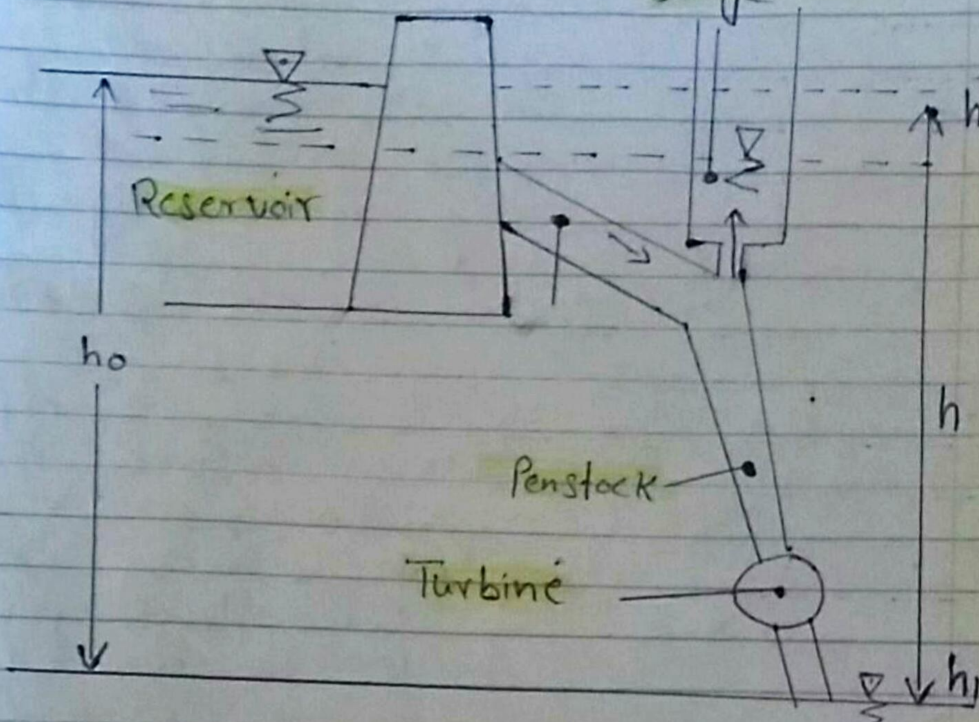
Q.1 (a)

Ans:

Diagram:



(1) Surge Chamber:

Whenever the Power house rejected the water load coming from penstock the water level in the surge tank rises & 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 & then water level reduce.

(ii) Penstock :- Penstocks are like large pipes laid with Some slope which carries water from intake structure or reserviour to the turbines. they run with some pressure so, sudden closing or opening 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. To overcome this pressure. heavy wall is provided for short length penstock & surge tank is provided in case of long length penstocks. Steel or Reinforced concrete is used for making penstocks. if the length is small. Separate penstock is used for each turbine Similarly if the length is big single large penstock is used & at the end it is separated into branches.

(iii) Turbine:- there are main two types of hydro power turbines. Impulse & reaction the types of hydropower turbine Selected for a project is based on the height of standing water - refered to as "head" and the flow, or volume of water, at the site. other deciding factors include how deep the turbine must be set, effeciency & cost.

(iv) Reservoir:

A reservoir is employed to store water which is further utilized to generate the power by runing the hydroelectric turbines.

-> In a reservoir the water collected from the cachment area is stored behind a dam.

-> catchment area gets its water from rain & streams.

-> The level of water surface in the reservuior is called Head water level.

(v) Dam: A dam is a barrier which confines or raise water for storage or division to create a hydraulic head.

-> Dams are generally made of concrete, stone masory, Rockfill or Timber.

Q.1 (b)
Ans:

~~Solution~~:. Given data:-

Available volume at pandage: $v = 5 \times 10^5 m^3$

Available head: $h = 100m$
Hydraulic efficiency: 85% 0.85

Electrical. efficiency: 0.94
Solution:
Therefore overall effeciency = $0.85 \times 0.94 = 0.80$

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

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

Q:2 (a)
Ans:

Types of Hydropower turbines:

(1) Impulse Turbine
(2) Reaction Turbine

Impulse: The steam velocity is very high & 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.

=> In impulse turbine, at inlet only kinetic energy available. But in reaction turbine, at inlet K.E energy as well as pressure energy both are available

Types of impulse Turbine:

(i) Pelton turbine
(ii) Cross-flow Turbine

(1) Pelton turbine:

=> 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.

=> 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 & exists on the other side.

(2) Cross flow Turbine:

it resembles a "squirrel cage" blower. the cross flow turbines 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 van at the entrance to the turbine directs the flow to a limited portion of the runner. the cross flow was developed to accommodate large water flows & lower heads than the pelton.

(2) Reaction Turbine:

=> A reaction turbine develops power from the combined action of pressure & moving water. the runner is placed directly in the water stream flowing over the blades rather than striking each indvidualy.

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

Types of Reaction Turbines:-

(i) Propeller Turbine
(ii) Francis "
(iii) Kinetic "

(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 runing in a pipe.

=> The pitch of the blades may be fixed or adjustable. they have more four types.

(i) Bulb Turbine
(ii) Straflo Turbine
(iii) Tube Turbine
(iv) Kaplan Turbine

(i) **Bulb Turbine:** The turbine & generator are a sealed unit placed directly in the water stream.

(ii) **Straflo Turbine:** The generator is attached directly to the perimeters of the turbine.

(iii) Tube Turbine: The penstocks bends just before or after the runner.

(iv) Kaplan Turbine: Both the blades & the wickets gates are adjustable, allowin for a widder range of operation.

(2) Francis Turbines:

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

(3) Kinetic Turbines: Kinetic turbine 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 utilized the water stream's natural

Pathway. Kinetic system do not required large civil works however they can use existing structures such as bridges & channels.

Selection of Turbines:

=> Net Head
-> Range 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 also be selected on the basis of their output power & rated discharge.

Kaplan / Francis Decision.

- **Kaplan**

-> Smoth operation to low flow.
-> Higher effeciency over a wide range
-> May result in a single unit instead of two francis.
-> Higher specific speed & rotational speed (smaller generator)

- **Francis**

-> Less expansive

Francis / Pelton decision

- **Pelton**

-> Less excavation cost
-> Better for erosive water
-> Better Part load efficiency
-> Less sensitive to head variation
-> wide operating range.
-> lower maintanance cost

- **Francis**

-> Higher specific speed & rotational speed.
-> Higher Peak efficiency.

Specific Speed for Diff Turbines

Types	Speed	Refrence
Pelton wheell	$ns = \frac{85.49}{(h)^{0.243}}$	siervo & Lugarest 1978
Francis	$ns = \frac{3763}{(h)^{0.854}}$	schweiger & Gregory 1989
Kaplan	$ns = \frac{2283}{(h)^{0.56}}$	//
Cross flow	$ns = \frac{513.25}{h^{(0.5)}}$	KPordze & warnick 1983
Bulb	$ns = \frac{1520}{h^{(0.2)}}$	//

Q:2 (b)

Ans:

Given data:

Head = h = 190m

Discharge = q = 2.2 m^3/s

overall efficency = η = 85% or 8.5

Solution:

using formula to calculate specific speed.

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

$$ns = \frac{85.49}{(190)^{0.243}} = 23.88 \text{ rpm}$$

using $P = \eta \rho q g h$ to obtained power output

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

$= 3485.5 \text{ KW}$

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

$= 285.32$ rpm

The no of poles required are computed by

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

$$P = \frac{120 \times 50}{285 \cdot 32}$$

$P = 21.02$ poles

we will select 24 Poles will rotate at 250 rpm at 50Hz. So the turbine will have diameter which can be calculated are

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

$= 2.12m$

For calculating Jet diameter

$$Q = \pi d_j^2 (Us)/4$$

Jet velocity $= u_j = \sqrt{2gh}$

$= \sqrt{2 \cdot 98 \times 190}$

$= 6105 m/sec$

Therefor Jet diameters will be

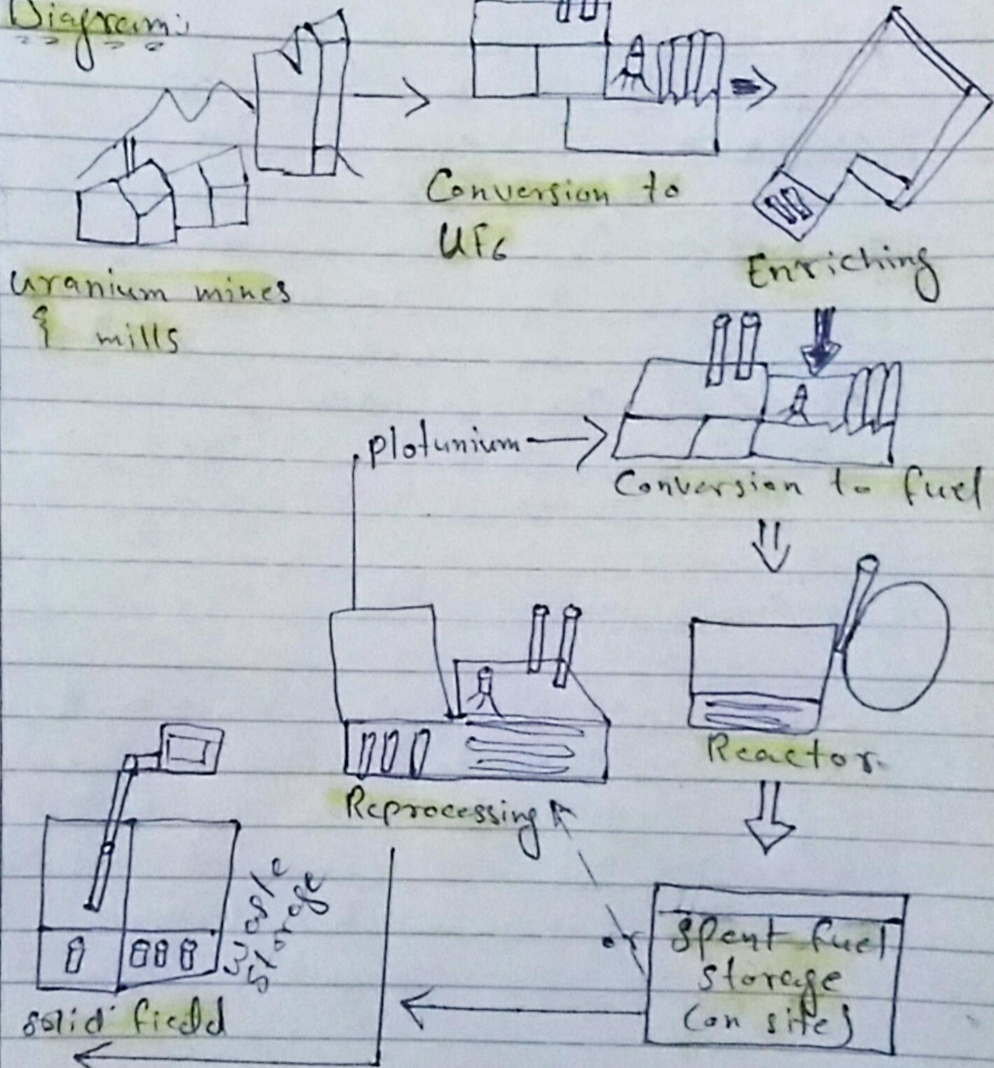
$$d_j \sqrt{\frac{4Q}{\pi u_j}} = \sqrt{\frac{4 \times 2 \cdot 2}{3.14 \times 61.05}}$$

$= 0.214m$

or $d_j = 21.4cm$

Q:3 Ans:

Diagram:



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 & ground to a fine slurry which is leached in sulfuric from the waste rock.
→ it is then recoverd from solution as uranium oxide (U_3O_8) Concentrate.
Somtimes this is Known as "Yellowcake"

(2) 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.

(3) Enriching:

⇒ Need to enrich uranium to at least 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
- Low velocity U-238
- High velocity U-235

Centrifuge Method:-

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

(4) fuel conversion:

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

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

=> The rods are then sealed & assembled in clusters to form fuel assemblies for use in the core of the nuclear reactor.

(5) Fuel Packaging in the Core:

=> Rods contain uranium enriched.

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

(6) The 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 & slow the chain reaction.

=> Control rods are made of cadmium, which absorb neutrons effectively.

(7) Moderators:

=> Neutrons produced during fission in the core are moving 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 the moderator.

(8) 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 & the remaining 1% is plutonium produced while the fuel was in the reactor.
=> Reprocessing extracts useable fissile U-238

(9) Nuclear waste Disposal:-

=> In the US no high level nuclear waste is ever disposed of it site is specially designed pools resembling large swimming pools (water cools the fuel & acts as a radiation shield) or in specially designed dry storage Containers.