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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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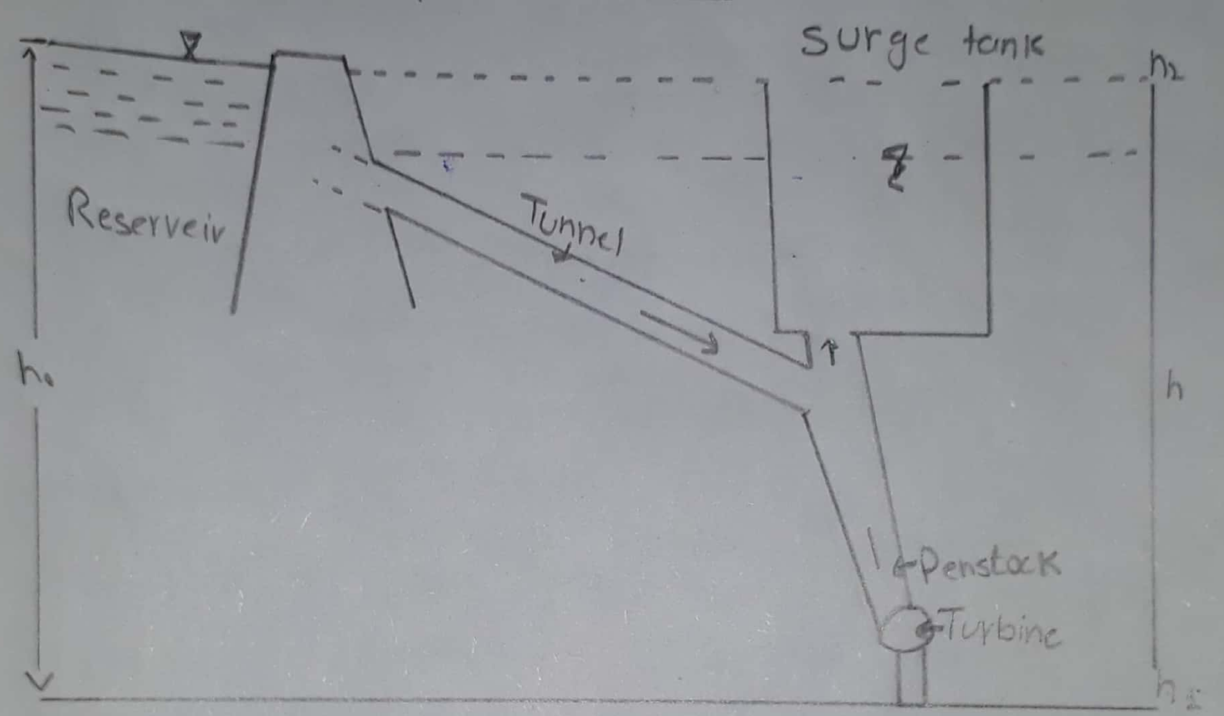
Question #01:

Part (a):

Answer:

Hydro-power plant:-



History:

- Hydro-power plant is power derived from the energy of falling or running water.
- First used by Greeks for grinding wheat.
- In 1753, French engineer Bernard Forest first give an idea about the use of hydropower.
- By late 19th Century, the electrical generator was developed.

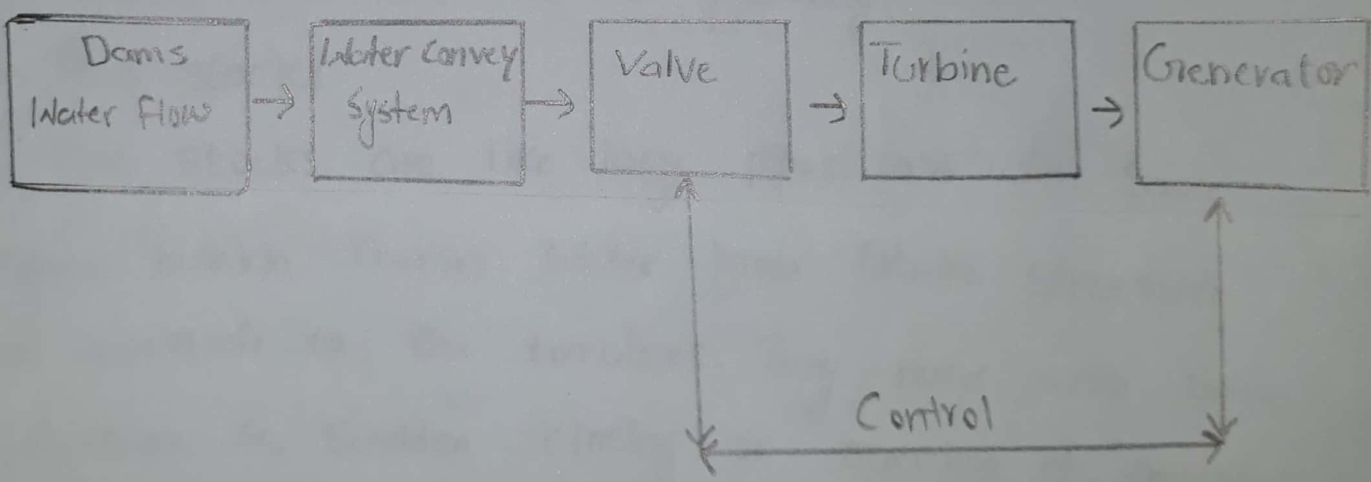
Hydro - Electricity:

Hydro-electricity is the term referring to electricity generated by hydro-power; the Production of electrical power through the Use of the gravitational force of falling or flowing water.

About 16-18% of global electricity generation.

Total Install Hydro-power Capacity is about 630 GW.

Hydro-Electric General Layout.



Components of Hydro-power plants:

1- Force-bay:

Force bay is a basin area of hydro-power plant where water is temporarily stored before going intake chamber. The storage of Water in Force bay decided based on required water demand in that area. The Water stored on the upstream side of DAM Can be Carried by penstocks to power house. In this case the Reservior as act as a forebay.

2- Pen stock:

Pen stocks are like large pipes. laid with Same Slope which Carries water from intake structure or reservoir to the turbines. They runs with some pressure. So, Sudden closing or opening of penstock gates. Can Cause water hammer effect to the Penstock.

3- Surge Chamber:

A Surge Chamber is a Cylindrical tank which is open at the atop to control the pressure in Penstock. It is Connected to pen-stock as closed as possible to the power house. There are different types of Surge tank available and they are selected based on the requirements of plant, length of Penstock.

4- Hydralic Turbines:

Hydralic turbine a device which Can Convert the hydralic energy into mechanical energy which again Converted into electrical energy by Coupling the Shaft of turbine to generator.

5- Power House:

Power house is a building provided to Protect the hydralic and electrical equipments.

p.

Question # 01

Part (B)

Given Data:

Hydratic efficiency : 85% or 0.85

available head : h : 100m

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

Electrical efficiency : 95% or 0.95

Over-all efficiency : $0.85 \times 0.95 = 0.80$

Required:

Capacity of Generator = E = ?

Formula Using:

$E = n\rho g h V$

Solution:

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

$E = 800 \times 981 \times 5 \times 10^5$

$E = 3920000 \times 10^5$

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

Question#02

Part(a):

Answer:

Turbine:

Is a rotary mechanical device that extract energy from a "fluid flow" and Converts it into useful work.

Types of Hydro-power Turbines:

There are two types of Hydropower turbines

1 Impulse Turbine
2 Reaction Turbine.

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 as well as pressure energy both are available.

types of Impulse Turbines:

1- 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.

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 blade & exit on the other.

2 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 frome 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 portion of the runner. The cross-flow was developed to accommodate larger water flows & lower heads than the Pelton.

2- Reaction Turbine:

→ The 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 turbine.

Types of Reaction Turbines:

1- Propeller Turbine:

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

The pitch of the blades may be fixed or adjustable.

Bulb turbine, straflo turbine, Tube turbine and Kaplan turbine are the types of Propeller turbine.

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

Parameters For Hydropower turbines Selection:

Head and Flow. In order to create electricity from hydro-power two parameters are critical:

Flow; or the minimum amount of water that is constantly available throughout the entire year.

Head; the difference in height

Question # 02

Part (B):

Given Data:

Head height = $h = 190m$

Discharge = $q = 2.2\ m^{3}/s$

Overall efficiency = 85% or 0.85

Required:

Select suitable turbine for hydro power scheme and determine turbine diameter & jet diameter?

Solution:

At a head of 190m, a sigle jet peston wheel turbine seeme most suitable so we can use following formula for calculated specific speed.

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

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

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

The output power can be obtained by using

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

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

$= 850 \times 21.582 \times 190$

$= 3485493$

$= 3485.4 \times 10^3$ W

$= 3485.4$ KW

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

$$= 23.88 \times \frac{(190)^{3/4}}{\sqrt{3485.4}}$$

$$= \frac{1222.079}{59.037}$$

$= 25532$ rpm

an alternater rated at 50Hz frequency with Synchronous speed approching 285.32 rpm but not greater is to be selected. The no of plus required are conputed by using

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

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

$$P = \frac{120 \times 50}{285.31}$$

$= 21.02$ poles.

Slecting 24 poles alternator will rotate at 250rpm at 50 Hz seems just right the turbine will have diameter which can be determied by using equation

$$D = 38.567 \times \frac{\sqrt{h}}{\eta}$$

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

$D = 2.12\,m$

The jet - diameter can be calculated by using equation

$$q = \pi\, dj^2\, (vj)/4$$

The jet velocity $= v_j = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 190}$

$v_j = 61.05\, m/sec$

jet diameter :

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

$d_j = 21.4\,cm$

Question#03

Answer:

Stages of Nuclear Fuel Cycle:

The nuclear fuel cycle represents the progress of nuclear fuel from creation to disposal.

The Nuclear fuel typically include the following stages.

Mining and Milling:

→ Uranium is usually mined by either surface 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 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.

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 hexafloori de (UF_6) at the conversion plant.

Enriching:

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

→ Two methods of Enriching

1) Gaseous Diffusion method
2) Centrifuge method.

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 Reactor Core:

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

→ Fuel rods contain enriched urainum.

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

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 neutron.

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

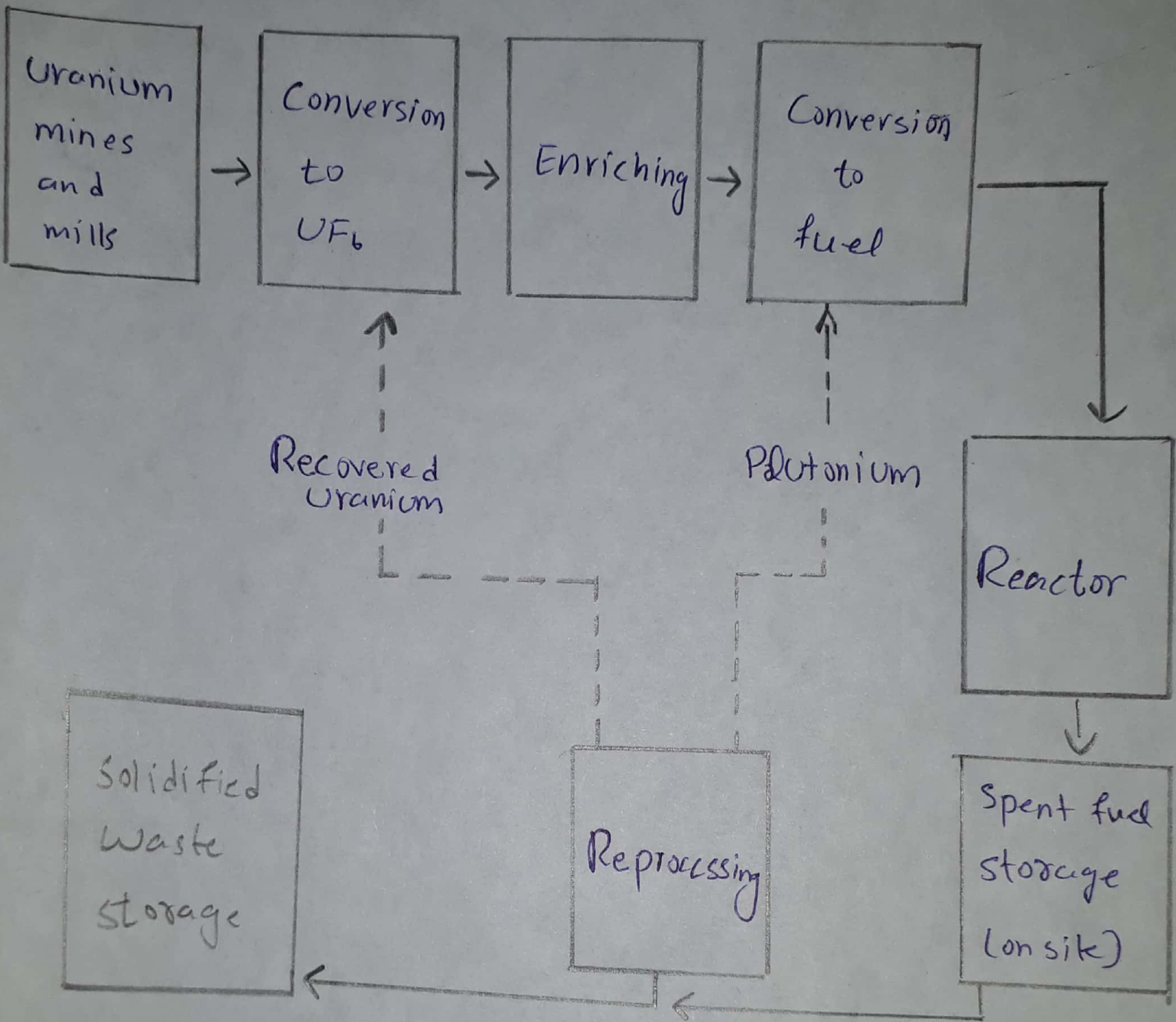
Uranium Reprocessing:

- Spent fuel still contains appoximately 96% of its original uranium, of which the fissionable U-235 content has been reduced to less than 1%.
- Reprocessing extracts useable fissile U-238.
- Most of the spent fuel can be reprocessed.

Nuclear Waste Disposel:

- In the US no high-level nuclear waste is even disposed of-it sits in specially designed pools resembling large swimming pools.
- 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 puplic heath.

Diagram:


Uranium mines and mills
Conversion to UF_6
Enriching
Conversion to fuel
Recovered Uranium
Plutonium
Reactor
Solidified Waste storage
Reprocessing
Spent fuel storage (on site)