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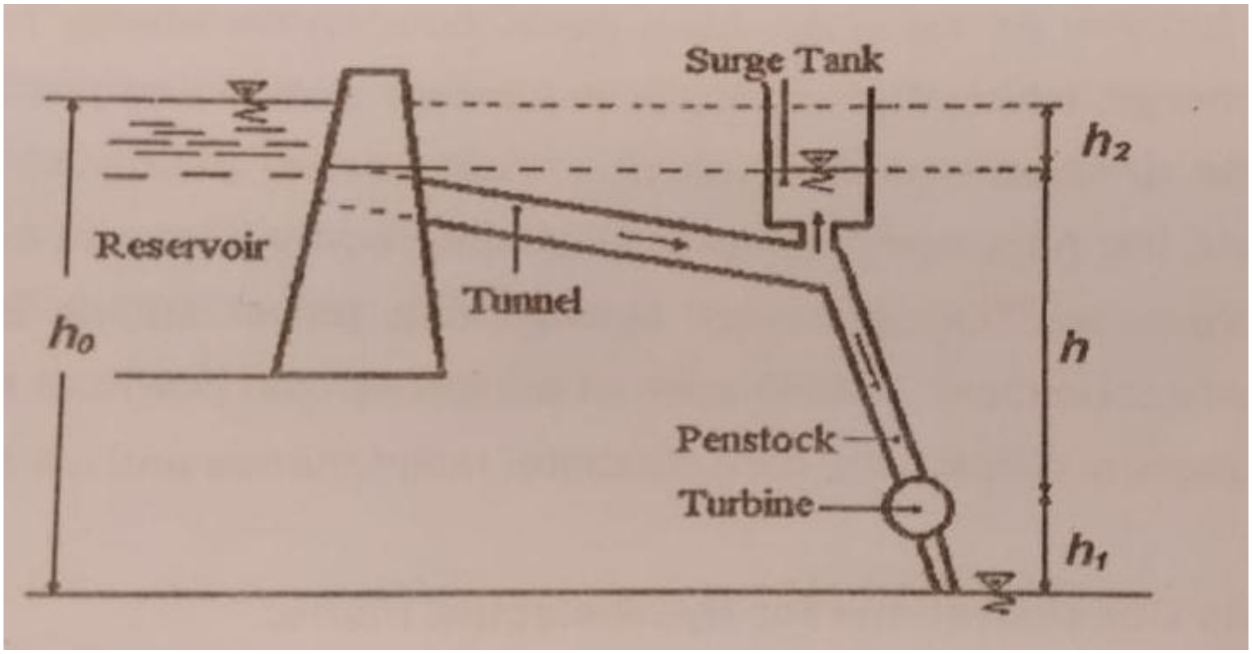
Power Generation

Terminal Examination *course Instructor: Engr.Sanaullah Ahmad*

Note: Attempt all Questions & Draw diagrams where necessary.	
Question No 1 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	***20***
Question No 2 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	***20***
Question No 3 Explain different stages of Nuclear Fuel Cycle? CLO 1	***10***

Answer 1A



Tunnel

The focusing on reconstruction and improvements of the tunnel system for upgrading of hydropower plants to peaking or pumped storage plants.

Reservoir

a large natural or artificial lake used as a source of water supply. "the more water we use, the more land has to be flooded for reservoirs"

Penstock

A penstock is a sluice or gate or intake structure that controls water flow, or an enclosed pipe that delivers water to hydro turbines and sewerage systems. The term is inherited from the earlier technology of mill ponds and watermills.

Turbine

Hydro turbines are devices used in hydroelectric generation plants that transfer the energy from moving water to a rotating shaft to generate electricity

Surge tank

Surge tanks are applied in hydropower plants to reduce the pressure forces during acceleration of the water, and to enable speed governing of the turbines.

Answer 1B

Given that:
Available volume at pondage: V = 5 x 105m3
Hydraulic efficiency: 85% 0.85
Available head: h = 100m
Electrical e efficiency: 0.94
Therefore: Overall efficiency:
0.85 x 0.94= 0.80
Using: E= n.p.g.h.V = 0.8 x 1000 x 9.81 x 100 x 5x 105
E = 3.92 x 10^ 11 W-s

Answer 2A

Turbine

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

Types of hydropower turbines

1. Impulse Turbine
2. Reaction Turbine

1. Impulse

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 Turbines

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 and exits on the other side.

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 portion of the runner. The cross-flow was developed to accommodate larger water flows and lower heads than 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 flows than compared with the impulse turbines.

Types of Reaction Turbines

(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 running in a pipe.
The pitch of the blades may be fixed or adjustable.

Types of Propeller turbines

Bulb Turbines

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

Straflo Turbines

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

Tube Turbines

The penstock bends just before or after the runner.

Kaplan Turbines

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

(ii)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.

(iii)Kinetic Turbines

Kinetic turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water. The systems 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 for selecting Turbine

- ✓ Height of standing water "head"
- ✓ Flow of water
- ✓ Volume of water
- ✓ How deep the turbine must be set
- ✓ Efficiency
- ✓ Cost
- ✓ Net Head
- ✓ Range of Discharge through turbine
- ✓ Rotational Speed

Q-2(b)Select a suitable turbine for a hydropower scheme with available head height of 190m and rated discharge of 2.2 m2/s with overall efficiency of 85%?

Also determine turbine diameter and jet diameter? Specific speed *Ns = 85.49/ (h)0.243. Diameter = 38.56 h/n. Jet Diameter q= (Πdj2)Vj/ 4 where Vj =* 2*gh* CLO 2

Answer 2B

Given data

Height h=190 m

Discharge q= 2.2 m2/s

overall efficiency =85%

At a head of 190 meter, a single jet pelton wheel turbine seems must suitable therefore from table,

The specific speed can be calculated by using

$Ns=85.49/(H)^{0.243}$

$Ns=85.49/190^{0.243}$

Ns=23.68

The power can be obtained by using

P= η.ρ q **g h**

P=0.85x1000x2.2.x9.8x190

$P=3485.5KW$

Using equestion

$N=[NS\ (H)^{5/4}] / \sqrt{P}$

$=23.68x(190)^{5/4} / \sqrt{3485.5}$

$N=285.32$ Rmp

An alternator rated at 50 Hz frequency with synchronous speed approaching 285.32 rpm but not greater is to be selected. the number of poles required are computed by using

$Ns=120f/p$

$p =120x50/285.32$

$p =21.02$ poles

selecting 24 poles alternator will rotate at 250 rpm at 50 Hz seems just right. This turbine will have a diameter which can be determined by using equation

$D=(38.567\ \sqrt{h})/n$

$=(38.567\ \ x\ \ \sqrt{192})/250$

$=2.12m$

Jet diameter can be calculated

$q=(ndj/h)vg$

the jet velocity is $vg =\sqrt{(2gh)}$

$=\sqrt{(2(9.8)(190))}$

$=61.05m/s$

$Ddj= V(4q/\pi vg)$

$=\sqrt{(4x2.2/3.14x61.05)}$

$=0.214m$

Thus turbine will have a standard diameter of 2 meter defined as the diameter of circle describe the buckets center line and diameter of jet is 20 cm

Answer 3

Nuclear energy

Nuclear energy is a powerful source of energy, generated during a nuclear reaction, by change in the nucleus of an atom. The source of nuclear energy is the mass of the nucleus and energy generated during a nuclear reaction is due to conversion of mass into energy (Einstein's Theory).

Different stages in Nuclear Energy

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 (metal)is crushed and ground to a fine slurry (thin liquid mixture) which is leached(filter) 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) 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

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

Moderators

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**

Light vs. Heavy Water

99.99% of water molecules contain normal hydrogen (i.e. with a single proton in the nucleus)
Water can be specially prepared so that the molecules contain deuterium (i.e. hydrogen with a proton *and* a neutron in the nucleus)
Normal water is called *light water* while water containing deuterium is called *heavy water*
Heavy water is a much better moderator but is very expensive to make

Boiling Water Reactor (BWR)

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 (PWR)

Water in the core heated to 315°C but is not turned into steam due to high pressure in the primary loop.
Heat exchanger used to transfer heat into secondary 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 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