Department of Electrical Engineering

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13122

Final Assignment

POWER GENRATION

SUMMER-2020 Dated 24-9-2020

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QUESTION: 1 (A)
ANSWER:

Main Elements of Hydroelectric Power Plant:

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 reservoir is a lake in high mountains and an artificial reservoir is made by constructing a dam across the river. Low head plants require very large storage reservoir. The capacity of reservoir depends on the difference between runoffs during high and lean flows.

Element # 2. Dam:

The function of dam is not only to raise the water surface of the stream to create an artificial head but also to provide the pondage, storage or the facility of diversion into conduits. A dam is the most expensive and important part of a hydro-project. Dams are built of concrete or stone masonry, earth or rock fill.

The type and arrangement depends upon the topography of the site. A masonry dam may be built in a narrow canyon. An earth dam may be best suited for a wide valley. The choice of dam also depends upon the foundation conditions, local materials and transportation available, occurrence of earth quakes and other hazards.

Element # 3. Forebay:

The forebay serves as a regulating reservoir storing water temporarily during light load period and providing the same for initial increase on account of increasing load during which water in the canal is being accelerated. In short, a forebay may be considered as an enlarged body of water just above the intake to store water temporarily to meet the hourly load fluctuations. This may either be a pond behind the diversion dam or an enlarged section of a canal spread out to accommodate the required widths of intake.

Where the hydroelectric plants are located just at the base of the dam, no forebay is required because the reservoir itself serves the purpose of the forebay. However, where the plants are situated away from the storage reservoir a forebay is provided.

Element # 4. Spillway:

This is constructed to act as a safety valve. It discharges the overflow water to the down-stream side when the reservoir is full, a condition mainly arising during flood periods. These are generally constructed of concrete and provided with water discharge opening shut off by metal control gates. By changing the degree to which the gates are opened, the discharge of the head water to the tailrace can be regulated in order to maintain the water level in the reservoir.

Element # 5. 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.

Booms prevent the ice and floating logs from going into the intake by diverting them to a bypass chute. Screens or trash racks are fitted directly at the intake to prevent the debris from going into the take. Debris cleaning devices should also be fitted on the trash racks.

Intake structures can be classified into high pressure intakes used in case of large storage reservoirs and low pressure intakes used in case of small ponds provided for storing small amount of water for daily or weekly load variations.

Element # 6. Surge Tank:

A reduction in load on the generator causes the governor to close the turbine gates and thus create an increased pressure in the penstock. This may result in water hammer phenomenon and may need pipe of extraordinary strength to withstand it otherwise the penstock may burst. To avoid this positive water hammer pressure, some means are required to be provided for taking the rejected flow.

This may be accomplished by providing a small storage reservoir or tank (open at the top) for receiving the rejected flow and thus relieving the conduit pipe of excessive water hammer pressure. This storage reservoir, called the surge tank is usually located as close to the power station as possible, preferably on ground to reduce the height of the tower.

QUESTION: 1 (B)
ANSWER:

Given that:

Available volume at pondage:
V = 5 x 105 m3
Available head:
h = 100m

Hydraulic efficiency: 85% 0.85
Electrical e efficiency: 0.94
Therefore:
Overall efficiency: 0.85 x 0.94= 0.80
Using:
E= npghV
E= 0.8 x 1000 x 9.81 x 100 x 5x 105
E = 3.92 x 10^ 11 W-s ANSWER

QUESTION: 2 (A)

Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines.

ANSWER:

There are two main types of hydro turbines: impulse and reaction. The type of hydropower turbine selected is based on the height of standing water—referred 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.

IMPULSE TURBINE:

The impulse turbine generally uses the velocity of the water to move the runner and discharges to atmospheric pressure. The water stream hits each bucket on the runner. There is no suction on the down side of the turbine, and the water flows out the bottom of the turbine housing after hitting the runner. An impulse turbine is generally suitable for high head, low flow applications.

Pelton:

A pelton wheel has one or more free jets discharging water into an aerated space and impinging on the buckets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum tailwater to permit operation at atmospheric pressure.

A Turgo Wheel is a variation on the Pelton and is made exclusively by Gilkes in England. The Turgo runner is a cast wheel whose shape generally 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:

A cross-flow turbine is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. 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.

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.

Propeller:

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. Through the pipe, the pressure is constant; if it isn't, the runner would be out of balance. The pitch of the blades may be fixed or adjustable. The major components besides the runner are a scroll case, wicket gates, and a draft tube. There are several different types of propeller turbines:

BULB TURBINE:

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

STRAFLO:

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

TUBE TURBINE:

The penstock bends just before or after the runner, allowing a straight line connection to the generator.

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

Francis:
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.

Kinetic:

Kinetic energy turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water rather than the potential energy from the head. The systems may operate in rivers, man-made channels, tidal waters, or ocean currents. Kinetic systems utilize the water stream's natural pathway. They do not require the diversion of water through manmade channels, riverbeds, or pipes, although they might have applications in such conduits. Kinetic systems do not require large civil works; however, they can use existing structures such as bridges, tailraces and channels.

QUESTION: 2 (B)
ANSWER:
H = 190m
A = 22 m/s
Percentage = 85%

Ns = 85.49

Diameter = 38.56

Solution:

We know that,

Diameter = 38.56 √ h/µ

Diameter = 38.56 ×16216

D = 625.28896 m

Jet diameter:

$q = (\mu di^2) vi/4$

Q = 34 ×625.288 6102/4

Q = 29951.7

QUESTION: 3
ANSWER:

Different stages of Nuclear Fuel Cycle:

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 (U308) 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 U308 is converted into the gas uranium hexafluoride (UF6) at a conversion plant.

Enriching

• Need to enrich uranium to at least 3% for a power plant
• Two Methods of Enriching
• Gaseous Diffusion Method
– UF6 (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 (UO2) 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
• 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 top 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.