13752

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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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Subject: Power Generation

Q#1(a): A. With the help of a diagram show different Elements of a Hydropower Plant?

Elements of a Hydropower Plant

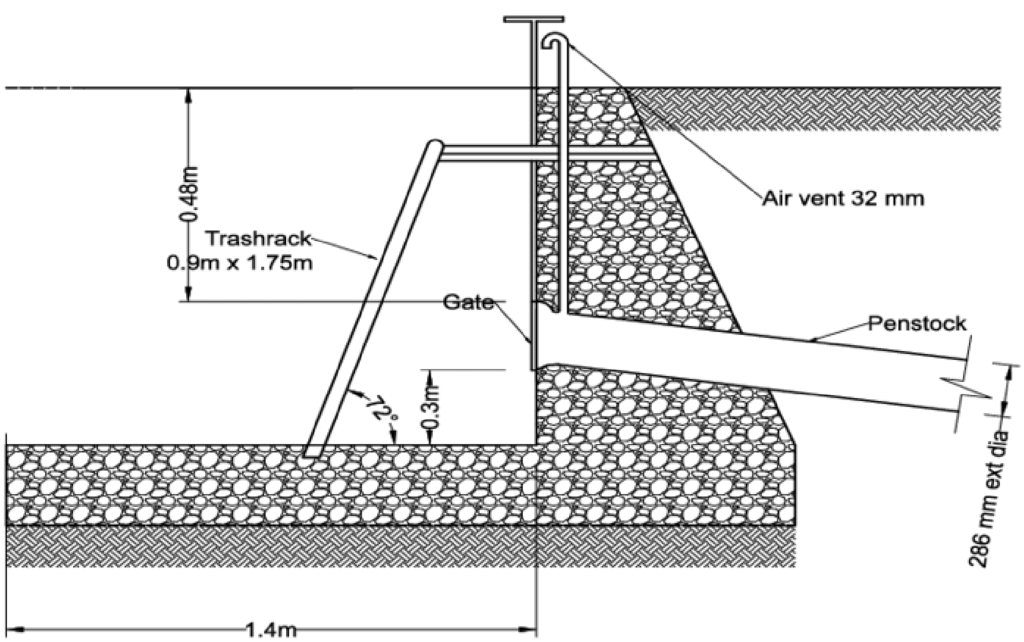
The major elements of a hydroelectric plant are as follows.

1. Forebay

A forebay is a basin area of hydropower plant where water is temporarily stored before going into intake chamber. The storage of water in forebay is decided based on required water demand in that area. This is also used when the load requirement in intake is less.

We know that reservoirs are built across the rivers to store the water, the water stored on upstream side of dam can be carried by penstocks to the power house. In this case, the reservoir itself acts as forebay.

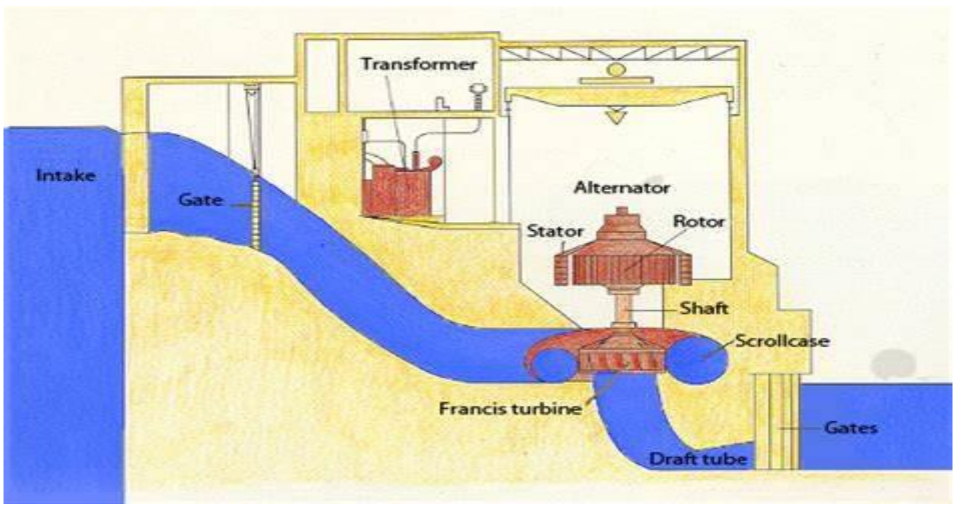
Diagram :



2. Intake Structure:

Intake structure is a structure which collects the water from the forebay and directs it into the penstocks. There are different types of intake structures are available and selection of type of intake structure depends on various local conditions.

Intake structure contain some important components of which trash racks plays vital role. Trash racks are provided at the entrance of penstock to trap the debris in the water.



If debris along with water flows into the penstock it will cause severe damage to the wicket gates, turbine runners, nozzles of turbines etc. these trash racks are made of steel in rod shape. These rods are arranged with a gap of 10 to 30 cm apart and these racks will separate the debris form the flowing water whose permissible velocity is limited 0.6 m/sec to 1.6 m/sec.

In cold weather regions, there is chance of formation of ice in water, to prevent the entrance of ice into the penstocks trash racks heated with electricity and hence ice melts when it touches the trash racks.

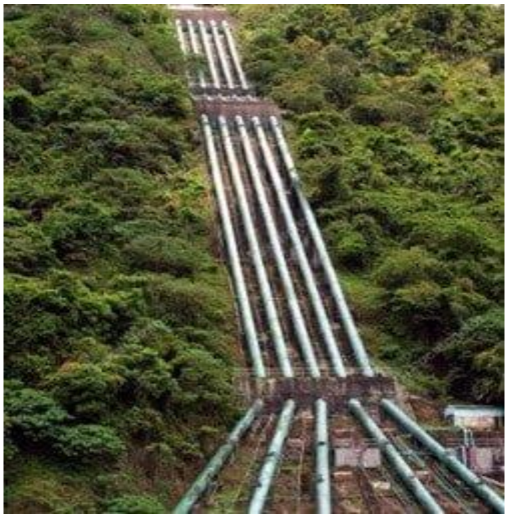
Other than trash racks, rakes and trolley arrangement which is used to clean the trash racks and penstock closing gates are also provided in intake structure.

3. Penstock:

Penstocks are like large pipes laid with some slope which carries water from intake structure or reservoir 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 and 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 and at the end it is separated into branches.



4. Surge Chamber

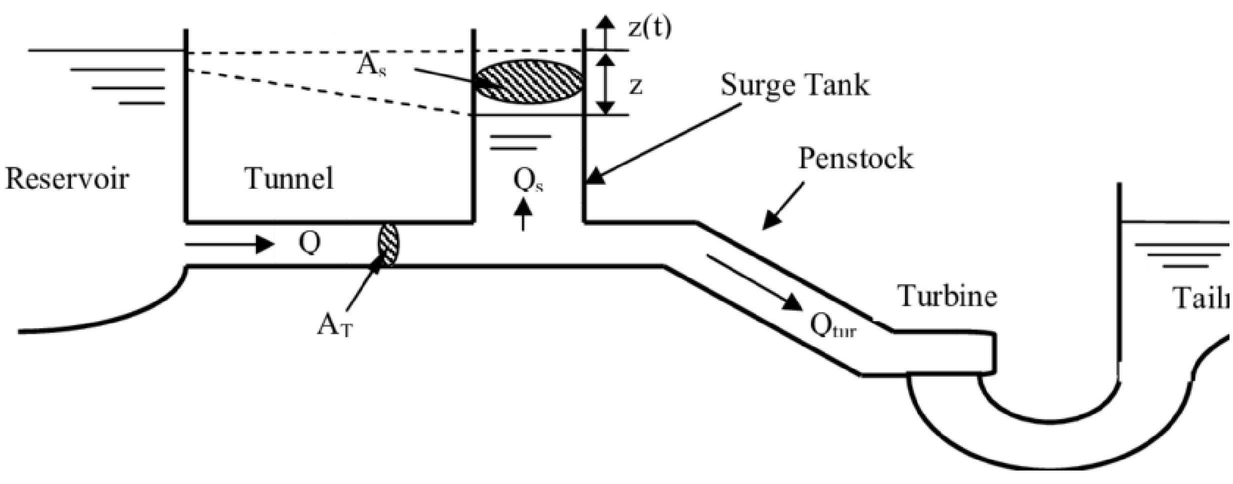
A surge chamber or surge tank is a cylindrical tank which is open at the top to control the pressure in penstock. It is connected to the penstock and as close as possible to the power house.

Whenever the power house rejected the water load coming from penstock the water level in the surge tank rises and 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 and then water level reduces. When the discharge is steady in the power house, water level in the surge tank becomes constant.

There are different types of surge tanks available and they are selected based on the requirement of plant, length of penstock etc.

Diagram :



5. Hydraulic Turbines

Hydraulic turbine, a device which can convert the hydraulic energy into the mechanical energy which again converted into the electrical energy by coupling the shaft of turbine to the generator.

The mechanism in this case is, whenever the water coming from penstock strike the circular blades or runner with high pressure it will rotate the shaft provided at the center and it causes generator to produce electrical power.

Generally hydraulic turbines are of two types namely

- Impulse turbine
- Reaction turbine

Impulse turbine is also called as velocity turbine. Pelton wheel turbine is example for impulse turbine. Reaction turbine is also called as pressure turbine. Kaplan turbine and Francis turbine come under this category.

Diagram:

6. Power House

Power house is a building provided to protect the hydraulic and electrical equipment. Generally, the whole equipment is supported by the foundation or substructure laid for the power house.

In case of reaction turbines some machines like draft tubes, scroll casing etc. are fixed with in the foundation while laying it. So, the foundation is laid in big dimensions.

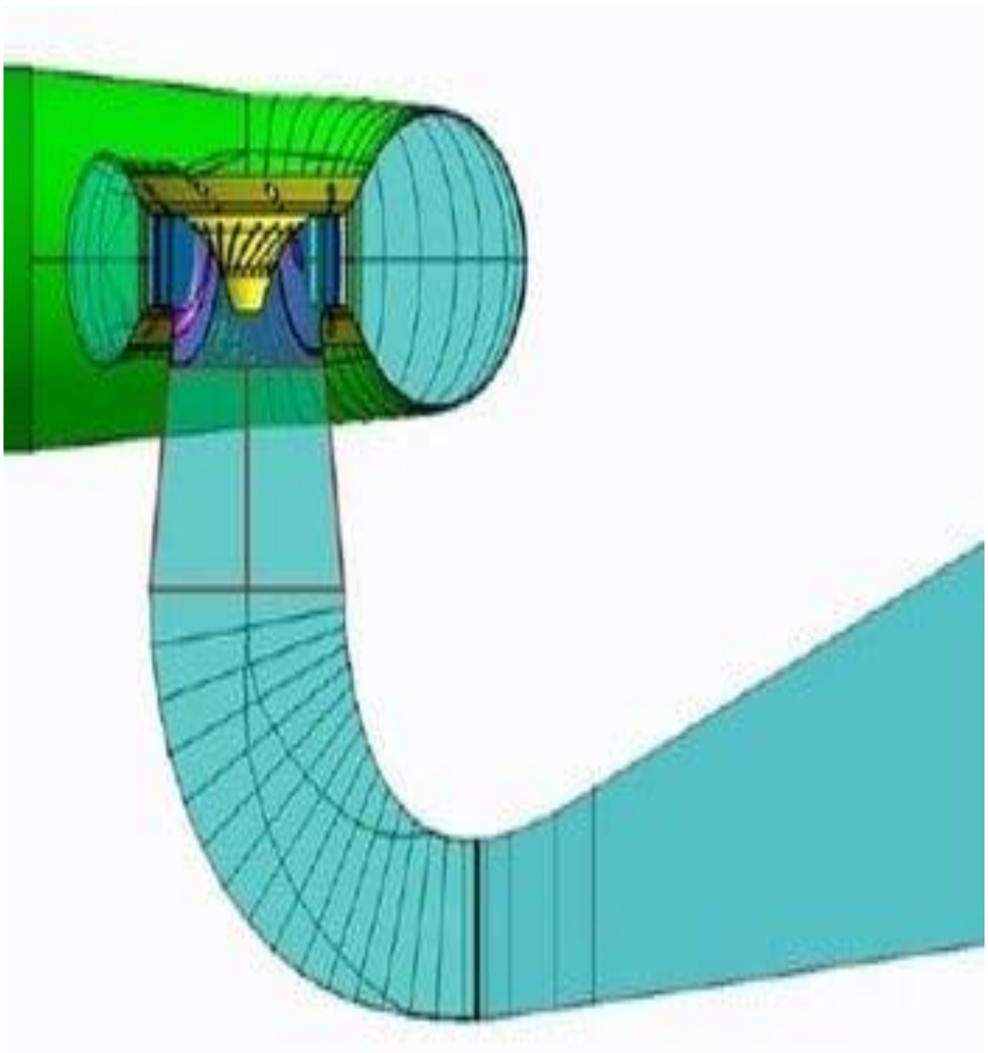
When it comes to super structure, generators are provided on the ground floor under which vertical turbines are provided. Besides generator horizontal turbines are provided. Control room is provided at first floor or mezzanine floor.

Diagram:

7. Draft Tube

If reaction turbines are used, then draft tube is a necessary component which connects turbine outlet to the tailrace. The draft tube contains gradually increasing diameter so that the water discharged into the tailrace with safe velocity. At the end of draft tube, outlet gates are provided which can be closed during repair works.

Diagram:



8. Tailrace

Tailrace is the flow of water from turbines to the stream. It is good if the power house is located nearer to the stream. But, if it is located far away from the stream then it is necessary to build a channel for carrying water into the stream.

Otherwise the water flow may damage the plant in many ways like lowering turbine efficiency, cavitation, damage to turbine blades etc.

This is because of silting or scouring caused by unnecessary flow of water from power house. Hence, proper design of tailrace should be more important.

Diagram:

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Q#1(b):Water for a small hydroelectric station is to be made available from a pondage with a volume of 5 x 105m 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.

Solution :

Given that :

Available volume at ponded : V = $5 \times 10^{11} m^3$

Available head :=100 m

Hydraulic efficiency = 85%=0.85

Electrical efficiency =94%=0.94

Therefore overall efficiency =0.85× 0.94 = 0.80

Using : E = npghV

Putting values in the formula.

=0.8 x 1000 x 9.81 x 100 x 5x 105

E = 3.92 x 10^ 11 W-s

= 0.85 answer

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Q#2(a):Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines

TURBINE:

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

Or

A machine for producing continuous power in which a wheel or rotor, typically fitted with vanes, is made to revolve by a fast-moving flow of water, steam, gas, air, or other fluid.

CLASSIFICATION OF TURBINE:

There are two types of turbines.
1: Impulse turbine
2: Reaction turbine

1: IMPULSE TURBINE:

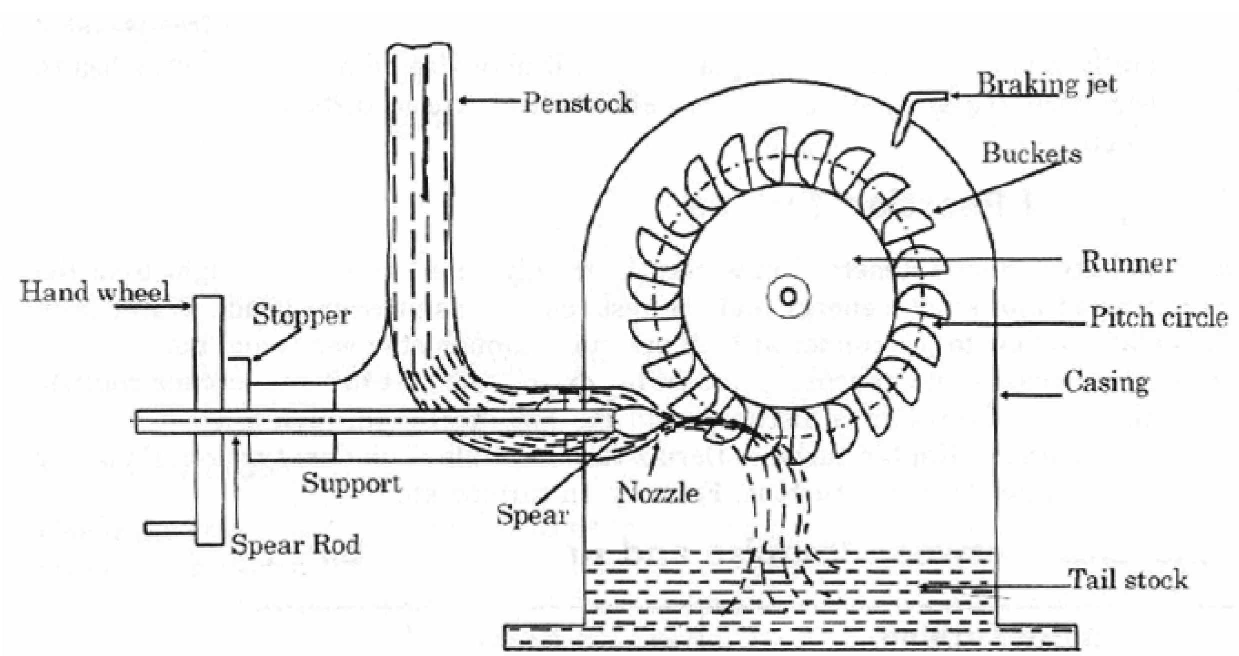
The impulse turbine generally uses the velocity of the water to move the runner. The water stream hits each bucket on the runner. An impulse turbine is generally suitable for high head, low flow applications. In impulse turbine, at inlet, only kinetic energy available. But in reaction turbine, at inlet kinetic energy as well as pressure energy both are available.

Impulse turbine is further classified in to two types.

- Pelton turbine
- Cross-flow turbine

PELTON TURBINE:

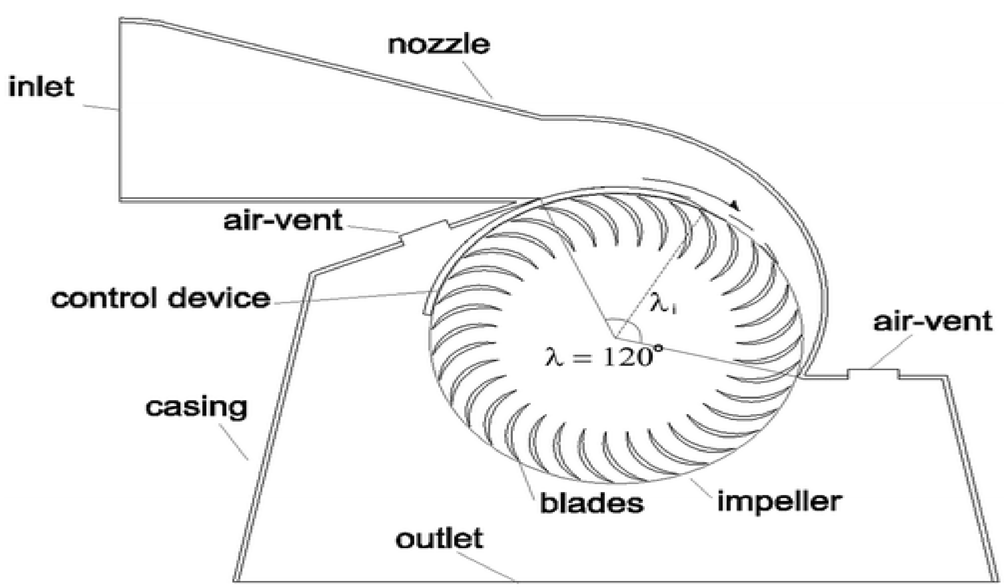
A Pelton wheel has one or more free jets, discharging water on the buckets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum tail water to permit operation at atmospheric pressure. A Turgo Wheel, resembles a fan blade that is closed on the outer edges. The water stream is applied on one side, goes across the blades and exits on the other side. The water in a Pelton turbine is moving quickly and the turbine extracts energy from the water by slowing the water down, which makes this an impulse turbine. When used for generating electricity, there is usually a water reservoir located at some height above the Pelton turbine.
The water then flows through the penstock to specialized nozzles that introduce pressurized water to the turbine. To prevent irregularities in pressure, the penstock is fitted with a surge tank that absorbs sudden fluctuations in water that could alter the pressure.



Cross-flow turbine:

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. These turbines are useful for a large range of hydraulic heads, bfrom only 1.75 meters to 200 meters, although usually crossflow turbines are chosen for heads below 40 meters. Crossflow turbines get energy from water by reducing the velocity, the pressure stays the same, which is why they're impulse turbines.

In addition to being used in smaller hydroelectric facilities, one benefit of these turbines is they require comparatively less complex maintenance to keep them working. Because of this, they are more suitable for use in remote communities. Although useful for a wide range of hydraulic heads and power outputs, generally these turbines are most efficient for low heads and low power outputs. Other turbines are likely more efficient and useful for large-scale applications



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. In a reaction turbine unlike in an impulse turbine the nozzle that discharge the working fluid are attached to the rotor. The acceleration of the fluid leaving the nozzles produce a reaction force on the pipes, causing the rotor to move in the opposite direction to that of the fluid. The pressure of the fluid changes as it passes through the rotor blades.in most case a pressure casement is needed to contain the working fluid as it acts on the turbine. In case of water turbines, the causing also maintains the suction imparted by the draft tube.

Reaction turbine is also classified in three types.

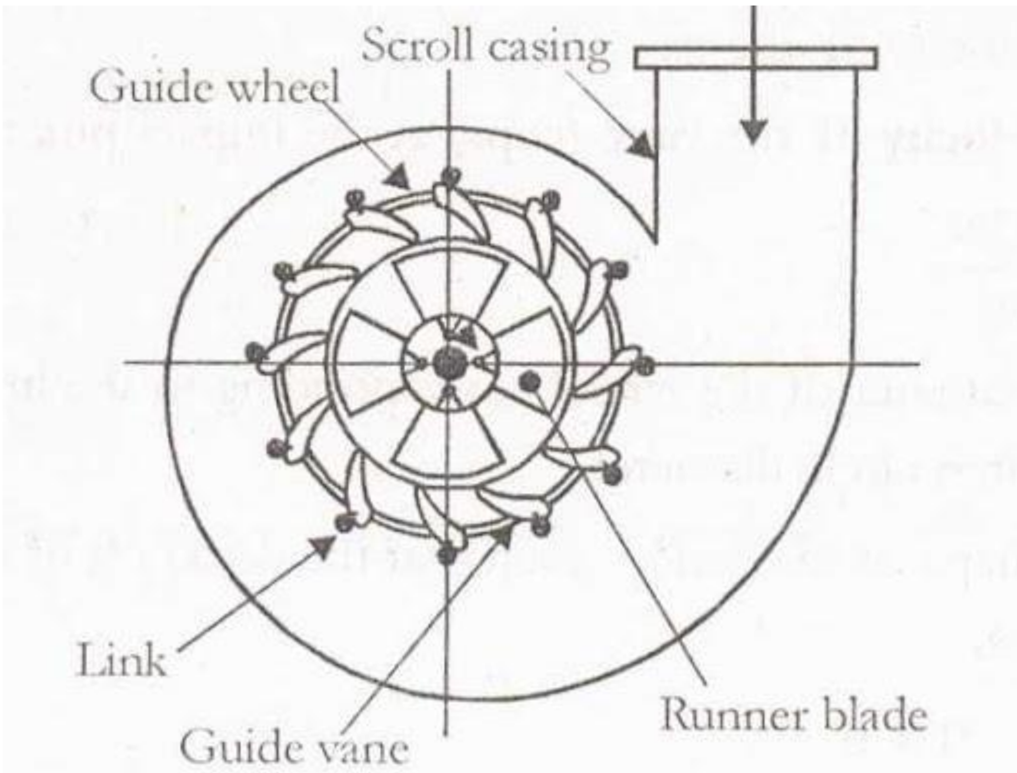
- Propeller Turbine
- Francis Turbine
- Kinetic Turbine

Propeller Turbine:

A propeller turbine generally has a runner with three to six blades in which the water contacts all of the blades constantly. The Propeller Turbine is an inward flow reaction turbine, similar to a Kaplan design, but with fixed blades. It is a very common turbine and works best with high flow rates. Its moving part (runner) is a propeller, similar to those that push ships and submarines through water.

The turbine has adjustable guide vanes that control the water flow in the turbine. They also direct the water at an angle to the back of the propeller. Students learn how the guide vane setting affects how the turbine works. The

turbine has a clear viewing window around the guide vanes and a clear draft tube so that students can see the turbine working.



Types of Propeller turbines:

- Bulb Turbine
- Straflo Turbine
- Tube Turbine
- Kaplan Turbine

Bulb Turbines:

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

Straflo turbine:

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

Tube turbine:

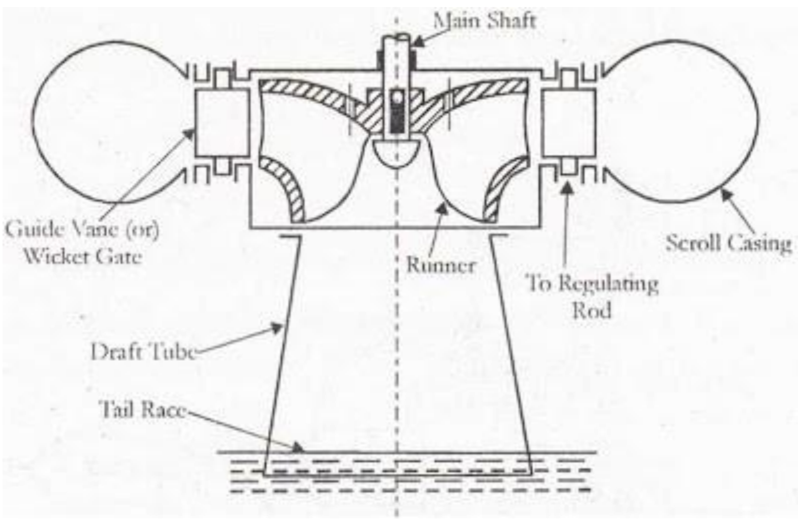
The penstock bends just before or after the runner.

Kaplan turbine:

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

Francis turbine:

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 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.

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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= (∏dj2)Vj/ 4 where Vj = $2gh$.

Given data:

Head =190m
Discharge=2.2m2/s
Overall efficiency= 85% or 0.85
A head of 190m a single jet Pelton wheel turbine seems most suitable.
Therefore, from table we calculate specific speed.

$$Ns = 85.49/\mathbf{190^{0.243}}$$

Speed Ns=23.88 rpm

Now we calculate power.
The output power can be calculated.

P=npqgh watts

P=0.85x1000x2.2x9.81x190

Power P=3485.5kw

Using equation, we have:

$$N = ns\, \boldsymbol{h^{3/4}}/\sqrt{\boldsymbol{p}}$$

$$N = 23.88 \times \mathbf{190^{3/4}}/\sqrt{\mathbf{3485.5}}$$

N=285.32 rpm

Now,

$$Ns=120f/p$$

Or

$$P=120x50/285.32$$

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

Selecting 24 poles will rotate at 250rpm at 50hz seems just right. Thus, will have a diameter which can be determined by using eq.

$$D=38.56 \sqrt{\boldsymbol{h}}/n$$

$$D=38.56\sqrt{\mathbf{190}}/250$$

$$=2.12 \text{ m}$$

1 answer:

DIAMETER IS 2.12 m

The jet diameter can be calculated using equation:

$$q= \pi \boldsymbol{dg}^{2}(vg)/4$$

the jet velocity= vj= $\sqrt{\mathbf{2}\boldsymbol{gh}}$

$=\sqrt{\mathbf{2}\boldsymbol{x}\mathbf{9.8}\boldsymbol{x}\mathbf{190}}$

Vj=61.05m/sec

2 answer:

Jet diameter:

$$dj=\sqrt{\mathbf{4}\boldsymbol{q}}/\pi vj$$

$$=\sqrt{\mathbf{4}\boldsymbol{x}\mathbf{2.2}}/3.14x61.05$$

$$=0.214m$$

So,

Jet diameter Dj= 0.214m

Q#3: Explain different stages of nuclear fuel cycles?

INTRODUCTION :

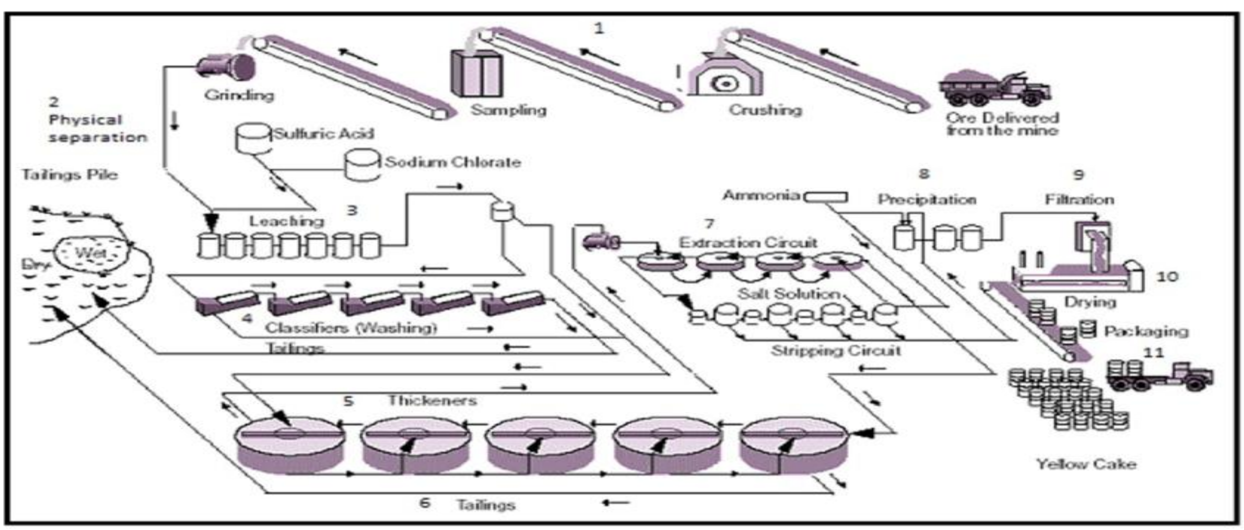
This brochure describes the nuclear fuel cycle, which is an industrial process involving various activities to produce electricity from uranium in nuclear power reactors. The cycle starts with the mining of uranium and ends with the disposal of nuclear waste. The raw material for today's nuclear fuel is uranium. It must be processed through a series of steps to produce an efficient fuel for generating electricity. Used fuel also needs to be taken care of for reuse and disposal. The nuclear fuel cycle includes the 'front end', i.e. preparation of the fuel, the 'service period' in which fuel is used during reactor operation to generate electricity, and the 'back end', i.e. the safe management of spent nuclear fuel including reprocessing and reuse and disposal. If spent fuel is not reprocessed, the fuel cycle is referred to as an 'open' or 'once-through' fuel cycle; if spent fuel is reprocessed, and partly reused, it is referred to as a 'closed' nuclear fuel cycle.

URANIUM MINING:

Uranium is a common metal that can be found throughout the world. It is present in most rocks and soils, in many rivers and in sea water. Uranium is about 500 times more abundant than gold and about as common as tin. There are three ways to mine uranium: open pit mines, underground mines and in situ leaching where the uranium is leached directly from the ore. The largest producers of uranium ore are Kazakhstan, Canada and Australia. The concentration of uranium in the ore could range from 0.03% up to 20%.

URANIUM MILLING :

Milling is generally carried out close to a uranium mine. The mined uranium ore is crushed and chemically treated to separate the uranium. The result is 'yellow cake', a yellow powder of uranium oxide (U3O8). In yellow cake the uranium concentration is raised to more than 80%. After milling, the yellow cake concentrate is shipped to a conversion facility.



ENRICHMENT :

Uranium is enriched in U-235 by introducing the gas in fast-spinning cylinders (‘centrifuges’), where heavier isotopes are pushed out to the cylinder walls. Uranium can also be enriched using older technology by pumping UF6 gas through porous membranes that allow U-235 to pass through more easily than heavier isotopes, such as U-238.

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