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AN OVERVIEW OF HYDRO-ELECTRIC POWER PLANT

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INTRODUCTION

Energy is a critical factor in developing countries for economic growth as well as for social development and human welfare. Hydropower is a renewable source of energy, which is economical, non-polluting and environmentally benign among all renewable sources of energy. For efficient operation of hydropower plants, in order to meet the electricity demand, the hydro energy is stored either in reservoirs for dam based schemes or settling basins for run-of-river schemes. These reservoirs or settling basins are filled with sediments over a period of time. This problem must be taken care of by sediment settling systems in power plants. However, lot of unsettled sediment pass through the turbines every year and turbine parts are exposed to severe erosion. The erosion of hydro turbine components is a major problem for the efficient operation of hydropower plants. These problems are more prominent in power stations which are of run-of-river types. The problem is aggravated if the silt contains higher percentage of quartz, which is extremely hard.

HYDRO POTENTIAL

India is endowed with economically exploitable and viable hydro potential assessed to be about 84,000 MW at 60% load factor. In addition, 6,780 MW in terms of installed capacity from Small, Mini, and Micro Hydel schemes have been assessed. Also, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified. It is the most widely used form of renewable energy. India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario.

The present installed capacity as on September 30, 2013 is approximately 39,788.40 MW which is 17.39% of total electricity generation in India. The public sector has a predominant share of 97% in this sector. National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj Jal Vidyut Nigam (SJVNL), THDC, NTPC-Hydro are a few public sector companies engaged in development of Hydroelectric Power in India.

Bhakra Beas Management Board (BBMB), an illustrative state owned enterprise in north India has an installed capacity of 2.9 GW and generates 12,000-14,000 million units per year. The cost of generation of energy after four decades of operation is about 20 paise/kWh. [citation needed] BBMB is a major source of peaking power and black start to the northern grid in India. Large reservoirs provide operational flexibility. BBMB reservoirs annually supply water for irrigation to 12.5 million acres (51,000 km2; 19,500 sq mi) of agricultural land of partner states, enabling northern India in its green revolution.

HISTORY OF HYDROELECTRICITY

Archaeologists confirm that the history of the storage dam goes back to 5000 years to 3000 BC. Vitruvius was the first architect to explain a water wheel which could generate power. Then Barbegal from France in the 4th century AD worked on water wheels and generated a system of sixteen water wheels which followed the principle of kinetic energy into mechanical energy.

STRENGTHS OF HYDRO POWER

- Environmental friendly, clean renewable
- High degree of flexibility
- Part of multipurpose project with additional benefits.
- Pumped storage for optimal integrate operation of grid

- Least operational and maintenance cost
- Additional benefits of Flood control, Tourism, fishery.
- Well recognized for obtaining financial support.

WEAKNESS OF HYDRO POWER

- Mainlydepends on rainfall/snowmelt.
- Run of river not for peaking
- High capital intensive.
- Remotely located
- Gestation period is very large.
- Relatively smaller units.
- Non standard occurrence.

OPPORTUNITIES OF HYDRO POWER

- Vast potential untapped
- Requirement for power peaking
- Greater concern towards increasing pollutions on land, water and in air causes leading inclination towards hydro
- Depletion of fossil fuels.

THREATS OF HYDRO POWER

- Ambitious plan for thermal/nuclear programme for power.
- Growing concern of environment.
- Prone to natural calamities.
- Submergence of land and displacement of population
- Apprehension on seismic disturbance
- Over emphasis of other renewable energy sources development.

WORKING PRINCIPLE OF HYDRO- ELECTRIC POWER PLANT

In hydroelectric power plants the potential energy of water due to its high location is converted into electrical energy. The total power generation capacity of the hydroelectric power plants depends on the head of water and volume of water flowing towards the water turbine.

The water flowing in the river possesses two type of energy:

- The kinetic energy due to flow of water and
- Potential energy due to the height of water.

In hydroelectric power and potential energy of water is utilized to generate electricity.

The formula for total power that can be generated from water in hydroelectric power plant due to its height is given

P= q*h*g

Where “p” is the power produced in “watt”
“Q” is the rate of flow of water which in cubic meter/second

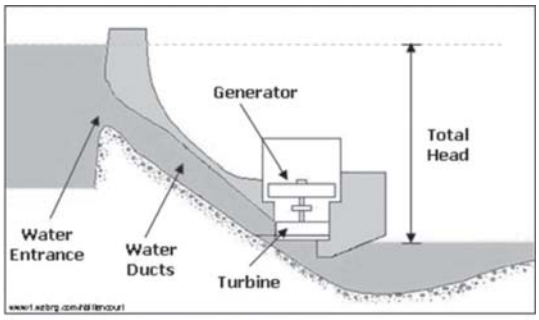

Fig. 1: Hydro Power Principle

“h”= height of water which is measured in “meter”
It’s also head of water.
The difference between source of water (from where water is taken) and the water’s outflow (where the water is used to generate electricity, it is the place near the turbines).
“g” is the gravity constant 9.81 m/second square

The formula clearly shows that the total power that can be generated from the hydroelectric power plants depends on two major factors

a. The flow rate of water or volume of flow of water and
b. Height or head of water.
c. More the volume of water and
d. More the head of water more is the power produced in the hydroelectric power plant.

To obtain the high head of water the reservoir of water should as high as possible and power generation unit should be as low as possible. The maximum height of reservoir of water is fixed by natural factors like the height of river bed, the amount of water and other environmental factors. The location of the power generation unit can be adjusted as per the total amount of power that is to be generated. Usually the power generation unit is constructed at levels lower than ground level so as to get the maximum head of water.

The total flow rate of water can be adjusted through the pen stock as per the requirements. If more power is to be generated more water can be allowed to flow through it.

COMPONENTSOF HYDROELECTRIC POWER PLANTS

Hydroelectric power plant requires various components for generating electrical power. Some of the major components in hydroelectric power plants are: Reservoirs, Dam, Trash Rack, Forebay, Surge Tank, Penstock, Spillway, Prime Mover and Generator, Draft Tube. The functions of all major components are discussed.

The basic requirement of a hydroelectric power station is a reservoir where large quantity of water is stored during

rainy season and used during the dry season. The reservoir is built by constructing a dam across the river. The water from the reservoir is drawn by the forebay through an open canal or tunnel. The water from the forebay is supplied to the water prime mover through the penstock which is located at the much lower level than the height of the water in the reservoir. Thus potential energy of water stored in reservoir is converted into kinetic energy and made to rotate the turbine. Turbine shaft is connected to synchronous generator or alternator for generating electricity. This generated power is stepped up using step-up transformer and delivered to load centers or grid. The regulation of water flow to the turbine depending on the electrical load demand is carried out by the governor system.

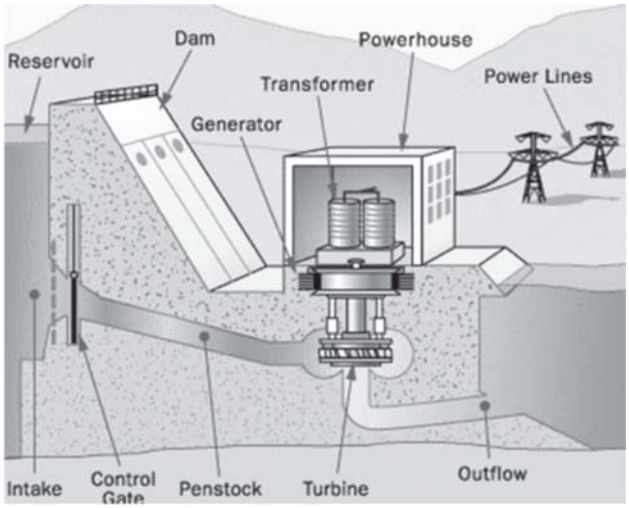

Fig. 2: Components of Hydro Electric Power Plant

Some of the components of hydroelectric power plants and their functions are given below:

WATER RESERVOIR

The function or purpose of reservoir is to store the water during rainy season and supply the same during dry season. This is in simple, water storage area. The water reservoir is the place behind the dam where water is stored. The water in the reservoir is located higher than the rest of the dam structure. The height of water in the reservoir decides how much potential energy the water possesses. The higher the height of water, the more its potential energy. The high position of water in the reservoir also enables it to move downwards effortlessly.

The height of water in the reservoir is higher than the natural height of water flowing in the river, so it is considered to have an altered equilibrium. This also helps to increase the overall potential energy of water, which helps ultimately produce more electricity in the power generation unit.

DAM

The function of dam is to increase the height of the water level (increase in the potential energy) behind it which ultimately increases the reservoir capacity. The dam also helps in increasing the working head of the power plant. Dams are generally built to provide necessary head to the power plant.

TRASH RACK

The water intake from the dam or from the forebay is provided with trash rack. The main function of trash rack is to prevent the entry of any debris which may damage the wicket gates and turbine runners or choke-up the nozzles of impulse turbine. During winter season when water forms ice, to prevent the ice from clinging to the trash racks, they are often heated electrically. Sometimes air bubbling system is provided in the vicinity of the trash racks which bring warmer water to the surface of the trash racks.

FOREBAY

The function of forebay is to act as regulating reservoir temporarily storing water when the load on the plant is reduced and to provide water for initial increment of an increasing load while water in the canal is being accelerated. In many cases, the canal itself is large enough to absorb the flow variations. In short, forebay is naturally provided for storage of water to absorb any flow variations if exist. This can be considered as naturally provided surge tank as it does the function of the surge tank. The forebay is always provided with some type of outlet structure to direct water to penstock depending upon the local conditions.

SURGE TANK

The main function of surge tank is to reduce the water hammering effect. When there is a sudden increase of pressure in the penstock which can be due sudden decrease in the load demand on the generator. When there is sudden decrease in the load, the turbine gates admitting water to the turbine closes suddenly owing to the action of the governor. This sudden rise in the pressure in the penstock will cause the positive water hammering effect. This may lead to burst of the penstock because of high pressures.

When there is sudden increase in the load, governor valves opens and accepts more water to the turbine. This results in creation of vacuum in the penstock resulting into the negative water hammering effect. Therefore the penstock should have to withstand both positive water hammering effect created due to close of governor valve and negative water hammering effect due to opening of governor valve. In order to protect the penstock from these water hammering effects, surge tank is used in hydroelectric power station.

A surge tank is introduced in the system between dam and the power house nearest. Surge tank is a tank provided to absorb any water surges caused in the penstock due to sudden loading and unloading of the generator. When the velocity of the water in the penstock decreases due to closing of turbine valves, the water level in the surge tank increases and fluctuating up and down till its motion is damped out by the friction. Similarly when the water accelerates in the penstock, water is provided by the surge tank for acceleration. Surge tank water level falls down and fluctuates up and down absorbing the surges.

INTAKE OR CONTROL GATES

These are the gates built on the inside of the dam. The water from reservoir is released and controlled through these gates. These are called inlet gates because water enters the power generation unit through these gates. When the control gates are opened the water flows due to gravity through the penstock and towards the turbines. The water flowing through the gates possesses potential as well as kinetic energy.

THE PENSTOCK

The penstock is the long pipe or the shaft that carries the water flowing from the reservoir towards the power generation unit, comprised of the turbines and generator. The water in the penstock possesses kinetic energy due to its motion and potential energy due to its height.

The total amount of power generated in the hydroelectric power plant depends on the height of the water reservoir and the amount of water flowing through the penstock. The amount of water flowing through the penstock is controlled by the control gates.

SPILLWAY

The function of spillway is to provide safety of the dam. Spillway should have the capacity to discharge major floods without damage to the dam and at the same time keeps the reservoir levels below some predetermined maximum level.

POWER HOUSE

A power house consists of two main parts, a sub-structure to support the hydraulic and electrical equipment and a superstructure to house and protect this equipment.

The superstructure of most power plants is the buildings that house all the operating equipment. The generating unit and the exciter is located in the ground floor. The turbines which rotate on vertical axis are placed below the floor level while those rotating on a horizontal axis are placed on the ground floor alongside of the generator.

WATER TURBINES

Water flowing from the penstock is allowed to enter the power generation unit, which houses the turbine and the generator. When water falls on the blades of the turbine the kinetic and potential energy of water is converted into the rotational motion of the blades of the turbine. The rotating blades cause the shaft of the turbine to also rotate. The turbine shaft is enclosed inside the generator. In most hydroelectric power plants there is more than one power generation unit.

There is large difference in height between the level of turbine and level of water in the reservoir. This difference in height, also known as the head of water, decides the total amount of power that can be generated in the hydroelectric power plant.

There are various types of water turbines such as Kaplan turbine, Francis turbine, Pelton wheels etc. The type of turbine used in the hydroelectric power plant depends on the height of the reservoir, quantity of water and the total power generation capacity.

GENERATORS

It is in the generator where the electricity is produced. The shaft of the water turbine rotates in the generator, which produces alternating current in the coils of the generator. It is the rotation of the shaft inside the generator that produces magnetic field which is converted into electricity by electromagnetic field induction. Hence the rotation of the shaft of the turbine is crucial for the production of electricity and this is achieved by the kinetic and potential energy of water. Thus in hydroelectricity power plants potential energy of water is converted into electricity.

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