ELECTRICAL POWER GENERATION, TRANSMISSION & DISTRIBUTION

Module 1

HYDROELECTRIC POWER PLANTS

SELECTION OF SITE FOR HYDROELECTRIC POWER PLANTS

Selection of hydroelectric plants location depends on the following several factors:

Availability of water. Water energy can be available in the form of either potential energy or kinetic energy. To extract the potential energy, a reservoir or pondage is required whereas to extract the kinetic energy run-of-river project is used. In all the cases, a huge amount of water is required. Normally, water is collected in reservoirs during the rain and used for the electricity production throughout the years. Hilly areas are most suitable for hydropower plants.

Storage of water. When the kinetic energy of water is low it is preferable to have the reservoirs to collect the water for use of electricity production. Due to wide variation of rainfall during the year makes it necessary to have the reservoirs. The storage capacity of water is calculated by mass curve. The capacity of plants is based on the water energy available taking into the account of losses due to evaporation and percolation.

Head of water. The availability of head depends upon the topography of the area. High head means high potential energy. To get most economical and effective head, it is necessary to consider all possible factors, which affect it.

Distance from power station to the load centres. The generating stations are normally connected to the main grid through the transmission lines. The costs of transmission lines are also considered during the selection of site.

Accessibility of site. The site should be easily accessed by rail or road for transporting the plant equipments etc.

Others. When deciding the site, some other social factors are also considered, such as the reservoir area should have less impact on the relocation of the human beings from that area. The fertile land can be submerged into water. Also the construction of dams may affect several other impacts on the ecology. The reservoir should not be in seismic zone otherwise any happening may create the flooding of several area, damage of dam, equipments etc.

MAIN COMPONENTS OF HYDROELECTRIC PLANTS

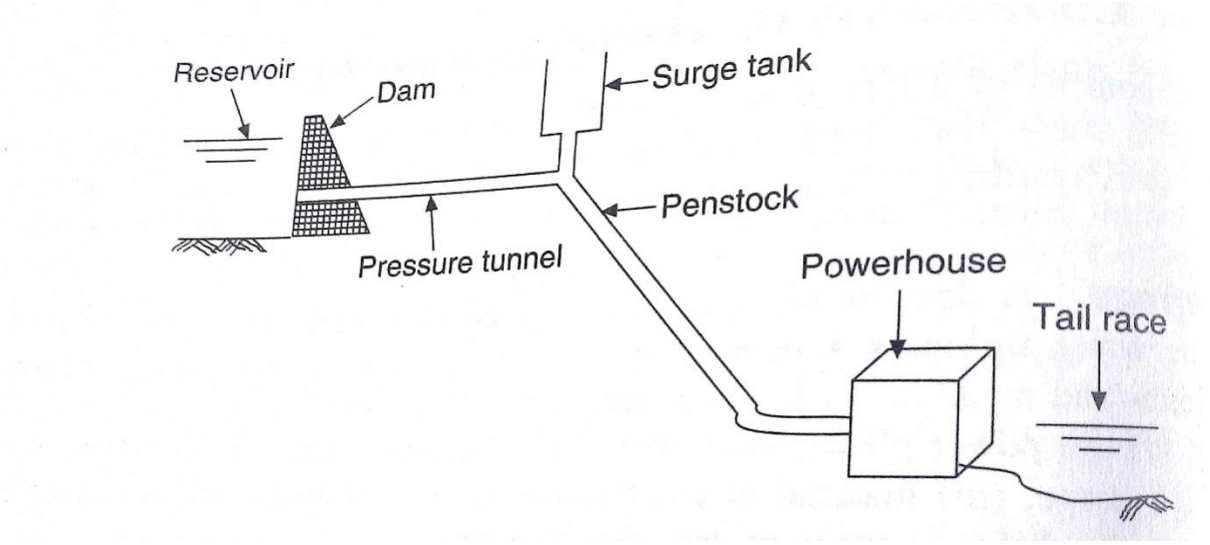
The main components of a typical hydroelectric plant are: dam, reservoir, water conduit system, tailrace, surge tank, trash rack, and powerhouse (which consists of generator, prime mover, switchyards, etc.). Figure 6.6 shows a typical layout of high-head hydroelectric plant.

Dam or barrage. A dam or barrage is constructed to provide a head of water to be utilized in the water turbines. A dam across the river is a very important component in most of the high- and medium-head hydropower plants. Dams are also built on top of hills, in case of pump storage power plants, where is no inflow. Dams can be classified based on their (i) function, (ii) shape, (iii) material of construction and (iv) hydraulic and structural design. Table 6.1 shows the different types of dam classifications.

The main considerations in the choice of dam sites are safety and economy. Other important factors are

1. Geology of foundation,
2. Hydrological considerations and river diversion during the construction,

Layout Of Hydrelectric Power Plant



Reservoir and forebay. The main purpose of a reservoir is to store water which may be used to generate electricity and for irrigation purposes. The water is mainly stored during the rainy season. The capacity of reservoir is decided by the water requirement for power generation. Forebay is a regulating reservoir storing water temporarily when the load on turbine is reduced and provide water when load is increased. It can be considered as the surge reservoir near the intake. This may be a pond behind the diversion dam or canal spread out.

Water-conduit system. A water-conduit system carries water from the reservoir to the turbine of powerhouse through the pressure tunnel or pipes called penstocks those may be laid above ground or underground.

Talirace Water is discharged into the tailrace after passing through the turbine, which carries it into the river. A tailrace is an open channel or a tunnel depending upon the powerhouse location. The discharge from all the turbines is collected in the tailrace at its beginning by means of branch channels. The tailrace may discharge into the original river itself or some other river.

Surge tank. It is provided to act as pressure-release valve of the water-conduit system from the effect of water hammer. When an additional storage space' (called surge rank), near turbine is

provided which stores water during the turbine load reduction and release water when sudden increase in load is required , it controls the pressure variation of penstock and prevents water hammer effect. It is analogous to the flywheel of internal combustion engine.

Different types of surge tanks are being used, namely, simple type, restricted orifice, differential type, expansion chamber type and overflow type.

Trash Rack: It is provided to stop the entry of debris, which might damage the gates and turbine runners or choking of nozzles of the impulse turbines.
It is placed across the intake

Prime Mover: The head of water is converted into the kinetic energy in prime movers , which rotates the shaft of the electric power generators (normally synchronous alternators).Thus, a prime mover, also called a turbine, converts the kinetic and potential energy of water into the mechanical energy.

The commonly used water turbines are Francis, Kaplan, Propeller, Pelton. Normally water turbines rotate on the vertical axis.

Powerhouse : Power house is normally located near the foot of the dam. It may be underground or open type. Water is brought to the power house with the help of penstock and passed to the turbines those rotate the alternators. The location of the power house is decided based on the maximum possible head at the turbine. In powerhouse there are several in house auxiliaries and controls

Spillway: It discharges the excess water of reservoir beyond the full permission level and acts as a safety valve of reservoir. If excess water is not discharged, water level of the reservoir will be raised and water may start flowing over the dam, a phenomenon known as overtopping. The spillways
can be classified as (A) Overflow spillway, (b) side spillway (c) emergency spillway, (d) chute or trough spillway and (e) shaftor siphon spillway

STEAM (THERMAL POWER PLANT

- Steam power is used to rotate the prime mover o the electric generator
- Heat energy → Mechanical Energy → Electrical Energy through Turbine – Generator system.
- Steam power plants are also called Thermal power plants

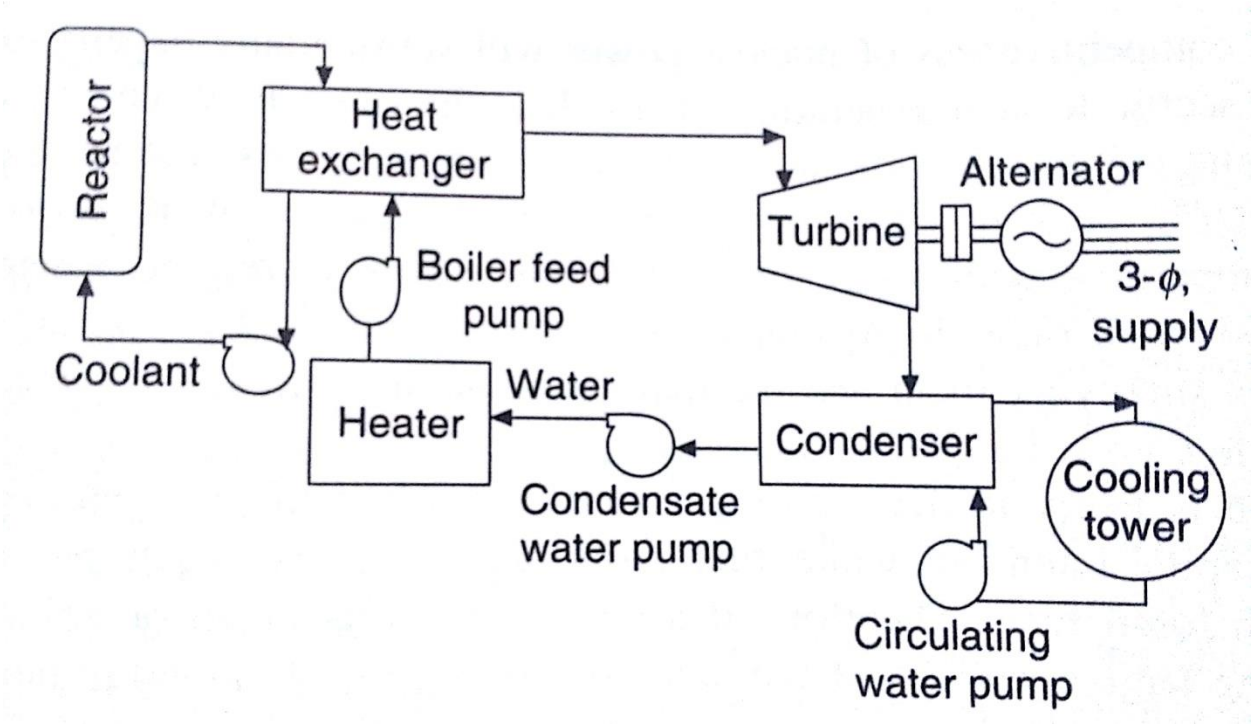
Selection of site or Thermal (Steam power plants

- Availability o land on reasonably cheap or its equipment and or future expansion
- Availability of sufficient & suitable amount of good boiler feed water & cooling water for condenses.
- Availability of fuel and its cost delivered to the boiler furnace.
- These plants can be either near to the coalmines or to the load centers.
- Stations having generating units of 500 MW or more are called super thermal power stations.

Main Flow circuit

- Fuel & ash circuit
- Air & Gas circuit
- Feed water & steam circuit
- Cooling water circuit

LAYOUT OF STEAM POWER PLANT



Main parts of Steam Power Plant

1. Boiler

- Boiler , which is the second tallest part after chimney is used for producing the steam and reheating it.
- Steam boilers are of two types

  1.Water tube Boilers

  2.Fire tube Boilers
- Capacity of steam boiler is epressed as the total heat transferred by the heating surace in BTU per hour.

2. Coal Mines

- Pulverized coal mines are used for drying of coal , Grinding , Separation of particles o desired size , forming proper fuel -air ratio

3. Boiler Feed pump

- A high capacity induction motor is used to feed water to the boiler
- Boiler feed pump is the highest power consuming auxiliaries in steam power plants

4. Air pre heater

- Air pre heaters are used to extract heat from flue gases to combustion air.
- Air pre heaters apply either convection & regeneration principle of heat transmission.

5. Draught System

- Main purpose of draught system is supply air to furnace and to take the flue gases from the boiler
- The pressure difference known as draft and measured in Cm

6. Economizers

- The Economizers are used to extract heat from the flue gases for the heating of feed water.
- It increase the resistance to the flow of flue gases and also reduce their temperature.

.7. Super heaters & Reheaters

- Super heaters are simple heat exchangers for imparting additional energy to steam for a given pressure.

- Reheater is a super heater is designed to bring the partially expanded steam back to superheat temperature by passing it through the tubes.

8. Turbines

- Turbine is used to rotate the synchronous motor , is a device , which convert steam energy to rotational kinetic energy.

9. Condenser

- Steam condenser is a device in which the exhaust steam from engines and turbines is condensed

10. Cooling tower

- Major section of the condensing section

11. Alternators

- Several generating units are used to increase the total capacity of the plant and high speed synchronous generators are used because efficiency of steam turbine is high at high speed.

Nuclear Power Plants

PROS & CONS OF NUCLEAR POWERGENERATION

Pros

- Nuclear fuel is inexpensive ,more available than fossil fuels, and easy to transport
- Nuclear reactors are safe in comparison to fossil fuel methods

Cons

- Cost of fuel is low, actual cost of producing energy is high

Selection of site for Nuclear power plants

I. Availability of water

II. Disposal of waste

III. Away from populated area

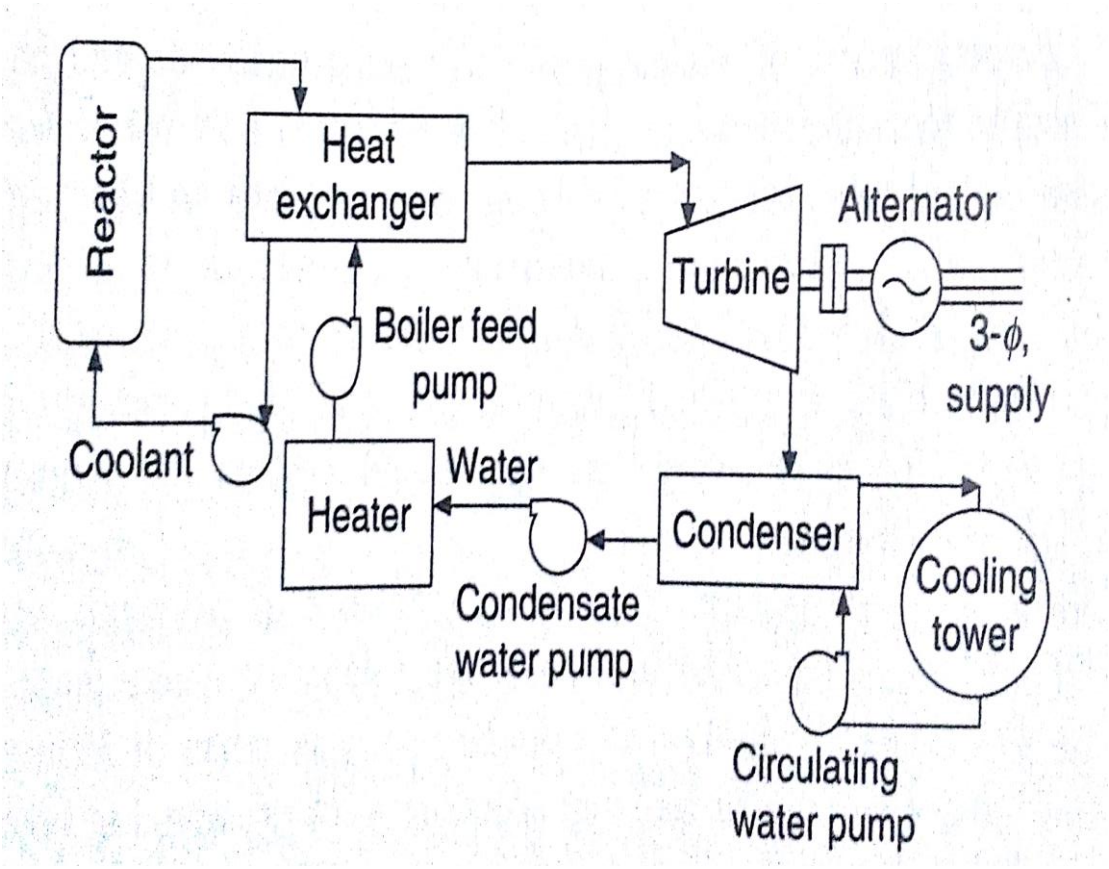
IV. Nearest to the load centres

V. Other factors

Accessibility to the road and rail are general consideration as heavy equipments are to be transported to the sites during construction.

Components of Nuclear power plant

Nuclear power plant using a heat exchanger



GAS POWER PLANTS

Advantages

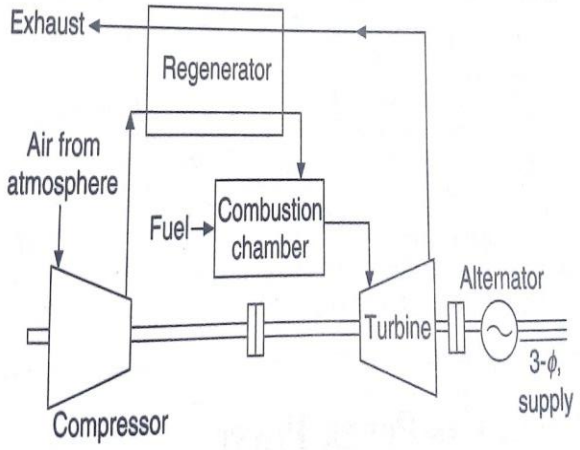
- Gas-Turbine system is a compact and required less space as compared to steam power plants
- Requires fewer auxiliaries and installation takes less time.
- It can be quickly started
- Virtually , there is no water requirement
- The capital cost is comparatively smaller than steam power plants

The efficiency of a simple gas turbine is low, Methods to increase the efficiencies are regeneration and reheating

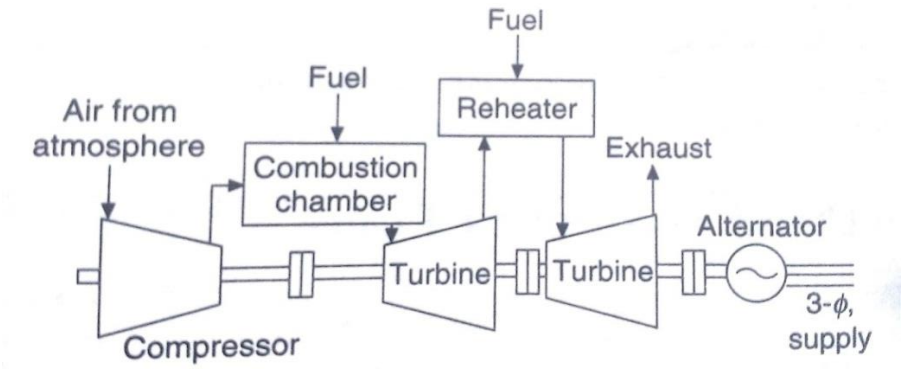
Regeneration: The device used for extracting the heat from heated gas is called regenerator or heat exchanger

Reheater: Partially expanded high temperature gas in turbine can be reheated so that it can be expanded further to produce additional work.

Layout of a gas –turbine power plant with a regenerator



Layout of Gas-Turbine power plant with reheater



DIESEL ENGINE POWER PLANTS

The following measures can be taken to ensure backup power in a crisis

1. Asses the risk
2. Install a standby generator
3. Have sufficient generator
4. Maintain your equipment
5. Contact rental power

Advantages of Diesel Power Plants

1. Capital per KW is low
2. Design and installation are simple and Cheap
3. These can be easily procured , installed and commissioned in less time
4. Compared to the thermal power plants , less space is required for sitting and fuel storage
5. Starting time and stopping time are very less

6. Have good efficiency approx. 40-45% ,which is higher than thermal power plants

Disadvantages of Diesel Power Plants

1. The operating cost of it is very high as diesel is more costly than coal
2. Their repair and maintenance costs are high
3. They have limited overload capacity
4. The noise and air pollution is more.