MODULE- 5

GENERATION, TRANSMISSION, DISTRIBUTION ILLUMINATION & ESTIMATION

5.1 GENERATION

5.1.1 Introduction : Electrical energy is superior to all other forms of energy due to the following resons.

1. Convenient form : It is a very convenient form of energy and can be easily converted into other forms of energy.
2. Easy control : The electrically operated machines have simple and convenient starting, control and operation.
3. Greater flexibility : Electrical energy can be easily transferred from one place to another with the help of conductors.
4. Cleanliness : Electrical energy is not associated with smoke, fumes or poisonous gases.

The conversion of energy available in different forms in nature into electrical energy is known as generation of electrical energy. Energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. These forms of energy can be converted into electrical energy by the use of suitable arrangements. The arrangement usually employs an alternator coupled to prime mover (See fig 5.1). The prime-mover is driven by the energy obtained from various sources.

energy $\xrightarrow{\text{Prime mover}}$ mechan $\xrightarrow{\text{alternator}}$

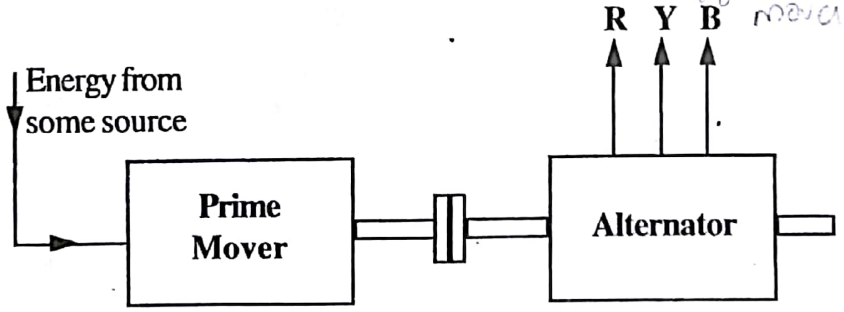

Fig 5.1

where it is converted into mechanical energy. Mechanical output of the pirme mover is further converted into electrical energy by the alternator.

5.1.2. Types of Generation:

Depending upon the form of energy converted into electircal energy, the generating stations are classified as given below.

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Conventional Sources of energy	Non conventional sources of energy
1. Hydro-electric 2. Thermal 3. Nuclear 4. Diesel	1. Solar 2. Wind 3. Wave 4. Tidal 5. Geothermal 6. Magneto hydro dynamic (MHD)

5.1.3. Hydro-electric Power Plants:

Hydro electric (hydel) power plants convert the energy stored in water into electrical energy by the use of water turbines coupled with generators. The water from a height (water head) is allowed to fall on the blades of a turbine through long pipes or tunnels called penstocks. This causes the turbine blades to rotate which in turn rotates the rotor of an alternator.

Depending upon the head or the height from which the water falls, the hydroelectric plants are classified as.

1. High head hydro electric plants : 200m and above
2. Medium head hydro electric plants : 50m to 200m
3. Low head hydro electric plants : Upto 50m

High head hydroelectric plants: A dam is constructed to make a storage reservoir, from where a high pressure tunnel is taken off to the valve house.

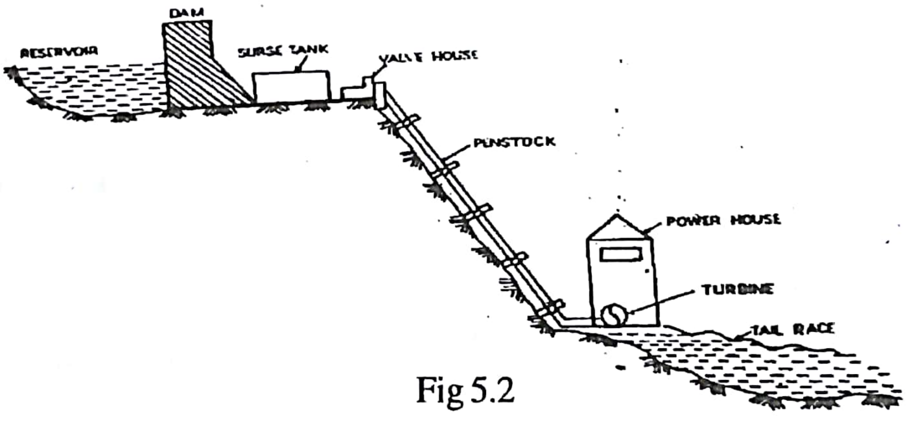

Fig 5.2

The penstocks are large pipes, which carry huge quantity of water from valve houses to the power house. A surge tank is situated just beside the valve house. In case due to reduction of load on the turbines the inlet valves to the turbines are suddenly closed, water hammer due to very high pressure is created which may damage the penstocks. Surge tank absorbs water hummer by increasing the water level and it. In case of heavy load, it will lower its water level and will increase the water supply to the turbine. The common type of turbine (prime mover) used is Pelton wheel.(See fig 5.2)

Medium head hydro electric plants: In these types of plants there is no need of surge tank. Water is generally carried in open channels from the main reservoir and then to the power house through the penstock. The common types of prime movers used in this case are Francis and Kaplan turbines (See fig. 5.3)

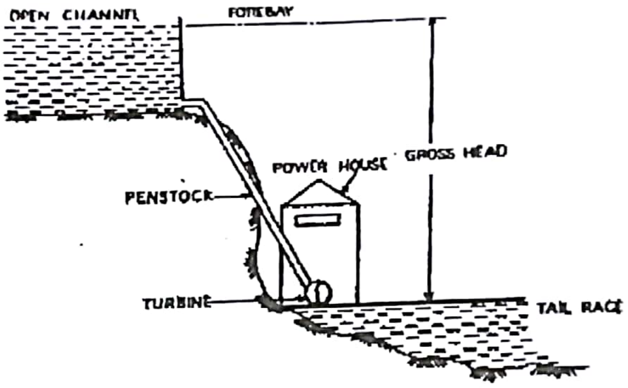

Fig. 5.3 Medium Head Hydro Electric Plant.

Low head Hydroelectric plants

A low head hydro electric plant stores water by constructing a dam across a river and the power house is installed near the base of the dam on the down-stream side. The tail-race of turbine is joined to the river on the down stream side (See Fig.5.4.)

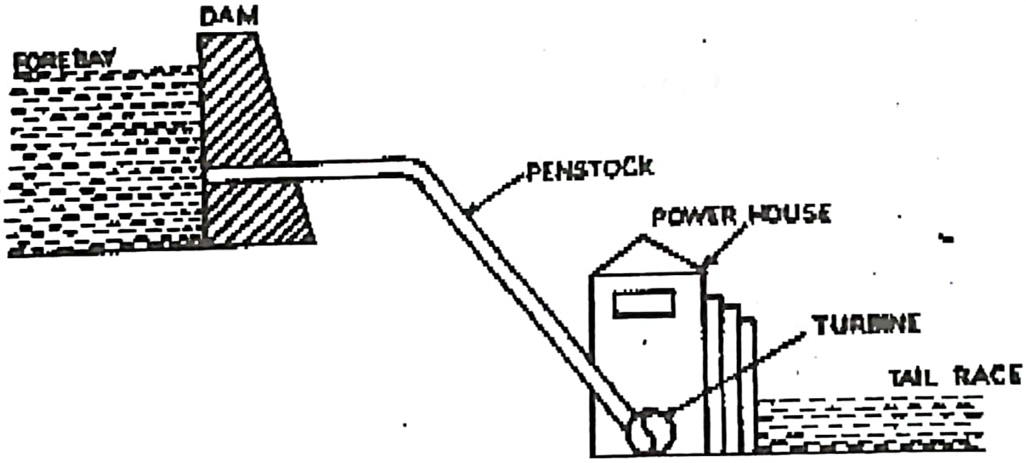

Fig 5.4

Classification of hydel plants based on plant capacity

1. Micro hydel plant	:	less than 5 MW
2. Medium capacity plant	:	5 to 100 MW
3. High capacity plant	:	101 MW to 1000MW
4. Super capacity plant	:	above 1000MW

Selection of site for hydro electric power stations

The following points should be taken into account while selecting the site for hydro-electric power station.

1. Availability of water : Hydel plants should be built at a place (eg. : river, canal) where adequate water is available at a good head.
2. Stoage of water : It is necessary to store water by constructing a dam in order to ensure the generation of power throughout the year.
3. Cost and type of land : The land for the construction of the plant should be available at a reasonable price. Further the bearing capacity of the site should be adequate to withstand the weight of heavy equipments which are to be installed.
4. Transportation facilities : The site should be accessible by rail and road so that necessary equipment and machinery could be easily transported.

5.1.4 Thermal Power Plant

These plants employ steam turbines to run the alternator. Steam is produced in a boiler, expanded in the turbine and is condensed in a condenser to be fed into the boiler again. Fig. (5.5.) shows a typical thermal power station. The plant can be divided into four main circuits namely

1. Fuel and ash circuit
2. Air and gas circuit
3. Feed water and steam circuit
4. Cooling water circuit

1. Fuel and ash circuit

Coal from the storage is fed into the boiler through coal handling devices. Ash produced as a result of combustion of coal collects at the back of the boiler and is removed to ash storage through ash handling equipment.

2. Air and gas circuit

Air from atmosphere is supplied to the combustion chamber of the boiler through the action of a forced draught fan. Air before being supplied to the boiler passes through the air pre-heater where it is heated by the heat of the flue gases which is then made to pass to the chimney.

3. Feed water and steam circuit

The condensate leaving the condenser is first heated in a low pressure heater and then in a high pressure heater. Then it goes to the boiler through the economiser. A small part of the steam and water in passing through the different components of the system is lost. Water is added to the feed water system as make up water.

The steam produced in the boiler is fed to the turbine where it expands and mechanical energy is produced. The turbine is coupled to a.c generator (alternator) which produces electrical energy.

4. Cooling water circuit

A large quantity of cooling water is required to condense the steam in the condenser . the cooling water may be taken from a river (if possible). If sufficient quantity is not available, the condenser may be cooled using a cooling tower.

Selection of site for Thermal power plant

1. Supply of fuel : Thermal plant should be located near the coal mines so that transportation cost is minimum.
2. Availability of water : As huge amount of water is required for the condenser, such a plant should be located at the bank of a river or near a canal to ensure the continuous supply of water.
3. Transportation facilities : A modern thermal plant often requires the transportation of material and machinery. Therefore, adequate transportation facilities must exist.
4. Cost and type of land : The power station should be located at a place where land is cheap and further extension, if necessary, is possible. Moreover , the bearing capacity of the land should be adequate to install heavy equipments.
5. Nearness to load centres : To reduce the Transmission cost, the plant should be located near the centre load.
6. Distance from populated area : As huge amount of coal is burnt in a steam power station, smoke and fumes pollute the surrounding area. This necessitate that the plant should be located at a considerable distance from populated areas.

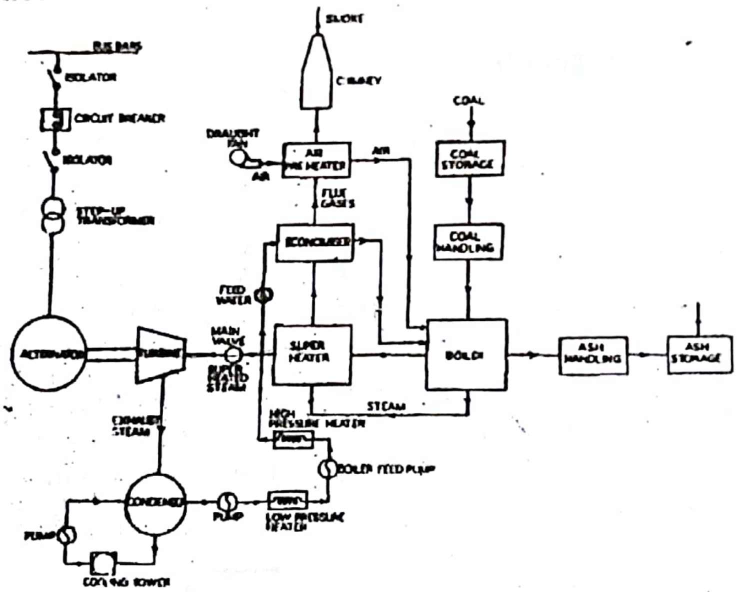

Fig 5. 5 Line diagram of a thermal power plant

5.1.5 Nuclear Power Plant A generating station in which nuclear energy is converted into electrical energy is known as nuclear power plant. In a nuclear power plant, heavy elements such as Uranium (U^{235}) or Thorium (Th^{232}) are subjected to nuclear fission in a special apparatus known as reactor. The heat energy thus released is utilised to produce steam at high temperature and pressure. The steam runs the turbine which converts steam energy into mechanical energy which inturn drives the alternator.

The schematic arrangements of a nuclear power station is shown in Fig. 5.6. The whole arrangement can be divided into the following stages.

1. Nuclear reactor
2. Heat exchanger
3. Steam turbine
4. Alternator

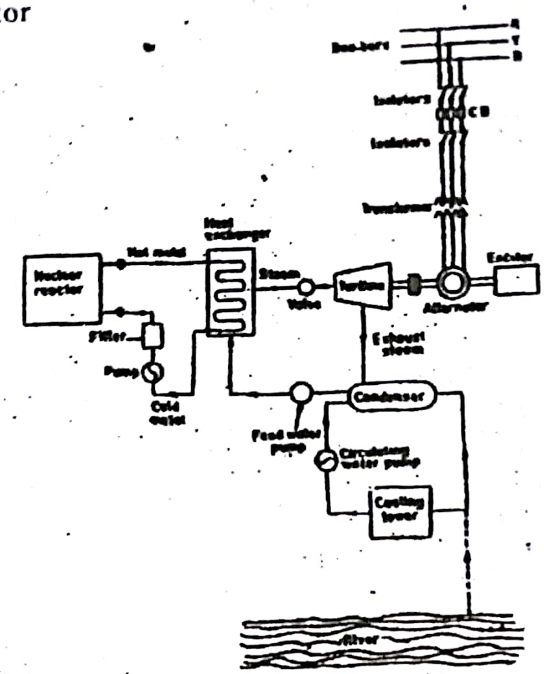

Fig 5.6 Schematic arrangement of nuclear power plant.

1. Nuclear reactor

It is an apparatus in which nuclear fuel is subjected to nuclear fission which controls the chain reaction. A nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of Uranium, moderator (graphite) and control rods. (See Fig. 5.7). The fuel rods constitute the fission material and release huge amound of energy when bombarded with slow moving neutrons. The moderator rods enclose the fuel rodswhich slows down the neutrons before they bombard the fuel rods. The control rods (eg. cadmium) absorbs neutron and thus regulates the supply of neutrons for fission. By adjusting the position of control rods, the intensity of chain reaction (or heat produced) can be increased or decreased. The heat produced in the reactor is removed by the coolant, generally a sodium metal. The coolant carries the heat to the heat exchanger.

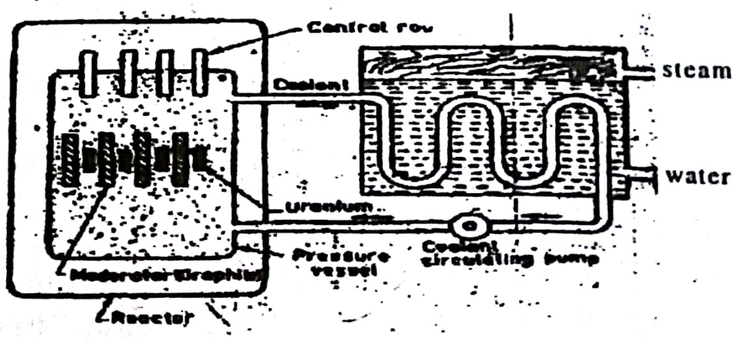

Fig 5.7 Nuclear Reactor

2. **Heat Exchanger :**

The coolant gives up heat to the heat exchanger which is utilised in raising the steam. After giving up heat, the coolant is again fed to the reactor.

3. **Steam turbine :**

The steam produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchanger through feed water pump.

4. **Alternator :**

Alternator converts mechanical energy into electrical energy. The output from the alternator is delivered to the bus-bars through circuit breaker and isolators.

Selection of site for Nuclear Power station

1. Availability of water : As sufficient water is required for cooling purposes, the plant site should be located where ample quantity of water is available, e.g. across a river or by sea side.

2. Disposal of waste : The waste produced by nuclear fission is generally radio active which must be disposed off properly to avoid health hazards. The waste should either be buried in a deep trench or disposed off in sea quite away from the sea shore. Therefore the site selected for such a plant should have adequate arrangement for the disposal of radio active waste.

3. Distance from populated areas : As there is a danger of presence of radio activity in the atmosphere near the plant, the site selected should be quite away from the populated area. As a precautionary measure, a 'dome' is used in the plant which does not allow the radioactivity to spread by wind or underground water ways.

4. Transportation facilities : To transport heavy equipment during erection and to facilitate the movement of workers, the site should have adequate transportation facilities.

5.1.6 Non Conventional Sources of Energy

3 The non-conventional sources are available 1 free of cost, are 2 pollution free and inexhaustible. Man has used these sources for many centuries in propelling ship, driving windmills, for grinding corn and pumping water etc. Because of the poor technologies then existing, the cost of harnessing energy from these sources was quite high. Also because of uncertainty of period of availability and the difficulty of transporting this form of energy , to the place of its use are some of the factors which came in the way of its adoption or development. It is hoped that with advancement in technology and

Supply Systems

Electric Supply System:

The conveyance of electric power from a power station to consumers' premises is known as **electric supply system.**

An electric supply system consists of three principal components *viz.*, the power station, the transmission lines and the distribution system. Electric power is produced at the power stations which are located at favourable places, generally quite away from the consumers. It is then transmitted over large distances to load centres with the help of conductors known as transmission lines. Finally, it is distributed to a large number of small and big consumers through a distribution network.

The electric supply system can be broadly classified into (*i*) d.c. or a.c. system (*ii*) overhead or underground system.

Now-adays, 3-phase, 3-wire a.c. system is universally adopted for generation and transmission of electric power as an economical proposition. However, distribution of electric power is done by 3-phase, 4-wire a.c. system. The underground system is more expensive than the overhead system. Therefore, in our country, overhead system is mostly adopted for transmission and distribution of electric power.(In certain densely populated cities, the underground system is being employed for distribution. This is to eliminate the danger to human life which would be present with overhead system and to avoid ugly appearance and inconvenience of pole lines running down the main thorough fares.)

Typical A.C. Power Supply Scheme

The large network of conductors between the power station and the consumers can be broadly divided into two parts *viz.*, transmission system and distribution system. Each part can be further sub-divided into two—primary transmission and secondary transmission and primary distribution and secondary distribution.

Fig. 7.1. shows the layout of a typical a.c. power supply scheme by a single line diagram. It may be noted that it is not necessary that all power schemes include all the stages shown in the figure. For example, in a certain power scheme, there may be no secondary transmission and in another case, the scheme may be so small that there is only distribution and no transmission.

(i) Generating station :

In Fig 7.1, G.S. represents the generating station where electric power is produced by 3-phase alternators operating in parallel. The usual generation voltage is11 kV(It may be 6·6 kV or even 33 kV in certain cases). For economy in the transmission of electric power, the generation voltage (*i.e.*, 11 kV) is stepped upto 132 kV (ormore depending upon the length of transmission line and the amount of power to be transmitted) at the generating station with the help of 3-phase transformers.The transmission of electric power at high voltages has several advantages including the saving of conductor material and high transmission efficiency. It may appear advisable to use the highest possible voltage for transmission of electric power to save conductor material and have other advantages. But there is a limit to which this voltage can be increased. It is because increase in transmission voltage introduces insulation problems as well as the cost of switchgear and transformer equipment is increased. Therefore, the choice of proper transmission voltage is essentially a question of economics. Generally the primary transmission is carried at 66 kV, 132 kV, 220 kV or 400 kV.

(ii) Primary transmission.

The electric power at 132 kV is transmitted by 3-phase, 3-wire overhead system to the outskirtsnof the city. This forms the primary transmission.

(iii) Secondary transmission.

The primary transmission linenterminates at the receiving station (*RS*) which usually lies at the outskirts of the city. At the receiving station, the voltage is reduced to 33kV by step-down transformers. From this station, electric power is transmitted at 33kV by 3-phase, 3-wire overhead system to various sub-stations (*SS*) located at the strategic points in the city. This forms the secondary transmission.

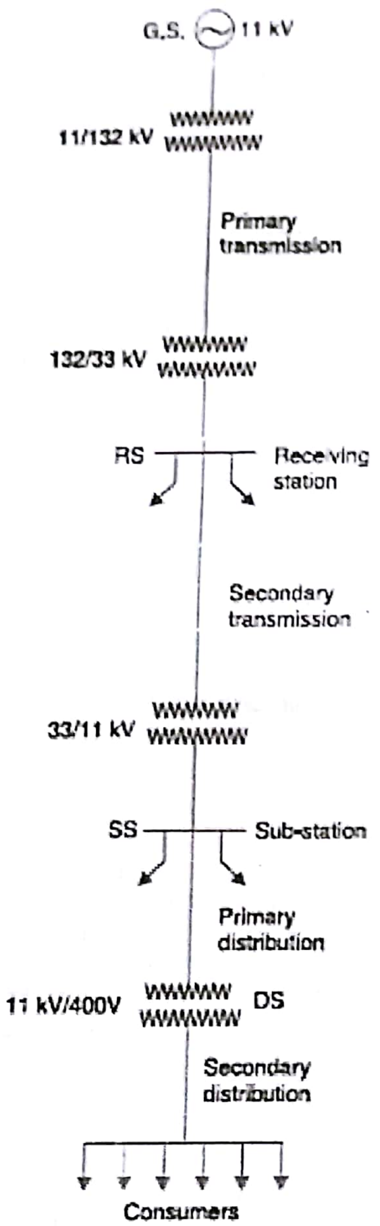

Fig. 7.1

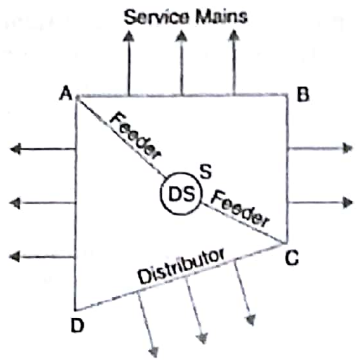

Fig. 7.2

(iv) ***Primary distribution.***

The secondary transmission line terminates at the sub-station (*SS*) where voltage is reduced from 33 kV to 11kV, 3-phase, 3-wire. The 11 kV lines run along the important road sides of the city. This forms the primary distribution. It may be noted that big consumers (having demand more than 50 kW) are generally supplied power at 11 kV for further handling with their own sub-stations.

(v) ***Secondary distribution.***

The electric power from primary distribution line (11 kV) is delivered to distribution sub-stations (*DS*). These sub-stations are located near the consumers' localities and step down the voltage to 400 V, 3-phase, 4-wire for secondary distribution. The voltage between any two phases is 400 V and between any phase and neutral is 230 V. The single-phase residential lighting load is connected between any one phase and neutral, whereas 3-phase, 400 V motor load is connected across 3-phase lines directly.

It may be worthwhile to mention here that secondary distribution system consistsof *feeders, distributors and service mains*. Fig. 7.2 shows the elements of low voltage distribution system. Feeders (*SC* or *SA*) radiating from the distribution sub-station (*DS*) supply power to the distributors (*AB*, *BC*, *CD* and *AD*). No consumer is given direct connection from the feeders. Instead, the consumers are connected to the distributors through their service mains.