Thermal, Hydel and Nuclear Power Stations

In this section we briefly outline the basics of the three most widely found generating stations –thermal, hydel and nuclear plants in our country and elsewhere.

2.1 Thermal plant

We have seen in the previous section that to generate voltage at 50 Hz we have to run the generator at some fixed rpm by some external agency. A turbine is used to rotate the generator. Turbine may be of two types, namely steam turbine and water turbine. In a thermal power station coal is burnt to produce steam which in turn, drives the steam turbine hence the generator (turbo set). In figure 2.2 the elementary features of a thermal power plant is shown.

In a thermal power plant coil is burnt to produce high temperature and high pressure steam in a boiler. The steam is passed through a steam turbine to produce rotational motion. The generator, mechanically coupled to the turbine, thus rotates producing electricity. Chemical energy stored in coal after a couple of transformations produces electrical energy at the generator terminals as depicted in the figure. Thus proximity of a generating station nearer to a coal reserve and water sources will be most economical as the cost of transporting coal gets reduced. In our country coal is available in abundance and naturally thermal power plants are most popular. However, these plants pollute the atmosphere because of burning of coals.

Stringent conditions (such as use of more chimney heights along with the compulsory use of electrostatic precipitator) are put by regulatory authorities to see that the effects of pollution is minimized. A large amount of ash is produced every day in a thermal plant and effective handling of the ash adds to the running cost of the plant. Nonetheless 57% of the generation in out country is from thermal plants. The speed of alternator used in thermal plants is 3000 rpm which means 2-pole alternators are used in such plants.

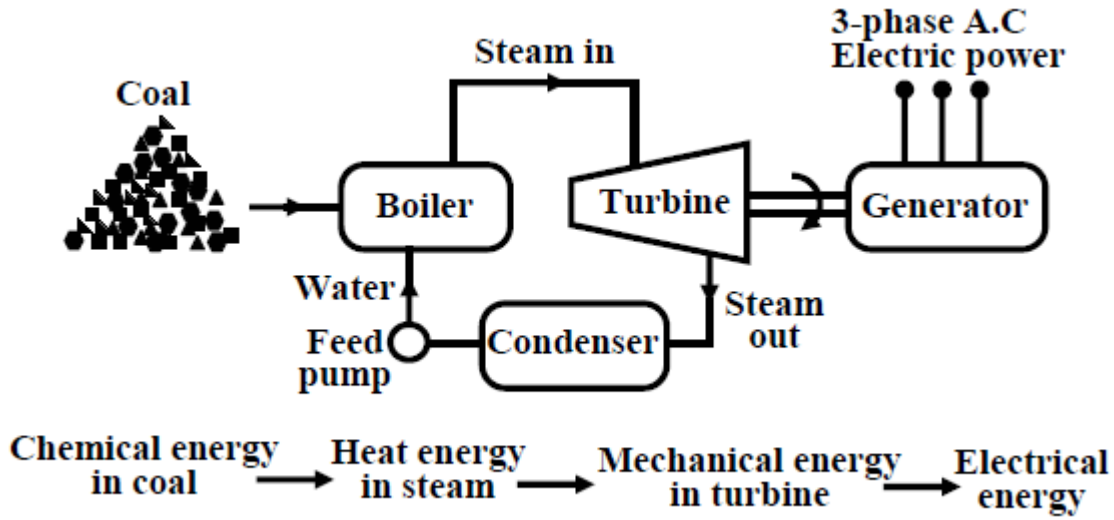

Figure 2.1: Basic components of a thermal generating unit.

2.2 Hydel plants

In a hydel power station, water head is used to drive water turbine coupled to the generator. Water head may be available in hilly region naturally in the form of water reservoir (lakes etc.) at the hill tops. The potential energy of water can be used to drive the turbo generator set installed at the base of the hills through piping called *pen stock*. Water head may also be created artificially by constructing dams on a suitable river. In contrast to a thermal plant, hydel power plants are eco-friendly, neat and clean as no fuel is to be burnt to produce electricity. While running cost of such plants are low, the initial installation cost is rather high compared to a thermal plants due to massive civil construction necessary. Also sites to be selected for such plants depend upon natural availability of water reservoirs at hill tops or availability of suitable rivers for constructing dams. Water turbines generally operate at low rpm, so number of poles of the alternator are high. For example a 20-pole alternator the rpm of the turbine is only 300 rpm.

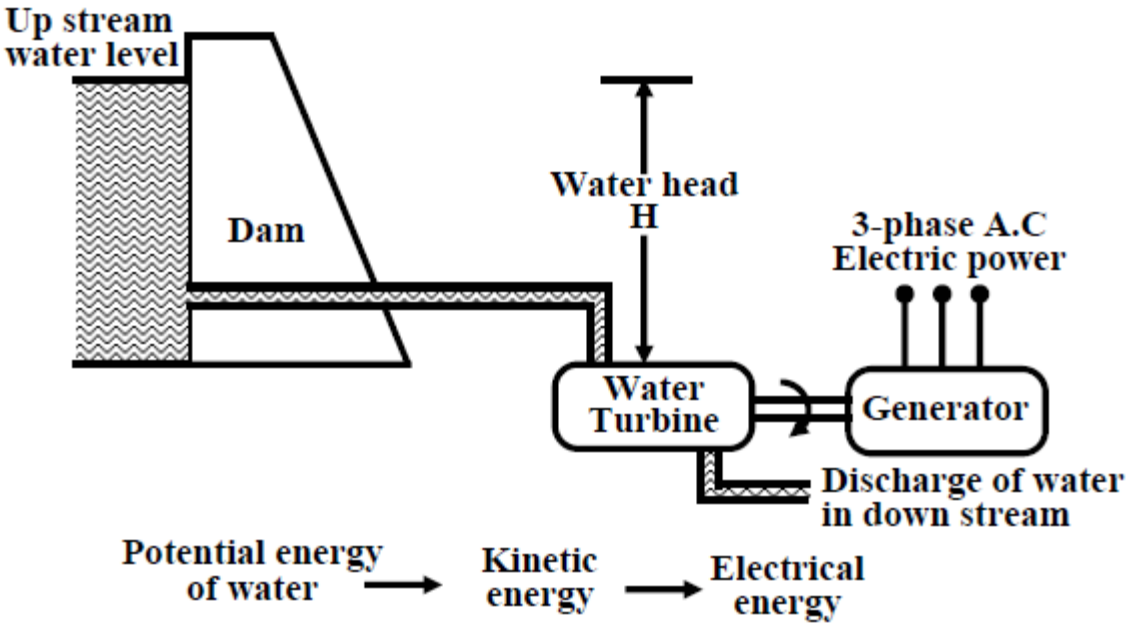

Figure 2.2: Basic components of a hydal generating unit.

2.3 Nuclear plants

As coal reserve is not unlimited, there is natural threat to thermal power plants based on coal. It is estimated that within next 30 to 40 years, coal reserve will exhaust if it is consumed at the present rate. Nuclear power plants are thought to be the solution for bulk power generation. At present the installed capacity of nuclear power plant is about 4300 MW and expected to expand further in our country. The present day atomic power plants work on the principle of nuclear fission of ^{235}U. In the natural uranium, ^{235}U constitutes only 0.72% and remaining parts is constituted by 99.27% of ^{238}U and only about 0.05% of ^{234}U. The concentration of ^{235}U may be increased to 90% by gas diffusion process to obtain enriched ^{235}U. When ^{235}U is bombarded by neutrons a lot of heat energy along with additional neutrons are produced. These new neutrons further bombard ^{235}U producing more heat and more neutrons. Thus a chain reaction sets up. However this reaction is allowed to take place in a controlled manner inside a closed chamber called nuclear reactor. To ensure sustainable chain reaction, moderator and control rods are used. Moderators such as heavy water (deuterium) or very pure carbon ^{12}C are used to reduce the speed of neutrons. To control the number neutrons, control rods made of cadmium or boron steel are inserted inside the reactor. The control rods can absorb neutrons. If we want to decrease the number neutrons, the control rods are lowered down further and vice versa. The heat generated inside the reactor is taken out of the chamber with the help of a coolant such as liquid sodium or some gaseous fluids. The coolant gives up the heat to water in heat exchanger to convert it to steam as shown in figure 2.4. The steam then drives the turbo set and the exhaust steam from the turbine is cooled and fed back to the heat exchanger with the help of water feed pump. Calculation shows that to produce 1000 MW of electrical power in coal based thermal

plant, about 6×10^6 Kg of coal is to be burnt daily while for the same amount of power, only about 2.5 Kg of ^{235}U is to be used per day in a nuclear power stations.

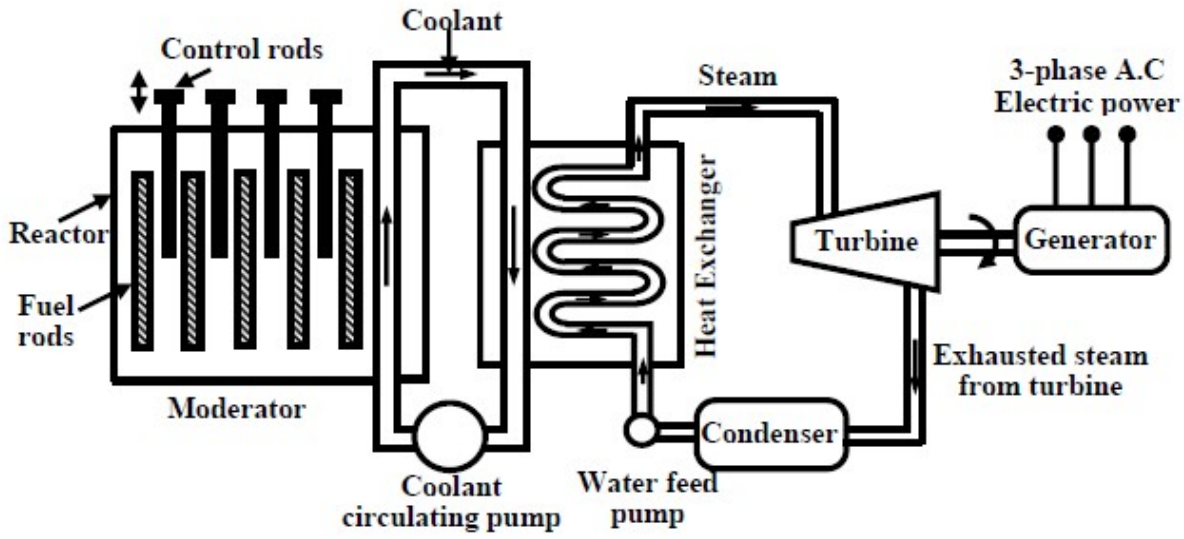

Figure 2.3: Nuclear Power generating unit.

The initial investment required to install a nuclear power station is quite high but running cost is low. Although, nuclear plants produce electricity without causing air pollution, it remains a dormant source of radiation hazards due to leakage in the reactor. Also the used fuel rods are to be carefully handled and disposed off as they still remain radioactive.

The reserve of ^{235}U is also limited and cannot last longer if its consumption continues at the present rate. Naturally search for alternative fissionable material continues. For example, plutonium (^{239}Pu) and (^{233}U) are fissionable. Although they are not directly available. Absorbing neutrons, ^{238}U gets converted to fissionable plutonium ^{239}Pu in the atomic reactor described above. The used fuel rods can be further processed to extract ^{239}Pu from it indirectly increasing the availability of fissionable fuel. Effort is also on to convert thorium into fissionable ^{233}U. Incidentally, India has very large reserve of thorium in the world.

Total approximate generation capacity and Contribution by thermal, hydel and nuclear generation in our country are given below.

Electrical systems in Aircrafts and Ships:

- ③ The function of the aircraft electrical system is to generate, regulate and distribute electrical power throughout the aircraft
- ③ New-generation aircraft rely heavily on electrical power because of the wide use of electronic flight instrument systems

Electrical Power Uses

Aircraft electrical power is used to operate:

- Aircraft Flight Instruments
- Essential Systems
- Passenger Services
- Essential power is power that the aircraft needs to be able to continue safe operation
- Passenger services power is the power that used for:
- Cabin lighting
- Operation of entertainment systems
- Preparation of food

Power Used

- Aircraft electrical components operate on many different voltages both AC and DC
- However, most of the systems use:
  - 115 VAC @ 400 Hz
  - 28 VDC
- 26 VAC is also used in some aircraft for lighting

Power Sources

- There are several different power sources on large aircraft to be able to handle excessive loads, for redundancy, and for emergency situations.
- These power sources include:
  - Engine driven AC generators
  - Auxiliary Power Units
  - External power
  - Ram Air Turbines
- Most often the APUs power is used while the aircraft is on the ground during maintenance or for engine starting
- However, most aircraft can use the APU while in flight as a backup power source
  - One exception to this is the B272, which only allows APU operation in the ground
- External power may only be used with the aircraft on the ground
- This system utilizes a Ground Power Unit (GPU) to provide AC power through an external plug on the nose of the aircraft
- GPUs may be either portable or stationary units

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