1.1 COAL BASED THERMAL POWER PLANT (Steam Power Station)

A generating station which converts heat energy of coal combustion into electrical energy is known as a steam power station.

A steam power station basically works on the Rankine cycle. Steam is produced in the boiler by utilizing the heat of coal combustion. The steam is then expanded in the prime mover (i.e., steam turbine) and is condensed in a condenser to be fed into the boiler again. The steam turbine drives the alternator which converts mechanical energy of the turbine into electrical energy. This type of power station is suitable where coal and water are available in abundance and a large amount of electric power is to be generated.

Schematic Arrangement of Coal based Thermal Power Plant:

The schematic arrangement of a modern steam power station is shown in fig.1.2. The whole arrangement can be divided into the following stages:

- Coal and ash handling arrangement
- Steam generating plant
- Steam turbine
- Alternator
- Feed water
- Cooling arrangement

Coal and ash handling plant:

The coal is transported to the power station by road or rail and is stored in the coal storage plant. From the coal storage plant, coal is delivered to the coal handling plant where it is pulverized (i.e., crushed into small pieces) in order to increase its surface exposure, thus promoting rapid combustion without using large quantity of excess air. The pulverized coal is fed to the boiler by belt conveyors. The coal is burnt in the boiler and the ash produced after the complete combustion of coal is removed to the ash handling plant and then delivered to the ash storage plant for disposal. The removal of the ash from the boiler furnace is necessary for proper burning of coal.

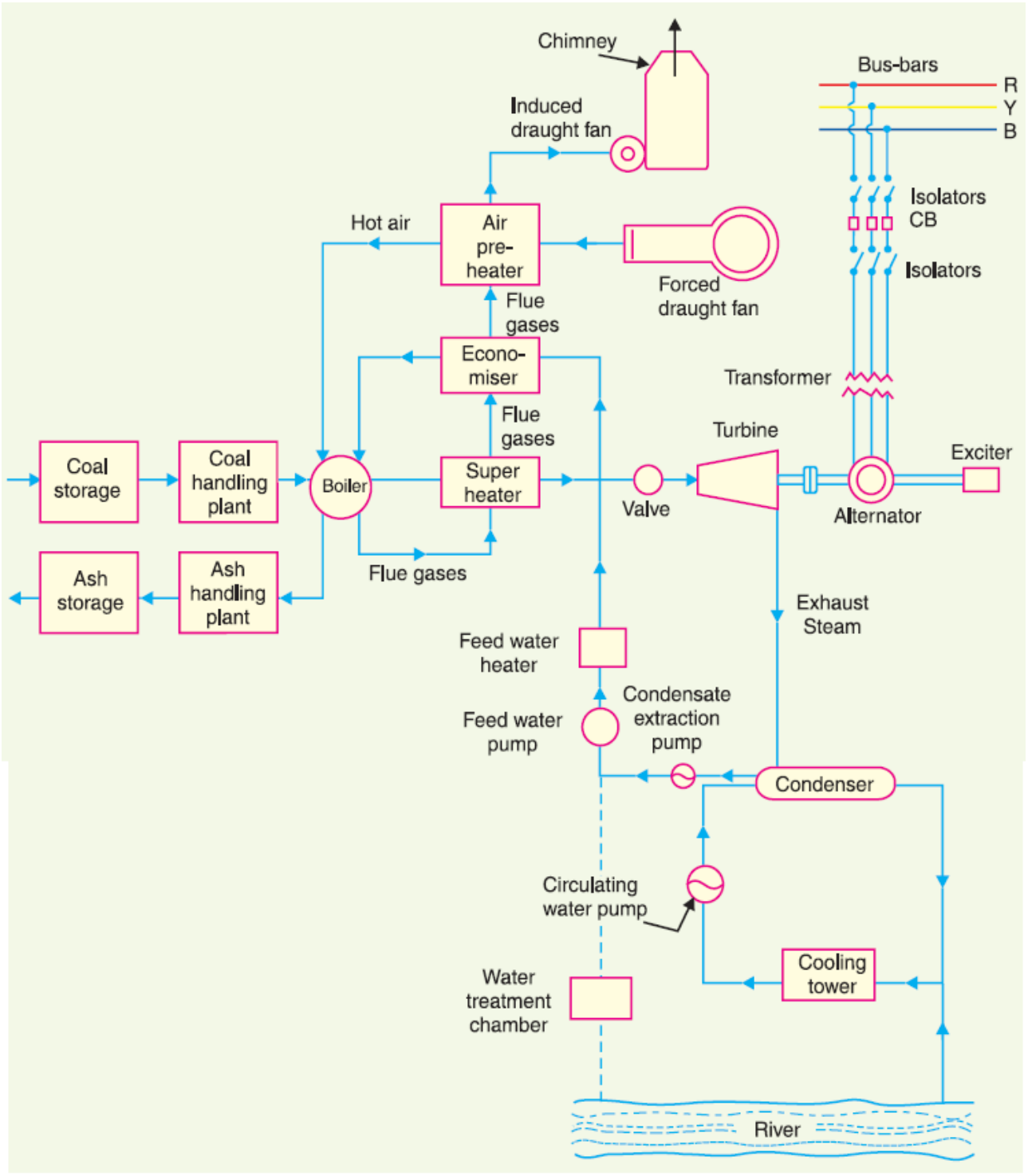

Fig 1.2 Schematic Arrangement of Coal based Thermal Power Plant

(Source: 'Principles of power system,' V.K.Mehta, Rohit Mehta)

A 100 MW station operating at 50% load factor may burn about 20,000 tons of coal per month and ash produced may be to the tune of 10% to 15% of coal fired i.e., 2,000 to 3,000 tons.

***Steam generating plant*:**

The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment for the utilization of flue gases.

- BOILER:

The heat of combustion of coal in the boiler is utilized to convert water into steam at high temperature and pressure. The flue gases from the boiler make their journey through superheater, economiser, air pre-heater and are finally exhausted to atmosphere through the chimney.

- SUPERHEATER:

The steam produced in the boiler is wet and is passed through a superheater where it is dried and superheated by the flue gases on their way to chimney. Superheating provides two principal benefits. Firstly, the overall efficiency is increased. Secondly, too much condensation in the last stages of turbine (which would cause blade corrosion) is avoided. The superheated steam from the superheater is fed to steam turbine through the main valve.

- ECONOMISER

An economiser is essentially a feed water heater and derives heat from the flue gases for this purpose. The feed water is fed to the economiser before supplying to the boiler. The economiser extracts a part of heat of flue gases to increase the feed water temperature.

- AIR PREHEATER

An air preheater increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced draught fan and is passed through air preheater before supplying to the boiler furnace. The air preheater extracts heat from flue gases and increases the temperature of air used for coal combustion. The principal benefits of preheating the air are: increased thermal efficiency and increased steam capacity per square metre of boiler surface.

Steam turbine:

The dry and superheated steam from the superheater is fed to the steam turbine through main valve. The heat energy of steam when passing over the blades of turbine

is converted into mechanical energy. After giving heat energy to the turbine, the steam is exhausted to the condenser which condenses the exhausted steam by means of cold water circulation.

Alternator:

The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy. The electrical output from the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.

Feed water:

The condensate from the condenser is used as feed water to the boiler. Some water may be lost in the cycle which is suitably made up from external source. The feed water on its way to the boiler is heated by water heaters and economiser. This helps in raising the overall efficiency of the plant.

Cooling arrangement

The steam exhausted from the turbine is condensed by means of a condenser. Water is drawn from a natural source of supply such as a river, canal or lake and is circulated through the condenser. The circulating water takes up the heat of the exhausted steam and itself becomes hot. This hot water coming out from the condenser is discharged at a suitable location down the river.

In case the availability of water from the source of supply is not assured throughout the year, cooling towers are used. During the scarcity of water in the river, hot water from the condenser is passed on to the cooling towers where it is cooled. The cold water from the cooling tower is reused in the condenser.

Choice of Site for Steam Power Stations:

In order to achieve overall economy, the following points should be considered while selecting a site for a steam power station:

a. **Supply of fuel:**

   The steam power station should be located near the coal mines so that transportation cost of fuel is minimum. However, if such a plant is to be installed at a place where coal is not available, then care should be taken that adequate facilities exist for the transportation of coal.

b. Availability of water:

As huge amount of water is required for the condenser, therefore, such a plant should be located at the bank of a river or near a canal to ensure the continuous supply of water.

c. Transportation facilities:

A modern steam power station often requires the transportation of material and machinery. Therefore, adequate transportation facilities must exist i.e., the plant should be well connected to other parts of the country by rail, road. etc.

d. Cost and type of land:

The steam 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 ground should be adequate so that heavy equipment could be installed.

e. Nearness to load centres:

In order to reduce the transmission cost, the plant should be located near the centre of the load. This is particularly important if DC supply system is adopted. However, if AC supply system is adopted, this factor becomes relatively less important. It is because AC power can be transmitted at high voltages with consequent reduced transmission cost. Therefore, it is possible to install the plant away from the load centres, provided other conditions are favourable.

f. Distance from populated area:

As huge amount of coal is burnt in a steam power station, therefore, smoke and fumes pollute the surrounding area. This necessitates that the plant should be located at a considerable distance from the populated areas.

Advantages:

i. The fuel (i.e., coal) used is quite cheap.
ii. Less initial cost as compared to other generating stations.
iii. It can be installed at any place irrespective of the existence of coal. The coal can be transported to the site of the plant by rail or road.
iv. It requires less space as compared to the hydroelectric power station.
v. The cost of generation is lesser than that of the diesel power station.

Disadvantages:

i. It pollutes the atmosphere due to the production of large amount of smoke and fumes.
ii. It is costlier in running cost as compared to hydroelectric plant.

Thermal Efficiency:

The ratio of heat equivalent of mechanical energy transmitted to the turbine shaft to the heat of combustion of coal is known as thermal efficiency of steam power station.

$$\eta_{Thermal} = \frac{Heat\ equivalent\ of\ mech.\ energy\ transmitted\ to\ turbine\ shaft}{Heat\ of\ coal\ combustion}$$

Overall efficiency:

The ratio of heat equivalent of electrical output to the heat of combustion of coal is known as overall efficiency of steam power station.

$$\eta_{overall} = \frac{Heat\ equivalent\ of\ electrical\ ouput}{Heat\ of\ coal\ combustion}$$

Overall efficiency = Thermal efficiency × Electrical efficiency