Electrical Power Engineering

Structure of Electric Power System

The function of an electric power system is to connect the power station to the consumer's loads by means of an interconnected system of transmission and distribution network, Figure (1.a, b) shows a one-line diagram of a simple power system. Therefore, an electric power system consists of three principal components:

1- Generating Stations (Power Stations P.S)

- Mechanical parts:

Source of mechanical energy (Boiler, Turbine)

- Electrical part:

Alternators, Transformers, Protection devices and measuring instruments.

2- Transmission Lines (T.L)

T.L are the connecting links between the power stations and the distribution system and lead to other power systems over interconnection.

There are two types:

- The overhead transmission line (O.H.T.L).
- Underground cables.

3- Distribution System

It connects all the individual loads to the Transmission lines (T.L).

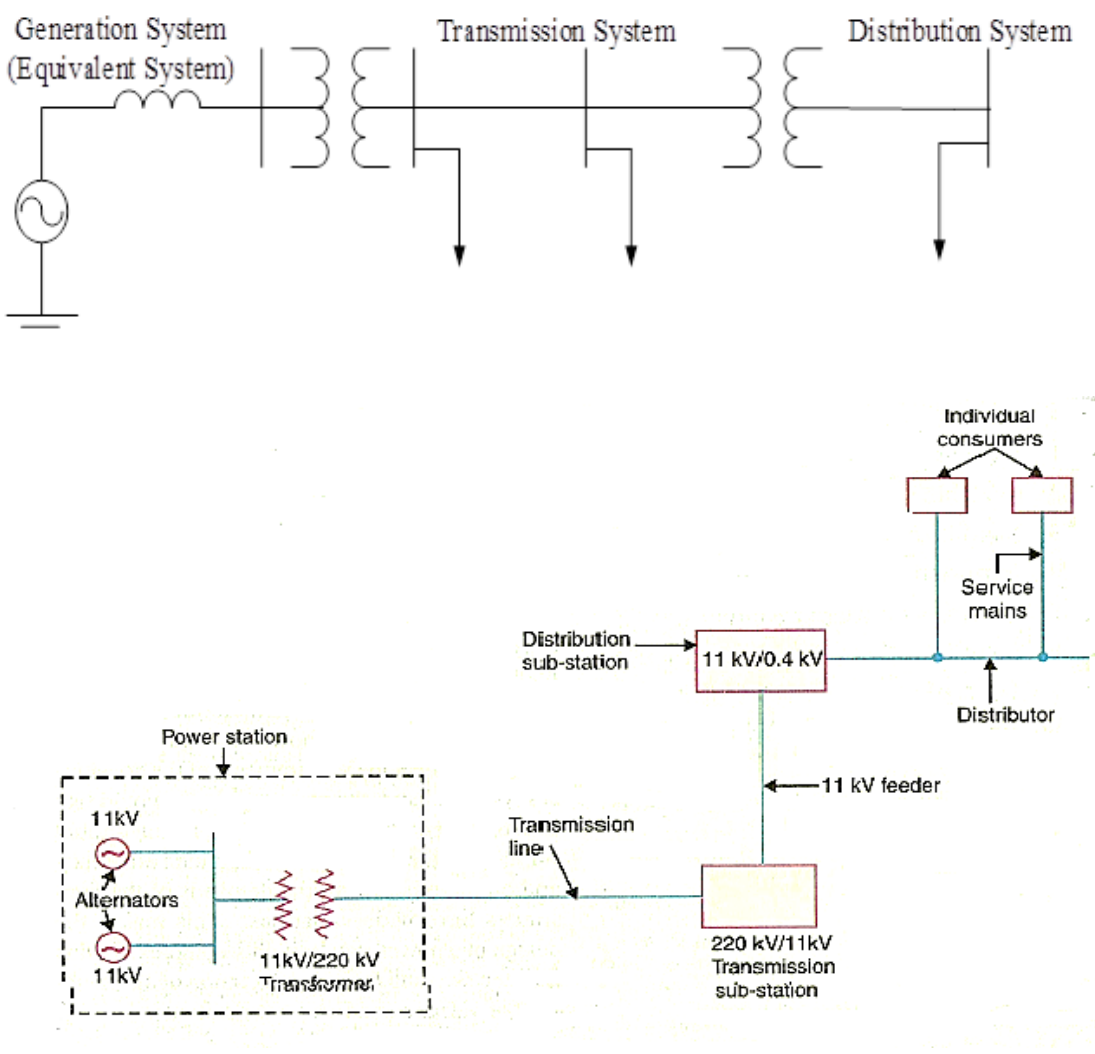

Figure (1) one-line diagram of a Power System.

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Generation Stations:

Bulk electrical power is proposed by special plants known as generating stations or power plants. A generating station essentially employs a prime mover coupled to an alternator for the production of electrical power. The prime mover (steam turbine, water turbine, etc.) converts energy from some other form into mechanical energy. The alternator converts mechanical energy of the prime mover into electrical energy. The electrical energy produced by the generating station is transmitted and distributed with the help of conductors to various consumers. Modern generating station employs several auxiliary equipment and instruments' to ensure cheap, reliable and continuous service. The generating stations are classified into:

1. Steam power station.
2. Hydroelectric power station.
3. Diesel power station.
4. Nuclear power station.

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1. Steam Power Station (Thermal station):

A generating station which converts heat energy of coal or oil combination into electrical energy is known as steam power station.

A steam power station basically works on the Rankin cycle. Steam is produced in the boiler by utilizing the heat of coal or oil combination. The steam is then expanded in the prime mover (steam turbine) and is condensed in condenser to be fed into the boiler again.

The steam turbine derives the alternator which converts mechanical energy of the turbine into electrical energy. This type of power station is suitable where coal or petrol and water are available in abundance and a large amount of electric power to be generated

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Schematic Arrangement of Steam Station:

The schematic arrangement of modern power system is shown in Figure (2).

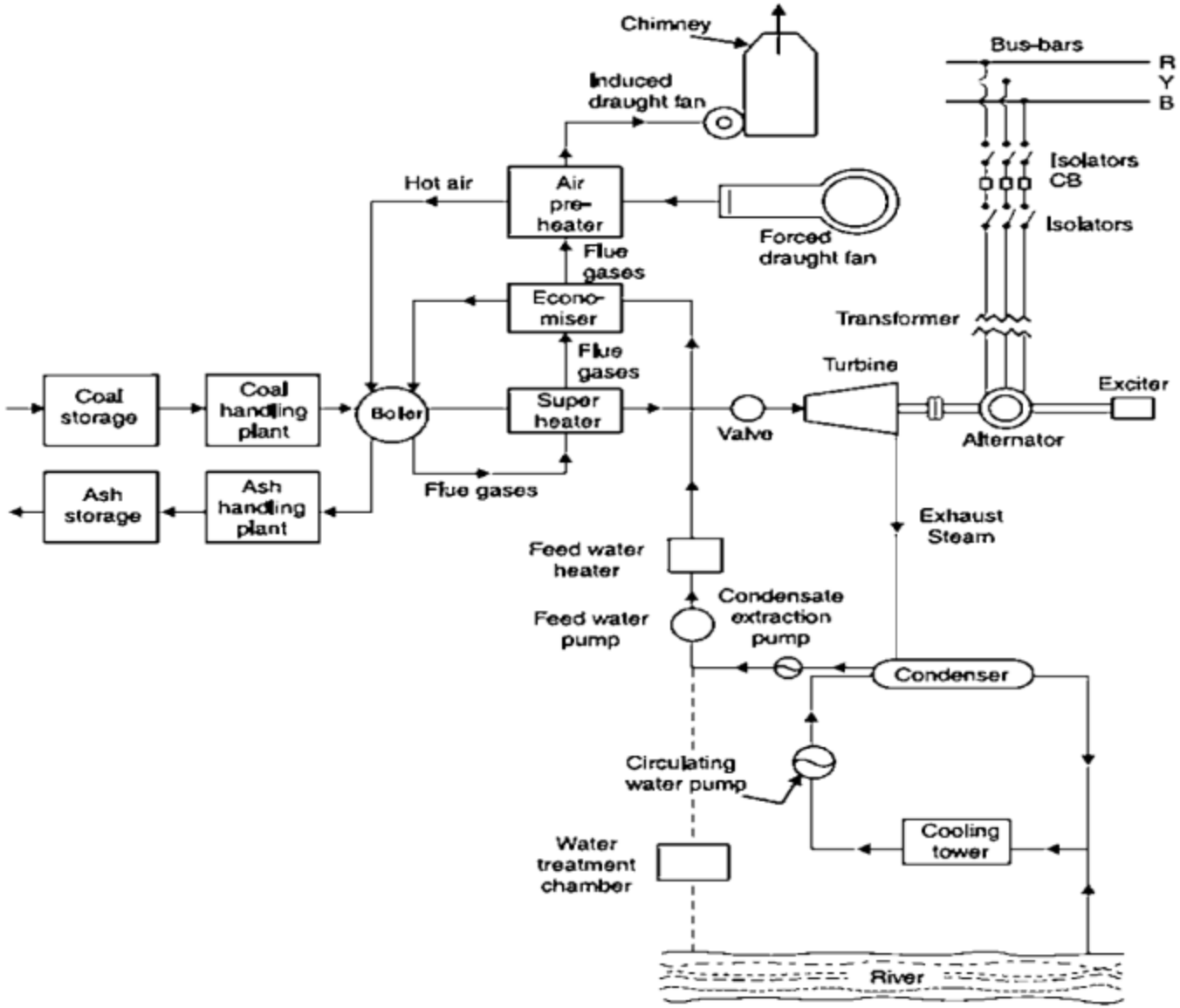

Figure (2) Schematic arrangement of steam power system

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The whole arrangement can be divided into the following stages:

1. Coal or oil and ash handling arrangement: from the coal or oil storage plant, coal or oil is delivered to the coal handling plant where it is pulverized (crashed into small pieces). The coal or oil burnt in the boiler and ash produced after the complete combination of coal or oil is removed to the ash handling plant and then delivered to ash storage plant for disposal.

2. Steam generating plant: it consists of :

a. ***Boiler:*** the heat of combination of coal and oil in the boiler is utilized to convert water into steam at high temperature and pressure. The flue gasses from the boiler make their journey through super heater, economizer, air pre-heater and finally exhausted to atmosphere through chimney.

b. ***Super heater:*** the steam produced in the boiler is wet; the super heater dried and superheats the gasses.

c. ***Economizer:*** it is a feed water heater and it deriver heat from the flue gasses.

d. ***Air pre-heater:*** it increases the temperature of the air supplied for coal or oil burning by driving heat from flue gasses.

3. Steam turbine: the dry and the superheated steam from the super heater are 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. Steam turbine are classified into two types those are: 1. Impulse turbine, 2. Reaction turbine.

4. Alternator: it converts mechanical energy of turbine into electrical energy. It is the main part of electrical system.

5. Feed water: the condensate steam from the condenser is used as feed water to the boiler.

6. Cooling arrangement: in order to increase the efficiency of the plant the steam exhausted from the turbine is condensed by the condenser. The circulating water takes up heat from the steam and it becomes hot. This hot water discharged down the river.

Choice of site of steam power station:

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

1. Supply of fuel.
2. Availability of water.
3. Transportation facilities.
4. Cost and type of land.
5. Nearness to load center.
6. Distance from population area.

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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.

2. Hydro-electrical station:

It's a generating station which utilizes the potential energy of water at a high level for the generation of electrical energy.

Hydroelectric power stations are generally located in hilly areas where dams can be built conveniently and large water can be obtained. In a Hydroelectric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (*i.e...* product of head and flow of water) into mechanical energy at the turbine shaft.

The turbine drives the alternator which converts mechanical energy into electrical energy. Hydroelectric power station are becoming very popular because the reserves of fuels (*i.e...* coal and oil) are depleting day by day. They have the added importance for flood control, storage of water for irrigation and water for drinking purposes.

Schematic arrangement of hydro-electrical station:

Although a hydro-electric power station simply involves the conversion of hydraulic energy into electrical energy, yet it embraces many arrangements for proper working and efficiency. The schematic arrangement of a modern hydro-electric plant is shown in Figure (3). The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock.

The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into mechanical energy. The turbine dives the alternator which converts mechanical energy into electrical energy.

A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close due to electrical load being thrown off.

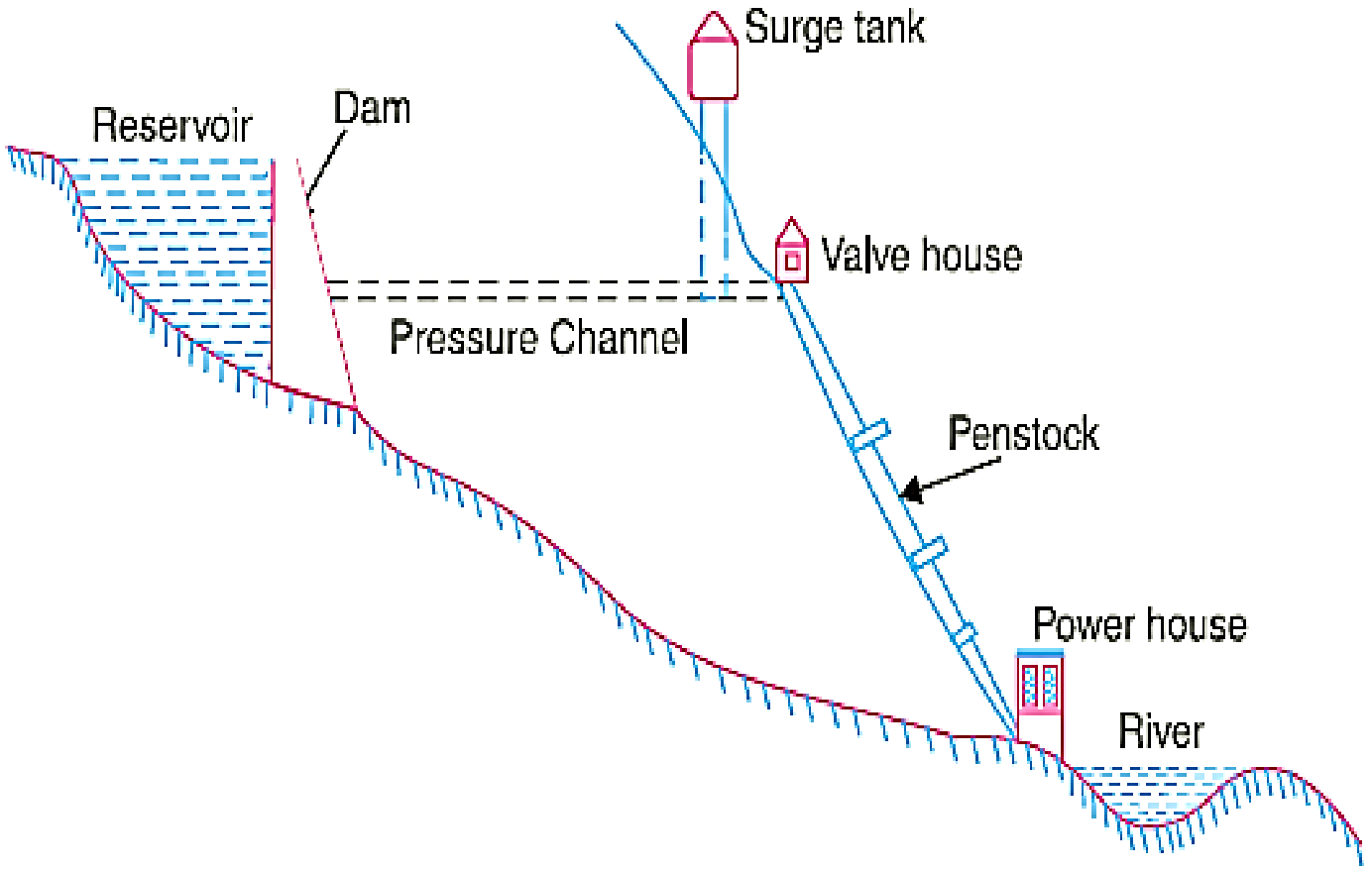

Figure (3) Schematic arrangement of hydro-electric power system

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Main parts of hydro-electric power station:

1. Reservoir: its purpose to store water.
2. Dam : it provide a head of water to utilized in the water turbine
3. Penstocks: pipes of large diameter, taking water from the intake works to the power house (turbine).
4. Prime mover: it converts kinetic energy of water into mechanical energy (turbine). There are two types: impulse and reaction turbine.
5. Power house: it consists of two main parts: turbine and the electrical equipment (Generator).

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Choice of site:

The following points should be taken into account when selecting the site of a hydro-electric power station:

(*i*) *Availability of water.* Since the primary requirement of a hydro-electric power station is the availability of huge quantity of water, such plants should be built at a place (*e.g.*, river, canal) where adequate water is available at a good head.

(*ii*) *Storage of water.* There are wide variations in water supply from a river or canal during the year. This makes it necessary to store water by constructing a dam in order to ensure the generation of power throughout the year. The storage helps in equalising the flow of water so that any excess quantity of water at a certain period of the year can be made available during times of very low flow in the river. This leads to the conclusion that site selected for a hydro-electric plant should provide adequate facilities for erecting a dam and storage of water.

(*iii*) *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 ground should be adequate to with-stand the weight of heavy equipment to be installed.

(*iv*) *Transportation facilities.* The site selected for a hydro-electric plant should be accessible by rail and road so that necessary equipment and machinery could be easily transported.

It is clear from the above mentioned factors that ideal choice of site for such a plant is near a river in hilly areas where dam can be conveniently built and large reservoirs can be obtained.

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Advantages

(*i*) It requires no fuel as water is used for the generation of electrical energy.

(*ii*) It is quite neat and clean as no smoke or ash is produced.

(*iii*) It requires very small running charges because water is the source of energy which is available free of cost.

(*iv*) It is comparatively simple in construction and requires less maintenance.

(*v*) It does not require a long starting time like a steam power station. In fact, such plants can be put into service instantly.

(*vi*) It is robust and has a longer life.

(*vii*) Such plants serve many purposes. In addition to the generation of electrical energy, they also help in irrigation and controlling floods.

(*viii*) Although such plants require the attention of highly skilled persons at the time of construction, yet for operation, a few experienced persons may do the job well.

Disadvantages

(i) It involves high capital cost due to construction of dam.

(ii) There is uncertainty about the availability of huge amount of water due to dependence on weather conditions.

(iii) Skilled and experienced hands are required to build the plant.

(iv) It requires high cost of transmission line as the plant is located in hilly areas which are quite away from the consumers.

Thanks