Unit1: Thermal Power Stations

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1. Introduction

Thermal power stations are an essential part of energy infrastructure that underpins modern life and industry activities by stably generating and supplying electricity. The role of thermal power generation is expected to remain as vital in the future, whereas this generation system faces a critical challenge: to reduce CO_2 emission by taking effective measures, including improved generation efficiency.

Against this backdrop, global attention is focusing on technology for super-critical thermal power generation. This technology allows power plants to achieve higher generation efficiency than the current steam-power generation method by creating higher temperature and higher pressure steam conditions using a boiler designed especially for that purpose, thus reducing the amount of CO_2 emitted. This environment-friendly method has recently received greater recognition and has begun to be introduced in power stations worldwide.

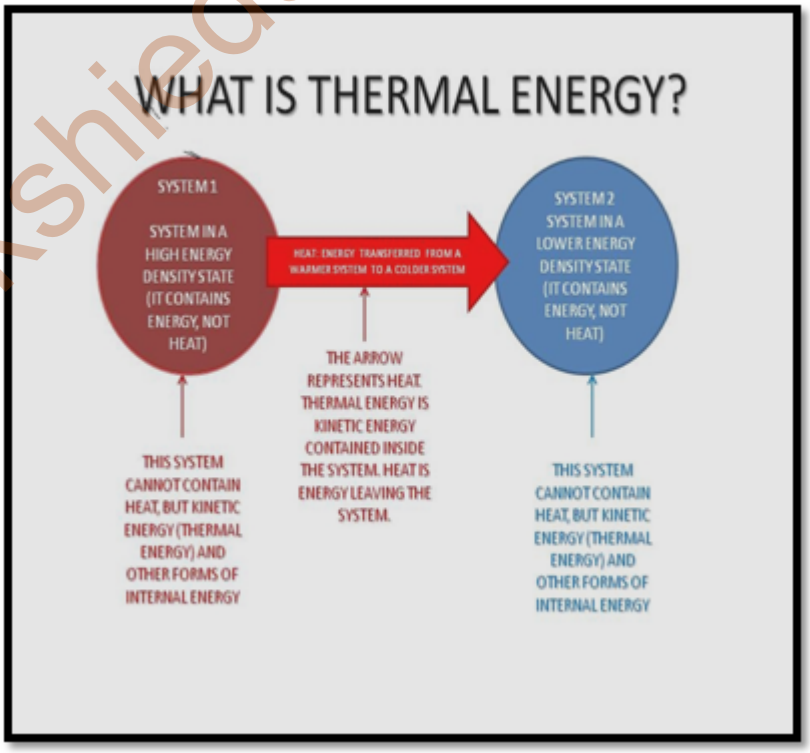

Figure: Thermal energy

2. Schematic Arrangement for Thermal Power Station

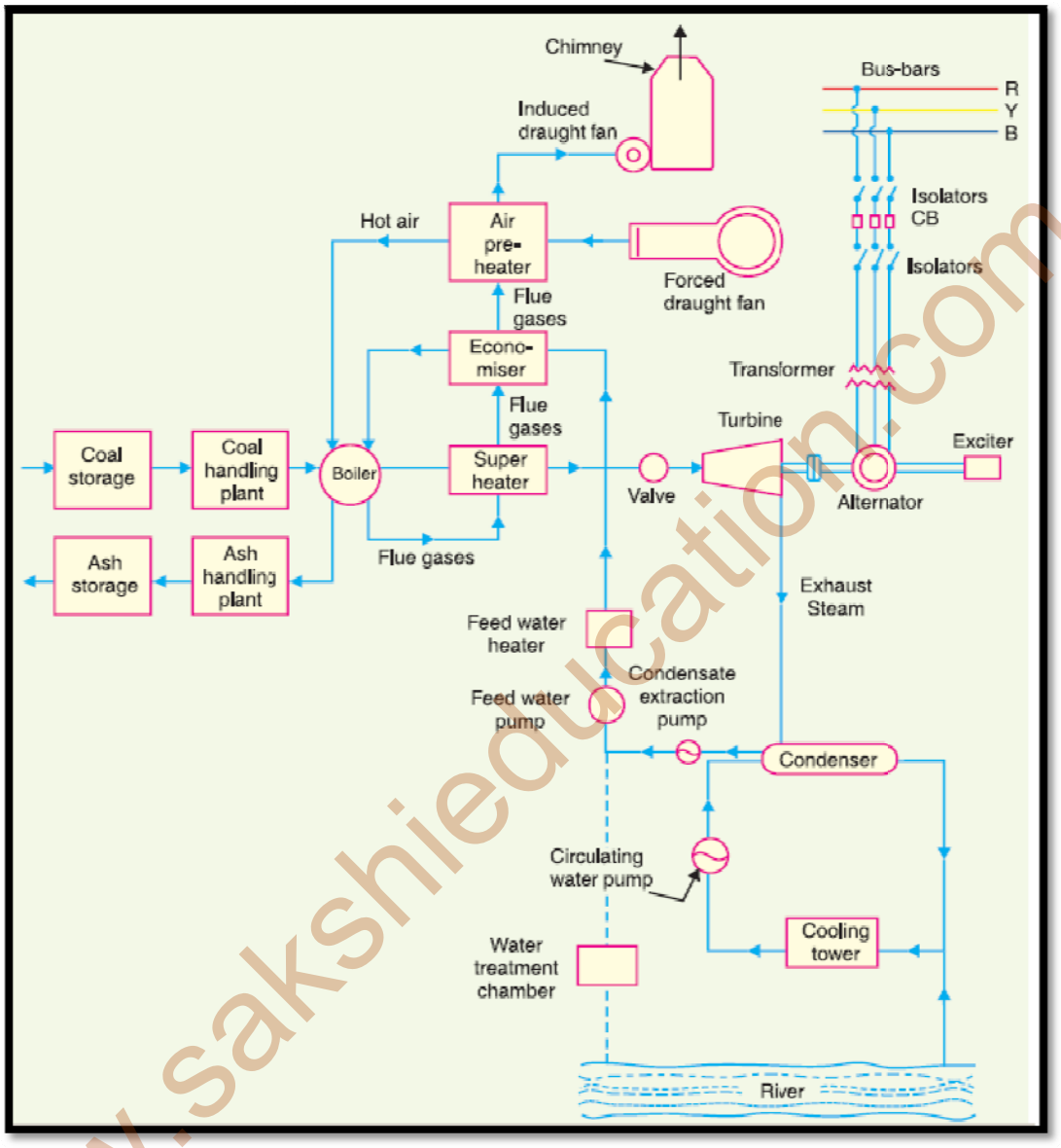

Figure: Schematic Arrangement for Thermal Power Station

Coal handling plant:

In a coal based thermal power plant, the initial process in the power generation is "Coal Handling". So in this article i will discuss the overall processes carried out at a Coal Handling plant in a coal based thermal power generating station.

The huge amount of coal is usually supplied through railways. A railway siding line is taken into the power station and the coal is delivered in the storage yard. The coal is unloaded from the point of delivery by means of wagon tippler. It is rack and pinion type. The coal is taken from the unloading site to dead storage by belt conveyors. The belt delivers the coal to 0m level to the pent house and further moves to transfer point.

The transfer points are used to transfer coal to the next belt. The belt elevates the coal to breaker house. It consists of a rotary machine, which rotates the coal and separates the light dust from it through the action of gravity and transfer this dust to reject bin house through belt.

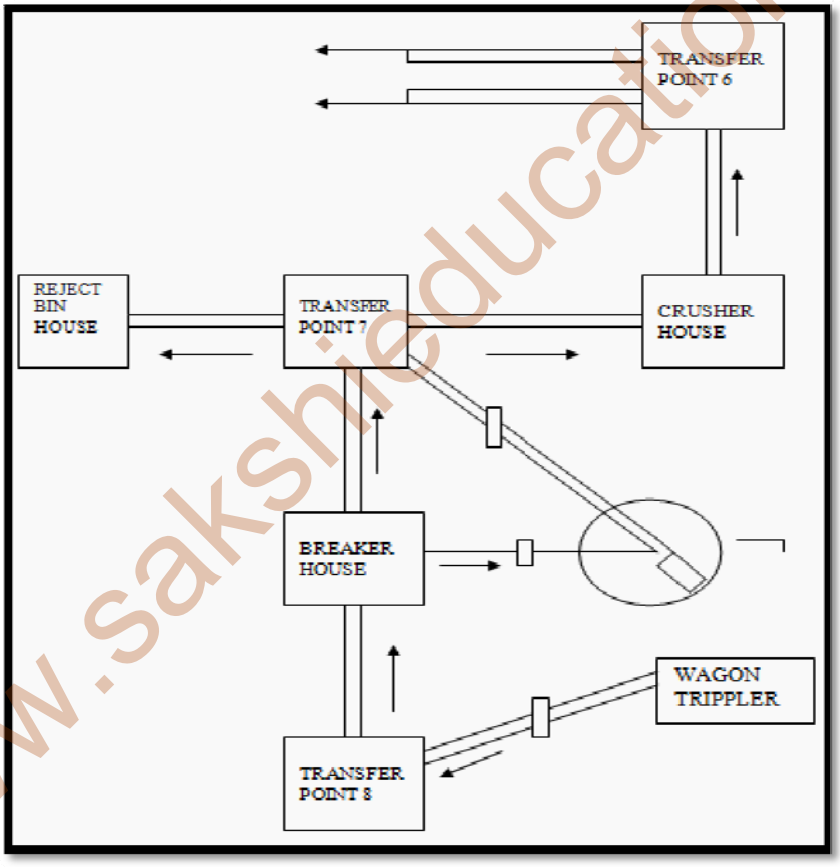

Figure: coal handling plant

Ash handling plant

Ash is the residue remaining after the coal is incinerated.SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO. In Thermal Power Plant's coal is generally used as fuel and hence the ash is produced as the byproduct of Combustion. Ash generated in power plant is about 30-40% of total coal consumption and hence the system is required to handle Ash for its proper utilization or disposal. Fly Ash (around 80% is the value of fly ash generated). Bottom ash (Bottom ash is 20% of the ash generated in coal based power stations.

Ash generated in the ESP which got carried out with the flue gas is generally called Fly ash. It also consists of Air pre heater ash & Economizer ash (it is about 2 % of the total ash content).

Ash generated below furnace of the steam generator is called the bottom ash.

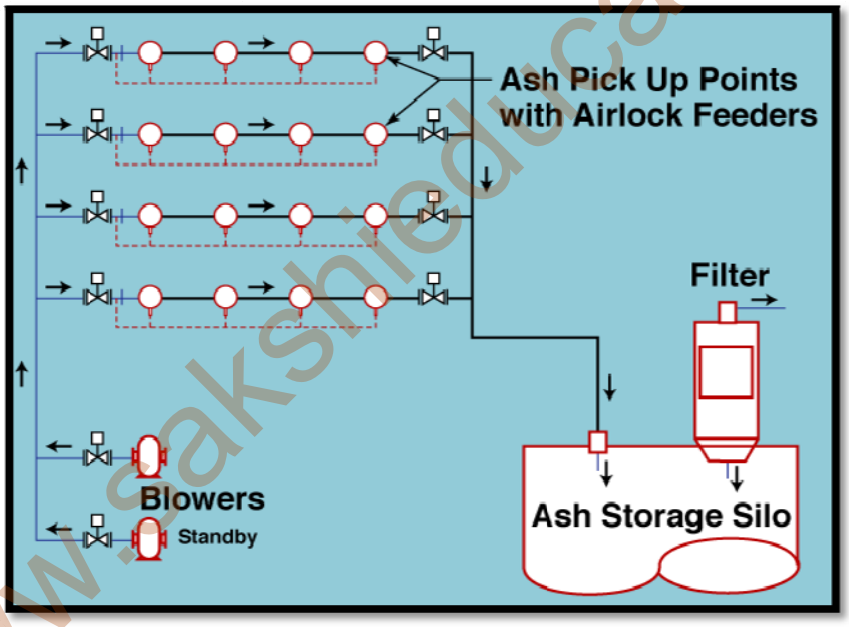

Figure: Ash handling plant

Steam

The steam turbine-driven generators have auxiliary systems enabling them to work satisfactorily and safely. The steam turbine generator being rotating equipment generally has a heavy, large diameter shaft.

The shaft therefore requires not only supports but also has to be kept in position while running. To minimize the frictional resistance to the rotation, the shaft has a number of bearings.

The bearing shells, in which the shaft rotates, are lined with a low friction material like Babbitt metal. Oil lubrication is provided to further reduce the friction between shaft and bearing surface and to limit the heat generated.

Water

A colorless, odorless compound of hydrogen and oxygen Water covers about quarters of the Earth's surface in solid form (ice) and liquid form, and is prevalent in the lower atmosphere in its gaseous form, water vapor. Water is an unusually good solvent for a large variety of substances, and is an essential component of all organisms, being necessary for most biological processes. Unlike most substances, water is less dense as ice than in liquid form; thus, ice floats on liquid water. Water freezes at 0°C (32°F) and boils at100°C (212°F). Chemical formula: H 2 O.

Flue gases:

Flue gases are the hot gases coming out of a chimney, venting a burner or a combustion chamber. Flue gas may contain oxides of carbon, nitrogen, and sulfur as well as fly-ash, other pollutants, and water vapor.

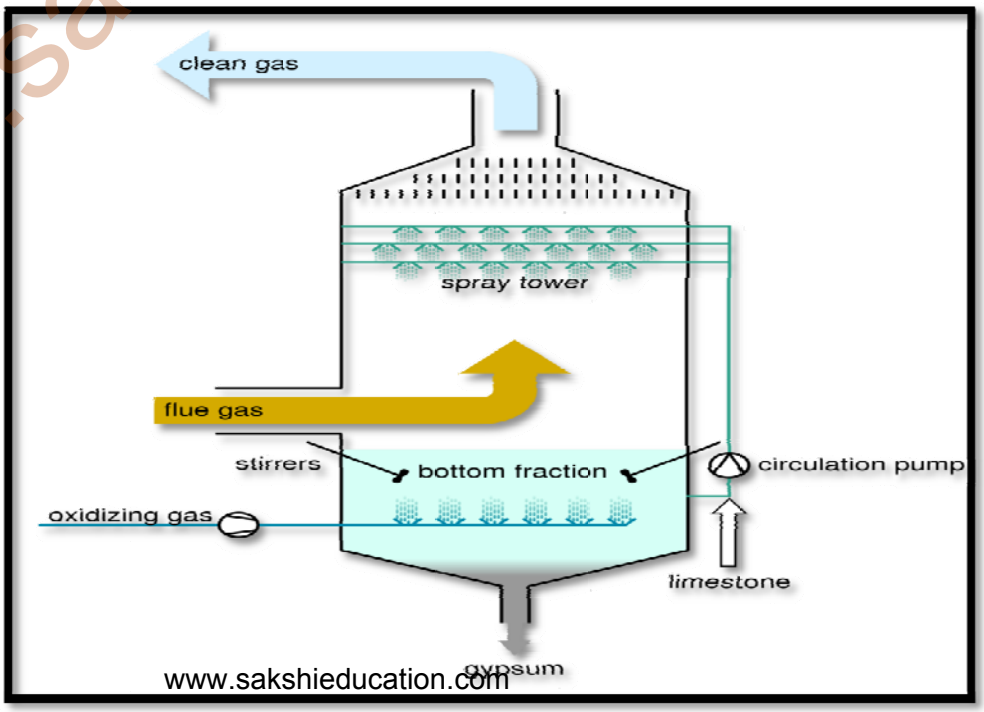

Figure: Fluid Gases

Air:

External fans are provided to give sufficient air for combustion. The Primary air fan takes air from the atmosphere and, first warming it in the air pre-heater for better combustion, injects it via the air nozzles on the furnace wall.

The induced draft fan assists the FD fan by drawing out combustible gases from the furnace, maintaining a slightly negative pressure in the furnace to avoid backfiring through any closing.

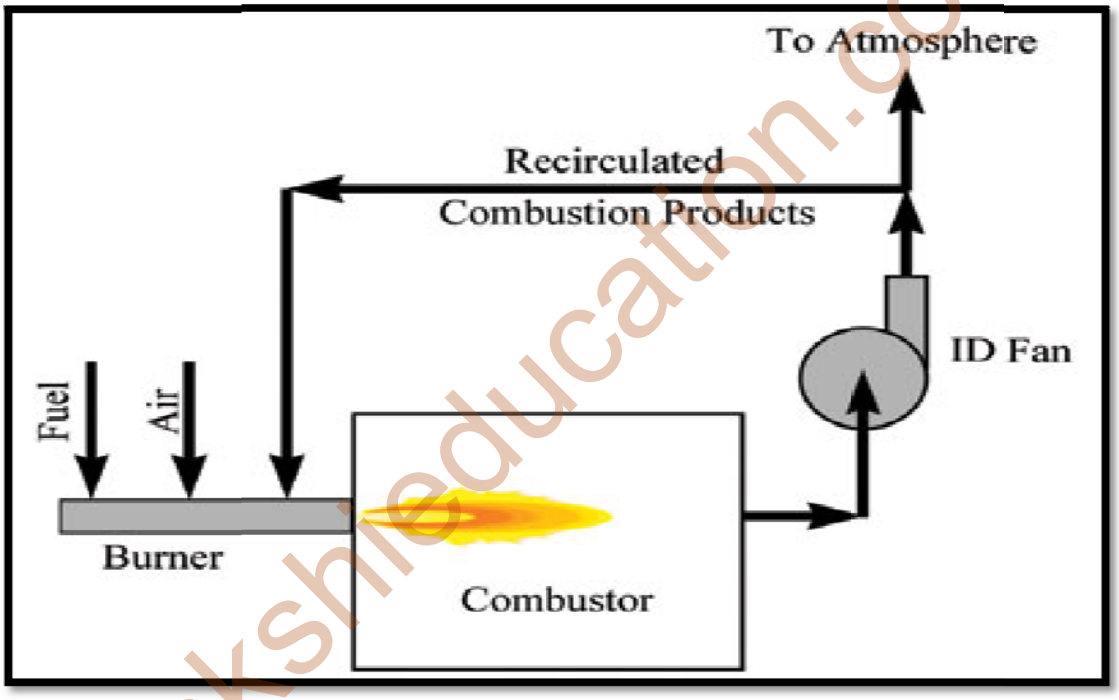

Figure: combination of fuel and air

Brief description Thermal Power Station of components:

Boiler

The heat of combustion of coal in the boiler is utilized to convert water into steam at higher temperature and pressure.

In Thermal Power Plant Boiler, Coal is burnt to heat up the water. The fuel is burnt inside the Boiler, whereas the water which is heated runs in tubes on the surface of the Boiler.

Thermal Power Plant Boilers are different because of the complexity of the process and different types of system involve in the entire combustion process.

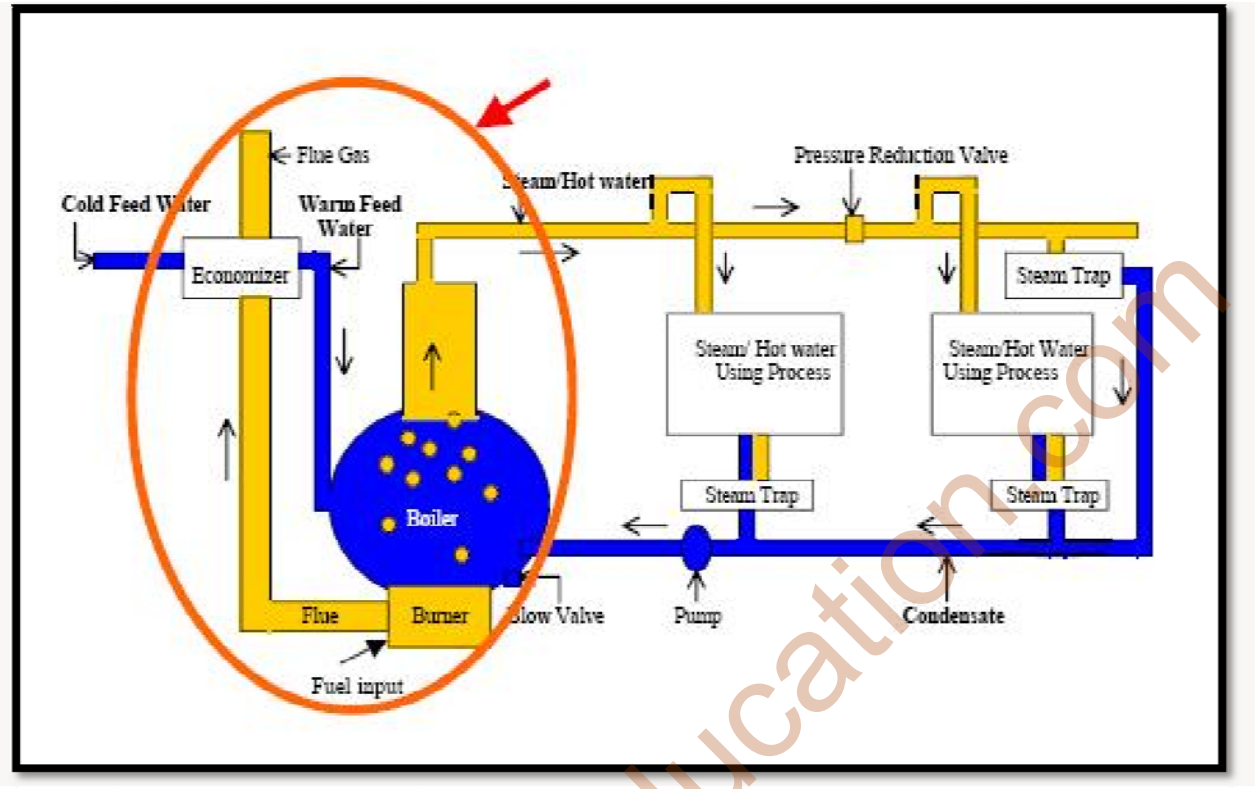

Figure: Boiler

Super heater

The steam produced initially in the boiler is wet(contains suspended droplets of water) which is passed through a super heater where it is dried (remove the suspended water droplets) by the heat of flue gases before let in to chimney. The super heated steam is fed to steam turbine though the main steam stop valve.

A super heater is a device used to convert saturated steam or wet steam into dry steam used for power generation or processes. There are three types of super heaters namely: radiant, convection, and separately fired. A super heater can vary in size from a few tens of feet to several hundred feet.

A radiant superheated is placed directly in the combustion chamber. A convection superheated is located in the path of the hot gases. A separately fired super heater, as its name implies, is totally separated from the boiler.

A super heater is a device in a steam engine, when considering locomotives, that heats the steam generated by the boiler again, increasing its

thermal energy and decreasing the likelihood that it will condense inside the engine. Super heaters increase the efficiency of the steam engine, and were widely adopted. Steam which has been superheated is logically known as superheated steam; non-superheated steam is called saturated steam or wet steam. Super heaters were applied to steam locomotives in quantity from the early 20th century, to most steam vehicles, and to stationary steam engines. This equipment is still an integral part of power generating stations throughout the world.

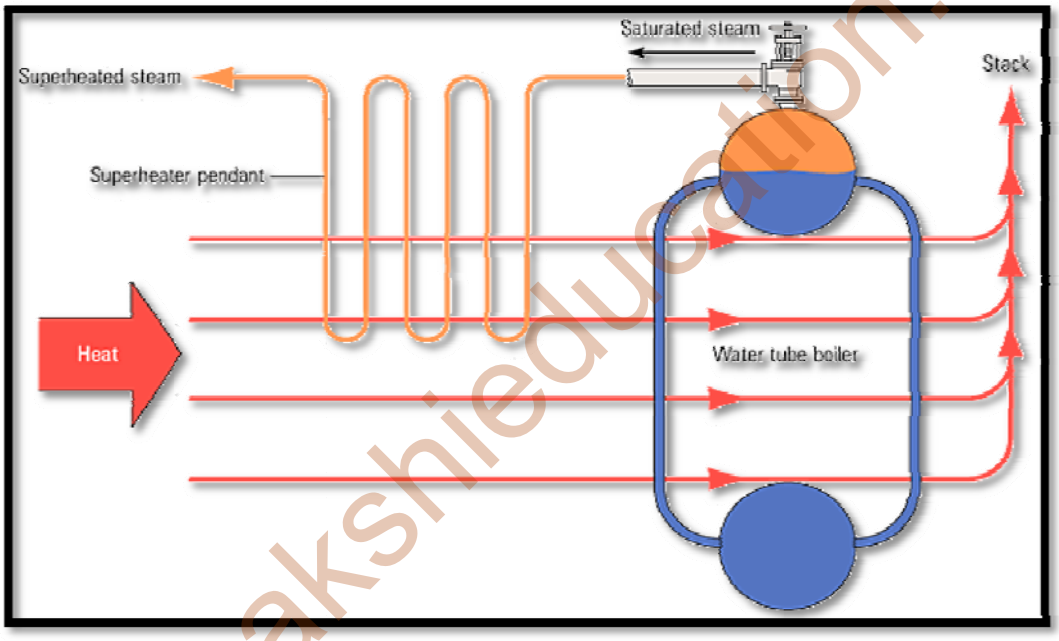

Figure: super heater

Economizer:

An Economizer is essential to feed water heater and drives heat from the fuel gases for this purpose, the feed water is fed to Economizer before supplying to the boiler.

Economizers are mechanical devices intended to reduce energy consumption, or to perform another useful function like preheating a fluid. The term economizer is used for other purposes as well: Boiler, power plant, heating, ventilating, and air-conditioning (HVAC).

In boilers, economizers are heat exchange devices that heat fluids, usually water up to, normally not beyond the boiling point of that fluid. Economizers are so named because they can make use of the enthalpy in fluid streams that are hot, but not hot enough to be used in a boiler, thereby recovering more useful enthalpy and improving the boiler's efficiency. They are a device fitted to a boiler which saves energy by using the exhaust gases from the boiler to preheat the cold water used to fill it (the feed water).

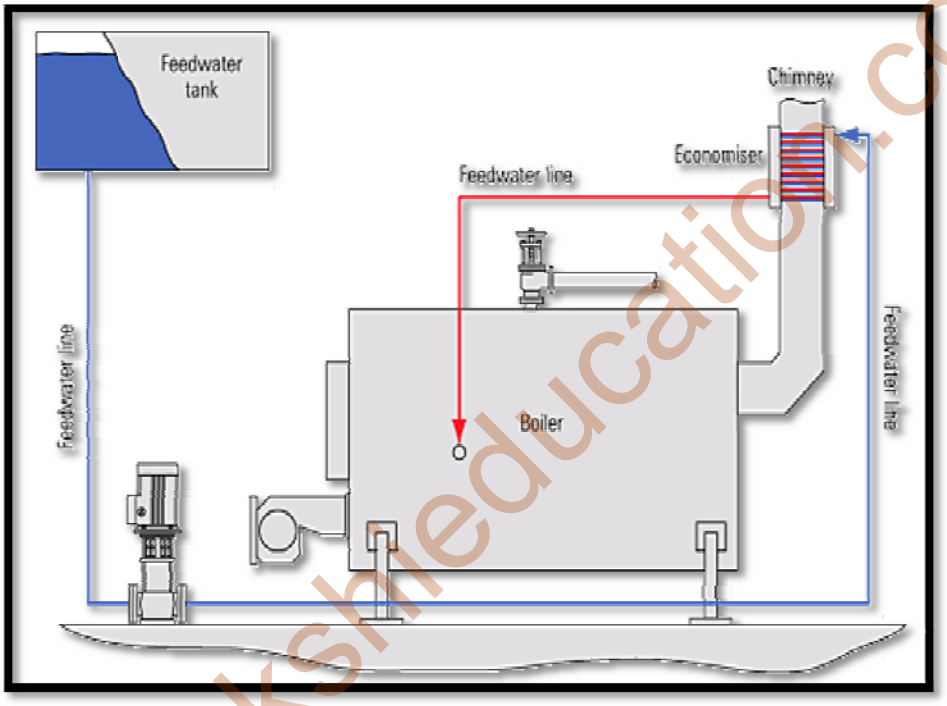

Figure: Economizer

Air pre-heater:

An air pre-heater increases the temperature of the air supplied by coal burning heat from fuel gases. Air is drawn from the atmosphere by forced draught fan and is passed through air pre-heater before supplying the boiler furnace.

An air preheated (APH), is a general term to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process. They may be used alone or to replace a recuperative heat system or to replace a steam coil.

In particular, this article describes the combustion air pre-heaters used in large boilers found in thermal power stations producing electric power from e.g. fossil fuels, biomasses or waste.

The purpose of the air preheated is to recover the heat from the boiler flue gas which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. As a consequence, the flue gases are also sent to the flue gas stack (or chimney) at a lower temperature, allowing simplified design of the ducting and the flue gas stack. It also allows control over the temperature of gases leaving the stack.

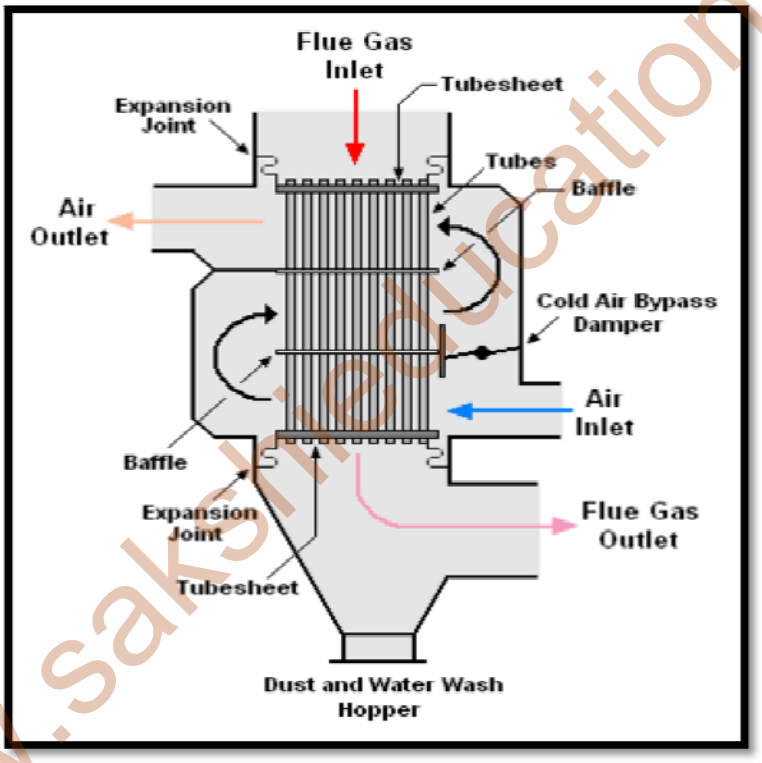

Figure: Air Preheater

Turbine

The super heater is fed to the steam turbine through main valve the heat energy of passing through the turbine to the mechanical energy the stem exhausted to condenser exhausted to cold water circulation.

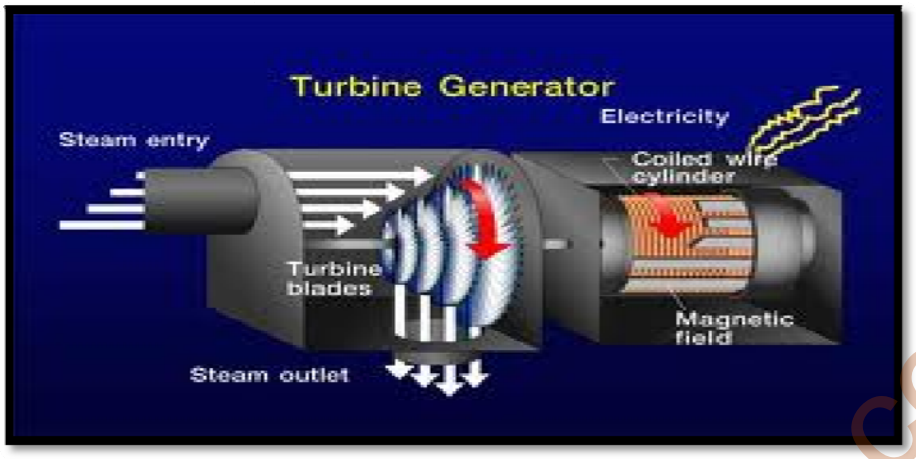

Figure: Turbine

Alternator

The alternator converts mechanical energy of turbines into electrical energy. The alternated electrical output is delivered to the bus bars, transformers and isolators.

Feed water

The condenser is used as feed water to the boiler. Some water may be lost cycle, which is suitably made up of external sources.

A feed water heater is a power plant component used to pre-heat water delivered to a steam generating boiler. Preheating the feed water reduces the irreversibility's involved in steam generation and therefore improves the thermodynamic efficiency of the system. This reduces plant operating costs and also helps to avoid thermal shock to the boiler metal, when the feed water is introduced back into the steam cycle.

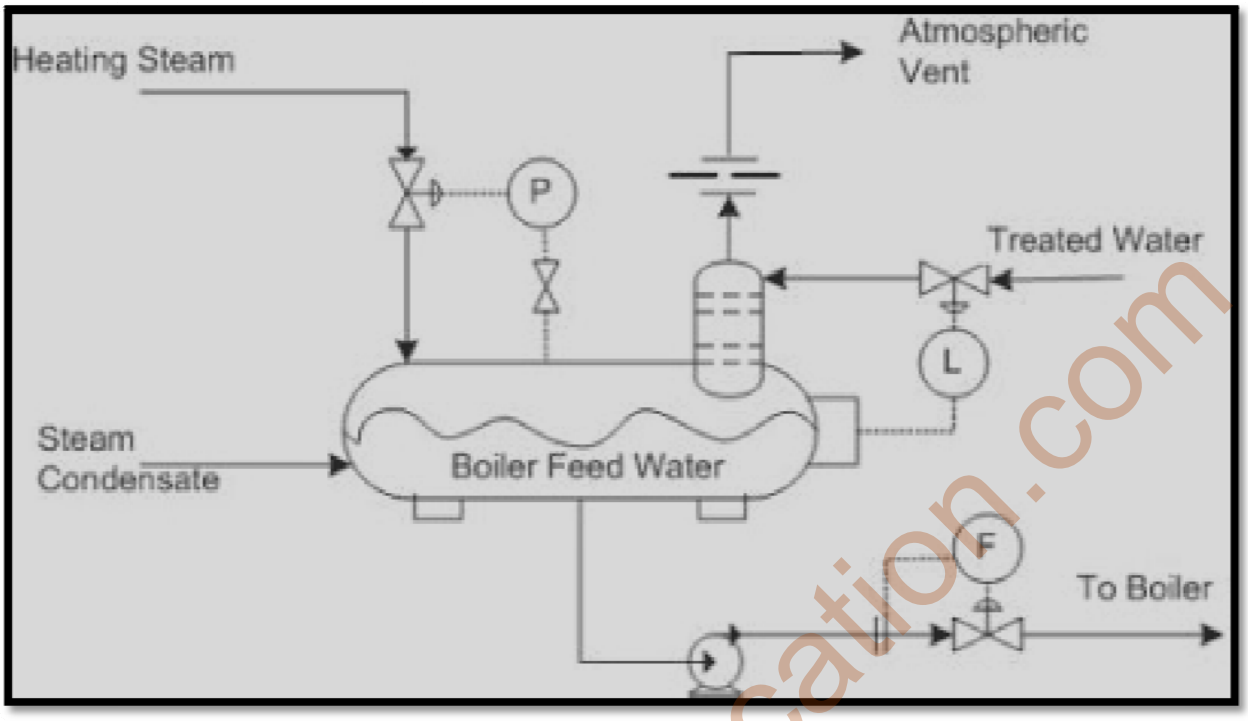

Figure: Feed water

Cooling arrangement

In order to improve the efficiency of the plant, the steam exhausted from the turbine is subjected to condense by means of condenser. The cold water from the cooling tower is reused.

Condensers

A condenser is a device or unit used to condense a substance from its gaseous to its liquid state, typically by cooling it. In doing so, the latent heat is given up by the substance, and will transfer to the condenser coolant.

In thermal Power plant we use surface condenser. Surface condenser is the commonly used term for a water-cooled shell and tube heat exchanger installed on the exhaust steam from a steam turbine in thermal power stations.

How thermal power plant “condenser” is different from other condenser?

In thermal Power plant we use surface condenser. Surface condenser is the commonly used term for a water-cooled shell and the tube heat exchanger installed on the exhaust steam from the steam turbine in thermal power stations.

Chimney

A chimney is a structure for venting hot flue gases or smoke from a boiler, stove, furnace or fireplace to the outside atmosphere.

What is the principle of working of chimney?

The working of chimney is based on natural draft or stack effect. The hot air being lighter rises to the top. The taller the chimney, more draught or draft is created.

Figure: Chimney

Cooling towers

A cooling tower is a heat rejection device which extracts waste heat to the atmosphere through the cooling of a water stream to a lower temperature. The cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature. In the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature.

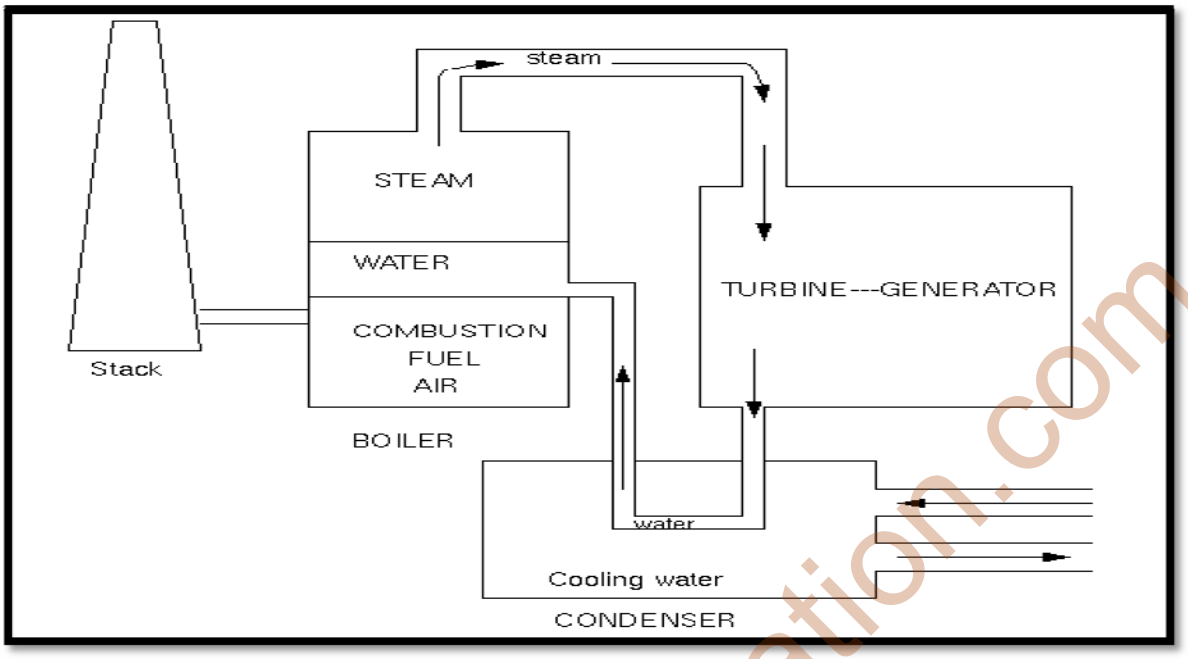

Figure: Brief diagram of thermal power station

Advantages and Disadvantages of thermal power station

Advantages:

1. The fuel used is quite cheap.
2. Less initial cost as compared to other generating plants.
3. It can be installed at any place respective of the existence of coal. The coal can be transported to the site of the plant by rail or road.
4. It requires less space as compared to Hydro power plants.
5. Cost of generation is less than that of diesel power plants.

Disadvantages:

1. It pollutes the atmosphere due to production of large amount of smoke and fumes.
2. It is costlier in running cost as compared to hydroelectric plants.