BEE505

POWER GENERATION SYSTEMS

3[RD] YEAR 5[TH] SEM

Unit one

1.. A generating station has the following daily load cycle :

Time (Hours)	*0—6*	*6—10*	*10—12*	*12—16*	*16—20*	*20—24*
Load (MW)	*40*	*50*	*60*	*50*	*70*	*40*

Draw the load curve and find (i) maximum demand (ii) units generated per day (iii) average load and (iv) load factor.

Solution. Daily curve is drawn by taking the load along *Y*-axis and time along *X*-axis. For the given load cycle, the load curve is shown in Fig. 3.6.

(*i*) It is clear from the load curve that maximum demand on the power station is 70 MW and occurs during the period 16—20 hours.

∴ Maximum demand = **70 MW**

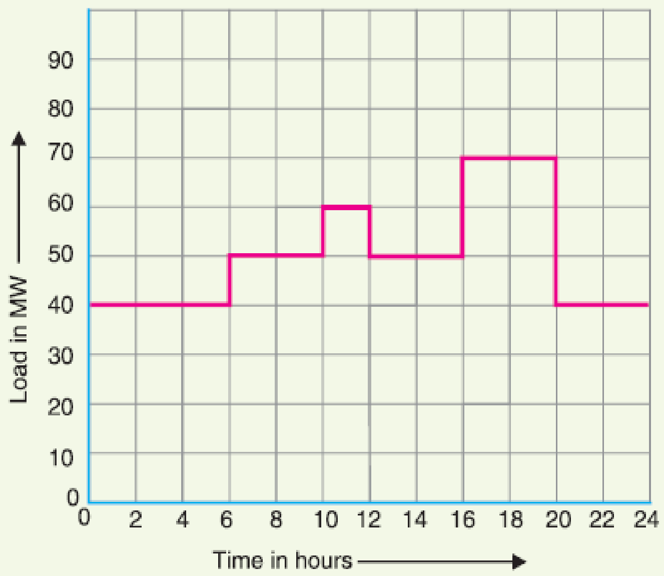


Fig. 3.6

(*ii*) Units generated/day = Area (in kWh) under the load curve

$= 10^3 [40 \times 6 + 50 \times 4 + 60 \times 2 + 50 \times 4 + 70 \times 4 + 40 \times 4]$

$= 10^3 [240 + 200 + 120 + 200 + 280 + 160]$ kWh

$= \mathbf{12 \times 10^5}$ **kWh**

(*iii*) Average load $= \dfrac{\text{Units generated / day}}{24 \text{ hours}} = \dfrac{12 \times 10^5}{24} =$ **50,000 kW**

(*iv*) Load factor $= \dfrac{\text{Average load}}{\text{Max. demand}} = \dfrac{50{,}000}{70 \times 10^3} = 0{\cdot}714 =$ **71·4%**

2... A generating station is to supply four regions of load whose peak loads are

10 MW, 5 MW, 8 MW and 7 MW. The diversity factor at the station is 1·5 and the average annual load factor is 60%. Calculate the maximum demand on the station ,annual energy supplied by the station. and also Suggest the installed capacity and the number of units.

Solution.

(*i*) Max. demand on station $= \dfrac{\text{Sum of max. demands of the regions}}{\text{Diversity factor}}$

$= (10 + 5 + 8 + 7)/1{\cdot}5 = \mathbf{20\ MW}$

(*ii*) Units generated/annum $=$ Max. demand $\times$ L.F. $\times$ Hours in a year

$= (20 \times 10^3) \times (0{\cdot}6) \times (8760)$ kWh

$= \mathbf{105{\cdot}12 \times 10^6\ kWh}$

(*iii*) The installed capacity of the station should be 15% to 20% more than the maximum demand in order to meet the future growth of load. Taking installed capacity to be 20% more than the maximum demand,

Installed capacity $= 1{\cdot}2 \times$ Max. demand $= 1{\cdot}2 \times 20 = \mathbf{24\ MW}$

Suitable unit sizes are 4, each of 6 MW capacity.

Tariff and any three types of tariff.

Tariff

The rate at which electrical energy is supplied to a consumer is known as **tariff**.

Types of Tariff

There are several types of tariff. However, the following are the commonly used types of tariff :

1. Simple tariff.

When there is a fixed rate per unit of energy consumed, it is called a **simple tariff** *or* **uniform rate tariff.**

In this type of tariff, the price charged per unit is constant *i.e.*, it does not vary with increase ordecrease in number of units consumed. The consumption of electrical energy at the consumer'sterminals is recorded by means of an energy meter. This is the simplest of all tariffs and is readily understood by the consumers.

2. Flat rate tariff.

When different types of consumers are charged at different uniform per unit rates, it is called a **flat rate tariff**.

In this type of tariff, the consumers are grouped into different classes and each class of consumersis charged at a different uniform rate. For instance, the flat rate per kWh for lighting load may be 60 paise, whereas it may be slightly less (say 55 paise per kWh) for power load. The different classes of consumers are made taking into account their diversity and load factors. The advantage of such a tariff is that it is more fair to different types of consumers and is quite simple in calculations.

3. Block rate tariff.

When a given block of energy is charged at a specified rate and the succeeding blocks of energy are charged at progressively reduced rates, it is called a **block ratetariff**.

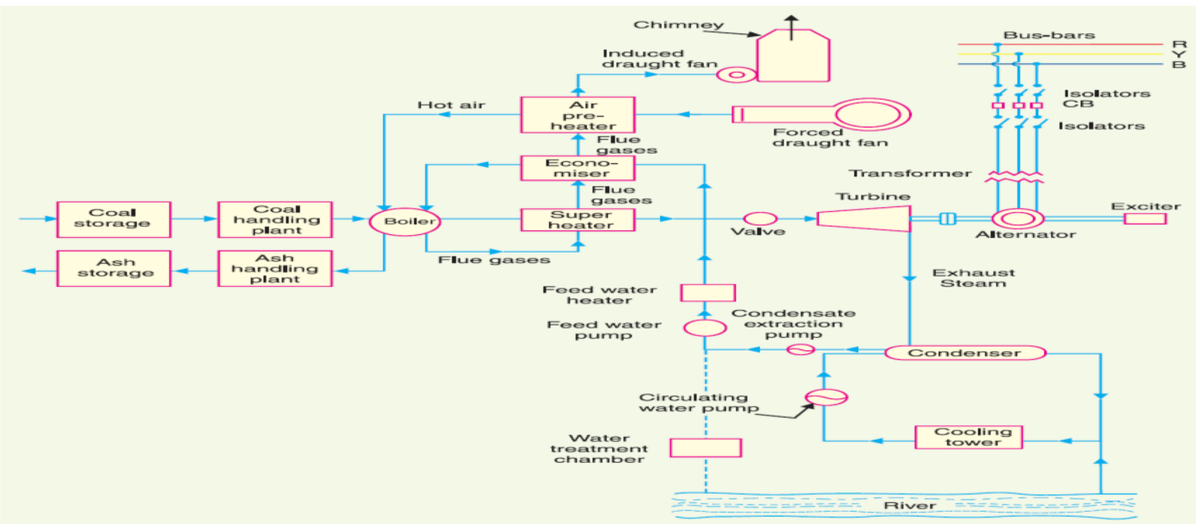
4. Two-part tariff.

When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called a **two-part tariff**.

Unit2

Steam Power Station (Thermal Station)

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



Schematic arrangement of Steam Power Station

Choice of Site for Steam Power Stations

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

(*i*) *Supply of fuel.* The steam power station should be located near the coal mines so thattransportation 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 thetransportation of coal.

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

(*iii*) *Transportation facilities.* A modern steam power station often requires the transportation ofmaterial 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.

(*iv*) *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.

(*v*) *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 *d.c.* supply system is adopted. However, if *a.c.* supply system is adopted, this factor becomes relatively less important. It is because *a.c.* 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.

(*vi*) *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 plantshould be located at a considerable distance from the populated areas.

Choice of Site for Hydro-electric Power Stations

The following points should be taken into account while selecting the site for 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 withstand 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.

advantages and disadvantages of diesel power station

Advantages

Ø Diesel power plants can be quickly installed and commissioned.

Ø Quick starting.

Ø Requires minimum labour.

Ø Plant is smaller, operate at high efficiency and simple compared to steam power plant.

Ø It can be located near to load centres.

Disadvantages

Ø Capacity of plant is low.

Ø Fuel, repair and maintenance cost are high.

Ø Life of plant is low compared to steam power plant.

Ø Lubrication costs are very high.

Ø Not guaranteed for operation under continuous overloads.

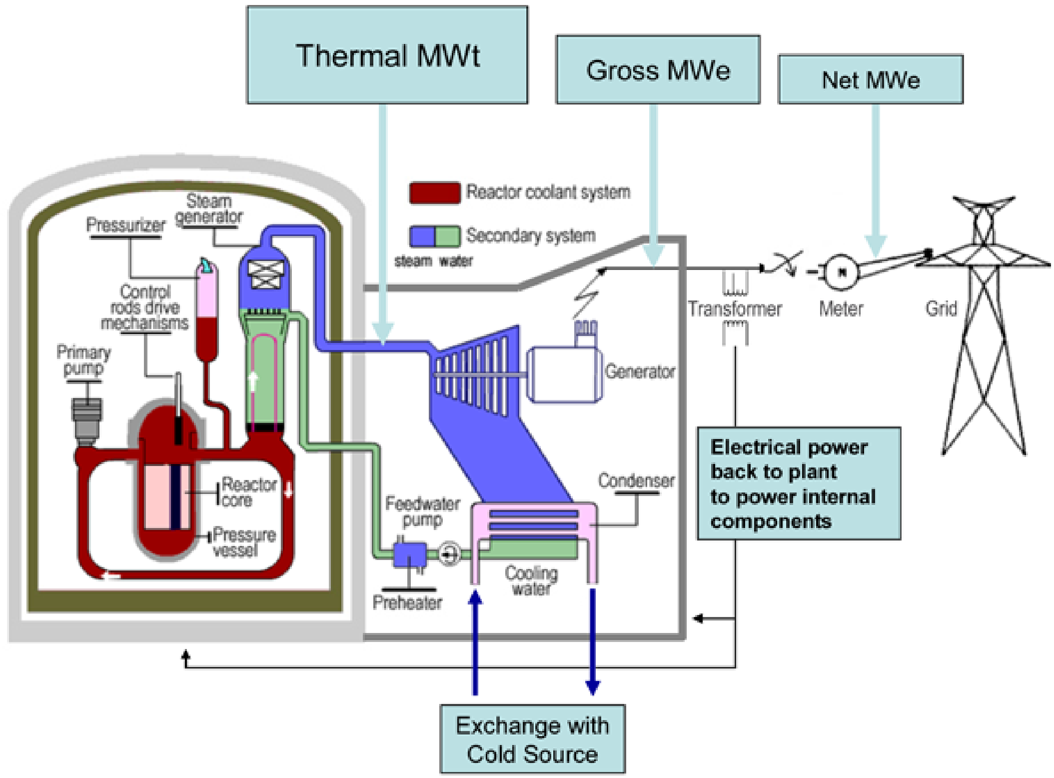
Ø Noise is a serious problem in diesel power plant.

Ø Diesel power plant cannot be constructed for large scale.

Nuclear Power Plant

A nuclear power plant is a thermal power station in which the heat source is one or more nuclear reactors. As in a conventional thermal power station the heat is used to generate steam which drives a steam turbine connected to a generator which produces

electricity. Nuclear power plants are usually considered to be base load stations, which are best suited to constant power output.



A nuclear reactor produces and controls the release of energy from splitting the atoms of certain elements. In a nuclear power reactor, the energy released is used as heat to make steam to generate electricity. (In a research reactor the main purpose is to utilise the actual neutrons produced in the core. In most naval reactors, steam drives a turbine directly for propulsion.)

Components of a nuclear reactor

There are several components common to most types of reactors:

Fuel.

Uranium is the basic fuel. Usually pellets of uranium oxide (UO_2) are arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core.* In a 1000 MWe class PWR there might be 51,000 fuel rods with over 18 million pellets.
Moderator.**Material in the core which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite.**

Control rods.

These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it.* In some PWR reactors, special control rods are used to enable the core to sustain a low level of power efficiently. (Secondary control systems involve other neutron absorbers, usually boron in the coolant – its concentration can be adjusted over time as the fuel burns up.).

Coolant.

A fluid circulating through the core so as to transfer the heat from it. In light water reactors the water moderator functions also as primary coolant. Except in BWRs, there is secondary coolant circuit where the water becomes steam. (See also later section on primary coolant characteristics.) A PWR has two to four primary coolant loops with pumps, driven either by steam or electricity – China's Hualong One design has three, each driven by a 6.6 MW electric motor, with each pump set weighing 110 tonnes.

Pressure vessel or pressure tubes.

Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the surrounding moderator.

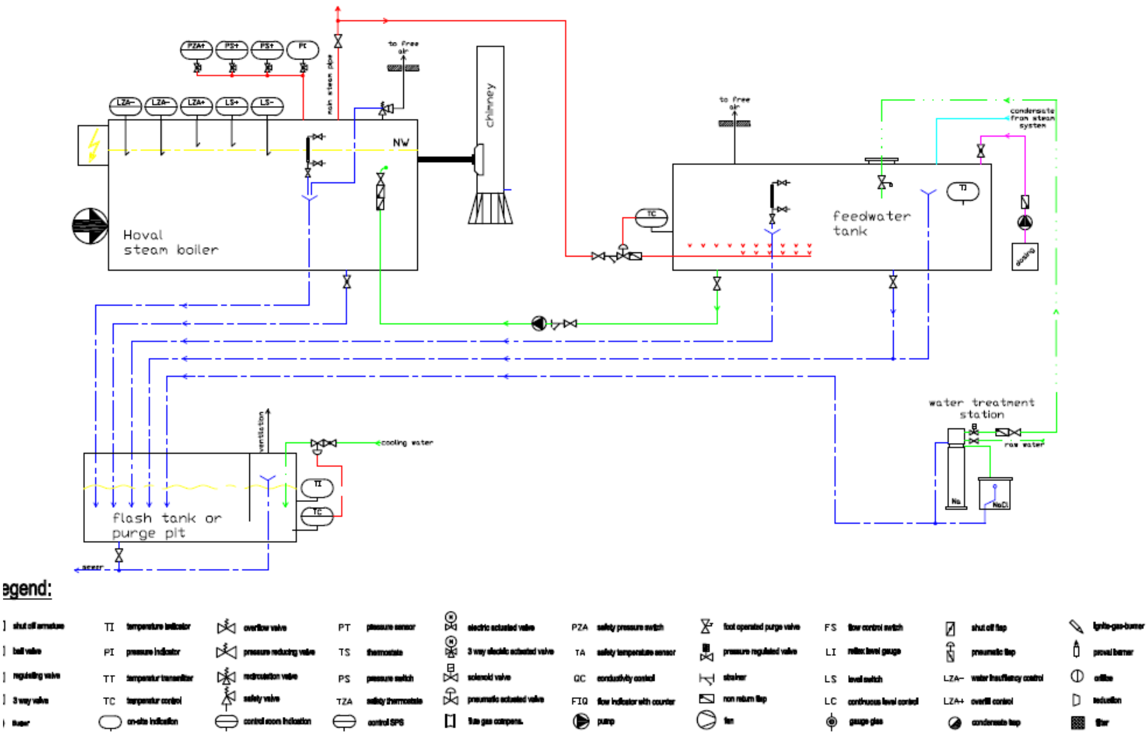
Steam generator.

Part of the cooling system of pressurised water reactors (PWR & PHWR) where the high-pressure primary coolant bringing heat from the reactor is used to make steam for the turbine, in a secondary circuit. Essentially a heat exchanger like a motor car radiator*. Reactors have up to six 'loops', each with a steam generator. Since 1980 over 110 PWR reactors have had their steam generators replaced after 20-30 years service, 57 of these in USA.

Containment.

The structure around the reactor and associated steam generators which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any serious malfunction inside. It is typically a metre-thick concrete and steel structure.

Unit 3



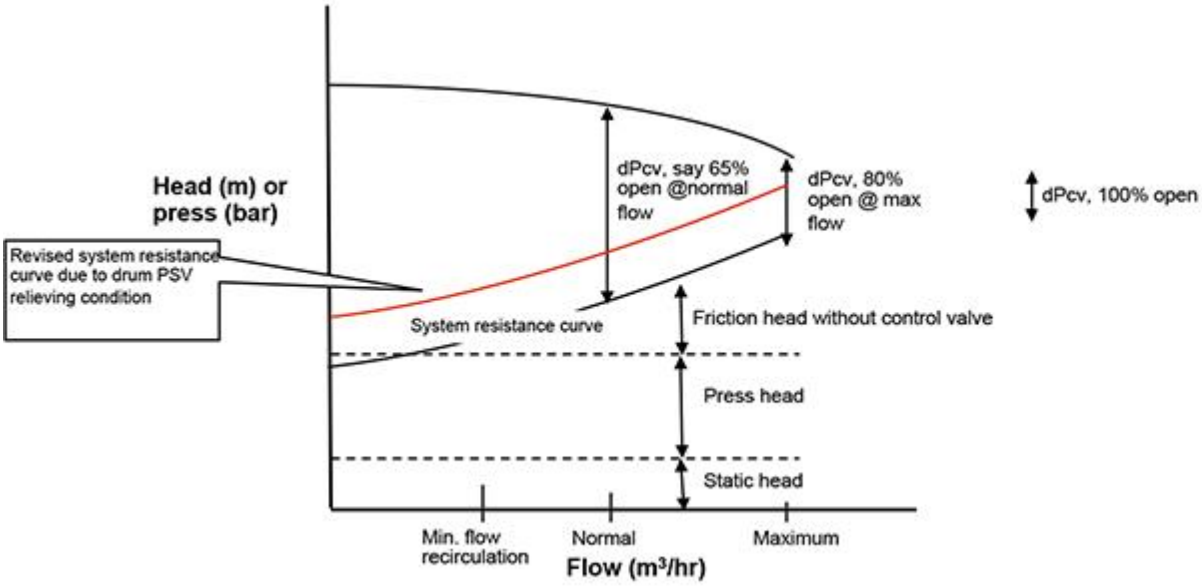
Feed water control

Feedwater control valves play a critical role in boiler operation. One important parameter of their design is the pressure drop at the rated condition as well as off-design conditions. However, conventional methods used for establishing control valve pressure drop cannot be used at face value without reviewing all plant operating scenarios.

In power plants with drum-type boilers and constant-speed main boiler feed pumps, the feedwater control valve (also referred to as the drum level control valve) provides the means for controlling flow to the boiler. On the other hand, in power plants equipped with variable-speed turbine-driven main boiler feed pumps, the feedwater control valves are usually eliminated from the main circuit but may still be used on the startup circuit with the smaller motor-driven startup feed pump.In either application, the feedwater control valve is in critical and severe service. As such, it must be sized and designed to provide adequate drum level control and cope with varying drum pressures expected over the range of plant operating conditions. In this regard, one of the important parameters to be evaluated is the control valve pressure drop at the rated condition, as well as during off-design conditions.

The control valve pressure drop needs to be established carefully, as it is a performance debit resulting from increase in horsepower associated with the pressure head of the boiler feed pump. Use of variable-speed drives or turbine drives on the boiler feed pump can avoid this debit by eliminating the control valve altogether. Boilers designed for sliding pressure operation generally utilize variable-speed drives or turbine drives not only to eliminate the control valve penalty but also to take advantage of minimized performance debits at part loads due to lower pump head. The part-load advantage is not available with fixed pressure operation, where boiler pressure remains constant and the pump pressure head must remain high, even at part loads.

Note that the difference between the boiler feed pump head-flow curve and the system resistance curve (Figure 1) provides the basis for the pressure drop available for the drum level control valve. During startup and low-load operation, when drum pressures are low, the valve may experience severe service due to high pressure drop. These conditions could lead to valve cavitation and subsequent destruction of the valve trim along with pipe hammer, which could lead to piping and piping support damage. It is, therefore, essential that the sizing and design of the drum level control valve be such that these problems are avoided. For this purpose, the entire range of service conditions should be provided on the valve data sheet, as this will enable the valve supplier to make the correct valve/trim selection.



Unit 4

.

Combustion control

Boilers are often the principal steam or hot water generator system used in industrial plant or commercial heating. Consequently, they must be designed to operate efficiently and safely whilst responding rapidly to any change in demand. Burner management systems must be equally adaptive. Eurotherm Process Automation provides efficient, well implemented control techniques capable of reducing operating costs whilst

providing resources for greater flexibility in plant management and control. Burner combustion control generally includes one or a combination of the following methods:

Regulation of excess air

Oxygen trim

Burner modulation

Air/fuel cross-limiting

Total heat control

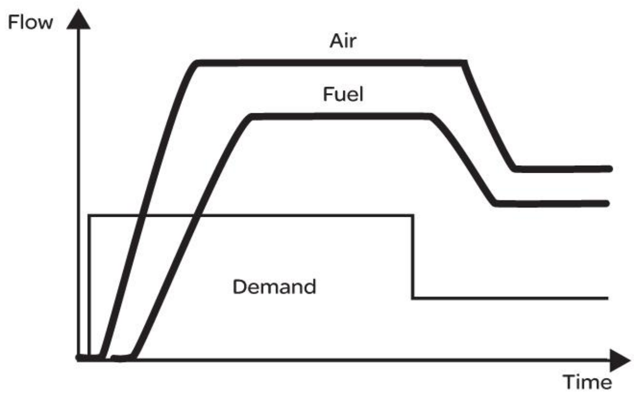


Figure 1 Boiler efficiency

Excess air regulation

In actual practice, gas, oil, coal burning and other systems do not do a perfect job of mixing the fuel and air even under the best achievable conditions.Additionally, complete mixing may be a lengthy process. Figure 1 shows that in order to ensure complete combustion and reduce heat loss, excess air has to be kept within a suitable range.

The regulation of excess air provides:

A better boiler heat transfer rateAn ‘advance warning’ of flue gas problems (excess air coming out of the zone of maximum efficiency)Substantial savings on fuel

Oxygen trim

When a measurement of oxygen in the flue gas is available, the combustion control mechanism can be vastly improved (since the percentage of oxygen in flue is closely related to the amount of excess air) by adding an oxygen trim control module, allowing:

Tighter control of excess air to oxygen setpoint for better efficiency

Faster return to setpoint following disturbances

Tighter control over flue emissions

Compliance with emissions standards

Easy incorporation of carbon monoxide or opacity override.

Burner modulation

Modulating control is a basic improvement in controlling combustion. A continuous control signal is generated by a controller monitoring the steam or hot water line.

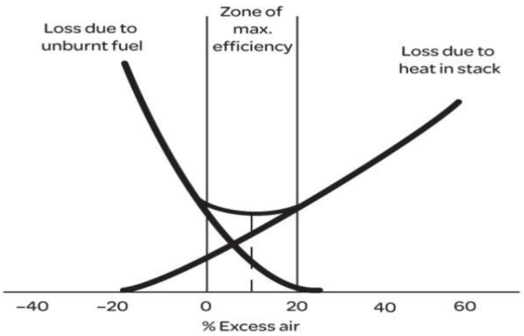


Figure 2 Cross-limiting combustion mechanism

Reductions in steam pressure or hot water temperature lead to an increase in firing rate. The advantages of introducing burner modulation in combustion control include:

Fuel and air requirements are continuously matched to the combustion demand

Steam pressure or hot water temperature is maintained within closer tolerances

Greater boiler efficiency

Weighted average flue gas temperature is lower

Air/fuel cross-limiting

A cross-limiting combustion control strategy ensures that there can never be a dangerous ratio of air and fuel within a combustion process. This is implemented by always raising the air flow before allowing the fuel flow to increase, as shown in Figure 2, or by lowering the fuel flow before allowing the air flow to drop.

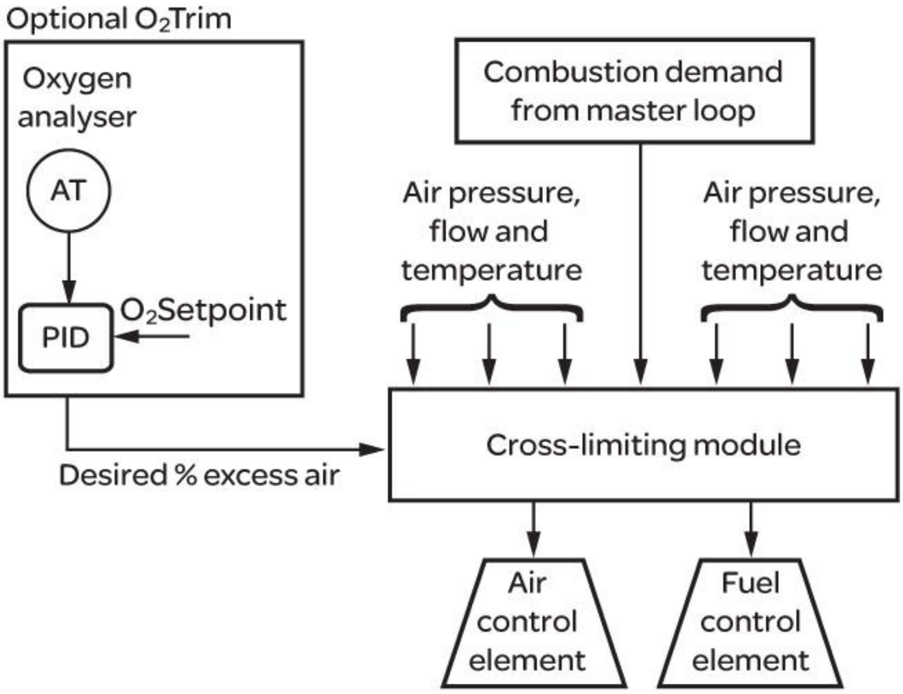


Figure 3 Cross-limiting combustion control with 06 trim

Figure 3 depicts a simplified control block diagram of the cross-limiting combustion circuit. Combination firing of multiple fuels simultaneously can also be easily accommodated within the scheme.

Cross-limiting combustion control is highly effective and can easily provide the following:

Optimization of fuel consumption

Safer operating conditions by reducing risk of explosion

Fast adaptation to variations in fuel and air supplies

Satisfaction of the plant demand for steam

Enhanced cross-limiting

Double cross-limiting combustion control is an enhancement to the above. It is achieved by applying additional dynamic limits to air and fuel setpoints. This translates to having the actual air/fuel ratio maintained within a preset band during and after transition. This method protects against having the demand signal driving the air/fuel ratio too lean, therefore reducing heat loss.

Total heat control

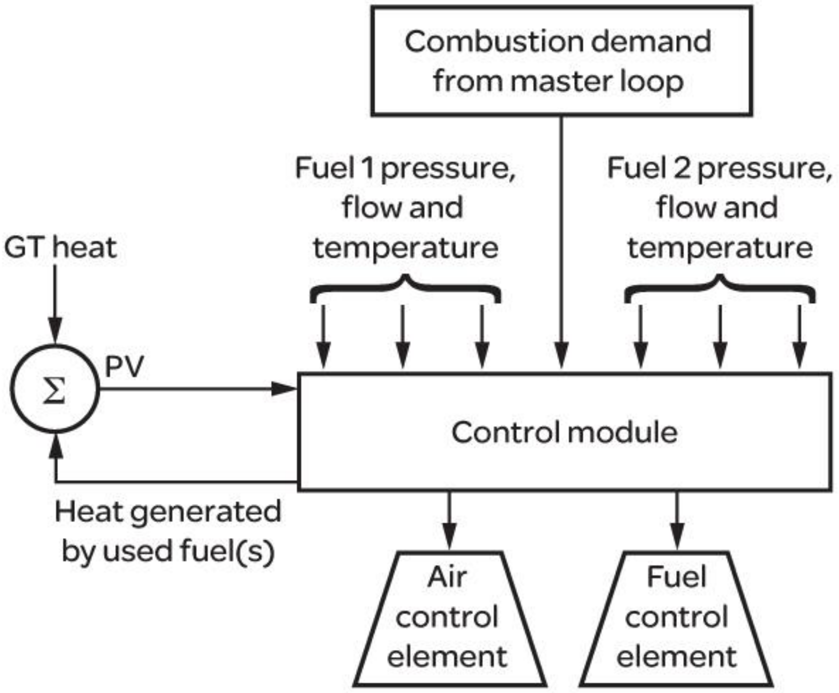


Figure 4 Total heat control

In situations where combustion is not the principal heat source and when several factors contribute to the total heat to be generated by a boiler, a control loop can be introduced in order to monitor and manage the generated heat. This is particularly true for CHP plants, where gas turbines and supplementary firing are used. This type of implementation is shown in Figure 4:

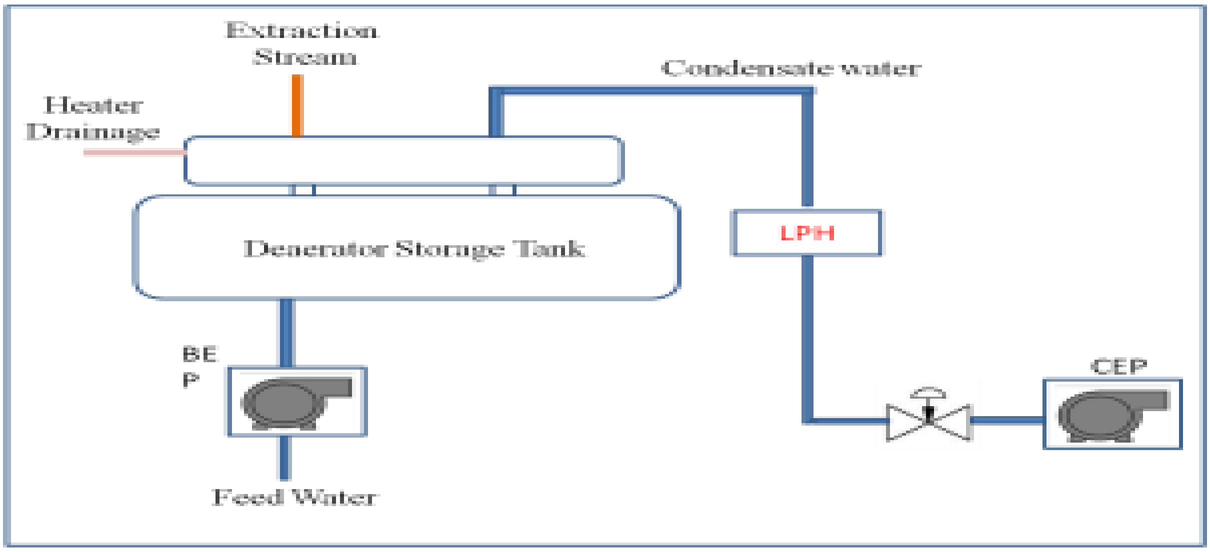
2Write short notes about . deaerator control.

Deaerator

The deaerator is an important feed-water system component which is used to remove the dissolved gases like oxygen and carbon dioxide in the feed water. The presence of theses gases in the feed-water which will enter in boiler or steam generator can causes a rapid corrosion in the tubes. So the deaerator uses the following techniques to dissolve the gases.

1) If the partial pressure of the liquid reduces then gas dissolved content will be reduced. This done by spraying the feed-water in deaerator.
2) If the temperature of the solution rises up to saturation temperature then the solubility content will reduces. This is that the feed-water is spared in the presence of high temperature steam and gets heated up so that the dissolved gases will flow through the deaerator vents. After the above process the feed water will be collected in

deaerator storage tank from which it is supplied to steam generator (boiler) through Boiler Feed water Pump (BFP).



effects of deaerator level

Deaerator high level:

If the water in deaerator storage tank level increases then the pressure in the deaerator increases which effects the inlet steam flow. This affects heating of inlet water which reduces the temperature of the water. So the removal of dissolved gasses will be disturbed.

Deaerator Low level:

The low level may not have significance affect on the deaeration process but due to this low level the outlet flow may reduce which is delivered to steam generator. There will be a trip sigal to BFP on deaerator low level. So the deaerator level should be maintained.

.lubrication and cooling system of turbine.

Lubrication

Turbines use a recirculating oil system where oil is collected in tanks after it has been pumped around by pressure and scavenge pumps. Oil coolers and filters are also used to remove any excess heat and any particulate matter picked up by the oil which could damage bearings and gears reducing the life of the engine.Oil in a turbine does not get

anywhere near the combustion process as in a piston engine where it lubricates the pistons and is exposed to these high temperatures, reducing service life and increasing the need to change oil on a very regular basis.AeroShell has a document about turbine engine oils**.There are basically two types of oil systems used in turbines: the full flow system and the other is with a pressure relief valve. The major difference is in the way how the oil flow is being controlled. In the cockpit there are indicators for pressure and temperature for each engine on both systems.A pressure relief valve sets the oil pressure to a predetermined value, much as in a piston model. There are variations where the valve settings varies depending on RPM, so that flow rate is constant. A full flow system runs without a pressure relief valve, thereby providing adequate oil flow even at maximum allowable RPM.An expendable oil system is sometimes used as this saves weight, there is no need for an oil cooler, filters or scavenge pumps. But oil usage is considerable and the system is not very common in normal day to day engines. They are found in vertical lift or booster engines, which are in use only for a short period of time.**

Cooling Oil

Cooling of engine oil is done by either ambient air or through a fuel heater / oil cooler core. Giving the advantage of heating the fuel going to the engine and reducing possible blockage due to ice in the fuel system.

Unit 5

distributed generation

Distributed generation is an approach that employs small-scale technologies to produce electricity close to the end users of power. DG technologies often consist of modular (and sometimes renewable-energy) generators, and they offer a number of potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than can traditional power generators. In contrast to the use of a few large-scale generating stations located far from load centers--the approach used in the traditional electric power paradigm--DG systems employ numerous, but small plants and can provide power onsite with little reliance on the distribution and transmission grid. DG technologies yield power in capacities that range from a fraction of a kilowatt [kW] to about 100 megawatts [MW]. Utility-scale generation units generate power in capacities that often reach beyond 1,000 MW.

Distributed generation takes place on two-levels: the local level and the end-point level. Local level power generation plants often include renewable energy technologies that

are site specific, such as wind turbines, geothermal energy production, solar systems (photovoltaic and combustion), and some hydro-thermal plants. These plants tend to be smaller and less centralized than the traditional model plants. They also are frequently more energy and cost efficient and more reliable. Since these local level DG producers often take into account the local context, the usually produce less environmentally damaging or disrupting energy than the larger central model plants.Basics for the Design of a Distributed Generation Power Conversion SystemSpecial issues and concerns must be addressed when dealing with medium and high power systems. These issues arise in instances where a design is being done for the support of power delivery to the utility and when incorporating the concepts of both DG and intentional islanding.
The following sections detail the reasoning behind the selection of using a VSI, common standards and regulations used for DG interconnections, and descriptions of challenges faced while implementing medium and high power systems

Principle of working and layout of MHD.

The **MHD generation** or, also known as **magneto hydrodynamic power generation** is a direct energy conversion system which converts the heat energy directly into electrical energy, without any intermediate mechanical energy conversion, as opposed to the case in all other power generating plants. Therefore, in this process, substantial fuel economy can be achieved due to the elimination of the link process of producing mechanical energy and then again converting it to electrical energy .

Principle of MHD Generation

The principal of **MHD power generation** is very simple and is based on Faraday's law of electromagnetic induction, which states that when a conductor and a magnetic field moves relative to each other, then voltage is induced in the conductor, which results in flow of current across the terminals.As the name implies,the magneto hydro dynamics generator shown in the figure below, is concerned with the flow of a conducting fluid in the presence of magnetic and electric fields. In conventional generator or alternator, the conductor consists of copper windings or stripswhile in an MHD generator the hot ionized gas or conducting fluid replaces the solid conductor. A pressurized, electrically conducting fluid flows through a transverse magnetic field in a channel or duct. Pair of electrodes are located on the channel walls at right angle to the magnetic field and connected through an external circuit to deliver power to a load connected to it. Electrodes in the MHD generator perform the same function as brushes in a conventional DC generator. The MHD generator develops DC power and the conversion to AC is done using an inverter.The power generated per unit length by MHD generator is approximately given by,

$$P = \frac{\sigma u B^2}{P}$$

Where, u is the fluid velocity, B is the magnetic flux density, σ is the electrical conductivity of conducting fluid and P is the density of fluid.
It is evident from the equation above, that for the higher power density of an MHD

generator there must be a strong magnetic field of 4-5 tesla and high flow velocity of conducting fluid besides adequate conductivity.

MHD Cycles and Working Fluids

The **MHD cycles** can be of two types, namely

Open Cycle MHD.

Closed Cycle MHD.

The detailed account of the types of MHD cycles and the working fluids used, are given below.

Open Cycle MHD System

In open cycle MHD system, atmospheric air at very high temperature and pressure is passed through the strong magnetic field. Coal is first processed and burnet in the combustor at a high temperature of about 2700°C and pressure about 12 ATP with pre-heated air from the plasma. Then a seeding material such as potassium carbonate is injected to the plasma to increase the electrical conductivity. The resulting mixture having an electrical conductivity of about 10 Siemens/m is expanded through a nozzle, so as to have a high velocity and then passed through the magnetic field of MHD generator. During the expansion of the gas at high temperature, the positive and negative ions move to the electrodes and thus constitute an electric current. The gas is then made to exhaust through the generator. Since the same air cannot be reused again hence it forms an open cycle and thus is named as open cycle MHD.

Closed Cycle MHD System

As the name suggests the working fluid in a closed cycle MHD is circulated in a closed loop. Hence, in this case inert gas or liquid metal is used as the working fluid to transfer the heat. The liquid metal has typically the advantage of high electrical conductivity, hence the heat provided by the combustion material need not be too high. Contrary to the open loop system there is no inlet and outlet for the atmospheric air. Hence, the process is simplified to a great extent, as the same fluid is circulated time and again for effective heat transfer.

geo thermal powerstation.

Geothermal Plant

Geothermal energy is an uninterrupted source of power. These power plants may operate 24-hours per day, but they also differ from the conventional plants in many key aspects. What are these differences? Read this article to find out.

- **The sun and the Earth's inner core are the two greatest energy sources on the planet. Utilising theses two forms of energy to produce electricity is going to be one method to fight global warming. One is a perpetual source of energy and other other a gigantic energy store. Why should we look for other sources?**

Even though the current geothermal power generation is minuscule 0.3 % of world generation, it holds a promising future. What, then, are the main components of a geothermal powerplant? How does it compare with conventional power plants?

- ## The Well

The most important part of any geothermal plant is the source of steam. Steam from the underground thermal reservoirs, 1000 to 2000 m deep, raises to the surface though bore holes drilled through the stones, rocks, and other layers. This is similar to a production well of an oil rig. Each location has one or many wells with the output connected to a header. Headers and pipes connect the wellheads to the power plant. Depending on the nature of the geothermal reserve, the wells may be located as far as 10 to 14 kilometers from the power plant.

Depending on the source, the steam from the wells can be either dry or moist. Wet steam passes through moisture separators where the water separates. The water or the brine then goes for reinjection back to the underground reservoir through reinjection wells.

The steam then goes to the turbine.

A properly located well can be a continuous energy source for many years.

- ## Turbines

The turbines in geothermal power plants have special requirements. The steam can be corrosive due to many Non Condensable Gases (NCG) including Hydrogen Sulphide. This requires special materials and corrosion protection for the turbine components. Special coatings protect the rotor, blades, and nozzles from corrosion.

The generation and transmission side of geothermal power plants is similar to conventional power plants.

- ### Condenser

As in conventional power plants, the steam condenses at a vacuum at the turbine exi,t so the work done by unit mass of steam is high. Most of the plants use direct contact condensers that use the condensed water itself as the cooling media.Cooling towers cool the hot condensate for use in the condensers and for plant cooling.

- ### Reinjection

The excess condensate and the brine from the separators returns back to the underground thermal reservoirs. Reinjection wells similar to the steam production wells are located in appropriate places. Some reservoirs can give outputs for years without re-injection.

Some plants reinject municipal waste water from nearby cities deep into the wells.

- ### NCG & H2S removal

The steam contains Non-condensable gases including Hydrogen Sulphide which separates in the condenser. Steam ejectors suck out these gases so that the vacuum is maintained in the condenser.

Depending on the Hydrogen Sulphide content special H2S removal systems are used.

- **These are the key components of a geothermal power plant.**

GEOTHERMAL POWER

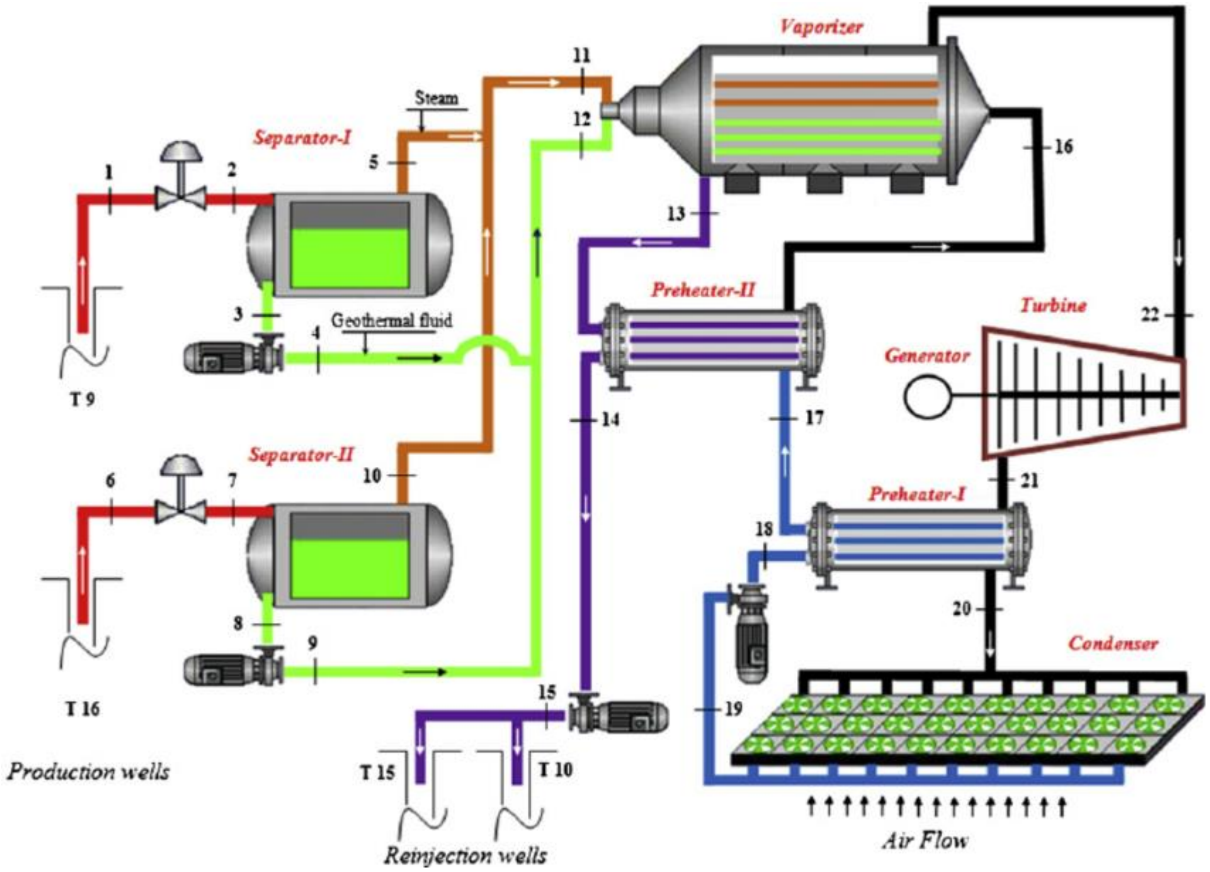
- **Energy from Mother Nature, renewable and non polluting can help in fighting global warming and climate change. Where can it be located? How is it different from conventional power plants? What are the specific advantages over other power systems? This article series discusses these aspects.**

- ## antages of Geothermal

Geothermal is a steady source of energy.

- Unlike wind power geothermal is a steady 24/7 power source. This is ideal for a reliable and steady base load operation.
- The energy source is steady for a very long period. Many geothermal wells are in service for more than 20 years.

- **Geothermal plants have no or only minimal environmental effects.**
  - No displacement of people in large areas like Hydro,
  - No effect on the vegetation or agriculture or forests. In fact all can go side by side.
  - Re-injection of the condensate or brine back into the Earth through the wells eliminate waste disposal problems.
  - No pollution since there is no SO2, Nox or CO2 emissions.
  - No ash to be disposed off.
- **There is no requirement of large water bodies like nuclear or thermal plants**
  - Condensed water itself is the cooling medium.
  - All plant cooling water requirements are from the condensed water.
  - There is no associated pollution of water nor damage to aquatic life.
- **The infrastructure requirement is also less than other plants.**
  - The area required is almost a quarter of what is required for a coal fired power plant.
  - The load on infrastructure like roads, ports, and other logistics is considerably less.
- **The technology level is less than high pressure steam power plants or nuclear plants**
  - Since the energy levels are comparatively low no special materials are required.
  - Unlike nuclear there is no risk of radioactivity or any associated problems.
- **The effects of cost increases are minimal.**



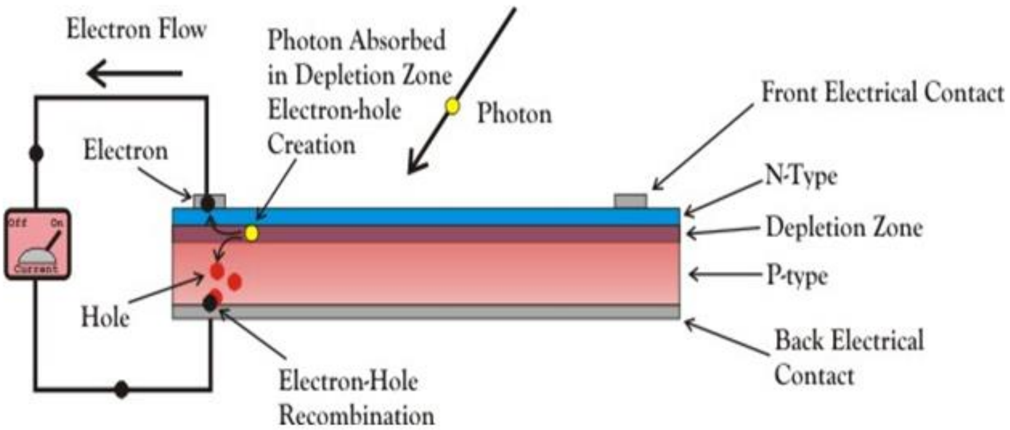
solar energy system.

Solar Cell

Solar Cell converts light energy into the electrical energy. A solar cell is basically a p-n junction diode. It utilizes photovoltaic effect to convert light energy into electrical energy.

Construction of Solar Cell

Although this is basically a junction diode, but constructionally it is littlebit different form conventyional p-n junction diode. A very thin layer of p-type semiconductor is grown on a relatively thicker n-type semiconductor. We provide few finer electrodes on the top of the p-type semiconductor layer. These electrodes do not obstruct light to reach the thin p-type layer. Just below the p-type layer there is a p-n junction. We also provide a current collecting electrode at the bottom of the n-type layer. We encapsulate the enti

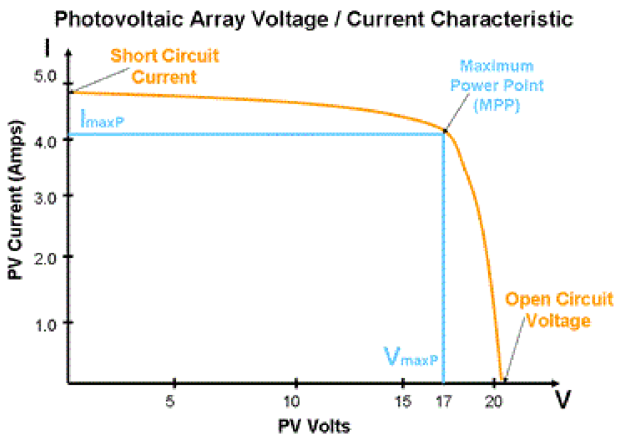


re assembly by thin glass to protect the **solar cell** from any mechanical shock.

Working Principle of Solar Cell

When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light, breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction. Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of barrier potential of the junction. Similarly, the newly created holes once come to the p-type side cannot further cross the junction became of same barrier potential of the junction. As the concentration of electrons becomes higher in one side i.e. n-type side of the junction and concentration of holes becomes more in another side i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage. If we connect a small load across the junction, there will be a tiny current flowing throgh it.

V-I Characteristics of a Photovoltaic Cell



Materials Used in Solar Cell

The materials which are used for this purpose must have band gap close to 1.5ev. Commonly used materials are-

Silicon. GaAs. CdTe. $CuInSe_2$

Criteria for Materials to be Used in Solar Cell

Must have band gap from 1ev to 1.8ev.

It must have high optical absorption.

It must have high electrical conductivity.

The raw material must be available in abundance and the cost of the material must be low.

Advantages of Solar Cell

No pollution associated with it.

It must last for a long time.

No maintenance cost.

Disadvantages of Solar Cell

It has high cost of installation.

It has low efficiency.

During cloudy day, the energy cannot be produced and also at night we will not get solar energy.

5.Give the applications of solar energy.

Uses of Solar Generation Systems

It may be used to charge batteries,Used in light meters.

It is used to power calculators and wrist watches.

It can be used in spacecraft to provide electrical energy.

Concentrating Solar Power (CSP): **Concentrating solar power (CSP) plants are utility-scale generators that produce electricity using mirrors or lenses to efficiently concentrate the sun's energy. The four principal CSP technologies are parabolic troughs, dish-Stirling engine systems, central receivers, and concentrating photovoltaic systems (CPV).**

Solar Thermal Electric Power Plants: **Solar thermal energy involves harnessing solar power for practical applications from solar heating to electrical power generation. Solar**

thermal collectors, such as solar hot water panels, are commonly used to generate solar hot water for domestic and light industrial applications. This energy system is also used in architecture and building design to control heating and ventilation in both active solar and passive solar designs.

Photovoltaics: **Photovoltaic or PV technology employs solar cells or solar photovoltaic arrays to convert energy from the sun into electricity. Solar cells produce direct current electricity from the sun's rays, which can be used to power equipment or to recharge batteries. Many pocket calculators incorporate a single solar cell, but for larger applications, cells are generally grouped together to form PV modules that are in turn arranged in solar arrays. Solar arrays can be used to power orbiting satellites and other spacecraft, and in remote areas as a source of power for roadside emergency telephones, remote sensing, and cathodic protection of pipelines.**

Solar Heating Systems: **Solar hot water systems use sunlight to heat water. The systems are composed of solar thermal collectors and a storage tank, and they may be active, passive or batch systems.**

Passive Solar Energy: **It concerns building design to maintain its environment at a comfortable temperature through the sun's daily and annual cycles. It can be done by (1) Direct gain or the positioning of windows, skylights, and shutters to control the amount of direct solar radiation reaching the interior and warming the air and surfaces within a building; (2) Indirect gain in which solar radiation is captured by a part of the building envelope and then transmitted indirectly to the building through conduction and convection; and (3) Isolated gain which involves passively capturing solar heat and then moving it passively into or out of the building via a liquid or air directly or using a thermal store. Sunspaces, greenhouses, and solar closets are alternative ways of capturing isolated heat gain from which warmed air can be taken.**

Solar Lighting: **Also known as daylighting, this is the use of natural light to provide illumination to offset energy use in electric lighting systems and reduce the cooling load on HVAC systems. Daylighting features include building orientation, window orientation, exterior shading, saw tooth roofs, clerestory windows, light shelves, skylights, and light tubes. Architectural trends increasingly recognize daylighting as a cornerstone of sustainable design.**