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Department Mechanical Engineering

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Energy And Power Engineering

(B.Tech, 2018 Course)

LABORATORY MANUAL

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Experiment No: 1 Study of performance of solar collectors.

solar collector

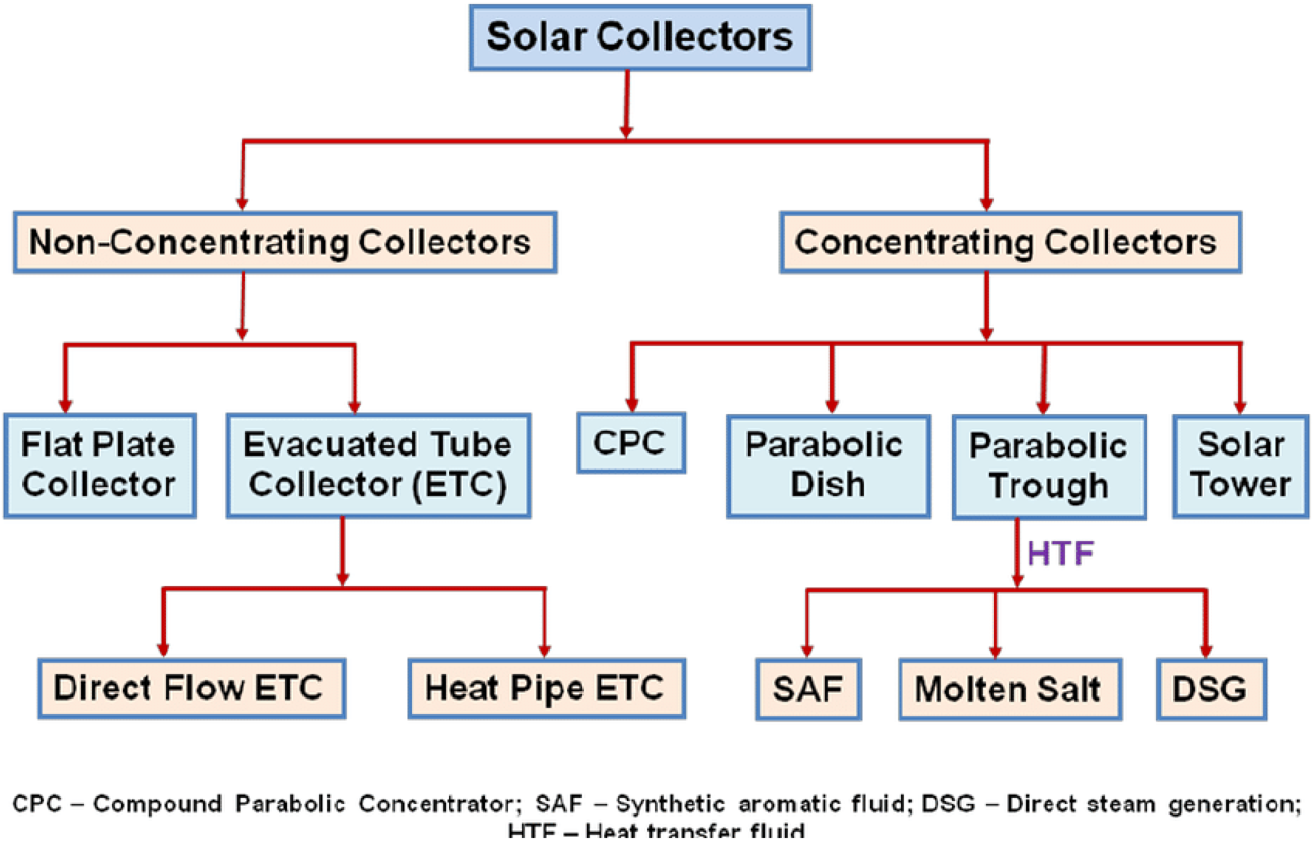
A **solar collector** is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. These collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions

The use of these solar collectors provides an alternative for traditional domestic water heating using a water heater, potentially reducing energy costs over time. As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants.

Figure 1. Solar Collector.[1]

Types of Solar Collectors :

here are many different types of solar collectors, but all of them are constructed with the same basic premise in mind. In general, there is some material that is used to collect and focus energy from the Sun and use it to heat water. The simplest of these devices uses a black material surrounding pipes that water flows through. The black material absorbs the solar radiation very well, and as the material heats up the water it surrounds. This is a very simple design, but collectors can get very complex. Absorber plates can be used if a high temperature increase isn't necessary, but generally devices that use reflective materials to focus sunlight result in a greater temperature increase



Flat Plate Collectors:

These collectors are simply metal boxes that have some sort of transparent glazing as a cover on top of a dark-colored absorber plate. The sides and bottom of the collector are usually covered with insulation to minimize heat losses to other parts of the collector. Solar radiation passes through the transparent glazing material and hits the absorber plate. This plate heats up, transferring the heat to either water or air that is held between the glazing and absorber plate. Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than traditional black paint. These plates are usually made out of metal that is a good conductor - usually copper or aluminum.

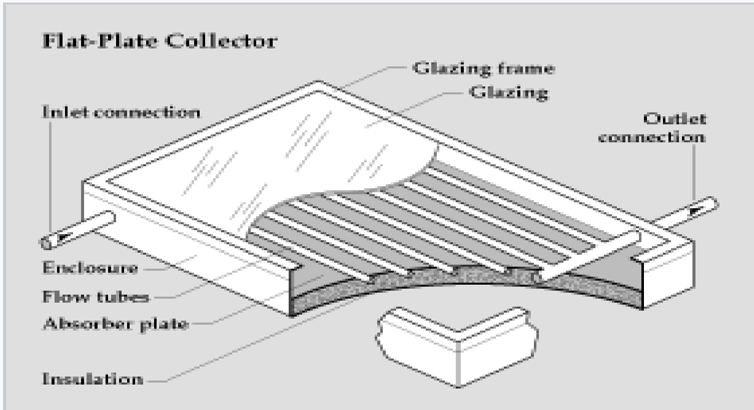


Figure 2. A diagram of a flat plate solar collector.[3]

Evacuated Tube Collectors

This type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings. They have an inner metal tube which acts as the absorber plate, which is connected to a heat pipe to carry the heat collected from the Sun to the water. This heat pipe is essentially a pipe where the fluid contents are under a very particular pressure. At this pressure, the "hot" end of the pipe has boiling liquid in it while the "cold" end has condensing vapour. This allows for thermal energy to move more efficiently from one end of the pipe to the other. Once the heat from the Sun moves from the hot end of the heat pipe to the condensing end, the thermal energy is transported into the water being heated for use.

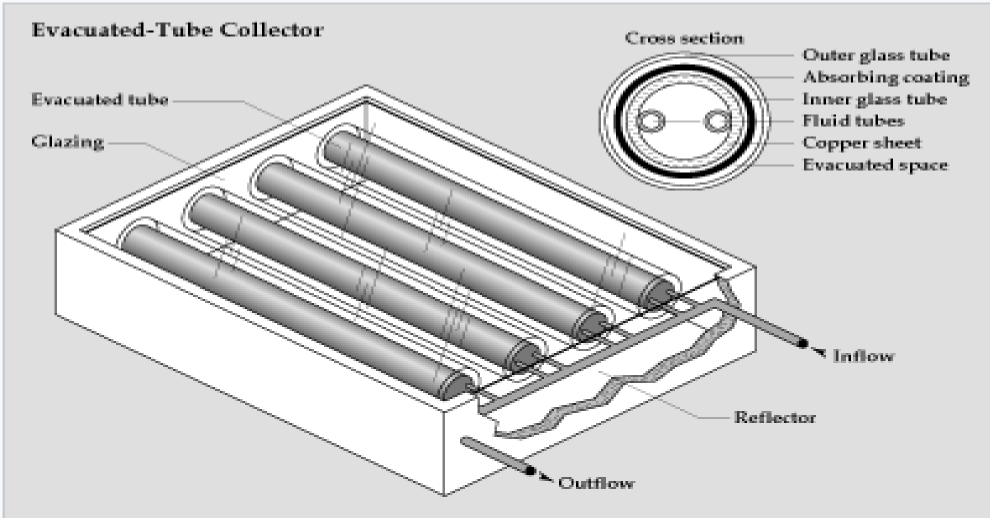


Figure 3. A diagram of an evacuated tube solar collector.[5]

Line Focus Collectors

These collectors, sometimes known as parabolic troughs, use highly reflective materials to collect and concentrate the heat energy from solar radiation. These collectors are composed of parabolically shaped reflective sections connected into a long trough. A pipe that carries water is placed in the center of this trough so that sunlight collected by the reflective material is focused onto the pipe, heating the contents. These are very high powered collectors and are thus generally used to generate steam for Solar thermal power plants and are not used in residential applications. These troughs can be extremely effective in generating heat from the Sun, particularly those that can pivot, tracking the Sun in the sky to ensure maximum sunlight collection.

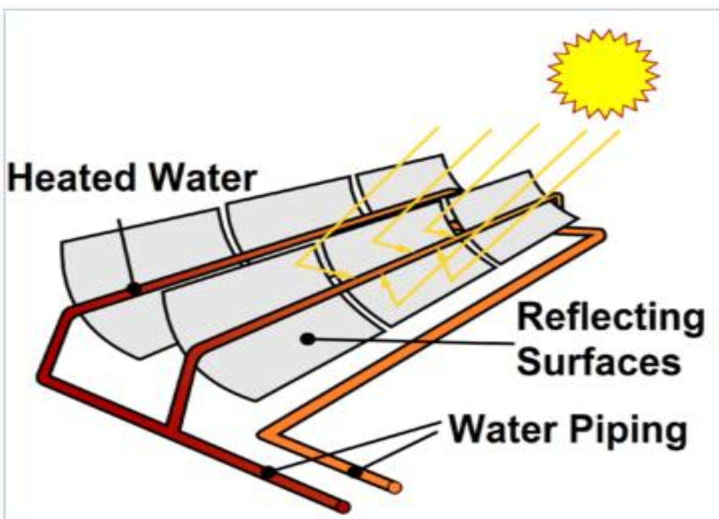


Figure 4. A diagram of a line focus solar collector.[7]

Point Focus Collectors

These collectors are large parabolic dishes composed of some reflective material that focus the Sun's energy onto a single point. The heat from these collectors is generally used for driving Stirling engines. Although very effective at collecting sunlight, they must actively track the Sun across the sky to be of any value. These dishes can work alone or be combined into an array to gather even more energy from the Sun

Point focus collectors and similar apparatuses can also be utilized to concentrate solar energy for use with Concentrated photovoltaics. In this case, instead of producing heat, the Sun's energy is converted directly into electricity with high efficiency photovoltaic cells designed specifically to harness concentrated solar energy.

Figure 5. A point focus solar collector.[9]

Experiment No: 2

Aim: Study of Solar Radiation by using Pyranometer.

Solar radiation measuring instruments are of two types:

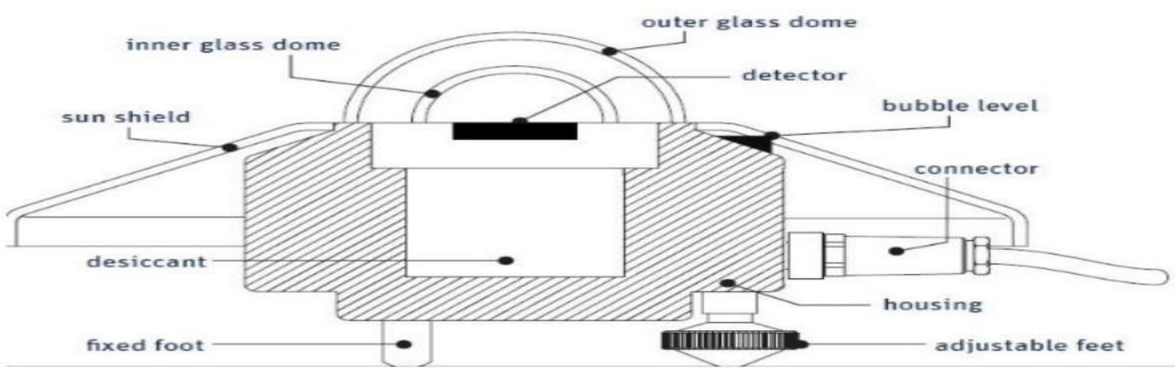
a) Pyranometer
b) Pyrheliometer

a) Pyranometer

Theory: A pyranometer is a type of actinometer used for measuring solar irradiance on a planar surface and it is designed to measure the solar radiation flux density (W/m2) from the hemisphere above within a wavelength range 0.3 µm to 3 µm. The name pyranometer stems from the Greek words (pyr), meaning "fire", and (ano), meaning "above, sky".

A typical pyranometer does not require any power to operate. However, recent technical development includes use of electronics in pyranometers, which do require (low) external power.

Procedure: A pyranometer is an instrument which measures either global or diffuse radiation. A black surface on the guard plate is covered by a transparent glass domes. The hot junctions of the thermopile are connected to black furnace and the cold junctions of thermopile are connected where there is no solar radiation. The other ends of thermopile are connected to millivoltmeter. The entire equipment rests on the mounting plate. The mounting plate is fixed on the plat form with the help of bolts. Leveling screws are provided



When the sunrays falling on the black surface, heat is generated inside the glass dome. This causes the temperature difference takes place in the two junctions of the thermopile. As a result, an e.m.f is generated and it is recorded in the millivoltmeter

Pyranometer Working Principle

The working principle of the pyranometer mainly depends on the difference in temperature measurement between two surfaces like dark and clear. The solar radiation can be absorbed by the black surface on the thermopile whereas the clear surface reproduces it, so less heat can be absorbed.

The thermopile plays a key role in measuring the difference in temperature. The potential difference formed within the thermopile is due to the gradient of temperature between the two surfaces. These are used to measure the sum of solar radiation.

But, the voltage which is generated from the thermopile is calculated with the help of a potentiometer. The information of radiation needs to be included through planimetry or an electronic integrator.

Types of Pyranometer

Pyrometers are classified into two types like thermopile pyranometer, photodiode-based pyranometer.

Thermopile Pyranometer

This type of pyranometer is used to measure the flux density of the solar radiation from a 180° angle. Usually, it measures 300nm to 2800 nm with a largely level spectral sensitivity. The first generation of this pyranometer includes the sensor that works as an active part by dividing black & white sectors equally. Irradiation was measured from the two sectors like white & black within the temperature. Here, the black sector is exposed to the sun whereas the white sector doesn’t expose to the sun.

These pyranometers are normally used in climatology, meteorology, building engineering physics, photovoltaic systems & climate change research.

Photodiode-based Pyranometer

Photodiode based pyrometer is also known as a silicon pyrometer. This is used to detect the segment of the solar spectrum between 400 nm & 900 nm. This photodiode changes the frequencies of the solar spectrum to current at high speed. This change will be influenced through the temperature with the raise in current, generated by the temperature rise.
These types of pyranometers are executed wherever the amount of irradiation of the noticeable solar spectrum needs to be measured and it can be done by using diodes with exact spectral responses.

These are used in cinema, lighting technique & photography; sometimes these are connected closely to photovoltaic system modules.

Advantages and Disadvantages

The **pyranometer advantages** and disadvantages are

- The temperature coefficient is extremely small
- Standardized to ISO standards
- Measurements of performance ration & performance index are accurate.
- Response time is longer compare to PV cell

The disadvantage of the pyranometer is, its spectral sensitivity is imperfect, so it does not observe the complete spectrum of the sun. So errors in measurements can occur.

Pyranometer Applications

The applications are

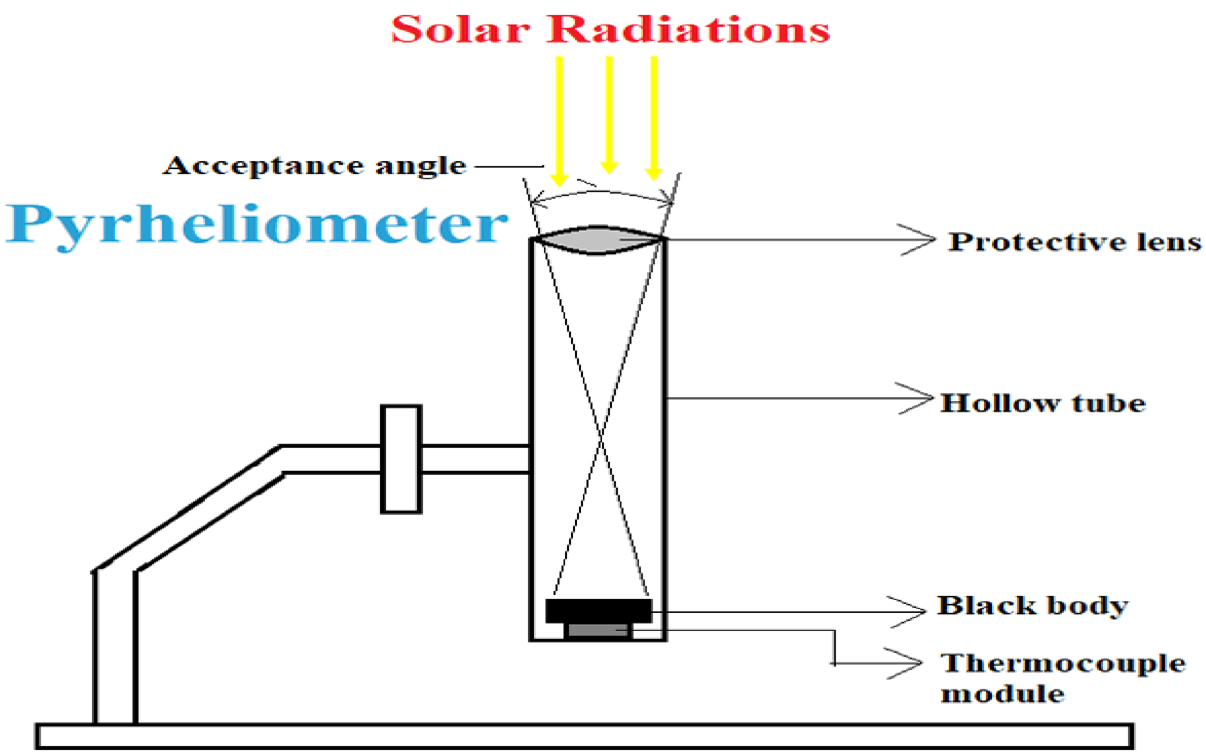
- The solar intensity data can be measured.
- Climatological & Meteorological studies
- PV systems design
- Locations of the greenhouse can be established.
- Expecting the requirements of insulation for building structures

b) Pyrheliometer

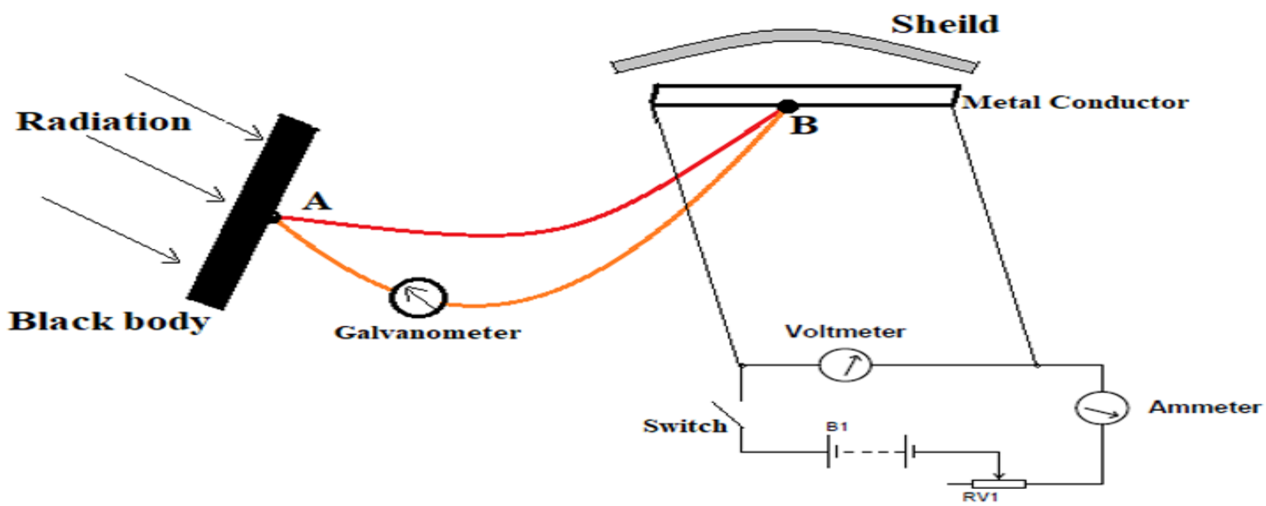
Pyrheliometer Working and Construction

Pyrheliometer is a device used for measuring direct beam radiation at normal incidence. Its outer structure looks like a long tube projecting the image of a telescope and we have to point the lens to the sun to measure the radiance. Here we will learn the **working principle of Pyrheliometer** and its construction.

To understand the basic structure of the Pyrheliometer, look at the diagram shown below.



Here the lens is pointed towards the sun and the radiation will pass through the lens, tube and at the end falls on to the black object present at the bottom. Now if we redraw the entire internal structure and circuit in a simpler manner it will look something like below.



In the circuit, it can be seen that the black body absorbs the radiation falling from the lens and as discussed earlier a perfect black body completely absorbs any radiation falls on it, so the radiation falling into the tube gets absorbed by the black object entirely. Once the radiation gets absorbed the atoms in the body get excited because of the increasing temperature of the entire body. This temperature increase will also be experienced by the thermocouple junction ‘A’. Now with **junction ‘A’ of the thermocouple at high temperature and junction ‘B’ at low temperature, a current flow takes place in its loop** as discussed in the working principle of the thermocouple. This current in the loop will also flow through the galvanometer which is in series and thereby causing a deviation in it. This **deviation is proportional to current, which in turn is proportional to temperature difference at junctions.**

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Deviation ∝ Current in loop ∝ Temperature difference at junctions.
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Now we will try to nullify this deviation in the galvanometer with the help of the circuit. The complete process for nullifying the deviation is explained in step by step below.

- First, close the switch in the circuit for starting the current flow.
- The current flows like,

Battery -> Switch -> Metal conductor -> Ammeter -> Variable resistor -> Battery.

- With this current flowing through the Metal conductor its temperature rises to a certain degree.
- Being in contact with the Metal conductor the junction ‘B’ temperature also rises. This reduces the temperature difference between the junction ‘A’ and junction ‘B’.
- Because of the reduction in temperature difference, the current flow in the thermocouple also decreases.

- Since the deviation is proportional to current the deviation of the galvanometer also decreases.
- In summary, we can say- The deviation in the galvanometer can be reduced by adjusting the rheostat to change the current in the Metal conductor.

Now keep adjusting the rheostat until the galvanometer deviation becomes completely void. Once this happens we can obtain voltage and current readings from the meters and do a simple calculation to determine the heat absorbed by the black body. This calculated value can be used to determine the radiation, as heat generated by the black body is directly proportional to the radiation. This radiation value is none another than direct beam solar radiation which we are desired to measure from the beginning. And with this, we can conclude the working of the Pyrheliometer.

Experiment No: 4
Study of combined cycle gas based and coal based Power plant.

a) Combined-Cycle Gas Power Plant

A combined-cycle gas turbine (CCGT) power plant is essentially an electrical power plant in which a gas turbine and a steam turbine are used in combination to achieve greater efficiency than would be possible independently. The gas turbine drives an electrical generator while the gas turbine exhaust is used to produce steam in an HX, called a heat recovery steam generator (HRSG), to supply a steam turbine whose output provides the means to generate more electricity. If the steam were used for heat then the plant would be referred to as a cogeneration plant.

It is important first to distinguish between a closed cycle power plant (or heat engine) and an open cycle power plant. In a closed cycle, fluid passes continuously round a closed circuit, through a thermodynamic cycle in which heat is received from a source at higher temperature, and heat rejected to a sink at low temperature and work output is delivered usually to drive an electric generator.

A gas turbine power plant may simply operate on a closed circuit as shown in Fig. 4.a.

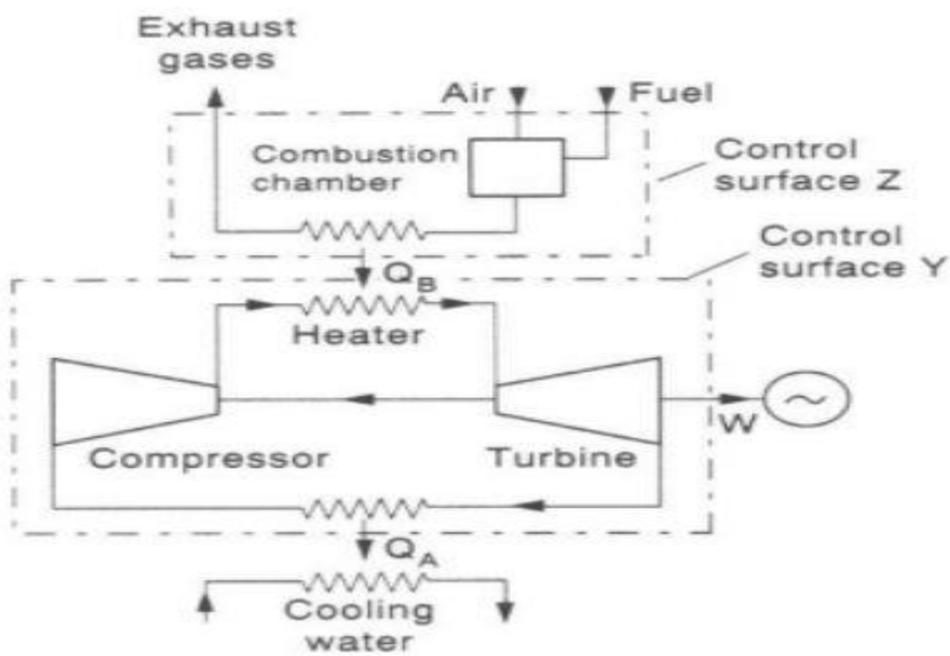


Fig. 4.a. **Closed circuit gas turbine plant.**

Most gas turbine plants operate in "open circuit", with an internal combustion system as shown in Fig.4.b Air fuel cross the single control surface into the compressor and combustion chamber, respectively, and combustion products leave the control surface after expansion through the turbine.

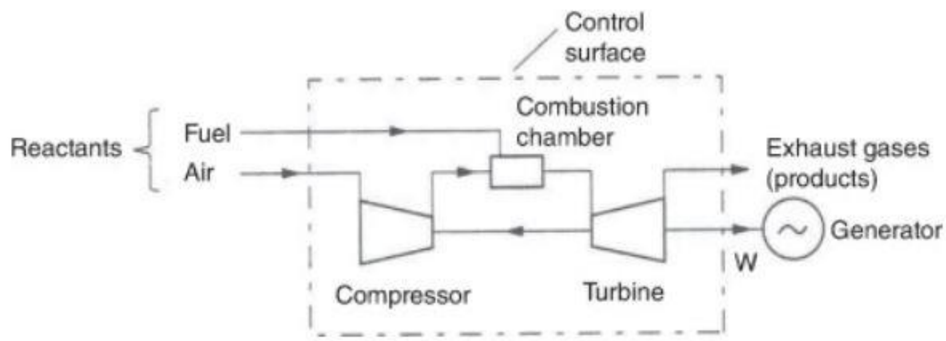


Fig.4.b **Open circuit gas turbine plant**.

The classical combined cycle for power production in a gas turbine and steam plant is normally associated with the names of Brayton and Rankine, respectively.
Fig.4.c is simple representation of CCGT system. It demonstrates the fact that a CCGT system is two heat engines in series. The upper engine is the gas turbine. The gas turbine exhaust is the input to the lower engine (a steam turbine). The steam turbine exhausts heat to a circulating water system that cools the steam condenser.

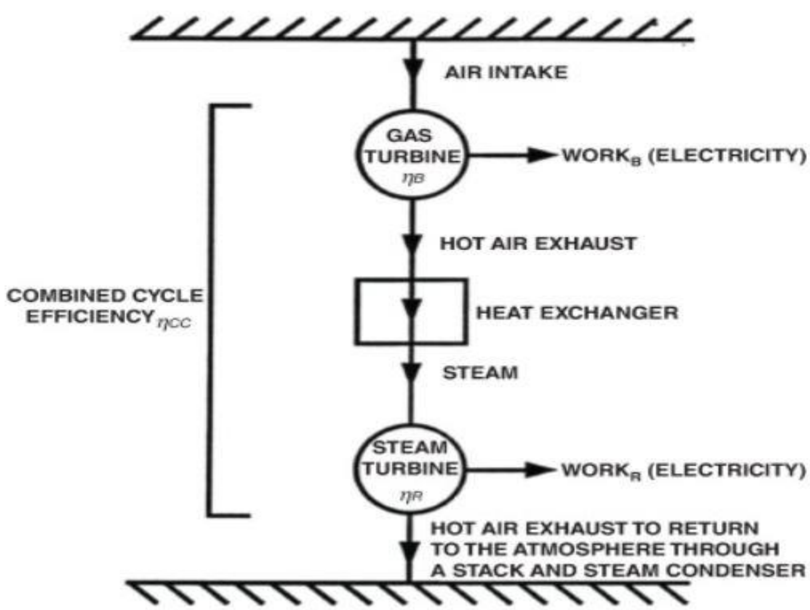


Fig.4.c **Schematic of combined-cycle (CCGT) plant.**

An approximate combined-cycle efficiency (η_{CC}) is given as

$$\eta_{CC} = \eta_B + \eta_R - (\eta_B \times \eta_R) \qquad \text{------4 d}$$

Eq.4 d states that the sum of the individual efficiencies minus the product of the individual efficiencies equals the combine cycle efficiency. This simple equation gives significant insight to why combine cycle systems are successful.

For example, suppose the gas turbines efficiency (Brayton) η_B is 40% (a reasonable value for a today's gas turbines) and that the steam turbine efficiency (Rankine) η_R is 30% (a reasonable value for a Rankine cycle steam turbine).
Utilizing Eq. (3.4) would lead to the following conclusion.
$\eta_{CC} = 0.4 + 0.3 – (0.4 \times 0.3)$
$\eta_{CC} = 0.58$
$\eta_{CC} = 58\%$

The combined-cycle efficiency of 58% is much greater than either the gas turbine or the steam turbines efficiencies separately. The 58% value is slightly misleading in that system losses were ignored. However, efficiency values in the 60% range have been recorded for CCGT systems in the past few years [6].

CCGT power plants come in many different configurations. Some companies choose to treat the gas turbine exhaust bypass stack as a commodity; others choose to incorporate a diverter damper into the turbine exhaust gas path. The diverter damper allows for the rapid configuration of the power plant as a combined cycle or simple cycle system. The initial cost of the diverter damper is much higher than the cost of treating the gas turbine exhaust stack as a commodity. However, the diverter damper allows for the gas turbines to be operated in simple cycle when HRSG or steam turbine repair or maintenance is required.

b) **Combined-Cycle** Coal **Power Plant (**Coal-fired power station**)**

A **coal-fired power station** or **coal power plant** is a thermal power station which burns coal to generate electricity. Worldwide there are over 2,400 coal-fired power stations, totaling over 2,000 giga watts capacity They generate about a third of the world's electricity, but cause many illnesses and the most early deaths, mainly from air pollution.

A coal-fired power station is a type of fossil fuel power station. The coal is usually pulverized and then burned in a pulverized coal-fired boiler. The furnace heat converts boiler water to steam, which is then used to spin turbines that turn generators. Thus chemical energy stored in coal is converted successively into thermal energy, mechanical energy and, finally, electrical energy.

Coal-fired power stations emit over 10 Gt of carbon dioxide each year, about one fifth of world greenhouse gas emissions, so are the single largest cause of climate change. More than half of all the coal-fired electricity in the world is generated in China. In 2020 the total number of plants started falling as they are being retired in Europe and America although still being built in Asia, almost all in China. Some remain profitable because costs to other people due to the health and environmental impact of the coal industry are not priced into the cost of generation, but there is the risk newer plants may become stranded assets.The UN Secretary General has said that OECD countries should stop generating electricity from coal by 2030, and the rest of the world by 2040.Vietnam is among the few coal-dependent fast developing countries that fully pledged to phase out unbated coal power by the 2040s or as soon as possible thereafter.

Operation:

As a type of thermal power station, a coal-fired power station converts chemical energy stored in coal successively into thermal energy, mechanical energy and, finally, electrical energy. The coal is usually pulverized and then burned in a pulverized coal-fired boiler. The heat from the burning pulverized coal converts boiler water to steam, which is then used to spin turbines that turn generators. Compared to a thermal power station burning other fuel types, coal specific fuel processing and ash disposal is required.

For units over about 200 MW capacity, redundancy of key components is provided by installing duplicates of the forced and induced draft fans, air preheaters, and fly ash collectors. On some units of about 60 MW, two boilers per unit may instead be provided. The hundred largest coal power stations range in size from 3,000MW to 6,700MW.

Fuel processing

Coal is prepared for use by crushing the rough coal to pieces less than 5 cm in size. The coal is then transported from the storage yard to in-plant storage silos by conveyor belts at rates up to 4,000 tonnes per hour.

In plants that burn pulverized coal, silos feed coal to pulverisers (coal mills) that take the larger 5 cm pieces, grind them to the consistency of talcum powder, sort them, and mix them with primary combustion air, which transports the coal to the boiler furnace and preheats the coal in order to drive off excess moisture content. A 500 MW plant may have six such pulverisers, five of which can supply coal to the furnace at 250 tonnes per hour under full load.

In plants that do not burn pulverized coal, the larger 5 cm pieces may be directly fed into the silos which then feed either mechanical distributors that drop the coal on a traveling grate or the cyclone burners, a specific kind of combustor that can efficiently burn larger pieces of fuel.

Boiler operation

Plants designed for lignite (brown coal) are used in locations as varied as Germany, Victoria, Australia, and North Dakota. Lignite is a much younger form of coal than black coal. It has a lower energy density than black coal and requires a much larger furnace for equivalent heat output. Such coals may contain up to 70% water and ash, yielding lower furnace temperatures and requiring larger induced-draft fans. The firing systems also differ from black coal and typically draw hot gas from the furnace-exit level and mix it with the incoming coal in fan-type mills that inject the pulverized coal and hot gas mixture into the boiler.

Ash disposal

The ash is often stored in ash ponds. Although the use of ash ponds in combination with air pollution controls (such as wet scrubbers) decreases the amount of airborne pollutants, the structures pose serious health risks for the surrounding environment. Power utility companies have often built the ponds without liners, especially in the United States, and therefore chemicals in the ash can leach into groundwater and surface waters.

Since the 1990s, power utilities in the U.S. have designed many of their new plants with dry ash handling systems. The dry ash is disposed in landfills, which typically include liners and groundwater monitoring systems. Dry ash may also be recycled into products such as concrete, structural fills for road construction and grout.

Fly ash collection

Fly ash is captured and removed from the flue gas by electrostatic precipitators or fabric bag filters (or sometimes both) located at the outlet of the furnace and before the induced draft fan. The fly ash is periodically removed from the collection hoppers below the precipitators or bag filters. Generally, the fly ash is pneumatically transported to storage silos and stored on site in ash ponds, or transported by trucks or railroad cars to landfills,

Bottom ash collection and disposal

At the bottom of the furnace, there is a hopper for collection of bottom ash. This hopper is kept filled with water to quench the ash and clinkers falling down from the furnace. Arrangements are included to crush the clinkers and convey the crushed clinkers and bottom ash to on-site ash ponds, or off-site to landfills. Ash extractors are used to discharge ash from municipal solid waste–fired boilers.

Flexibility

A well-designed energy policy, energy law and electricity market are critical for flexibility.Although technically the flexibility of some coal-fired power stations could be improved they are less able to provide dispatch able generation than most gas-fired power plants. The most important flexibility is low minimum load, however some flexibility improvements may be more expensive than renewable energy with batteries.

Coal Power Generation

As of 2020 two-thirds of coal burned is to generate electricity. In 2020 coal was the largest source of electricity at 34%.Over half coal generation in 2020 was in China. About 60% of electricity in China, India and Indonesia is from coal.

In 2020 worldwide 2059 GW of coal power was operational, 50 GW was commissioned, and 25 GW started construction (most of these three in China); and 38 GW retired (mostly USA and EU).

Efficiency:

There are 4 main types of coal-fired power station in increasing order of efficiency are: subcritical, supercritical, ultra-supercritical and cogeneration (also called combined heat and power or CHP).Subcritical is the least efficient type, however recent innovations have allowed retrofits to older subcritical plants to meet or even exceed efficiency of supercritical plants

Experiment No: 5

Study of load curves and selection of plants for power generation

ECONOMICS IN PLANT SELECTION:

A power plant should be reliable. The capacity of a power plant depends upon the power demand. The capacity of a power plant should be more than predicted maximum demand. It is desirable that the number of generating units should be two or more than two. The number of generating units should be so chosen that the plant capacity is used efficiently. Generating cost for large size units running at high load factor is substantially low. However, the unit has to be operated near its point of maximum economy for most of the time through a proper load sharing programme. Too many standbys increase the capital investment and raise the overall cost of generation.

The thermal efficiency and operating cost of a steam power plant depend upon the steam conditions such as throttle pressure and temperature.

The efficiency of a boiler is maximum at rated capacity. Boiler fitted with heat recovering devices like air preheater, economiser etc. gives efficiency of the order of 90%. But the cost of additional equipment (air preheater economiser) has to be balanced against gain in operating cost.

Power can be produced at low cost from a hydropower plant provided water is available in large quantities. The capital cost per unit installed is higher if the quantity of water available is small. While installing a hydropower plant cost of land, cost of water rights, and civil engineering works cost should be properly considered as they involve large capital expenditure.

The other factor, which influences the choice of hydropower plant, is the cost of power transmission lines and the loss of energy in transmission. The planning, design and construction of a hydro plant is difficult and takes sufficient time.

The nuclear power plant should be installed in an area having limited conventional power resources. Further a nuclear power plant should be located in a remote or unpopulated are to avoid damage due to radioactive leakage during an accident and also the disposal of radioactive waste should be easy and a large quantity of water should be available at the site selected. Nuclear power becomes competitive with conventional coal fired steam power plant above the unit size of 500 mW.

The capital cost of a nuclear power plant is more than a steam power plant of comparable size. Nuclear power plants require less space as compared to any other plant of equivalent size. The cost of maintenance of the plant is high.

The diesel power plant can be easily located at the load centre. The choice of the diesel power plant depends upon thermodynamic considerations. The engine efficiency improves with compression ratio but higher pressure necessitates heavier construction of equipment with increased cost. Diesel power plants are quite suitable for smaller outputs. The gas turbine power plant is also suitable for smaller outputs. The cost of a gas turbine plant is relatively low. The cost of gas turbine increases as the sample plant is modified by the inclusion of equipment like regenerator, reheater, and intercooler although there is an improvement in efficiency of the plant by the above equipment. This plant is quite useful for regions where gaseous fuel is available in large quantities

In order to meet the variable load the prime movers and generators have to act fairly quickly to take up or shed load without variation of the voltage or frequency of the system. This requires that supply of fuel to the prime mover should be carried out by the action of a governor. Diesel and hydropower plants are quick to respond to load variation as the control supply is only for the prime mover. In a steam power plant control is required for the boilers as well as turbine. Boiler control may be manual or automatic for feeding air, feed water fuel etc. Boiler control takes time to act and therefore, steam powers plants cannot take up the variable load quickly. Further to cope with variable load operation it is necessary for the power station to keep reserve plant ready to maintain reliability and continuity of power supply at all times. To supply variable load combined working of power stations is also economical.

For example to supply a load the base load may be supplied by a steam power plant and peak load may be supplied by a hydropower plant or diesel power plant

The size and number of generating units should be so chosen that each will operate on about full load or the load at which it gives maximum efficiency. The reserve required would only be one unit of the largest size. In a power station neither there should be only one generating unit nor should there be a large number of small sets of different sizes. In steam power plant generating sets of 80 to 500 mW are quite commonly used whereas the maximum size of diesel power plant generating sets is about 4000 kW. Hydro-electric generating sets up to a capacity of 200 mW are in use in U.S.A.

ECONOMIC OF POWER GENERATION

Economy is the main principle of design of a power plant. Power plant economics is important in controlling the total power costs to the consumer. Power should be supplied to the consumer at the lowest possible cost per kWh. The total cost of power generation is made up of fixed cost and operating cost. Fixed cost consists of interest on capital, taxes, insurance and management cost. Operating cost consists of cost of fuel labour, repairs, stores and supervision. The cost of power generation can be reduced by

(i) Selecting equipment of longer life and proper capacities.
(ii) Running the power station at high load factor.

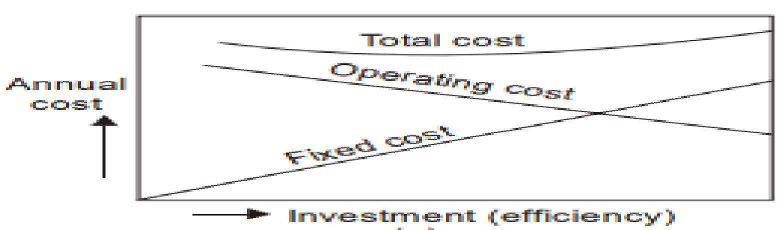
(iii) Increasing the efficiency of the power plant.
(iv) Carrying out proper maintenance of power plant equipment to avoid plant breakdowns.
(v) Keeping proper supervision as a good supervision is reflected in lesser breakdowns and extended plant life.
(vi) Using a plant of simple design that does not need highly skilled personnel.

Power plant selection depends upon the fixed cost and operating cost. The fuel costs are relatively low and fixed cost and operation and maintenance charges are quite high in a case of a nuclear power plant. The fuel cost in quite high in a diesel power plant and for hydro power plant the fixed charges are high of the order of 70 to 80% of the cost of generation. Fuel is the heaviest items of operating cost in a steam power station. A typical proportion of generating cost for a steam power station is as follows :

Fuel cost = 30 to 40%
Fixed charges for the plant = 50 to 60%
Operation and maintenance cost = 5 to 10%

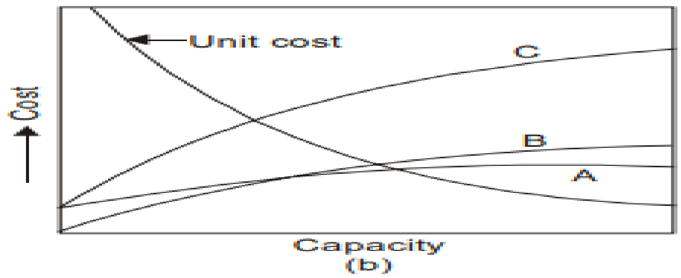
The power generating units should be run at about full load or the load at which they can give maximum efficiency. The way of deciding the size and number of generating units in the power station is to choose the number of sets to fit the load curve as closely at possible. It is necessary for a power station to maintain reliability and continuity of power supply at all times. In an electric power plant the capital cost of the generating equipment's increases with an increase in efficiency. The benefit of such increase in the capital investment will be realized in lower fuel costs as the consumption of fuel decreases with an increase in cycle efficiency.

Fig. (a) shows the variation of fixed cost and operation cost with investment



(a)

Fig. (b) shows the variation of various costs of power plant versus its capacity.



Factors in consideration to choose a site :

The identification of a site for a power plant selection depends on various factors like land, space, water, cost, transport, fuel, availability of cooling water, nature of the load, etc. Apart from these factors, there are a few sub-factors involving in this process.

Cost of Transmission of Energy

The location of a power plant should be as close to the load center as possible. This will help in reducing the losses in transmission and transmission costs. Hydroelectric, nuclear, and steam power plants cannot be located near the load centers. So, their transmission lines must be of larger, moderate, and shorter lengths respectively. Power plants which run on diesel and gas can be located near the load center and hence transmission losses can be minimized. However, modern power plants are of large capacities and they help us to feed a grid that supplies electrical power to large areas.

Cost of Fuel:

One of the most important criteria to be considered while choosing the type of power plant for setting up in some particular location is the cost of the fuel. But in hydroelectric power plants, fuel cost does not matter because the source of power here is water hence it must be available in large quantities and at sufficient head. In the case of thermal plants, the availability of coal and its cost are important considerations. Thermal power plants are most economical near coal mines and by the side of a river or canal. Fuel used in a nuclear power plant is expensive and hence it is difficult to get.

Cost of Land and Taxes:

The costs of land and the tax on it, depends on the proposed power plant. The land cost if it is near a load center like a big city will be much higher than at a remote place. The taxes for land in the center of a commercial city would also be higher than those in remote areas. Therefore, the cost of land and taxes is also a significant point to be considered in the economic selection of a site.

Space Requirement:

If the building to be built and space requirement are both large, then the cost of it will be high. Thus, large power plants located near the center of gravity of load like hearts of big cities are not economical. A hydroelectric power station requires tons of space for construction works like dams etc. and also the space required is much larger than other types of power plants. Also, several arrangements have to be made in the building as special features in a hydroelectric power plant. The location should be such that the cost of land is not excessive also water should be available at enough head.

Availability of Site for Water Power:

It is required to explore a suitable source of water and sites for a hydroelectric power plant before deciding the type of power plant for a given location. The land topography, rainfall, catchment area for water, a suitable site for storing the water behind the dam are some of the considerations. Other considerations include the cost for civil engineering works like the construction of a dam and a huge quantity of water at the required head.

Storage Space for Fuel:

A thermal power plant requires space for the storage of coal which depends on the size of the plant. Coal should be available for at least the next 2 to 3 weeks on site. The requirement of reserve stock changes for the power plant is based on its location. It may not be necessary to store a large quantity if the plant is near a coal mine. whereas a large stock may be required if it is not near a source of fuel.

Nature of Load:

The nature of the load to be supplied affects the choice of the power plant to a certain extent. If there are sudden variations in load and in turn the load factor is poor and also if the load is small, it is smarter to choose a thermal power plant as they are more adaptable than nuclear power plants. This is because a thermal plant can be started quickly and can be put to share full load within a few minutes which is not the case with nuclear power plants. The reactor in a nuclear power plant does not respond to the fluctuations of load efficiently hence a Nuclear power plant is not well suited for varying loads. Nuclear power plants also need a longer time (2-3 hours) for starting and taking the load. If a hydroelectric power plant of small or suitable capacity is available, it can be started quickly and take up the load, and thus can be employed for the varying loads.

POWER PLANT SELECTION

e) Hydroelectric power plant:

As discussed earlier, the hydroelectric power plant runs on the kinetic energy derived from moving water or when it falls from a height that is used to run the turbine. This kind of power plant has to be situated near a dam which has been built close to a source of water. The kinetic energy of the moving water is converted to mechanical energy in a turbine. The most commonly used turbine for the hydroelectric power plant is the Francis turbine. The turbine consists of blades that rotate when water flows through it. The speed of the water directly affects the production of energy. This mechanical energy is then converted to electrical energy in a generator. Hydroelectric energy is considered as the cleanest energy of all the types of energy generation.

f) Thermal power plant

A thermal power plant is a power plant that utilizes the heat generated by burning a fuel mostly coal. The heat generated from the fuel is used to heat up water which converts into steam and runs the turbine. Here the heat energy is converted into mechanical energy and the generator converts it into electrical energy. There are several types of coal used in a thermal power plant. Anthracite coal is the mainly used solid fuel in these. But, the majority of the thermal power plants also used bituminous coal. The thermal power plant is not a very clean way of producing energy as it releases a lot of harmful gases into the environment mainly if the coal is not burnt properly. Also, it releases greenhouse gases like carbon dioxide which in turn contributes to global warming.

g) Nuclear power plant

The nuclear power plant is closely related to the thermal power plant. This is because, in a nuclear power plant, nuclear fission takes place in which the nucleus of an atom splits into two or more smaller nuclei. When this happens a lot of energy is let out in the form of heat. This is used to convert water into steam like in a conventional thermal power plant and further, it turns the turbine which is attached to a generator and the generator converts the mechanical energy produced in the turbine into electrical energy.