UNIT-I

BASIC CONCEPTS OF SOLAR ENERGY

ESSAY QUESTIONS

ocean waters.

Q. 3. Explain about Solar radiation and classify.

Solar radiation, often called the solar resource or just sunlight, is a general term for the electromagnetic radiation emitted by the sun. Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies. However, the technical feasibility and economical operation of these technologies at a specific location depends on the available solar resource.

Solar Radiation can be classified into two types:

Direct radiation :

It is also known as "beam radiation" or "direct beam radiation" is used to describe solar radiation travelling on a straight line from the sun down to the surface of the earth.

Diffuse radiation :

It describes the sunlight that has been scattered by molecules and particles in the atmosphere but that has still made it down to the surface of the earth. In simple terms, direct radiation has a definite direction but diffuse radiation follows a much more scattered, uncertain path. Because when the radiation is direct, the rays are all travelling in the same direction, an object can block them all at once. Therefore, it can be noted that shadows are only produced when direct radiation is blocked. During times when the sky is clear and the sun is very high in the sky, direct radiation is around 85% of the total insolation striking the ground and diffuse radiation accounts for about 15%. As the sun lowers into the sky, the percent of diffuse radiation keeps increasing until it reaches 40% when the sun is 10° above the horizon. Atmospheric conditions like clouds and pollution also increase the chances of diffused radiation. On an extremely overcast day, pretty much 100% of the solar radiation is diffuse radiation. Technically speaking, the larger the percentage of diffuse radiation, the less the total insolation.

Direct/diffuse ratio varies with latitude and climate :

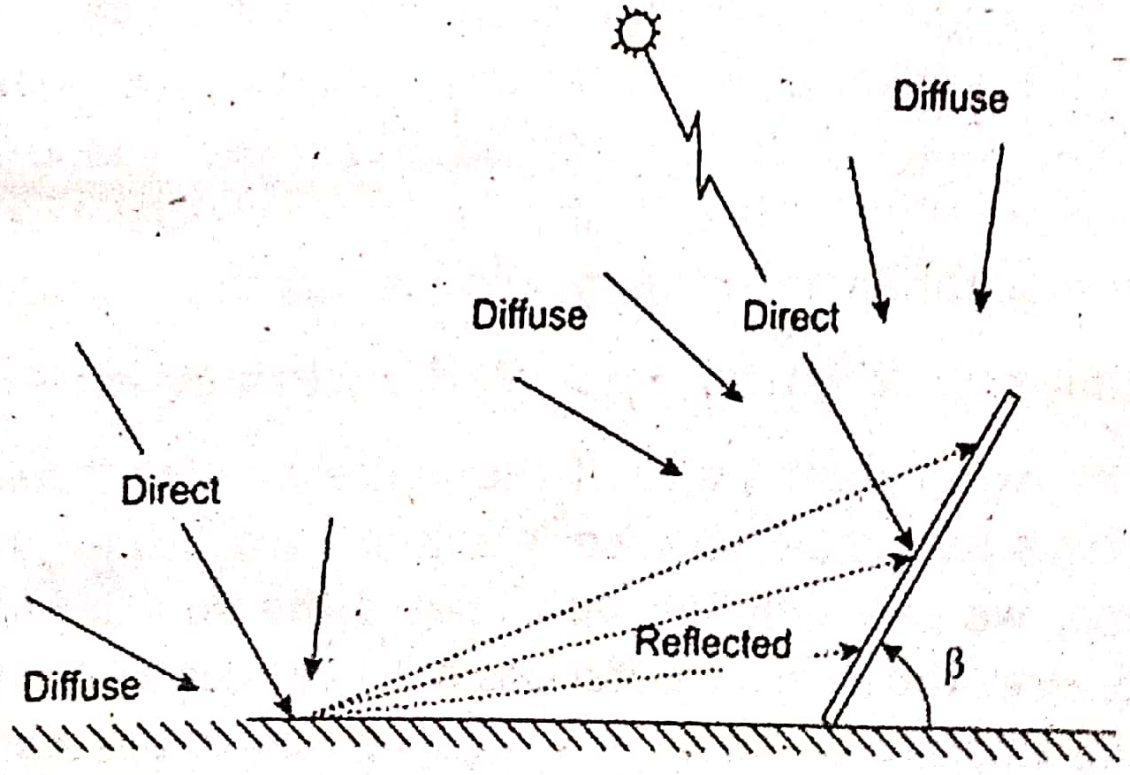
The percentage of the sky's radiation that is diffuse is much greater in higher latitude, cloudier places than in lower latitude, sunnier places. Moreover, the percentage of diffuse radiation tends to be higher in the winter than the summer in

this higher latitude, cloudier places. The sunniest places, by contrast, tend to have less seasonal variation and therefore more direct radiation.

Reflected radiation :

This refers to the kind of radiation that has been reflected off the ground. Asphalt reflects about 4% of the light that strikes it and a lawn of about 25%. However, solar panels tend to be tilted away from where the reflected light is going. Moreover, reflected radiation rarely accounts for a significant part of the sunlight striking their surface.

An exception is in very snowy conditions which can sometimes raise the percentage of reflected radiation quite high. Fresh snow reflects 80 to 90% of the radiation striking it.



Q. 6. What is a Pyrometer. Explain working of it and give its applications?

The physical quantity which can be described as hotness or coldness of any object or substance is called *temperature*. It can be measured in different units and scales according to the requirement. The temperature of any material can be measured by using different methods and devices. Temperature measuring devices are used to measure the energy level of the physical property or any substance. According to the physical property of the material, the temperature can be measured by using these methods like *thermometers* (liquid in glass), electric *resistance* thermometer, radiation thermometer/ infrared thermometers/ pyrometers, *thermocouple*, silicon diode, bimetallic devices, bulb and capillary devices, constant volume gas, and pressure gas thermometers. The SI unit of temperature is Kelvin (k), other than this, it can be measured in Celsius scales (C) and Fahrenheit scale (F).

Pyrometer :

Pyrometer also is known as an Infrared thermometer or Radiation thermometer or non-contact thermometer used to

detect the temperature of an object's surface temperature, which depends on the radiation (infrared or visible) emitted from the object. Pyrometers act as photodetector because of the property of absorbing energy and measuring of EM wave intensity at any wavelength.

These are used to measure high-temperature furnaces. These devices can measure the temperature very accurately, precisely, pure visually and quickly. Pyrometers are available in different spectral ranges (since metals - short wave ranges and non-metals-long wave ranges).

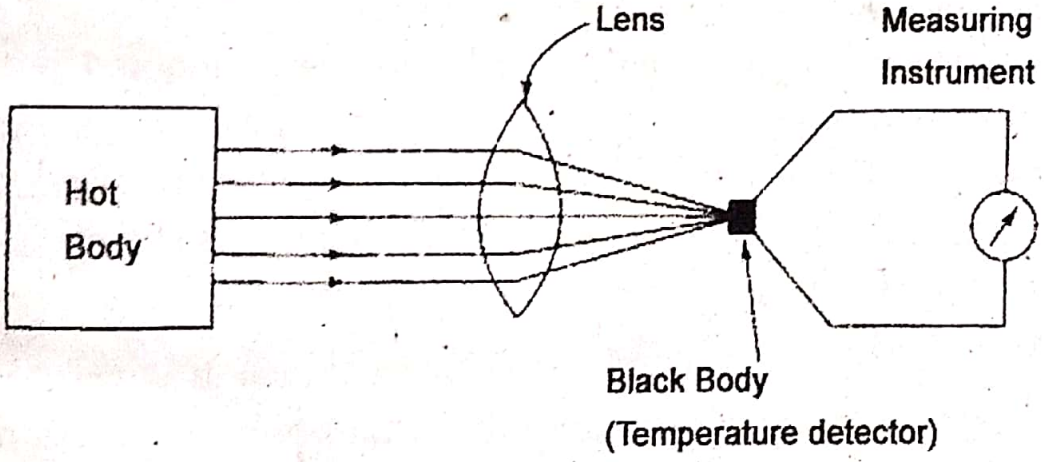


FIg : Pyrometer-diagram

Color pyrometers are used to measure the radiation emitted from the object during the temperature measurement. These can measure the object's temperature very accurately. Hence the measuring errors are very low with these devices.

Color pyrometers are used to determine the ratio of two radiation intensities with two spectral ranges. These are available in series of Metis M3 and H3 and handheld portables Capella C3 in different versions.

High-speed pyrometers are used to temperature more fastly and quickly than M3 devices. These are available in combination with 1-color and 2-color pyrometers. These devices

can create clear temperature profiles of fast-moving objects and control the adequate temperature level.

Working Principle of Pyrometer :

Pyrometers are the temperature measuring devices used to detect the object's temperature and electromagnetic radiation emitted from the object. These are available in different spectral ranges. Based on the spectral range, pyrometers are classified into 1-color pyrometers, 2-color pyrometers, and high-speed pyrometers.

The basic principle of the pyrometer is, it measures the object's temperature by sensing the heat/radiation emitted from the object without making contact with the object. It records the temperature level depending upon the intensity of radiation emitted. The pyrometer has two basic components like optical system and detectors that are used to measure the surface temperature of the object.

When any object is taken whose surface temperature is to be measured with the pyrometer, the optical system will capture the energy emitted from the object. Then the radiation is sent to the detector, which is very sensitive to the waves of radiation. The output of the detector refers to the temperature level of the object due to the radiation. Note that, the temperature of the detector analysed by using the level of radiation is directly proportional to the object's temperature.

The radiation emitted from every targeted object with its actual temperature goes beyond the absolute temperature (-273.15 degrees Centigrade). This emitted radiation is referred to as Infrared, which is above the visible red light in the electromagnetic spectrum. The radiated energy is used for detecting the temperature of the object and it is converted into electrical signals with the help of a detector.

Types of Pyrometers :

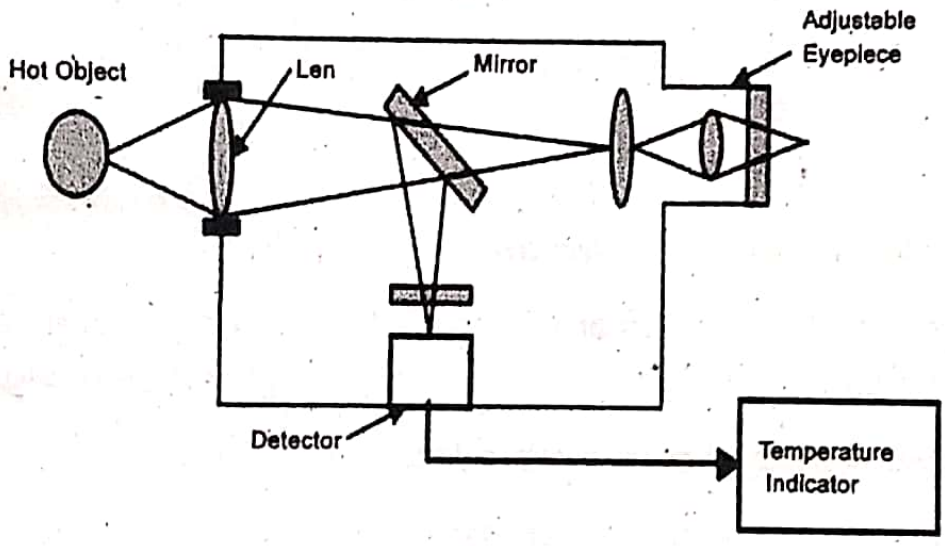
To detect the different object's temperature, pyrometers are classified into two types. They are,

(i) Optical Pyrometers

(ii) Infrared or Radiation pyrometers

(i) Optical Pyrometers :

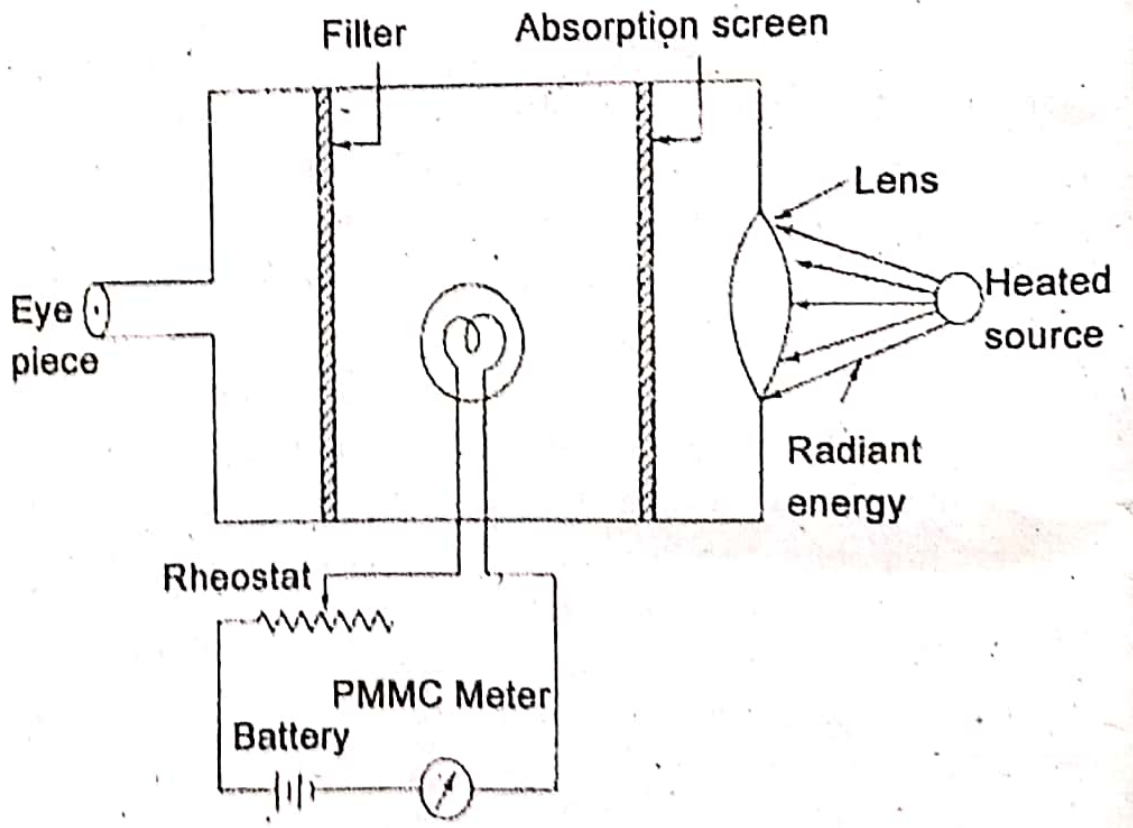
These are one of the types of pyrometers used to detect thermal radiation of the visible spectrum. The temperature of the hot objects measured will depend on the visible light they emit. Optical pyrometers are capable of providing a visual comparison between a calibrated light source and the targeted object's surface. When the temperature of the filament and the object's surface is the same, then the thermal radiation intensity caused due to the filament merges and into the targeted object's surface and becomes invisible. When this process happens, the current passing through the filament is converted into a temperature level.



(ii) Infrared or Radiation Pyrometers :

These pyrometers are designed to detect thermal radiation in the infrared region, which is usually at a distance of 2-14 μm. It measures the temperature of a targeted object from the

emitted radiation. This radiation can be directed to a thermocouple to convert into electrical signals. Because the thermocouple is capable of generating higher current equal to the heat emitted. Infrared pyrometers are made up of pyroelectric materials like Polyvinylidene fluoride (PVDF), triglycine sulphate (TGS), and lithium tantalate ($LiTaO_3$).



Advantages and Disadvantages :

Usually, Pyrometers are compared with thermometers and also have some advantages and disadvantages while using.

The advantages of pyrometer are :

(I) It can measure the temperature of the object without any contact with the object. This is called non-contact measurement.

(II) It has a fast response time.

(iii) Good stability while measuring the temperature of the object.

(iv) It can measure different types of object's temperature at variable distances.

The disadvantages of pyrometer are :

(i) Pyrometers are generally rugged and expensive.

(ii) Accuracy of the device can be affected due to the different conditions like dust, smoke, and thermal radiation.

Applications :

Pyrometers are used in different applications such as :

(i) To measure the temperature of moving objects or constant objects from a greater distance.

(ii) In metallurgy industries.

(iii) In smelting industries.

(iv) Hot air balloons to measure the heat at the top of the balloon.

(v) Steam boilers to measure steam temperature.

(vi) To measure the temperature of liquid metals and highly heated materials.

(vii) To measure furnace temperature.

SHORT ANSWER QUESTIONS

Q. 2. What is Zenith angle?

The solar zenith angle is the angle between the sun's rays and the *vertical direction*. It is closely related to the solar altitude angle, which is the angle between the sun's rays and a horizontal plane. Since these two angles are complementary, the cosine of either one of them equals the sine of the other. They can both be calculated with the same formula, using

results from *spherical trigonometry*. At solar noon, the zenith angle is at a minimum and is equal to latitude minus *solar declination angle*. This is the basis by which ancient mariners navigated the oceans.Solar zenith angle is normally used in combination with the *solar azimuth angle* to determine the position of the Sun as observed from a given location on the surface of the Earth.

$$\text{Cos } \theta_s = \text{Sin } \alpha_s = \text{Sin } \phi \text{ Sin } \delta + \text{Cos } \phi \text{ Cos } \delta \text{ Cos h}$$

Where

θ_s is the solar zentth angle

α_s is the solar zentth angle, α_s

$=90-\theta_s$

h is the hour angle, in the local solar time

δ is the Current declination of the Sun.

Φ is the local latitude.

Q. 5. What are the differences between Pyrheliometer and Pyranometer?

Both the instruments like Pyrheliometer and Pyranometer are used to calculate solar irradiance. These are related in their intention but there are some dissimilarities in their construction and working principle.

Pyranometer	Pyrheliometer
It is one kind of acidometer mainly used to measure the solar irradiance over a planar surface.	This instrument is used to measure direct ray solar irradiance.
It uses thermoelectric detection principle.	In this, the thermoelectric detection principle is used.
In this, the measurement of increasing temperature can be done through thermocouples which are linked in series otherwise series-parallel to build a thermopile.	In this, the increasing temperature can be calculated through thermocouples that are allied in series/series-parallel to create a thermopile.
This is frequently used in meteorological research stations.	This is also used in meteorological research stations.
This instrument calculates direct solar radiation.	This instrument calculates global solar radiation.

VERY SHORT ANSWER QUESTIONS

Q. 1. What is solar constant and what is its value?

The constant of solar energy is the total radiation energy received from the Sun per unit of time per unit of area on a theoretical surface directed perpendicular to the Sun's rays and at Earth's implying the distance from the Sun. The value of the constant is said to be approximately 1.366 kilowatts per square meter.

Q. 3. What is air mass ?

An air mass is a large volume of air in the atmosphere that is mostly uniform in temperature and moisture. Air masses

can extend thousands of kilometres in any direction, and can reach from ground level to the stratosphere—16 kilometres (10 miles) into the atmosphere.

Q. 7. *What is the difference between direct and diffuse radiation?*

The solar radiation that reaches the Earth's surface without being diffused is called direct beam solar radiation. The sum of the diffuse and direct solar radiation is called global solar radiation. Atmospheric conditions can reduce direct beam radiation by 10% on clear, dry days and by 100% during thick, cloudy days.