Government polytechnic kendrapara

DEPARTMENT

OF

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

LECTURE NOTES

Semester : 6th

Subject: RENEWABLE ENERGY SOURCES (TH-4)

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Chapter - 1 01

Renewable and Non-renewable energy sources.

Though all energy sources are available in nature, the production of fossil energy sources such as coal, oil, gas takes millions of year. These sources are being consumed by the world much faster than their replenishment. With limited availability these sources are likely to be exhausted in another century. These sources are therefore termed as non renewable energy sources.

Energy sources such as solar, wind, hydro and various form of biomass, and marine energy sources (wave and tidal) are inexhaustable energy sources available in nature. These are termed as renewable energy sources.

Renewable - solar, wind, hydro, wave, tidal.

Non Renewable energy:- Coal, oil, gas.

Energy and Environment

The use of fossil fuels by the industry (Coal, oil, and gas) leads to environment pollution by emitting oxides of sulphur (SO_x) nitrogen (NO_x) particulates and Carbon mono-oxide. In addition, refrigerant systems use chloroflouro carbons which on discharge or leakage deplete ozonne layer of the atmosphere.

The use of biomass and coal for domestic cooking and some industrial process is the main reason of particulates, smoke, and smog.

Petrol and diesel engine motor vechile emits wide variety pollutants mainly carbon monoxide, oxide of nitrogen (NO_x), volatile organic compounds and particulates

Origins of Renewable energy sources

All available energy sources in the world today arise basically from the following three different primary sources that occurs in nature continiously.

1. Isotopic dissociation in the Core of earth
2. Movement of the planet
3. Thermonuclear reactions in the sun.

The largest energy flow comes from solar radiation which is also responsible for the development of fossil energy sources namely gas oil, coal, by the process of bioconversion that occoured inside the earth million years ago. The supply of fossil energy sources is negligibly small in compareison to annual energy flow from the sun on earth.

Another renewable energy sources that originate from earth itself is the geothermal energy. The potential of geothermal energy is much lesser compared to that of solar radiation

The third renewable sources occur as a result of movement of planets, The resulting gravitational pull between earth and the planets manifests itself in the form of tides. However the theoretical potential of the tidal force is still less by a factor in Comparison to the thermal energy potential

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Geo Thermal energy sources

Geo thermal energy is generated in the earths core. 6000km below the surface. The core of the earth continiously produces temperature higher than the suns surface by slow decay of radio active particles.

Technology and resource type

There are various ways of utilizing geothermal energy which are classified as follows.

Dry steam sources. Dry super heated steam which can either be extracted directly from geothermal reservoirs or which comes out directly may be used to run a turbine and subsequent produces electricity.

- Wet steam sources. Geo thermal reservoirs which remain under pressure gives rise to a steam mixture with temperature between 180° to 370°. After the steam separates from water it can be used to produce electricity. The remaing water is usable for space heating or for absorption based air conditioning system

Solare Radiation

The sun, which is the largest member of the solare system, is a sphere of intensely hot gaseous matter having a diameter of 1.39×10^8 m. and an average distace of 1.495×10^{11} m from earth. At the innermost region the core temperature is estimated between 8×10^6 to 40×10^6 K. as it has a density about 100 times that of water and pressure of 109 atm. Such high inner temperature is maintained by enormous energy released due to continious fusion reaction Thus the sun is a big natural fusion reactor. The most important of them is a reaction in which four hydrogen atoms (proton) combine to form one helium atom. The mass of helium nucleus is less than that of four proton, the difference of mass having been converted to energy in a fusion reaction as follows:

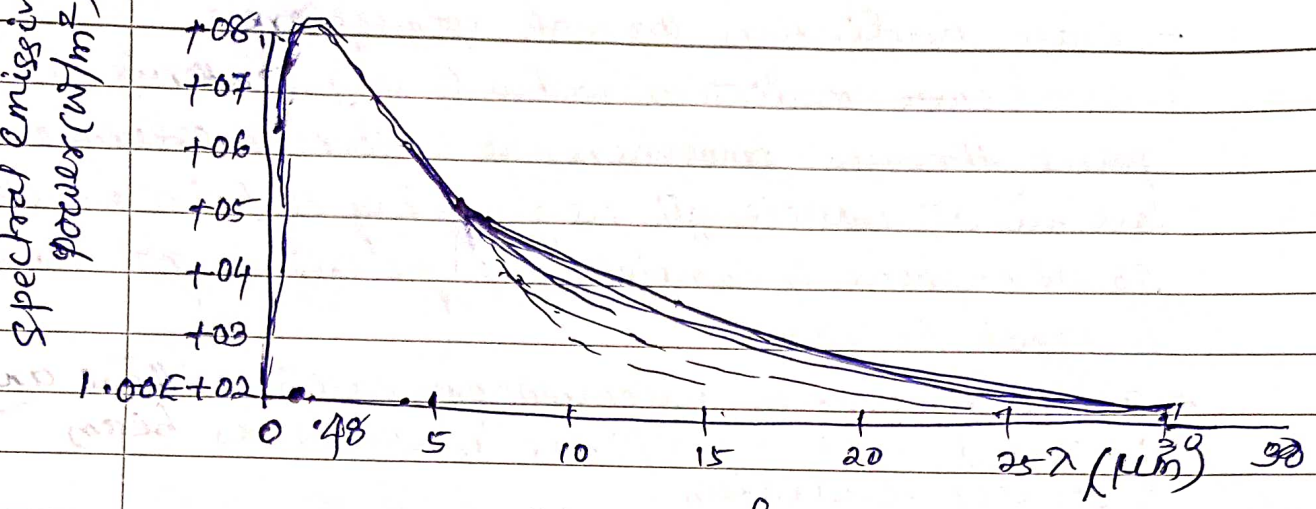
$$4(_1H^1) \longrightarrow {}_2He^4 + 26.7 MeV.$$

The surface of the sun is maintained at a temperature of approximately 5800°K.

The energy radiated away from a black body at temperature T and wavelength λ can be obtained from Plank's blackbody radiation formula.

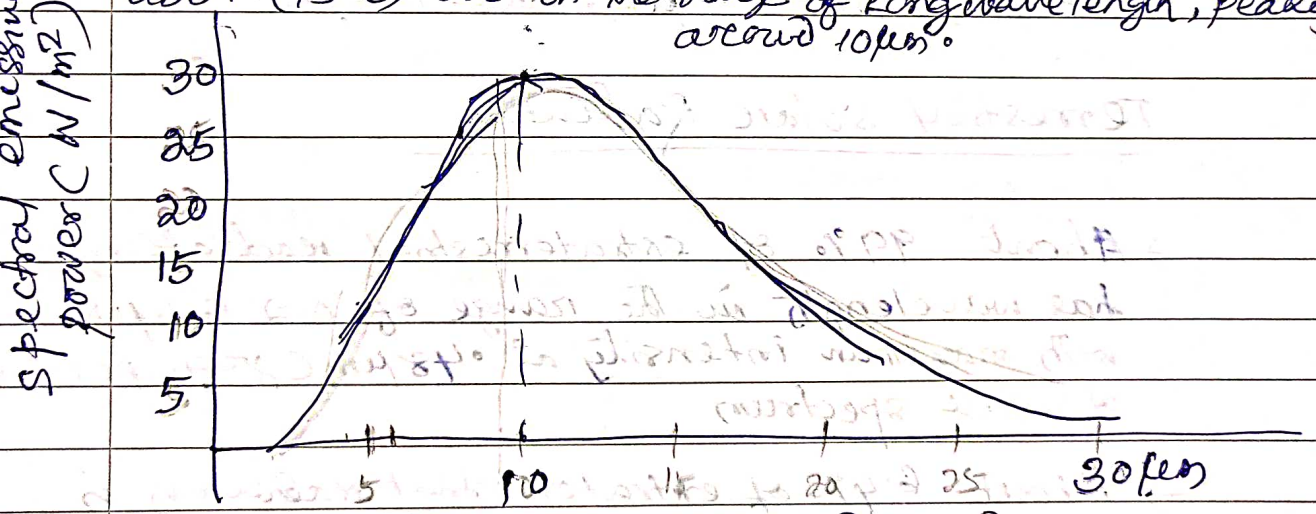
$$W_\lambda = \frac{2\pi h^2 \lambda^{-5}}{e^{hc/\lambda KT} - 1}. \quad W/m^2/\text{unit wavelength}$$

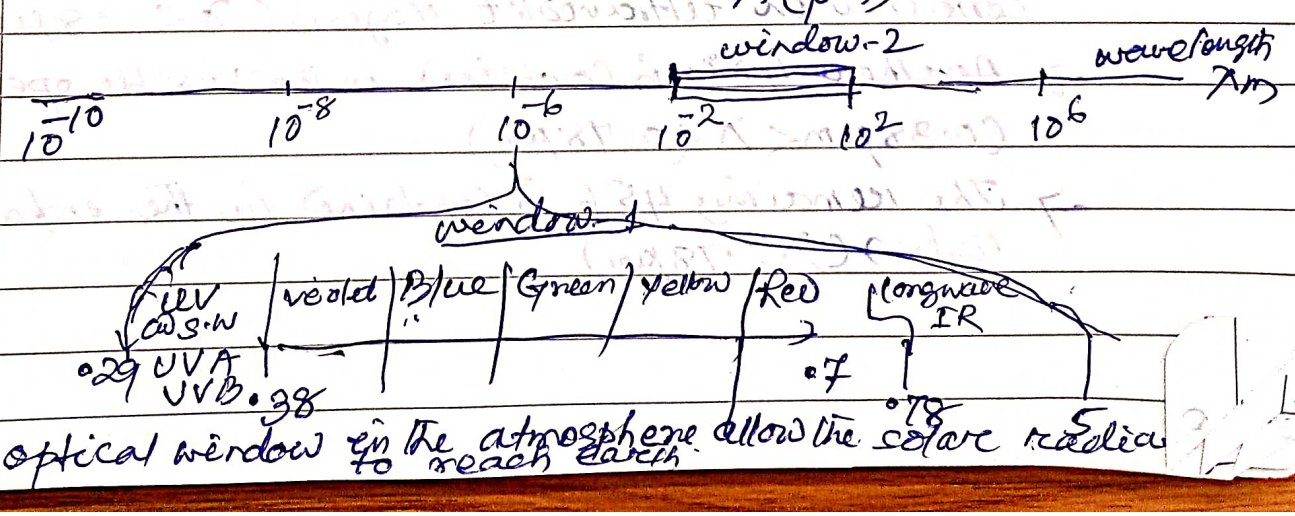
where h = planks Constant
K = Boltzman Constant



Radiation from sun

The radiation emitted from the sun is about 5760°K lies in the range of very shortwave length of 10^{-20} μm to very high frequency radiation of very long wavelength of several kilometer and peaking around 0.48 μm. and that from earth at 288°K (15°C) lies in the range of long wavelength, peaking around 10μm.





optical window in the atmosphere allow the solar radiation to reach earth

Solare Radiation through atmosphere:

Solare radiation without any scattering passes through atmosphere, it suffers considerable loss in all wavelength region. For certain wavelength the atmosphere is completely opaque and is not allowed to reach the earth.

⇒ Solare radiation received on earth without any scattering in the atmosphere is known as beam or direct radiation.

⇒ Solare radiation received from the sun after multiple scattering is known as diffused or sky radiation.

⇒ In view of solare energy utilisation only optical window is important, because the maximum intensity is contained in this region between 0.30 and 0.78 μm wavelength.

Terrestrial Solare Radiation

→ About 99% of extraterrestrial radiation has wavelength in the range of 0.2 to 4 μm with maximum intensity at .48 μm (green portion of visible spectrum)

→ About 6.4% of extraterrestrial radiation is contained in ultraviolet region ($\lambda < .38$ μm)

→ Another 48% is contained in the visible spectrum ($0.38\ \mu m < \lambda < 0.78\ \mu m$)

→ The remaining 45.6 is contained in the infrared region ($\lambda > 0.78$ μm)

→ There is almost Complete absorption of shortwave radiation in the range ($\lambda < 0.29 \mu m$) and infrared radiation in range ($\lambda > 2.3$) in the atmosphere.

→ From the point of view of terrestrial application of solar energy, radiation only in the range of wavelength between 0.29 to 2.3 μm is significant.

→ The earth's atmosphere contain various gaseous constituents, suspended dust, and other minute solid and liquid particulate matter

→ These are air molecules, ozone, oxygen, nitrogen, Carbondioxide, carbon monoxide, water vapour dust, and water drop-lets.

→

Absorption

The intensity and the spectrum of radiation that is available on the surface of earth depends on the following physical process

→ Reflection of extraterrestrial atmosphere and on earth surface
→ Scattering on earth atmosphere
→ Absorption.

→ The reflection from earth surface is known as albedo. This part of the extra-terrestrial radiation goes to space in the form of shortwave-radiation and is not available for terrestrial use.
→ The remaining part undergoes multiple scattering with particles present in the atmosphere
→ Some part of the radiation is absorbed by atmosphere.

Absorption selective absorption of various wavelengths occurs by different molecules. The absorbed radiation increases the energy of the absorbing molecules, thus raising their temperature.

a) Nitrogen, molecular oxygen, and other atmospheric gases absorb the X-ray and extreme ultraviolet ray
⇒ Ozone absorbs a significant amount of ultraviolet radiation in the range ($\lambda < 0.38\mu m$)
⇒ Water vapor H_2O, CO_2 absorb almost completely the infrared radiation range ($\lambda > 2.3\mu m$)
⇒ Dust particle, air molecule absorb a part of solar radiant energy, irrespective of wavelength

2. Scattering :- Scattering by dust particle and air
→ molecule (gaseous particles) involves redistribution of incident energy. /
→ A part of the scattered radiation is lost reflection back to space and the remaing is directed downwards towards earth surface from different directions as diffused radiation.

Incident radiation on the earth surface consists of following two component.

1. Direct or beam radiation : Radiation reaching the earth directly after a part of extraterrestrial energy gets absorbed and scattered

2. Diffused Radiation. Which reaches the earth after multiple scattering by the earth atmosphere.

The total radiation at any location on the surface of earth is the sum of beam radiation and diffuse Radiation is known as Global radiation

Global Radiation = Direct radiation + Diffused radiation

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Measurement of solar radiation

solar radiation data are measured mainly by the following instruments.

1) Pyranometer: It is designed to measure global radiation (usually on the horizontal surface)

When shaded from beam radiation by using a disk which is made by shadow ring, a pyranometer measures diffused radiation.

2) Pyrheliometer: An instrument that measures the beam radiation by using a long narrow tube to collect only beam radiation from the sun at normal incident

3) Sunshine meta Recorder: It measures the sunshine hours in a day.

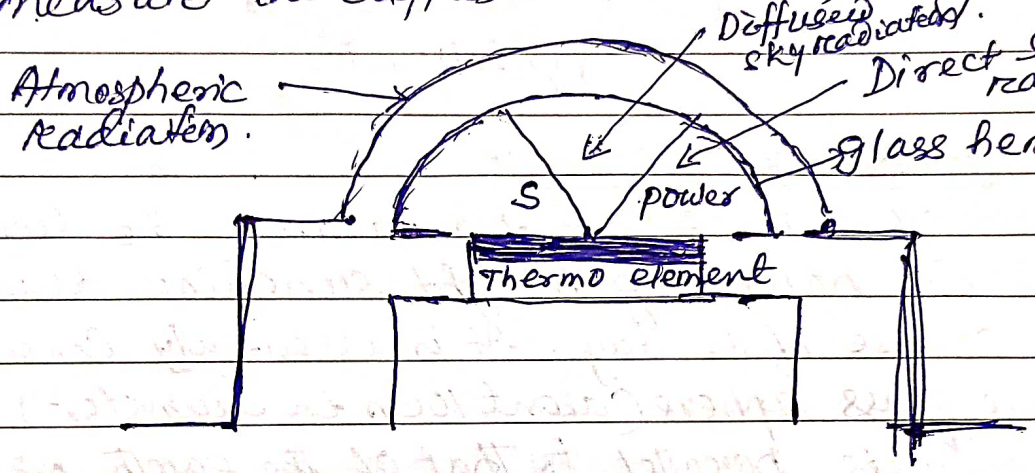
Pyranometer

A pyranometer is designed to respond to radiation of all wavelengths and hence accurately measures the total power in the incident spectrum. It consist of a thermopile whose sensitive surface consists of circular, blackened, hot junction exposed to the sun, the cold junction being completely shaded. The temperature difference between hot and cold junction is the function of radiation falling on the sensitive surface.

The sensing element is covered by two concentric hemispherical glass dome to shield it from wind and rain.

A radiation shield surrounding the outer dome and coplannare with sensing element. prevents direct solare radiation from heating the base of the instrument. The instrument has a voltage output 9μV/W/m² and output impedance 650Ω.

The pyranometer with shaded band to prevent beam radiation from reaching the sensing element measure the diffused radiation only.



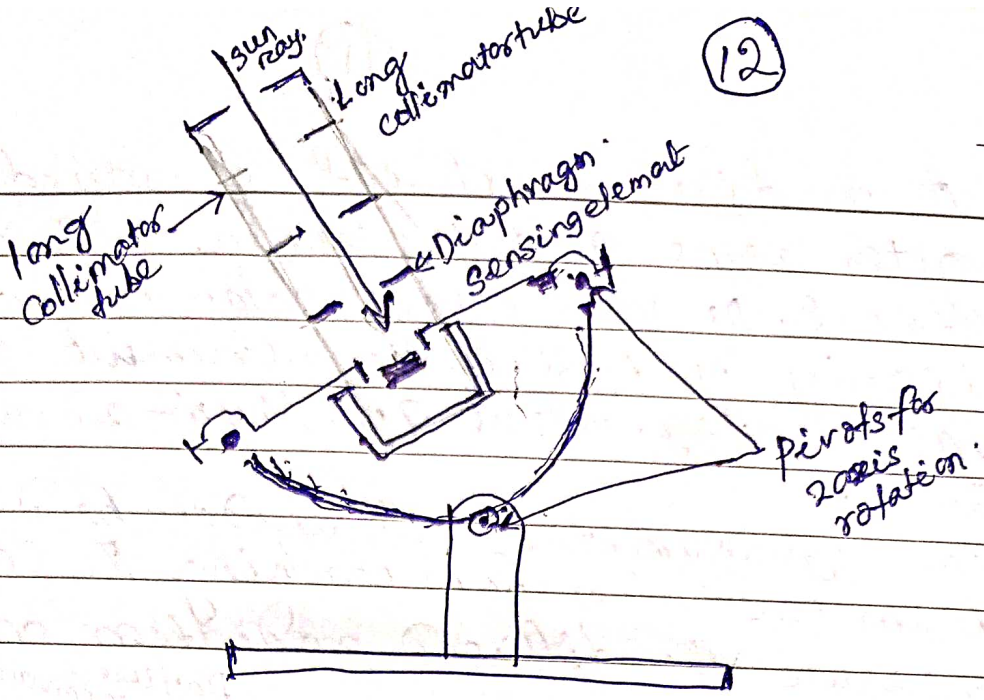
Pyranometer - global solare radiation

Pyrheliometer The normal incidence pyrheliometer uses a long collimator tube to collect beam radiation whose field of view is limited to a solid angle of 5.5° by appropriate diaphragms inside the tube.

→ The inside of the tube is blackened to absorb any radiation incident at angles outside the collection solid angles.

→ At the base of the tube a wirewound thermopile having a sensitivity of approximately 8μV/W/m² and an output impedance 200Ω is provided.

→ The tube is sealed with dry air to eliminate absorption of beam radiation either a tube by water vapour. A tracker is needed for continuous reading



Pyrheliometer.

Sunshine Recorder

The instrument measures the duration in hours of bright sunshine during the course of the day. It is essentially consists of a glass sphere (about 10cm in diameter) mounted on axis parallel to that of the earth within a spherical section (Bowl). The bowl and glass sphere are arranged in such a way that the sun's rays are focussed sharply at a spot on a card held in a groove in the bowl. The card is prepared from special paper bearing a timescale. As the sun moves the focussed bright sunshine burns a path along this paper. The length of the trace thus obtained on the paper is the measure of the duration of the bright sunshine.

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Solar Collectors

Based on temperature range, solar thermal energy can be divided into three broad categories

(a) Low temperature system <150°C. swiming pool heating, domestic hotwater, space heating and cooling solar drying, solar desalination.

(b) Medium Temperature system (150°-400°C), Exa. Industrial process heat (Paper and food industry) Power stations.

(c) High Temperature system (400°-1000°C). examples. Industrial process heat for manufacturing, metal, cement and glass, power generation in solar tower power plant and solar disc power plant.

The collection of solar energy radiation and its subsequent transfer to a flowing fluid is essentially achieved by means of solar thermal collectors that are of two kinds.

1) Flat plate Collectors
2) Concentrating collector.

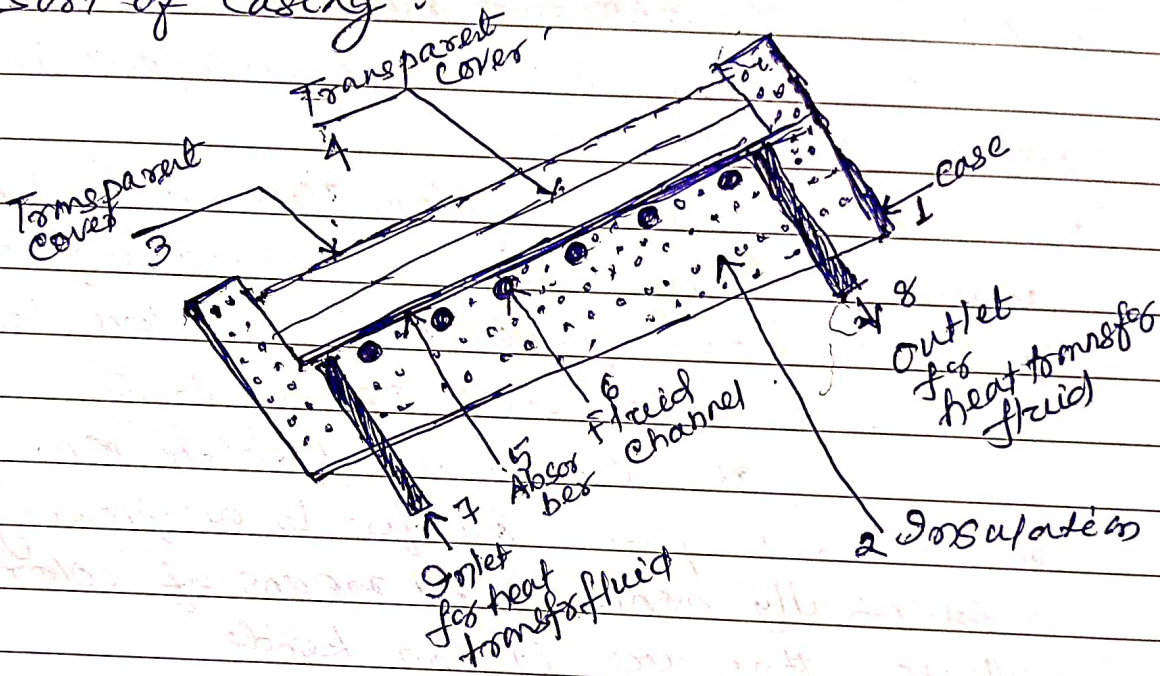
Flat plate Collector: These are employed for low temperature application in the range upto 100°C.

The fig shows the schematic of a flate plate Collector. It consists of black coated plate made of plastic or metal which absorbs solar energy and converts into heat. The plate is known as absorber. Fluid channels are welded below the absorber for carrying a heat transfer ~~fluid~~ fluid. This heat transfer fluid transports the heat from absorber to the system where it is utilised. In order to

reduce the heat losses the back side of the collector. below the absorber and the sides of the collector are equipped with appropriate insullation.

⇒ The front of the absorber is covered with transparent glass sheets

⇒ The whole thing is sealed in a box or some sort of casing.



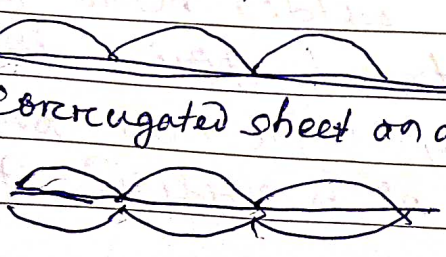
Many absorber design have been used in collectors with liquid as heat transport medieem.

(a)

(b) Tubes bonded in upper surface plate

(c) rectangular tubes bonded to plate

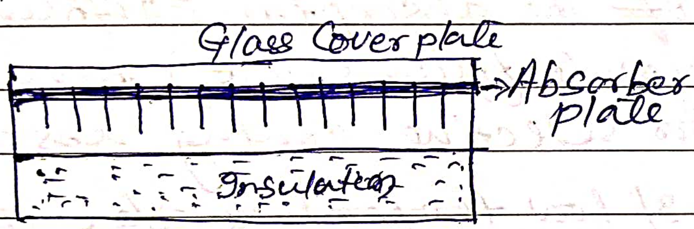
(d) Corrugated sheet on a flate plate



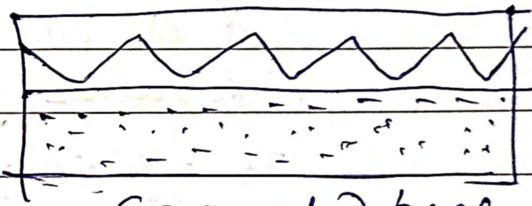
Different design of solare air heating Collector

The solare air heating collects is similar to a liquid flatplate collector with a change in Configuration of the absorber and tube as shown in fig. The value of heat transfer coefficient between the ~~heat transfer element~~ absorber plate and air is low. For this region the surface are sometimes roughened or longitudinal fins are provided in the airflow passage. Corrugated V shaped, matrix etc. are also some of the variations of shapes of the absorber plate.

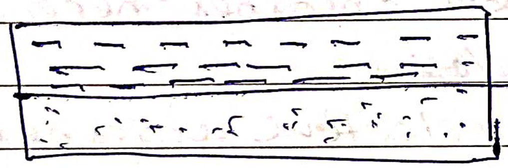
The principal applications of these Collectors are drying for agricultural and industrial purpose.



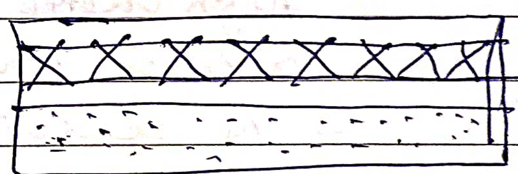
Fin type



Corrugated type.



Metal matrix



Thermal trap type

Optical characteristics of absorber plate

The most important component of solar collector is absorber plate which exhibits characteristic of a high value of absorptivity for incoming solar radiation and low value of emissivity.

→ In different wavelength regions, however the absorption and emission is different.

→ The wavelength dependence allows the use of selective coating on the absorber that can have a high absorption coefficient in the visible ~~spectrum~~ region of solar spectrum and low emission coefficient in the infrared region.

→ The ratio of the absorption coefficient and the emission coefficient (α/ϵ) have a very high value for selective coating absorber.

→ ~~The efficiency of low temperature solar system can be increased several times by using the high value~~ high value α/ϵ absorber because of reduced radiation loss.

→ The behaviour of selective absorbers can be understood by writing an optical balance equation

$$\alpha + \rho = 1$$

α = absorptivity

ρ = Reflectivity

— In short wave — α - higher, ρ = small

in long wave — α - small, ρ - large

Some examples of selective surface layers are copper oxide, nickel black and black chrome.