

UNIT - 02

(SUB - KOE 074)

RENEWABLE ENERGY RESOURCES

ONE - SHOT

CHEMISTRIES

Topics :-

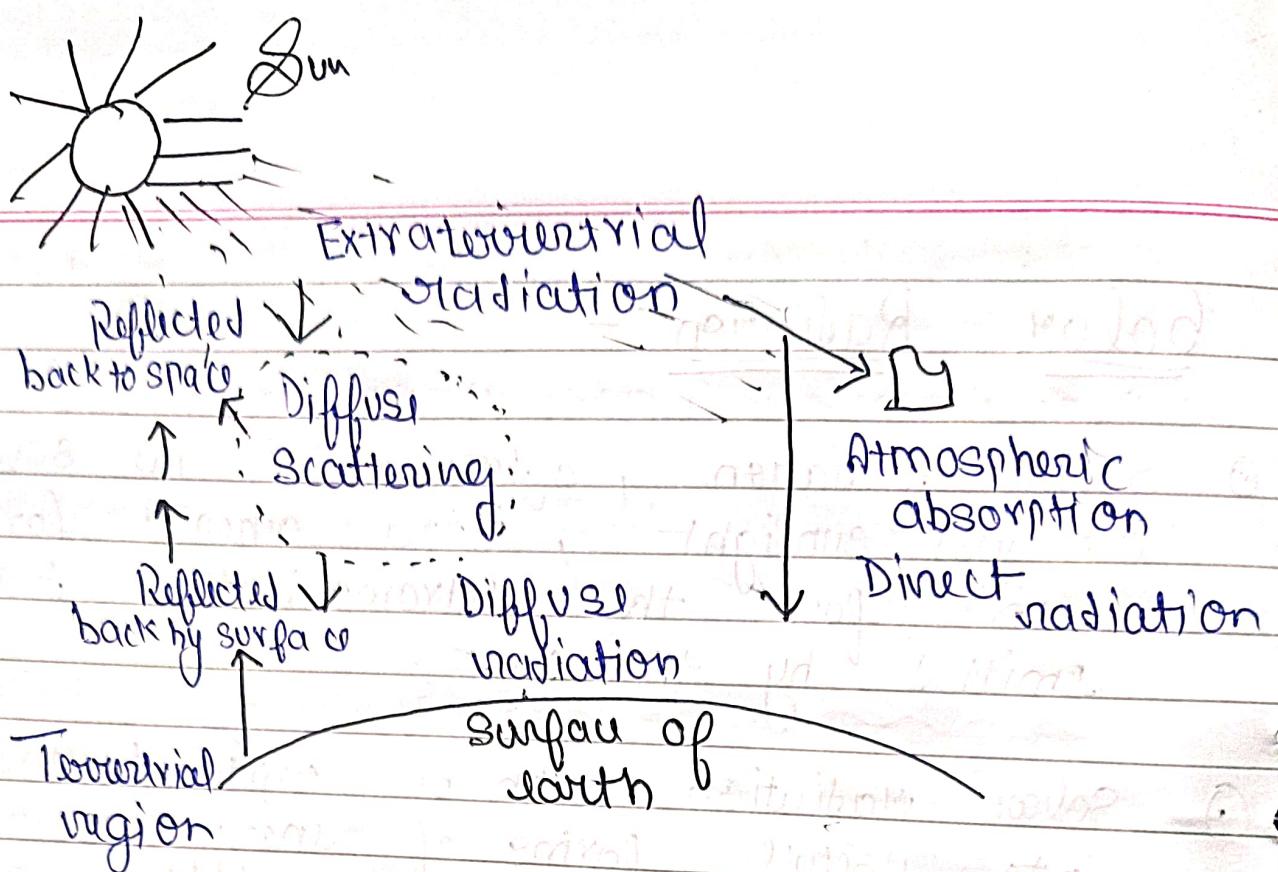
- ① Solar Radiation
- ① Solar collector & Classification
- ① Solar Flat Plate Collector
- ① Materials for Flat Plate Collector
- ① Application and advantage & disadvantage
- ① Performance of Flat Plate Collector
- ① Focusing Material of Collector
- ① Application of Collector
- ① Performance of Collector
- ① Solar thermal Power plant
- ① Thermal Energy Storage for Heating & Cooling
- ① Limitation

Solar Radiation :-

- ① Solar Radiation, often called the solar resources or just sunlight, is a general form, or term for the electromagnetic radiation emitted by the sun.
- ② Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies.

Types:-

- a) Extraterrestrial Solar Radiation:-
→ The intensity of the sun's radiation outside the earth's atmosphere is called extraterrestrial and has no diffuse components.
- b) Terrestrial Solar Radiation:-
→ The radiation we receive on the earth surface is called terrestrial radiation and is nearly 70% of extraterrestrial radiation.



- ① Beam Radiation (I_b): - Solar radiation received on the Earth's surface without change in direction.
- ② Diffuse Radiation (I_d): - The radiation received on a terrestrial surface (scattered by aerosols and dust) from all parts of the sky + dome.
- ③ Total Radiation (I_t): - The sum of beam and diffusion radiation ($I_b + I_d$).
- ④ Air mass (m_a): - The path length that solar radiation travels through the Earth's atmosphere.

Direct Radiation

- ① Travels straight from the sun to the surface.
- ② More intense and concentrated.
- ③ Creates sharp, well-defined shadows.
- ④ Dominant on clear, sunny days.

Diffuse Radiation

- ① Scattered in multiple direction by the atmosphere.
- ② Weaken and spread out.
- ③ Produces soft, less-defined shadows.
- ④ Dominant on cloudy, hazy or polluted days.

Solar Constant:-

- ① Solar constant is the amount of solar energy hitting a 1 square meter area at the top of Earth's atmosphere when Earth is at an average distance from the sun.
- ② The standard value of the solar constant based on experimental measurements is 1367 W/m^2 with an accuracy of $\pm 1.5\%$.

$$I_0 = I_{sc} \left[1 + 0.033 \cos \frac{360n}{365} \right]$$

IS units

in days

★ Day length! - The time of sunrise, sunset and the duration of the day length depends upon latitude of location & month in a year

★ LAT:- LAT stands for local apparent time.

① The time used for calculating Hour Angle.

$$\text{LAT} = \text{Standard time} + \text{Equation of time (correction)} \\ + 4 (\text{Standard time longitude} - \text{longitude loc})$$

★ Altitude Angle! - The angle between the sun and the observer's horizon.

★ Incident Angle! - The angle at which solar radiation strikes a surface.

★ Latitude Angle! - The angle formed between the sun's rays and line perpendicular to the Earth surface at a specific location, measured from the equator.

★ Hour Angle! - The angle that describes the position of the sun relative to the observer's local solar time

$$\text{Hour angle} = 15^\circ \times (\text{local Solar Time} - 12)$$

★ Zenith Angle! - The zenith angle is the angle b/w the sun and the point directly overhead of an observer.

SOLAR COLLECTOR !

SAKTU 2023-2024

- ① Solar collector are used to collect the solar energy and convert this energy into the thermal energy by absorbing them.
- ② This thermal energy is further used for heating a collector fluid such as water, oil or air.
- ③ It is designed for high absorption and low emission.
⇒ Classified into two types! -

- 1] Non-concentrated collectors! - Those collectors capture sunlight without focusing it.
→ They are designed to absorb solar energy directly.
- (a) Flat-Plate collectors! -
→ A flat panel with a glass cover absorbs sunlight. The heat is transferred to a fluid (like water) circulating through the panel.
→ Best for heating water, pool heating.
- (b) Evacuated tube collectors! -
→ Glass tubes with a vacuum inside help to keep the heat trapped inside. Sunlight heats up the absorber within each tube, and an fluid inside absorb heat.
→ Ideal for high-efficiency water heating.

2] Concentrated collector! - These collectors focus sunlight using mirrors or lenses to generate higher temperatures.

(a) Parabolic trough collectors! - Long, curved mirror focus sunlight onto a receiver tube, which collect the concentrated solar energy.
→ Typically used for large-scale industrial application.

(b) Fresnel collectors! → These use flat mirrors arranged in a pattern to focus sunlight onto a receiver tube.
→ They are also used for industrial application for generating high temp. heat or electricity

SOLAR FLAT PLATE COLLECTORS

- ① Flat plate collector is simplest in design and it is most important part of any solar thermal energy system.
- ② In this collector both direct and diffuse radiations are absorbed and converted into useful heat.
- ③ Flat plate collector is a type of device that is used to capture heat from solar radiation; it is used to convert solar energy into heat energy.

⇒ Components :-

i) Absorber Plate :

→ Absorber plate is used to grasp and absorb solar radiation.

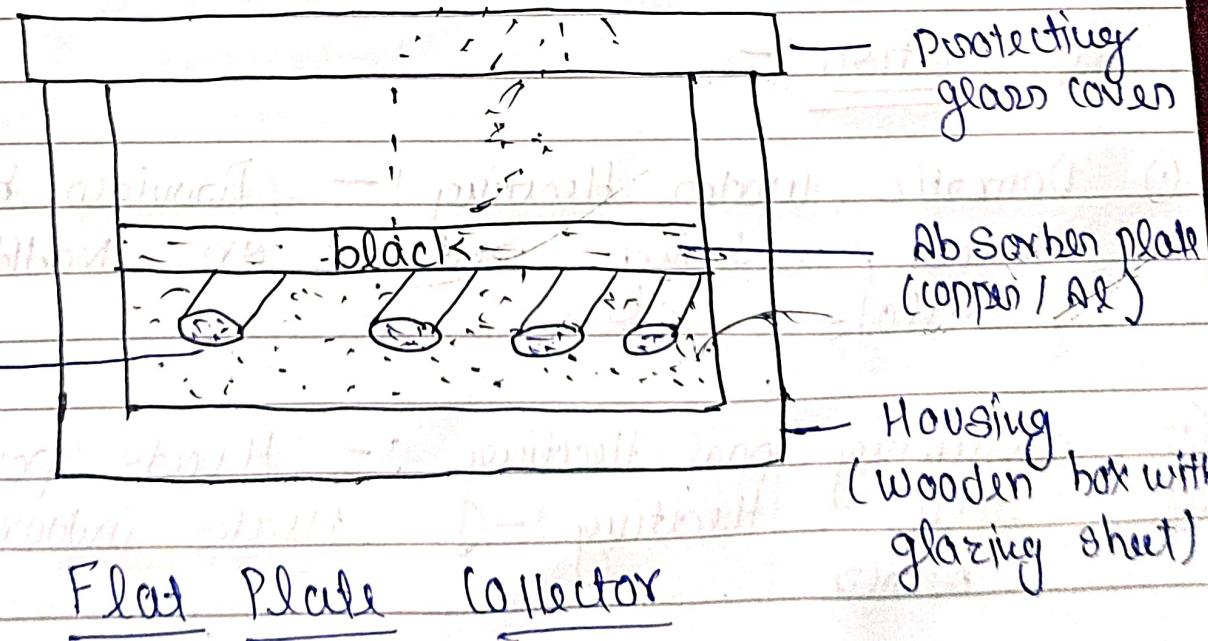
→ The plate is usually metallic (copper, Al or steel), sometimes plastics have been used in some low temp. Application.

ii) Transparent covers :-

→ There are one or more sheets made of glass for trapping the heat received by the absorber plate.

iii) Insulation :- It minimizes the heat losses by conduction.

iv) Box :- It contains the above component and keep them into desired position.



⑨ Materials used in flat Plate collector

Component	Common Materials	Purpose
Absorber plate	Copper, Aluminium, Steel	To absorb solar energy and convert into heat
Glazing (cover)	Tempered glass, Acrylic, Polycarbonate	To let sunlight in while trapping heat inside
Insulation	Mineral wool, fibreglass, foam	To prevent heat loss from the back and sides
Frame	Aluminum, steel, plastic	To support and hold all the component together
Tubes	Copper, Aluminium, Stainless steel	To carry the heat transfer fluid

Application :-

⑩ Domestic water Heating :- Provides hot water for homes, reducing reliance on traditional heating methods

- ① Swimming pool heating :- Heats pool water
- ② Space heating :- Heats indoor spaces in homes

- ① Industrial process heat.
- ② Desalination
- ③ Agriculture Heating
- ④ Solar Air Heating.

⇒ Advantage and Disadvantage

Advantages:-

- ① Low cost
- ① Easy to manufacture
- ① Less maintenance
- ① Permanently fixed
- ① Collect both beam and diffuse radiation

Disadvantage:-

- ① Limited Efficiency in cold climates
- ① low - Temperature Application
- ② Space - Requirements
- ① Seasonal performance

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Performance Analysis of Flat Plate Collector :-

a) Fin Efficiency Factor (F_e) :- Fin efficiency is a measure of how well a fin transfers heat and is calculated as the ratio of the actual heat transfer to the maximum possible heat transfer.

$$\eta = Q_{\text{actual}} / Q_{\text{max}}$$

b) Collector Efficiency Factor (F_c) :- It is defined as the ratio of how much useful heat goes to the fluid versus how much heat escapes to the environment.

$$F_c = Q_u / A_c [x_0 T_0 I_t - U_L (T_f - T_a)]$$

c) Collector Heat Removal Factor (F_h) :-

The collector heat removal factor (FR) is the ratio of the actual heat transfer to the maximum possible heat transfer through a collector plate.

$$F_h = \frac{Q_u}{A_c [x_0 T_0 I_t - U_L (T_f - T_a)]}$$

d) Collector Efficiency (η_c) :- Collector efficiency is a measure of how much sunlight a solar collector turns into useful heat for the fluid flowing through it.

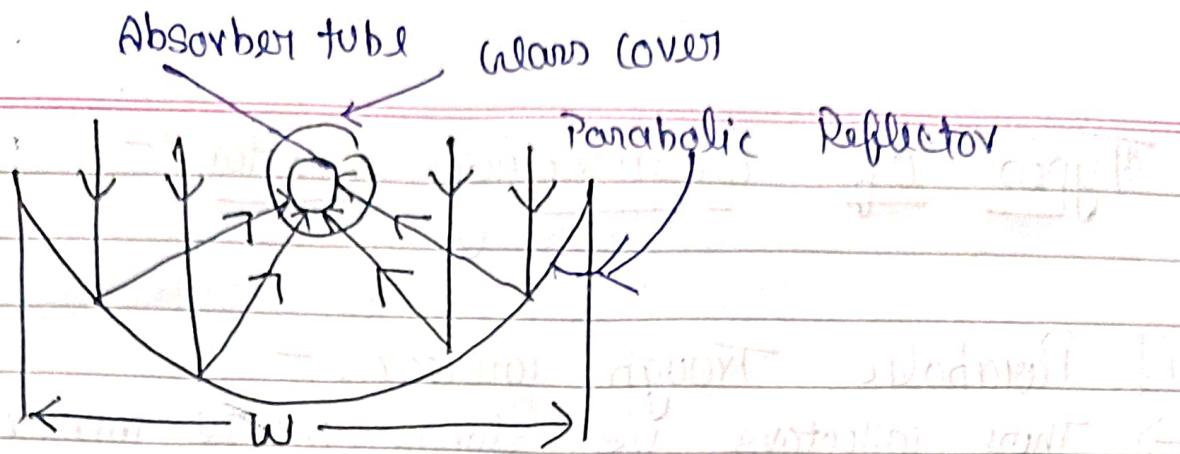
$$\eta_c = \frac{Q_u}{A_c I_t}$$

⇒ Factors which affect the performance of flat plate collector:

- ① Solar Radiation! - More Sunlight means better performance.
- ① Tilt and Orientation! - Correct positioning maximizes sunlight absorption.
- ① Ambient temperature! - Higher outside temperature cause more heat loss
- ① Material! - High-quality absorber and cover materials improve heat capture
- ① Insulation! - Good insulation reduces heat loss
- ① Flow Rate: Optimal fluid flow balances heat transfer and temperature
- ① Cover Plate Quality! - Clear, thermal-insulating covers enhance efficiency.
- ① Wind Speed! - High winds speed increase heat loss
- ① Maintenance: - Regular cleaning prevents dust buildup and preserves performance.

FOCUSING OF COLLECTOR:

- ① Concentrating solar collector is a device to collect solar energy with high intensity of solar radiation on the absorbing surface by the help of reflector or refractor



Principle:-

- ① Concentrating solar collector uses reflective surface to concentrate sunlight to a small area, where it absorbed and converted to heat.

Working of Concentrating Solar Collector:-

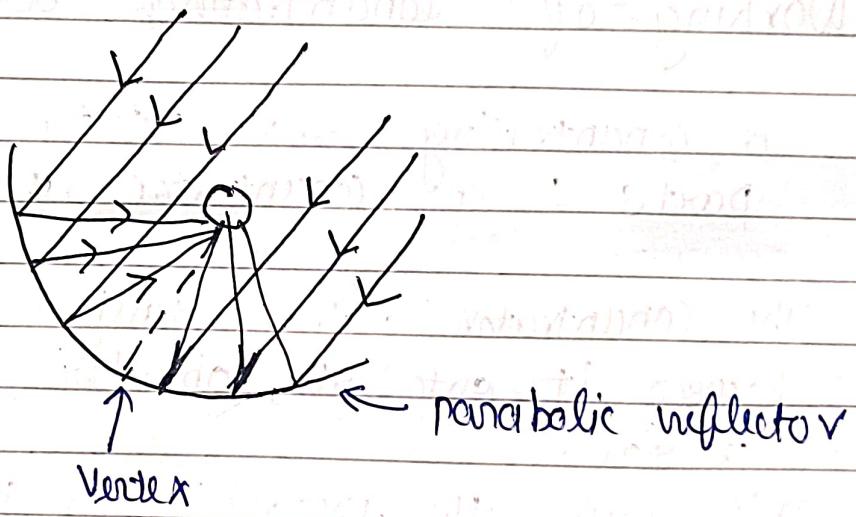
- ① A concentrating solar collector consist of two main parts : a concentrator and an absorber.
- ② The concentrator gathers sunlight from a large area and focuses it onto the absorber which is much smaller in size.
- ③ This way, the energy from the sun is concentrated on a smaller surface.
- ④ By concentrating the sunlight, the system can heat a fluid to very high temp, up to 500°C or more.
- ⑤ These collector are very efficient because they loss less energy compared to non-concentrating collector.

~~Direct energy & heat reduction~~

Types of Concentrating collector ! -

1] Parabolic Trough collector ! -

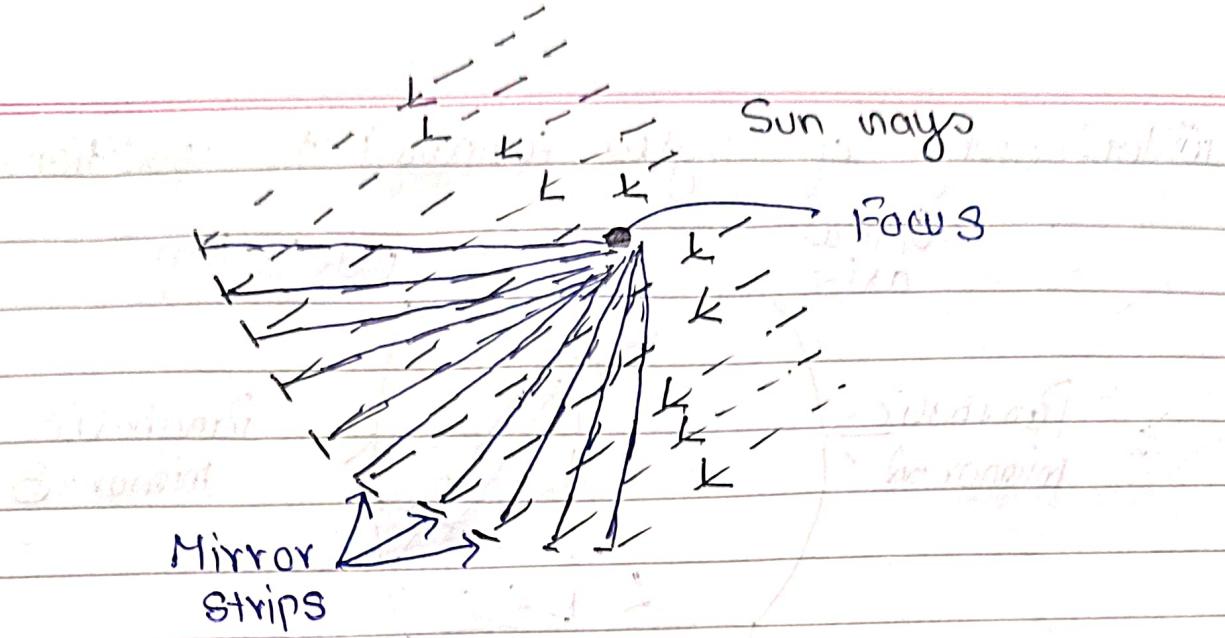
- These collectors use long, curved mirrors shaped like a parabola to focus sunlight onto a receiver tube positioned along the focal line of the trough.
- The receiver absorbs the concentrated heat and transfer it to a fluid running through the tube which is then used to generate steam or power turbines.



2] Mirror Strip reflector ! -

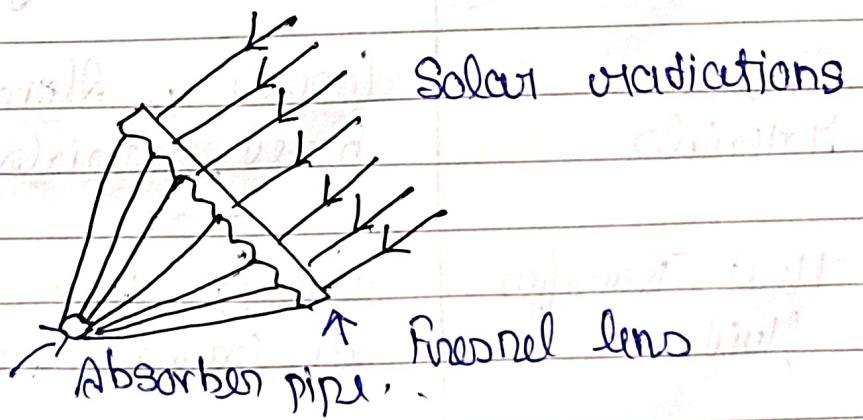
A mirror strip reflector is a type of solar concentrator that uses flat, linear strips of reflective material to focus sunlight onto a receiver.

- The strips are typically arranged in a way that focuses sunlight along a line, rather than on a single point, as in some other concentrating solar collector.



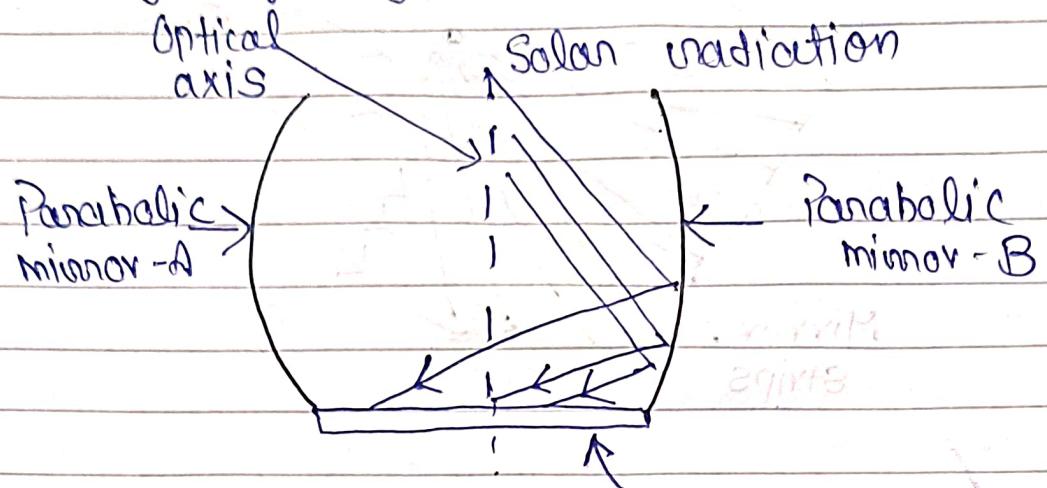
3] Fresnel lens collector! - A Fresnel lens collector is a type of concentrating solar collector that uses a Fresnel lens to focus sunlight onto a receiver.

→ The Fresnel lens is a flat, lightweight lens with a series of concentric, grooved sections designed to bend and focus light more efficiently than a conventional lens.



4] Compound parabolic concentrator! - It is a type of solar concentrator that uses a parabolic shape to collect and focus sunlight, but with a design that allows it to capture sunlight from a

wider range of angles compared to traditional concentrator



- Flat receiver (absorber)

Material used for concentrating collector :-

Component

Material

① Reflective Surfaces

Aluminium, Silver, Gold, Stainless Steel
Glass or Acrylic

② Absorber Materials

Copper, Aluminium, Steel, Carbon
based Materials, Selective Coatings

③ Heat Transfer fluids

Water, Oil, Molten Salts, Air
or Gases

④ Structural Materials

Concrete, Steel, Aluminium Alloys

⑤ Thermal Storage materials

Molten Salt, Concrete, Water

Application of Concentrating Collector :-

- ① They are used for which need high amount of heat such as power generation.
- ② They are used in Solar power plant.
- ③ They used to collect large solar energy which is used to convert water into steam.

Advantage of Concentrating Collector :-

- ① Higher Efficiency
- ② Less material use
- ③ Cost-Effectiveness for Large-Scale Application.
- ④ Use of High-Efficiency Cells
- ⑤ Reduced Land Area

Disadvantage of Concentrating Collector :-

- ① High Initial cost
- ② Requires Direct Sunlight
- ③ Environmental Impact

Performance Analysis :-

→ Concentration Ratio (C) :- It is defined as the ratio of the effective aperture ratio to the absorber tube area.

$$C = \frac{\text{Effective aperture ratio}}{\text{Absorber tube area}}$$

→ Interrupt Factor (γ)! - It is defined as the ratio of radiation interrupted by absorber tube to the total reflected radiation.

$$\gamma = \frac{\text{Radiation interrupted by absorber tube}}{\text{Total reflected radiation}}$$

→ Collector Efficiency Factor (F_c)! - Collector efficiency factor is given by the relation!

$$F_c = \frac{1}{U_1 \left[\frac{1}{U_1} + \frac{D_o}{D_i h_f} \right]}$$

→ Instantaneous Collector Efficiency (η_i)! Instantaneous collector efficiency is given by the relation

$$\eta_i = \frac{q_u}{(I_{brb} + I_{DF})WL}$$

q_u = useful heat gain

I_{brb} = Beam radiation normally incident on aperture

I_{DF} = Diffuse radiation

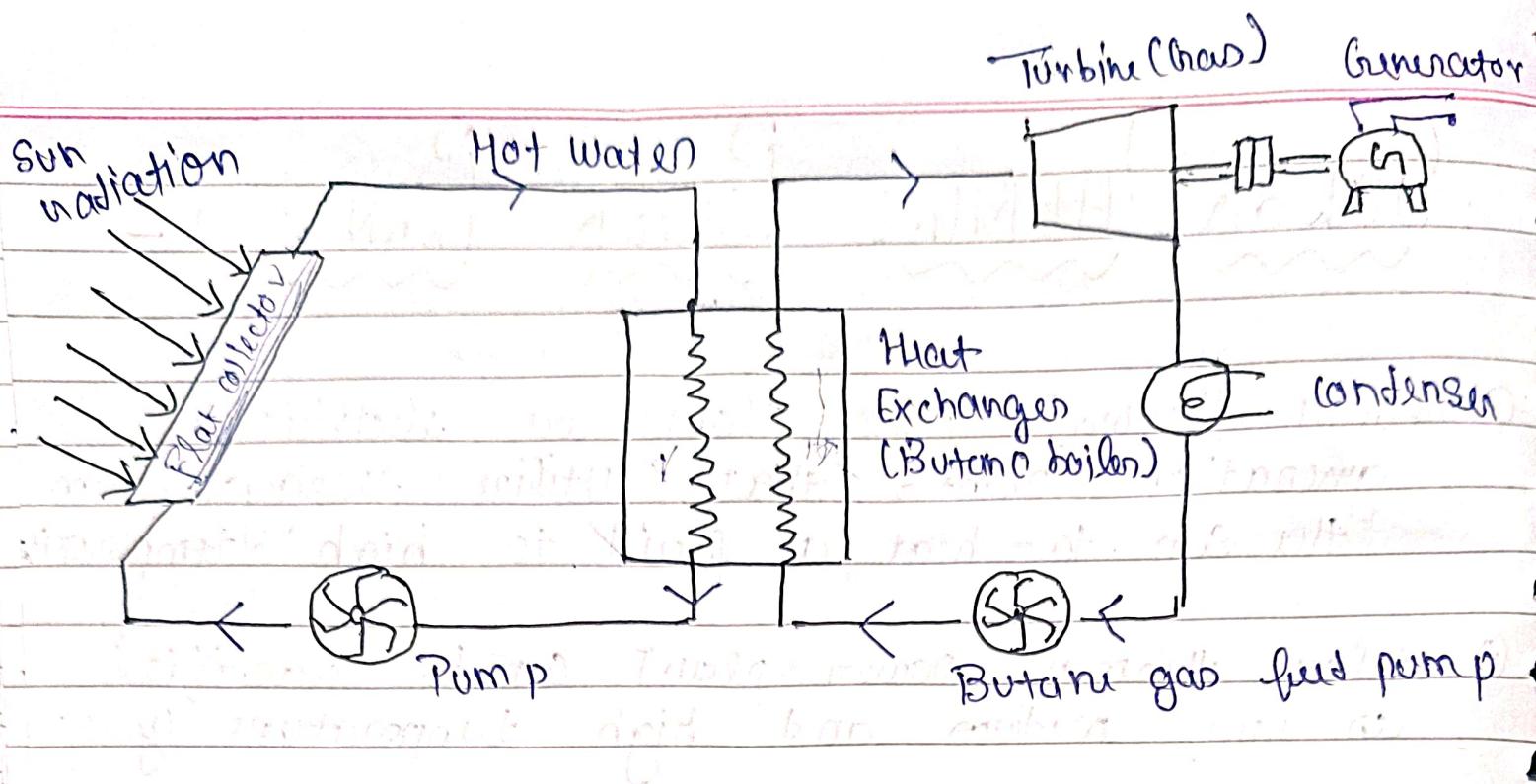
L = length of concentrator

SOLAR THERMAL POWER PLANTS :-

- ① Solar thermal power plants are electricity generation plants that utilize energy from the sun to heat a fluid to high temperature.
- ② Solar thermal power plant can be classified as low, medium and high temperature cycle.
- ③ Low temperature cycle operate at about 300°C
- ④ Medium temperature cycle operate at about 400°C
- ⑤ High temperature cycle operate at above 500°C

Low Temperature Solar Power Plant :-

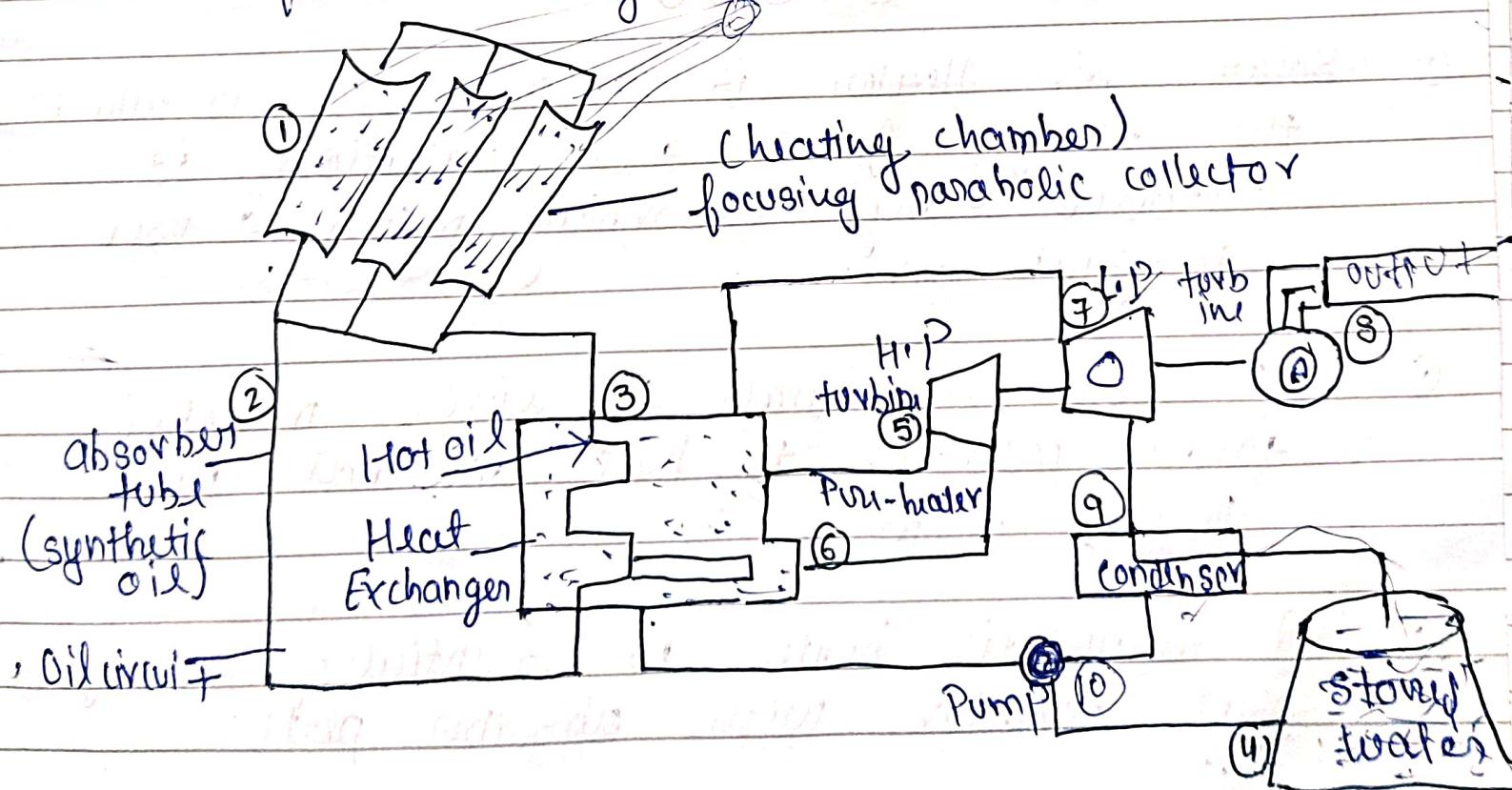
- ① A low temperature solar power plant uses flat-plate collector array.
- ② These collectors used a dark, heat-absorbing plate covered with transparent glass to trap sunlight.
- ③ As sunlight hits the plate, it heats the fluid running through tubes attached to the plate.
- ④ This heated fluid can be used to generate electricity.



- ① A flat-plate solar collector captures energy from sunlight.
- ② This collected energy is converted into heat.
- ③ The heat water that flows through pipe in the solar collector.
- ④ The heated water flows to a heat exchanger which is also called the "butane boiler".
- ⑤ In the heat exchanger, the hot water transfers its heat to butane, a gas that heats up and turns into high pressure gas.
- ⑥ The high pressure butane gas flows into a turbine causing it to rotate.
- ⑦ The rotating turbine creates mechanical power, which drives a generator to produce electricity.
- ⑧ After passing through the turbine, the butane gas loses pressure, that gas move to condenser than move to Butane boiler with the help of pump.

2] Medium temperature Solar Power Plant

- ① Medium temperature collector used
concentrators to reach temperature between 100°C to 400°C .
- ② So, array is used concentrated parabolic trough type, collects solar radiations.
- ③ Heat carried to storage tank.
- ④ Further in the steam generator.
- ⑤ Steam goes to drive steam-turbine.
- ⑥ Mechanical energy of turbine drives the generator.
- ⑦ It convert it into electrical energy.
- ⑧ Exhaust steam comes to condenser where it is condensed by cold water from cooling tower and pumped.



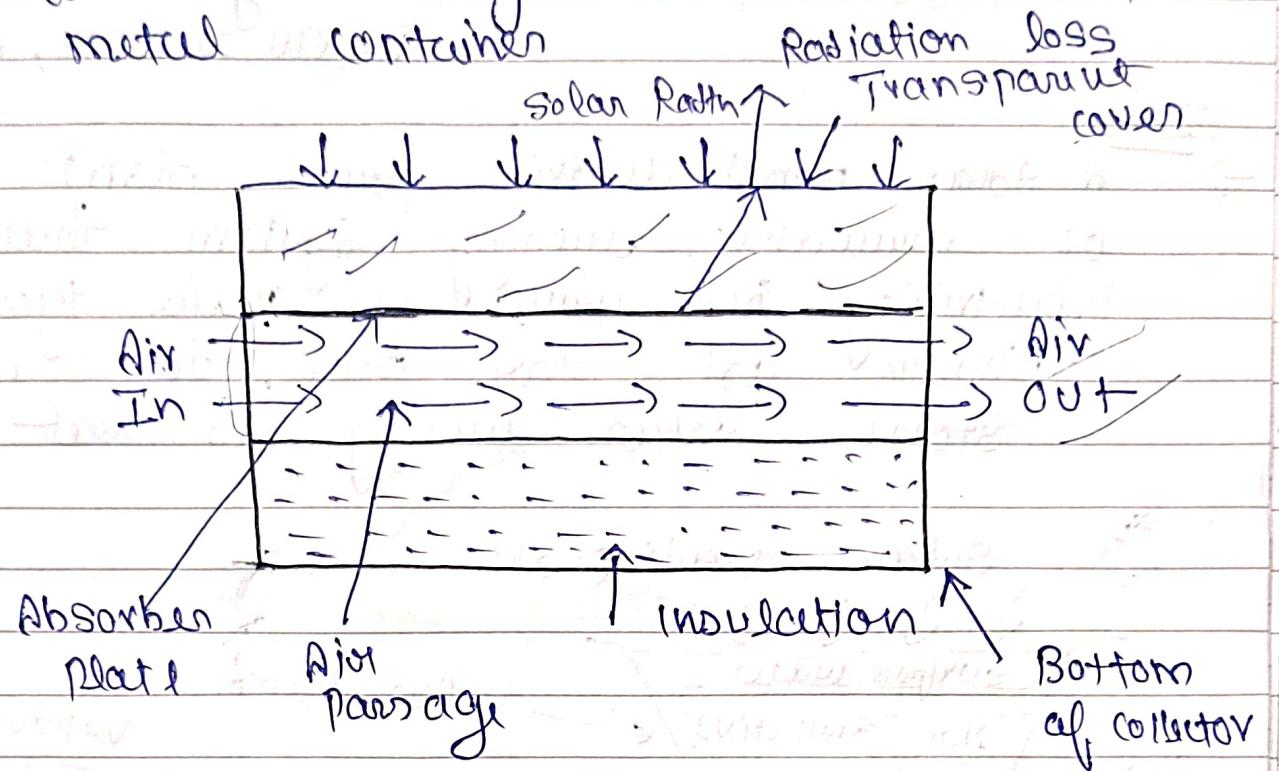
3] High pressure solar power plant

- ① In high temperature solar thermal power plant we can obtain temperature up to 1500°C .
- ② In this type of solar thermal power plant we use parabolic dish type collector or central receiver.
- ③ By parabolic dish very high intensity solar arrays incident on common point.
- ④ that's why fluid get heated and it convert water in to steam moves the prime mover.

Solar Air Heaters

- ① Solar Air Heater is a technology in which the energy from solar radiation is captured by absorbing medium & used to heat air.
- ② It use roof, wall or window mounted solar collector to heat air that passes through them.
- ③ A solar air heater is essentially a flat plate collector with absorber plate

- ① It is a transparent cover system at top & insulation at the bottom.
- ② The whole assembly is enclosed in a sheet metal container.

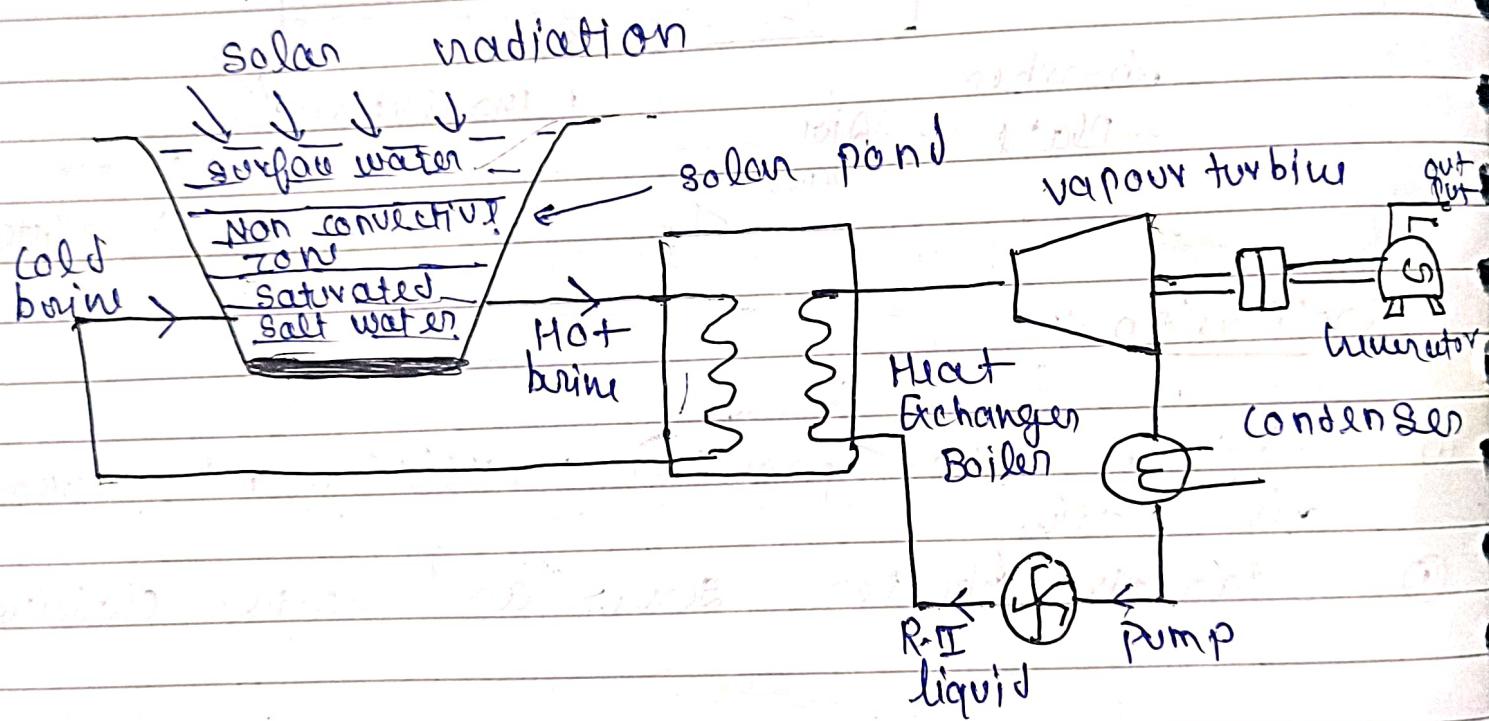


Application :-

- ① Solar air heater provides ventilation and process air heating.
- ② Solar air heater serves as weather cladding.

Q With the help of diagram explain the working of solar pond based electric power plant with diagram ?
 I AKTU 2023-24, AKTU 2022-2023

→ Sol A solar pond electric power plant is a type of renewable energy system that generates electricity by using a special type of pond, known as solar pond, to collect and store solar energy as heat.



- ① A solar pond has layers of water with increasing salt concentration toward the bottom
- ② Sunlight heat the bottom layer, where the salinity traps and stored the heat
- ③ The heat from the bottom is transferred to a working fluid via a heat exchanger

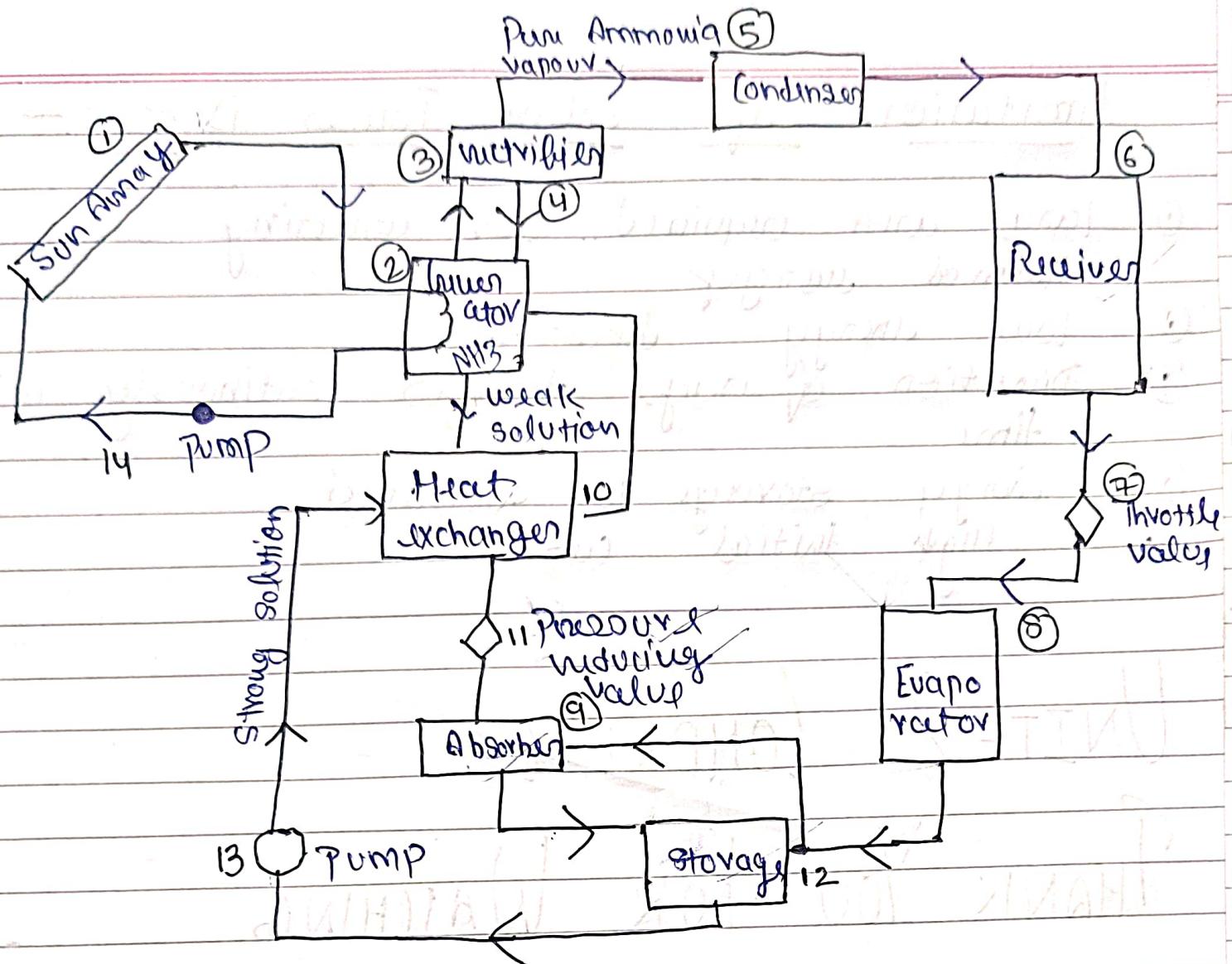
- ① The heated working fluid vaporized, creating high-pressure gas that drives a turbines
- ② The turbine powers a generator to produce electricity
- ③ The gas cools, condenses, and is cycled back to the heat exchanger.

Thermal Energy Storage for Cooling:-

- (a) Solar Power Refrigeration System
- ① Solar energy can be used for cooling the buildings and preserving food by refrigeration
 - ② The cycle used for cooling with utilization of solar energy is vapour absorption cycle
- => Working :-
- ① The basic function of solar collector is to collect more rays from sun and then converted to heat energy
 - ② The function of generator is to collect

heat energy from solar collector through pump and boil aqueous ammonia solution to convert it in vapour form

- ① The main function of rectifier is to separate water and ammonia vapour.
- ② The main function of condenser is to change the phase of vapour refrigerant means convert it vapour to liquid.
- ③ The receiver collect liquid refrigerant.
- ④ The throttle valve helps in cooling effect.
- ⑤ The basic function of evaporator is to produce cooling effect by absorbing the space heat.
- ⑥ The main function of absorber is to absorb weak and strong solution.
- ⑦ The function of pump is to help in the circulation of solution.



B) Solar Air Conditioning System

- A solar air conditioning system is simply a system of cooling and heating that utilises solar power, rather than electricity.
- This can be done through passive solar, solar thermal energy conversion and photovoltaic conversion.
- It is eco friendly as well as energy efficient.

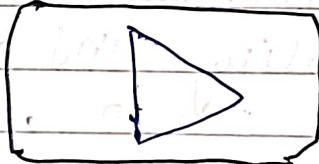
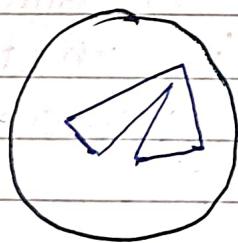
Limitation of Solar Power Plants

- ① Large area required for collecting solar thermal energy
- ② Low energy density
- ③ Direction of rays changes continuously with time
- ④ Energy storage is essential
- ⑤ High initial cost

UNIT-2 COMPLETE

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