CONCENTRATING SOLAR COLLECTOR

NIMISHA LONEES K
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CONCENTRATING COLLECTOR

- A solar collector that uses ***reflective surfaces*** to concentrate sunlight onto a small area, where it is absorbed and converted to heat or, in the case of ***solar photovoltaic (PV) devices,*** into electricity.

- Concentrators can increase the power flux of sunlight hundreds of times.

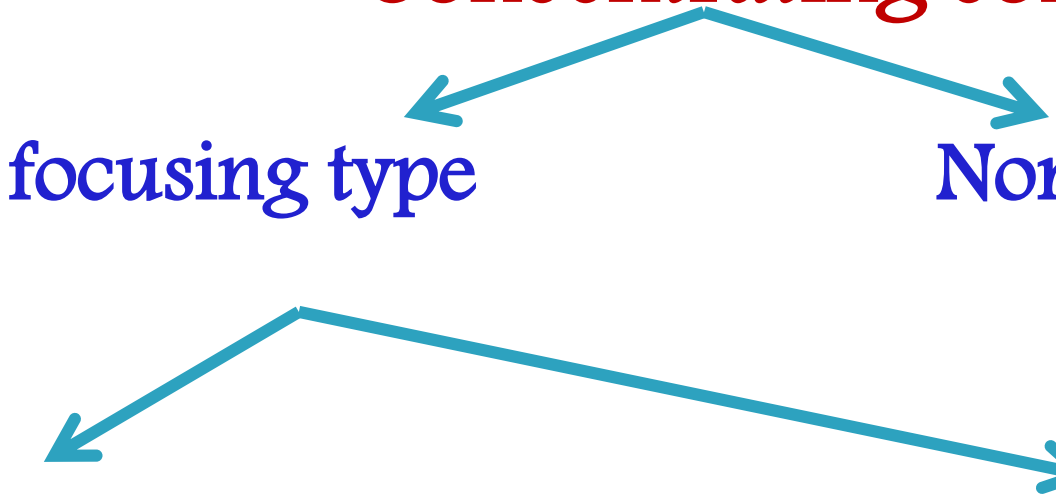
- The principal types of concentrating collectors include: **compound parabolic, parabolic trough, fixed reflector moving receiver, fixed receiver moving reflector, Fresnel lens, and central receiver.**

- A PV concentrating module uses ***optical elements*** (Fresnel lens) to increase the amount of sunlight incident onto a PV cell.

- Concentrating PV modules/arrays track the sun and use concentrating devices to reflect direct sunlight onto the solar cell to produce electricity directly.

- Concentrating solar collectors in ***Concentrated Solar Power (CSP)*** facilities concentrate sunlight onto a receiver where it heats a heat transfer fluid that subsequently exchanges its absorbed heat to water to produce steam to power a steam turbine-generator (STG) to produce electricity.

Concentrating collectors



1.Parabolic trough collector

2.Mirror strip reflector

3.Fresnal lens collector

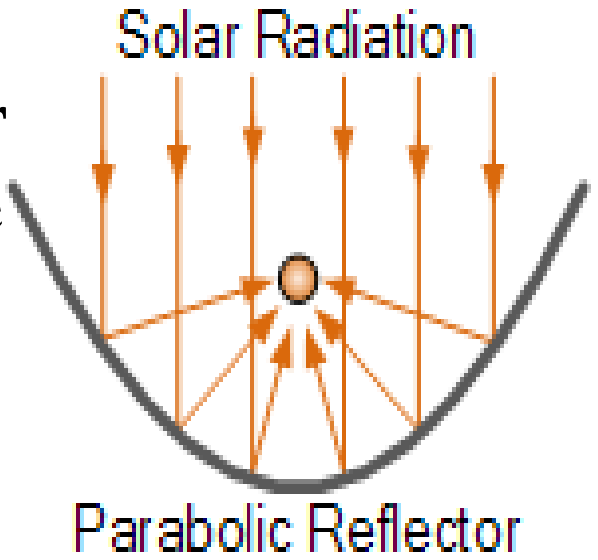
4.Flat plate collector with adjustable mirrors

5.compound parabolic concentrator

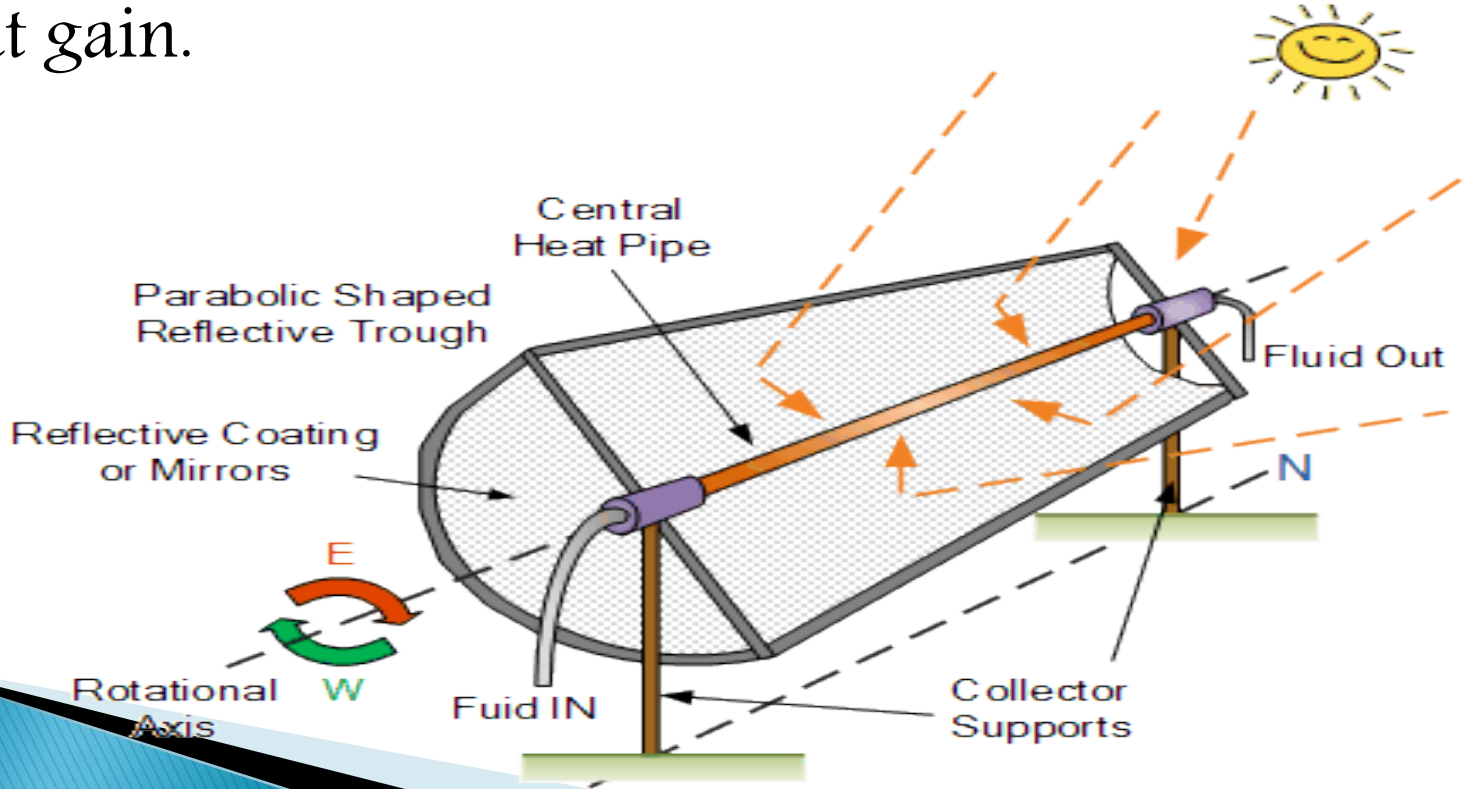
PARABOLIC TROUGH COLLECTOR

- The parabolic trough reflector is a solar thermal energy collector designed to capture the sun's direct solar radiation over a large surface area and focus, or more generally "concentrate it" onto a small focal point area increasing the solar energy received by more than a factor of two which means more overall heat per square meter of trough.
- Concentrating solar collectors for residential applications are usually a "U-shaped" parabolic trough that concentrates the sun's energy on an absorber heat tube called a receiver that is positioned along the focal point axis of the reflective trough.

- **Parabolic Trough Reflectors** or **PTR**, are made by simply bending a sheet of reflective or highly polished material into a parabolic shape called a parabola. Since solar light waves essentially travel parallel to each other, this type of solar collector can be pointed directly into the sun and still achieve a total focal output from all parts of the trough shaped reflector as shown.
- parabolic trough reflectors use only direct solar radiation to heat the receiver tube as diffused solar radiation cannot be focused onto the absorber making them less effective when the skies are cloudy or the sun is out of alignment.



- most concentrating collectors require some form of mechanical equipment that constantly orients the collectors towards the sun keeping the heat pipe absorber at the correct focal point. This is achieved by using a Tracking Solar Concentrator that aligns the trough with the sun throughout the day, maximising the solar heat gain.

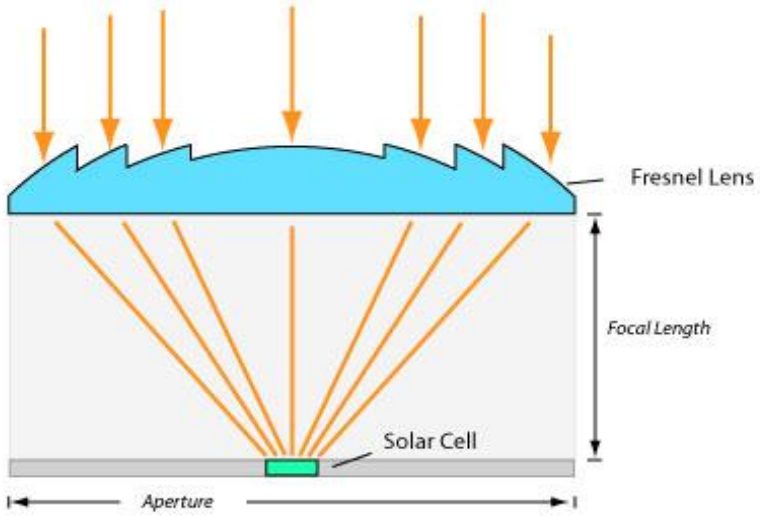


MIRROR STRIP REFLECTOR

- A number of plain or slightly curved(concave),mirror strips are mounted on a flat base
- The angles of the individual mirrors are such that they reflect solar radiation from a specific direction to the same focal line.

FRESNEL LENS COLLECTOR

- It utilizes the focusing effect of a Fresnel lens
- To be fully effective the Fresnel lens must be continuously aligned with the sun in two direction, both along and perpendicular to its length
- This is achieved by orienting the troughs in the north south direction.
- The solar radiation is focused in to the absorber from the top



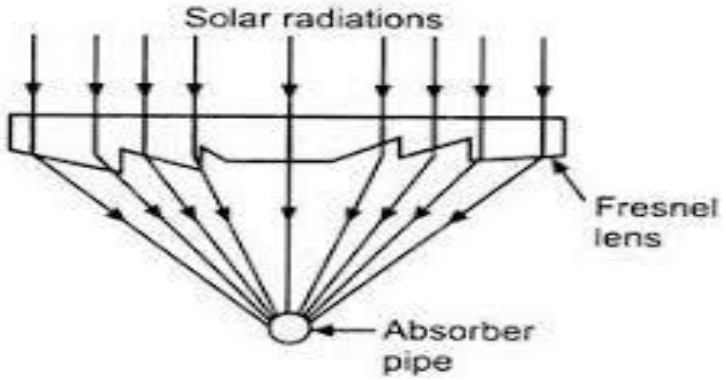


Fig. 3.7. Fresnel lens collector.

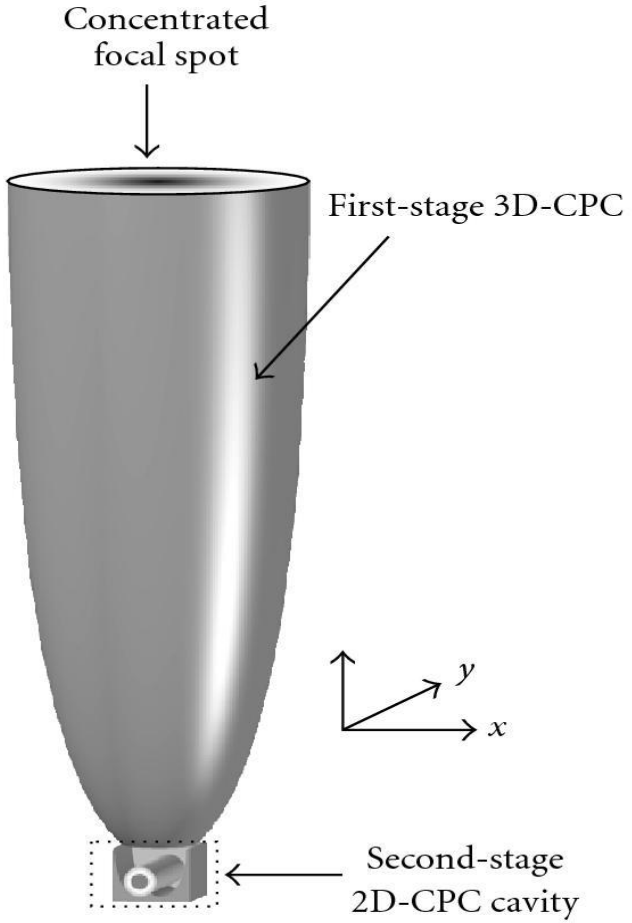
- The rounded triangular trough serves only as a container and plays no role in concentrating the solar energy
- *Receiver pipe*: the receiver pipe of a parabolic line focusing collector has the same general characteristic as a flat plate collector

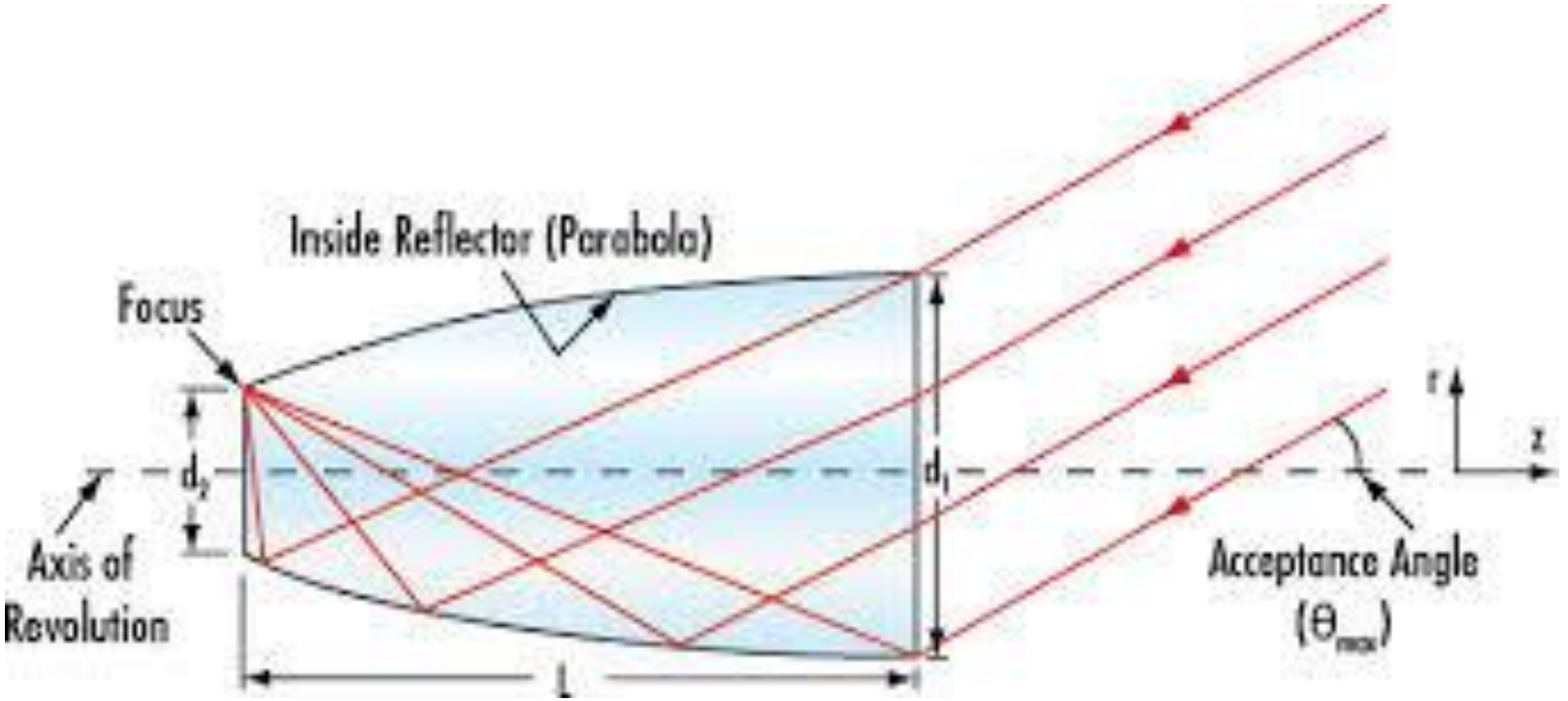
Linear Fresnel Lens Collector

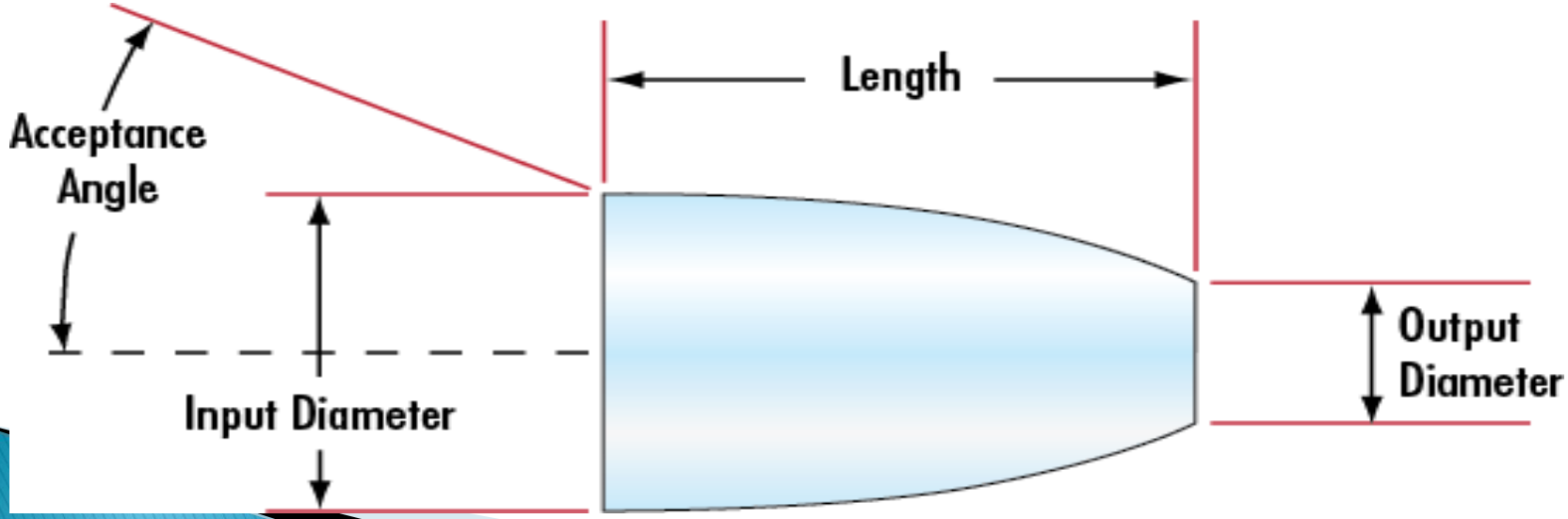
COMPOUND PARABOLIC CONCENTRATORS

Compound Parabolic Concentrators (CPCs) are designed to efficiently collect and concentrate distant light sources, with some acceptance angle.

Compound Parabolic Concentrators are critical components in solar energy collection, wireless communication, biomedical and defence research, or for any applications requiring condensing of a divergent light source.

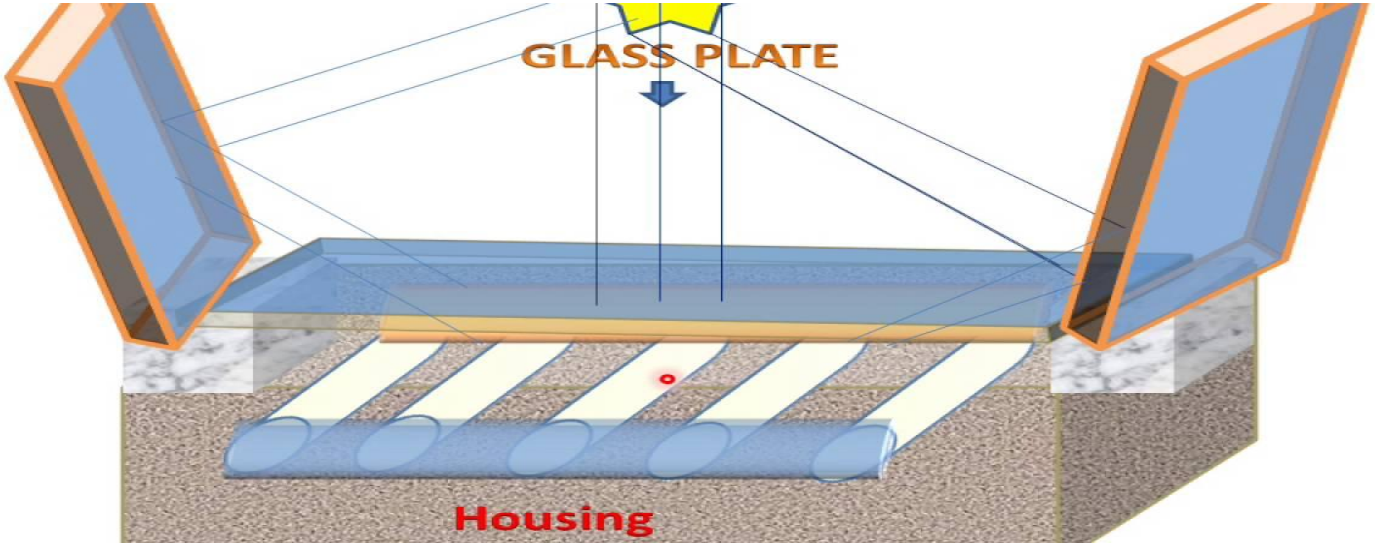



Inside Reflector (Parabola)
Focus
Axis of Revolution
Acceptance Angle
(θ_{max})
d_2
d_1
L
r
z


Acceptance Angle
Length
Input Diameter
Output Diameter

Flat plate collector with adjustable mirrors

- Flat mirrors are frequently used to increase the heat output from flat-plate collectors.
- They are generally oriented in an east-west direction and are mounted below and/or above the collector panels.
- The annual performance of a mirror-boosted system can be improved by allowing periodic adjustments of the mirrors alone or of the panel-mirror units.



- In order to Seasonal adjustments of the mirrors suffice to maintain acceptable values of the concentration and there is relatively little advantage in providing for collector panel adjustments..
- A double-mirror system (adjustable trough) provides higher concentrations than a single-mirror system for equal mirror area. Adjustable trough configurations with zero acceptance angle provide higher annual average concentration ratios than those with non-zero acceptance angles.

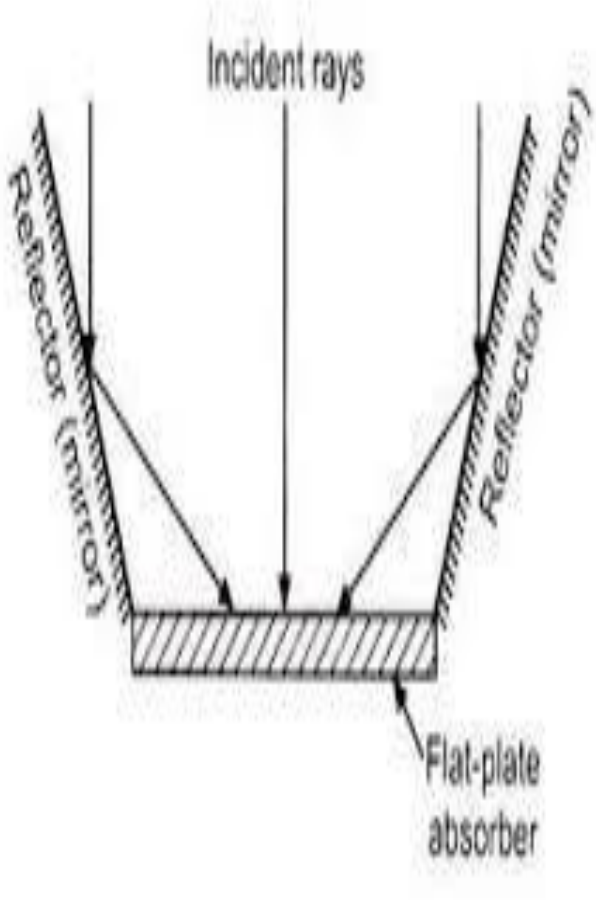


Fig. 3.8. Flat-plate collector absorber with adjustable mirrors.

What are the advantages & disadvantages of concentrating collectors over flat plate collectors?

ADVANTAGES

- 1.Reflecting surfaces require less material in concentrating collectors than in flat plate collectors.
- 2.Absorber area is smaller in concentrating collectors. So insulation intensity is greater in concentrating collectors than flat plate collectors.
- 3.Small area of absorber/unit is there in concentrating collectors than in flat plate collectors.

- 4.Little or no antifreeze is required in concentrating collectors to protect absorber in a concentrator system.
- 5.Because temperature attainable with concentrator collector is high, amount of heat stored is larger in concentrator collector.
- 6.Concentrating collector is used for power generation while flat plate collector is not used for power generation.
- 7.In solar heating & cooling, application high temperature of working fluid is attainable.

DISADVANTAGES

- 1.Non uniform flux on absorber is there in concentrating collectors than in flat plate collectors. While in flat plate collectors uniform flux is there.
- 2.Additional optical losses occur in concentrating collectors than in flat plate collectors.
- 3.High initial cost is there for concentrating collectors. Flat plate collectors are cheaper.
- 4.Additional requirement for maintenance is required in concentrating collectors than in flat plate collectors. While in flat plate collectors, not much maintenance is required.

- 5.Only beam component is collected in concentrating. While in flat plate collectors , both diffused & beam radiations are collected in concentrating collectors.

- 6.It is necessary to have an absorber to track sun image in concentrating collectors.