Design and Fabrication of Solar Water Heater using Fresnel Lens

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***Abstract*— Global climate change has resulted to hunt for non-conventional energy sources in place of conventional fossil fuel-based energy sources. We are using Fresnel lens as a concentrator because it gives very high concentration on focal point. Fresnel lens is an optical device which concentrates the incoming light onto a spot or onto a line. This means that the temperature at that point will be significantly high. Utilizing this temperature for solar thermal applications will definitely be helpful for solar thermal power plants as the water can directly be converted into steam. This report discusses about the various applications of Fresnel lens and how advantageous it can be to be utilized in solar thermal applications.**

Keywords—Fresnel Lens, Copper tube Spiral Collector

I. FRESNEL LENS

Fresnel lens is a component which focuses light onto a single point or a line. There are basically two types of Fresnel lenses. One is the Spot Fresnel lens and the other is the Linear Fresnel lens. The spot Fresnel lens focuses the light onto a spot on the object and the linear Fresnel lens focuses light onto an entire line on the object. The lens consists of concentric groves in spot Fresnel lens and parallel groves in linear Fresnel lens [2].

The groves are the main part of the lens. It focuses light according to its design based on concentric or parallel nature of the groves. Concentric groves focus light onto a single point and parallel lens focuses onto a line. Major development in the field of Fresnel lens PV concentrator systems are being made due to the fact that radiation on the cell increases with increase in temperature. Dual axis tracking, point focus Fresnel lens is used for concentrating the radiation on to the center.

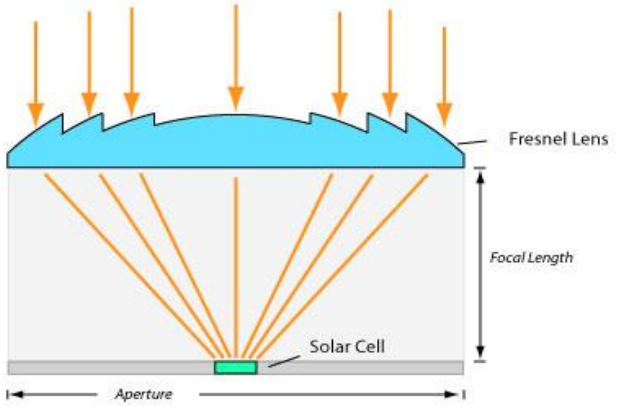


Figure 1: Fresnel lens [1]

II. EASE OF USE

A. Spot Fresnel lens.

The working principle of a lens is based on the law of refraction according to which a light ray travels in a straight path in a homogeneous transparent medium, but when it passes through the interface of a transparent medium having different density; it gets deviated from its original path at the interface. When light enters from rarer medium to a denser medium, it bends towards the normal, but when light enters from denser medium to rarer medium, it bends away from the normal, this phenomenon is due to change in velocity of light in a different medium as the resistance offered by medium also changes.

Figure 2: Spot Fresnel lens

Spot Fresnel concentrates the sunlight into one circular spot and as a result we get an increased temperature at the spot. Since all the radiations and light is focused on one spot. Fresnel lens is a modified form of a conventional lens, in which the contour profile of the conventional lens is maintained and undesired material removed, thus absorption losses and material requirement reduced substantially.

II. SPIRAL COPPER TUBE COLLECTOR

Selecting a spiral copper tube as a collector due to reduction in size then normal straight copper tube collector. As copper has the good conductivity and malleability it can be easily wound in the spiral tubes.

The copper tubes are supported with the help of parabolic dish. It helps to keep the tubes locked in a single place so that its movement is restricted.

The dimension of spiral collector are as follows:

Diameter of Copper tube = 19.65mm.

No. of turns = 18 nos.

Length of Copper tube = 32.32m.

Spacing between two tubes = less than 1 mm.

Figure 2: Copper tube collector with parabolic dish

III. COLLECTOR TRACKING MECHANISM

The sun changes the declination angle at 0.4 Deg. every day and moves and rate of 5cm approx.per 10 min after during the duration of operation. The Collector movement mechanism is made of steel square channel and slotted for the movement of the collector. The length of this channel is kept 1500mm so that it can facilitate the movement of sun throughout the year. One end is pivoted to the centre of frame and other end is supported with the help of castor wheel.

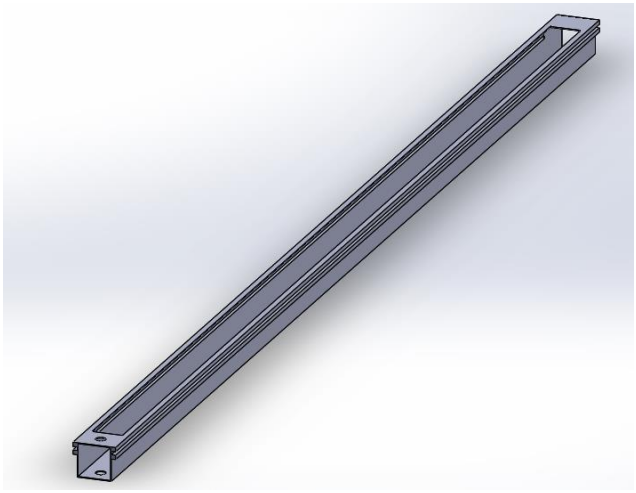


Figure 3: Collector movement mechanism

IV. SUPPORT FRAME

The support frame is one of the major component as it holds the Fresnel lens at a specific height from the ground as per requirement. Also, it helps Fresnel lens to be stable and sturdy so that it does not get disturbed due to movement of wind. The collector movement mechanism is also pivoted to the base of the support so that it becomes one complete setup. Instead of individual components.

V. METHODOLOGY

Cold water enters at one end of flat spiral copper tube flowing at a constant flow rate. The solar rays coming from sun are parallel to each other when they pass through lighter medium air to denser medium Fresnel lens. They tend to change the path due to draft in the Fresnel lens. The draft angle decides whether the rays while be focused in dense spot or wide spot. It is determined by F-number. The sun rays after passing through Fresnel lens tend to move in an inclined path and meet together in a Focal point.

The copper tube act as absorber and is placed at the location of spot of Fresnel lens. The collector tracking mechanism tracks keep the collector and copper tube at proper position so that the spot is always son the tubes. Copper tubes absorbs the heat from the spot and heat transfer by the mode of convection occur between copper tube and water. The water ultimately absorbs the heat from copper tube which is supplied due to the spot of Fresnel lens. The water after absorbing heat moves out of the spiral tube and the water is recirculated again until the desired temperature is obtained.

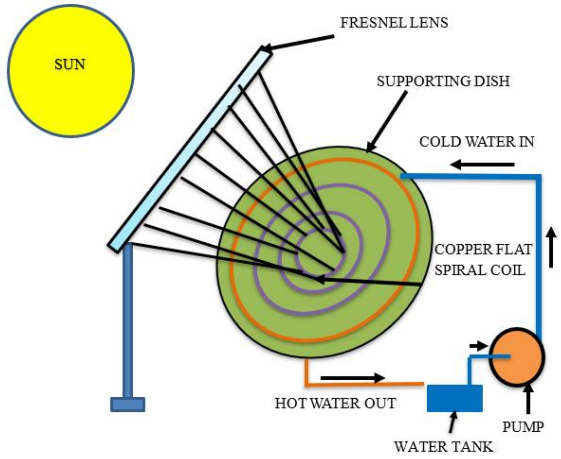


Figure 4: schematic diagram of the setup.

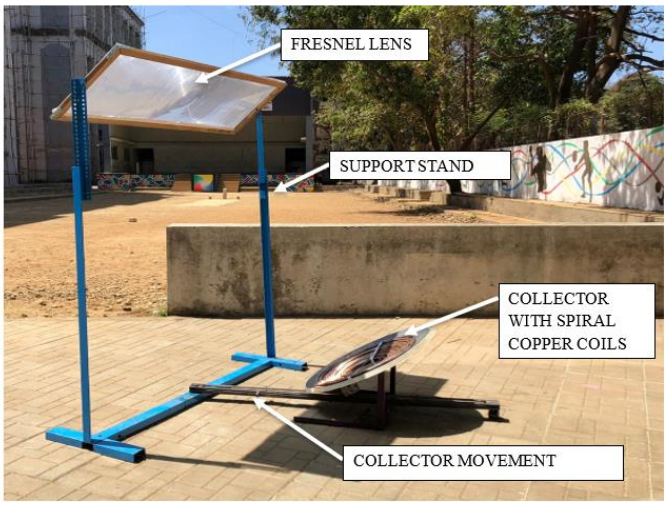
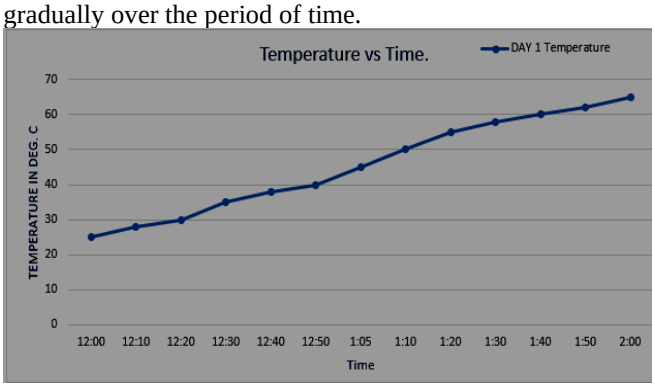


Figure 5: Experimental setup

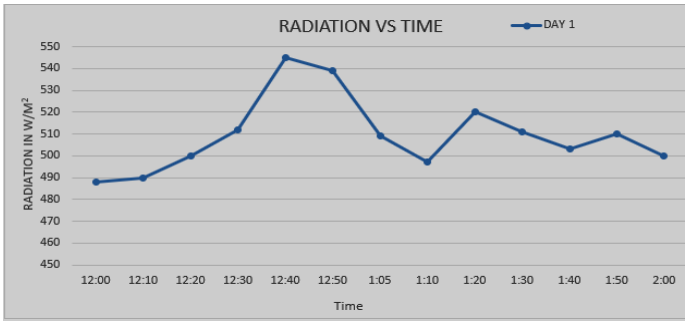
VI. RESULT AND DISCUSSION

It was observed as that as the spot intensity varies as per time of the day. The experiment was performed between 12:00pm to 2:00pm. The temperature of water increases gradually over the period of time.



Graph 1: Temperature vs. Time

In the above graph the temperature was taken in digital thermometer ranging from 0º to 125°C. It can be seen that at 12:00 pm the temperature of water is 25°C but when this water is been repeatedly circulated in the setup its temperature starts to rise at very slow rate.



Graph 2: Radiation vs Time

As we can see in the above the intensity of solar radiation vs time. The radiation was measured using solar power meter in W/m^2 unit. As the sun progresses throughout the day the solar radiation varies first till 12:40 pm it increased till 545 W/m^2, then it starts to reduce as the time progresses and varies everyday due to changing earth's declination angle.

As per above graph's and results obtained this water heater can be made to heat water for domestic purpose only and the heated water can be stored in an insulated tank so that the it can be used later when the sunshine is not present. This setup can also be automated so that the human effort required to position the collector can be eliminated. Automation will be the future scope and improvement to be done and using different type of Fresnel lens.

VII. REFERENCE

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