Effective Utilization of Heat Generated Using Solar Parabolic Disc Concentrators for Domestic Purposes

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Abstract— This work deals with the use of Bi- axial Manual Tracking Solar Parabolic Disc Concentrator (SPDC) to generate hot air and use it for residential and industrial applications such as domestic water heating, heating of swimming pools, space heating, water processes for industrial heating and agricultural drying etc. Bi- axial manual Tracking Solar Parabolic Disc Concentrator is fabricated and experiments were conducted by using the above setup. Results were tabulated and analysed. During analysis it is observed that a maximum temperature range of 160° - 180° C is obtained between 12.00-2.30pm. The temperature obtained above is sufficient enough especially for domestic applications mentioned above. This way, this setup can reduce the dependency on electricity for domestic purposes.

Index Terms— Bi- axial Manual Tracking, Domestic purposes, Heat generated, Solar Parabolic Disc Concentrator, Solar energy.

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1 INTRODUCTION

INDIA is largely dependent on fossil fuels for power generation. 61% of power generation takes place from Coal. The extensive use of fossil fuels has threatened the sustainability of ecosystem. Also fossil fuel resources are depleting fast and it is found that they will exhaust within 30-50 years [1]. India has a huge potential for renewable energy sources like Solar Energy, Wind Energy etc. But only 10% of total power generation is harnessed using renewable energy sources. India's power need is very high as its population is second highest in the world. Demand of power is more than supply in India. Therefore, there is a necessity to reduce the use of electricity for certain applications.

The solar radiation has peak energy of roughly 1375 watts per square meter which strikes the earth's atmosphere. All of it doesn't reach the earth's surface. It is diminished by absorption and reflection. The clouds principally, reflect 25% back into space [2]. The atmosphere absorbs another 23%. This absorption is selective with ozone strongly absorbing ultraviolet wavelengths, and carbon dioxide and water strongly absorbing infrared wavelengths. This leaves just 52% to hit the earth's surface. Out of this amount 90% is absorbed and 10% is reflected back to space. This power of sun can be harnessed by using different solar energy extracting devices and converting that into desired form of energy for domestic and industrial purposes. Solar concentrating systems are able to serve properly with a temperature range of 80^0-250^0C [4], taking advantage of their sun light focusing characteristic and high thermal and optical performance.

A Bi-axial Manual Tracking Solar Parabolic Disc Concentrator was fabricated and the performance testing is done. The above system can be used when the solar rays are at high intensity, usually between 10 am to 3 pm. The heat generate using this system can be used for domestic applications like water heating, heating of swimming pools, space heating and agricultural drying thus reducing the dependency on electricity for domestic purposes.

2 LITERATURE REVIEW

Many researches have been done on solar applications and its equipments. Many modifications and innovations are made on these equipments for the efficient performance. In this regard, majority of the researchers have published their work in different media. A review of the literature is very much necessary to carry out further research in this area. Therefore, a review was conducted through some online search, journal papers textbooks etc. to identify and understand the different methods of extraction of solar energy and converting it into heat energy.

By literature review, it was found that Parabolic Concentrators fulfils all the basic requirements which are essential for efficient performance of solar appliances. A comparison between parabolic trough and parabolic dish concentrators [1] shows that dish concentrators are 3-5% more efficient than trough concentrators. For both parabolic trough and parabolic dish concentrators, the proper selection of reflective material for the dish/ trough is very essential.

With respect to the reflective material, studies have been done on different reflective materials like glass, Stainless steel sheet, aluminium foil etc. Upon review, Stainless steel [5] was chosen as the best option which fulfilled all the basic requirements needed for optimum performance. Similarly, review was done on various concepts related to Tracking, Dish area, Receiver shape, mounting, receiver material [3], Heat transfer concepts like convection, conduction and radiation [4]

Based on the above literature review points a fabrication of Bi-axial Manual Tracking Solar Parabolic Disc Concentrator was designed and fabricated. In this, a Parabolic dish of 2m in diameter with stainless steel as reflective material and mild steel/Copper as receiver. A suitable passage for flow air is provided with inlet and outlet openings. Air absorbs the heat while flowing over the receiver which can be used for domestic applications.

3 Design of Solar Parabolic Dish Concentrator

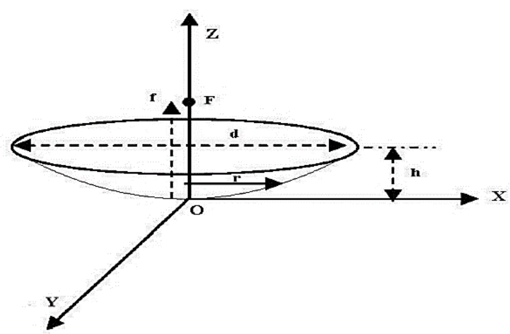

Figure 1: Parabolic dish concentrator parameters

The surface area of parabola can be calculated by using the formula,

$$S= \{[1+(d/4f)^2]^{3/2}-1\}$$

To calculate the focal distance, the following equation is used,

$$f= d^2/16h$$

Where, d= diameter of dish=2m
f=focal length of dish=1.2m
h=height of dish=0.2m

4 System Components

Important system components are mentioned below:

4.1 Frame for dish

The frame is used to support the dish. The material of the frame is Galvanized Iron. It contains a square shaped hollow pipe arrangement upon which a circular plate is welded. There are 12 sections in the frame. The shape of the frame is as shown in figure 2. The shape of the dish is a parabola.

Figure 2: Frame for Dish

4.2 Reflector

28-gauge Stainless Steel sheet is used as reflector material. 12 sheets are cut to the shape of frustum of cone to match the shape of frame as shown in figure 3. The sheets are bolted to the frame. The reflector reflects and concentrates the solar ray's incident on it on to the receiver fixed to the frame. The parabolic shape enables the solar ray's incident on reflector to concentrate at a point on receiver as shown in figure 3.

Figure 3: Stainless steel as reflector material

4.3 Receiver:

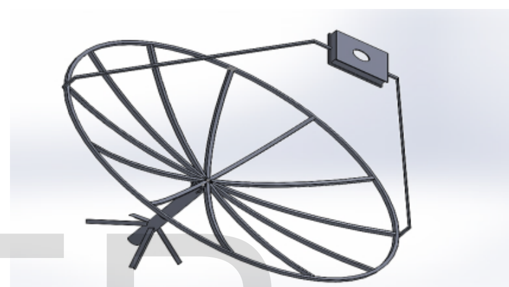

Figure 4: Reveiver

Copper is used as receiver material. It has high thermal conductivity. Its diameter is 0.3m. The receiver is placed at the focal point. The copper plate heats up due to concentrated rays. This is as shown in figure 4.

4.4 Air flow system

Air flow system consists of a closed passage for the flow of air. Air is passed over the receiver during which air gets heated. The speed and area of flow of air must be optimized to get hot air sufficient enough for the respected application.

4.5 Application set up

Hot air generated is used for areca drying. Areca usually takes 60 days for complete drying. By using this process, we can fasten up the drying process.

5 WORKING

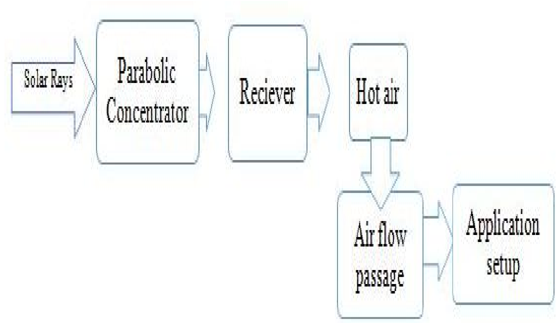

Figure 5: Working of the process

Figure 5 shows the working of the process. The solar ray's incident on parabolic concentrator gets reflected and concentrated on to a receiver. Air is passed over receiver through closed passage. Air takes up the heat by forced or free convection and becomes hot. The hot air is passed to an application setup. After use, an outlet is provided for exit of air. This is as shown in figure 6.

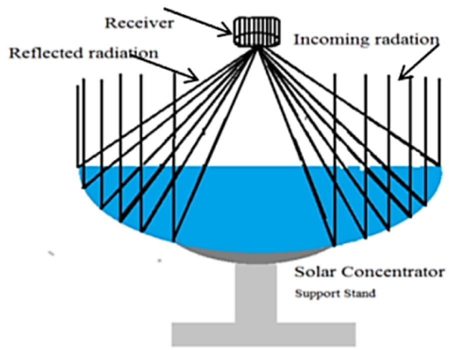

Figure 6: Parabolic Concentrator working

Parabolic dish is tilted to due south direction at an angle of 6^0 with respect to horizontal [4]. The dish can be tilted from east to west and also be rotated with respect to horizontal manually. The stand provided for the dish is strong and balanced enough to hold the dish. Dish has to be tilted 15^0 every hour manually to keep dish plane parallel to sun's plane to achieve required temperature. The operating hours are in the range of 6-8 hours.

6 RESULTS AND DISCUSSION

Experiments were carried out using the fabricated solar disc parabolic concentrator, during the experimentation solar intensity, temperature of hot air and absorber temperature were determined by using probe and infra-red thermometer.

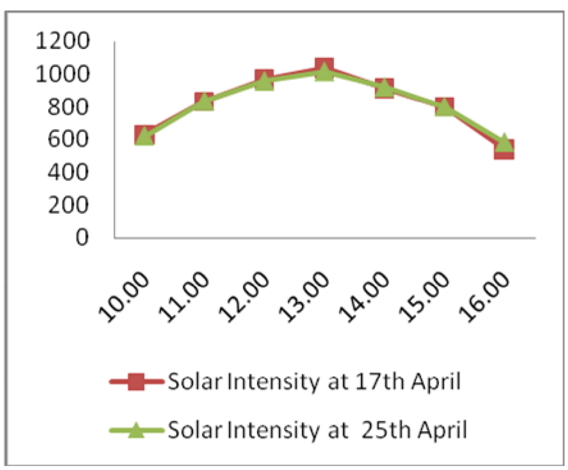

Figure 7: Solar intensity Vs Time

The above Graph shows the change in solar intensity with time. The maximum solar intensity occurred every day around 13.00 hrs. The heat gain was increased depending on time and solar intensity. The solar intensity is approximately constant throughout the day and was varied by the type of the day just as sunny day or rainy day.

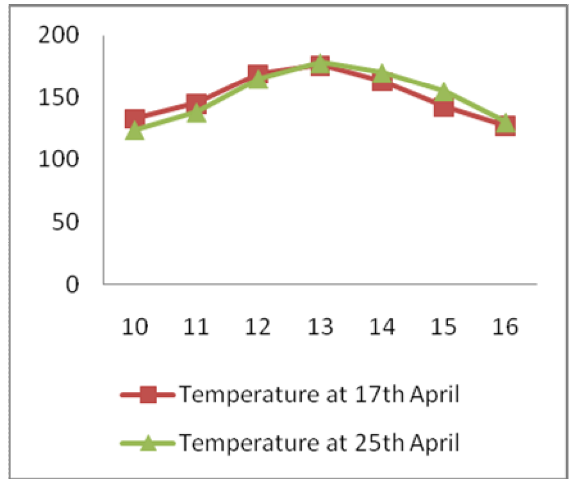

Figure 8: Temperature Vs Time

The above Graph shows the change in hot air temperature with time. The maximum hot air temperature obtained every day around 13.00hr and it is ranging from 160° C to 180 °C. The lowest temperature was observed as 120˚C at 4:15pm on a sunny day. This was the least temperature observed on a sunny day.

7 CONCLUSION

Based on the results and discussions carried out in the previous section the following conclusions can be drawn.

- Parabolic solar dish concentrator shows good performance on heating of air (max temp. 160° C to 180 °C).
- Generation of hot air mainly depends on the solar radiation intensity and total sunshine hour, in this study, maximum productivity and temperature is achieved in time between 12am-2.30pm.
- Parabolic dish concentrator has better system efficiency.
- The heat generation can be increased by changing the flow rate.

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