Low-Cost Concentrating Solar Collector for Steam Generation

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Abstract

Due to ever increasing need of energy and dependence on fossil fuels to meet energy requirements, a lot of efforts are being put on developing new renewable, environment friendly and clean energy resources as an alternative. Concentrating Solar Power (CSP) is one such unique renewable energy technology. CSP systems have the ability to provide electricity, refrigeration, and water purification in one unit. Concentrating Solar Collectors are widely used for harnessing the Sun's energy to create Solar Power. A step in this process is the generation of steam that can be used for sterilization of medical equipment. However, for personal use and small-scale utilization, the cost of such collectors is much beyond the scope of the common man. This is typically due to high costs of currently available solar collectors. In this project, the scope of building an economic solar collector for small-scale application using convex lens as the concentrator is explored. A prototype of the solar collector is fabricated. Steam is generated by focusing sun rays using four convex lens `onto a boiler, which has excellent heat conductivity properties. The water in the boiler get heated by solar energy and gets converted in to steam. This steam was passed into a medical sterilizing box and used to heat medical apparatus. The testing of prototype was done for consecutive days and temperature of 1320C obtained was satisfactory for generation of steam.

Keywords: Boiler, COP, Energy saving, Convex Lens, Solar collector

I. INTRODUCTION

Sun is the primary source of all energy sources. It is one source that can provide continuous good quality energy radiations. The rise of renewable energy usage is primarily because of this reliable source. Solar energy can be used in a variety of forms, directly or indirectly, and for innumerable reasons starting from very basic processes like photosynthesis to complex energy conversions to burning uranium to creating mass destruction bombs. The list goes on and on. Along with the sun, water is one great human necessity. Not only for the body to function but to sustain mankind on planet Earth. The position of the sun and the availability of water make our planet habitable. These two elements are used in an enormous array of combinations to make life easier. Evaporation and condensation are the bases of all these activities. Our project uses the concept of evaporation in a slightly modified manner. The primary aim is to develop the cheapest possible Solar Collector to generate steam with sufficient efficiency for small-scale application. The possibility of replacing the conventional concentrators with convex lens is explored to minimize cost while maintaining efficiency.

II. PROPOSED SYSTEM

There are four convex lenses that are arranged in a circular frame. The frame is so designed that it boasts about moving in both the X and Y axis. There are four convex lenses that can be adjusted to consider a minor alteration in the sun's motion. This setup is sufficient to attain a concentrated band of solar rays that can be focused as per requirements. The next step is to focus it onto a boiler which is made up of mild steel. It consists of two metal sheets of 1.5mm thickness. The edges of the sheets are bended and then joined by using TIG welding because of small thickness of plate. The capacity of the boiler is around 68ml. Water from the

storage tank is passed through the copper tube to the boiler. Inlet and outlet valves are provided before and after boiler. Once water is passed into the boiler, highly focused solar beams heat it until it forms steam. This steam generated is released from a narrow nozzle opening. The steam so generated can be passed through a regulator for applications such as medical instrument sterilization or suitable any other applications. The entire frame along with the convex lenses moves according to the sun's motion by adjusting mechanism. Adjusting mechanism consists 12w synchronous motor, belt, rack and pinion. It is designed such that it rotates 180^0 in 12 hours. The cost of these components is very minimal. Moreover, all the components are locally available and can be instantly assembled when required. Another cost saving aspect is the lack of transportation for movement of individual components. Thus along with cost, much time can also be saved.

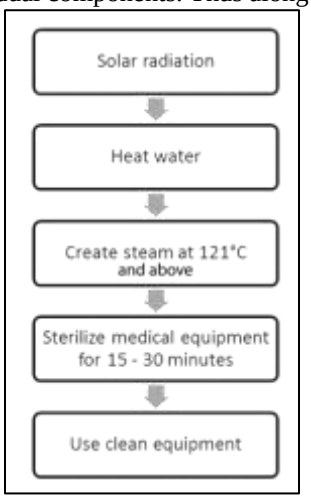

Fig. 1: Functional diagram

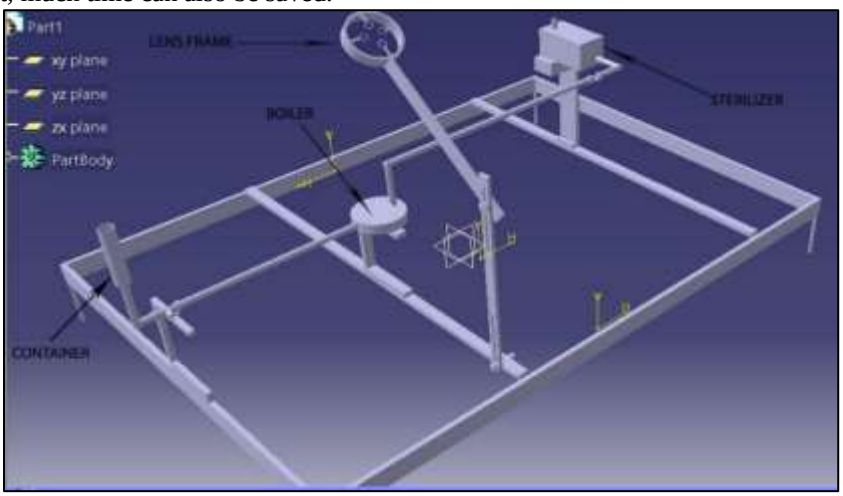

Fig. 2: CAD drawing of proposed project

Fig. 3: Miniature model

III. TECHNICAL SPECIFICATIONS

A. *Convex lens (Circular)*

- Diameter - 65mm
- Focal length - 250mm

B. *Frame (Rectangular)*

- Length - 590mm
- Breadth - 430mm
- Height - 490mm

C. *Copper Pipe*

- Diameter - 6mm
- Total length -762mm

D. *Sterilizing chamber*

- Length - 170mm
- Width - 105mm
- Thickness - 45mm

IV. EXPERIMENT AND RESULTS

The convex lens used in the prototype, of 65mm diameter, concentrates sunlight at a spot that is at a temperature of 180°C. 4 such lenses were used, each giving the same temperature when focused aptly. The spots are concentrated on the boiler that contains water to be converted into steam. The boiler conducts heat evenly, and transfers it to the water that starts boiling when it reaches the temperature of 100°C, after approximately 21 minutes for a volume of around 68 ml satisfying the requirement for medical sterilization. The steam generated is slow because of the absence of a constant pressure source that could be increased using a piston mechanism or syringe push mechanism. If the tube is filled with already-hot water initially, the process of heat generation is faster. The water heats maximum up to 4 pm according to the Indian time that is more than enough for our purpose. The temperature is measured with the help of a digital thermometer and temperature values are plotted in the table

Table 1:

TIME	11.30 AM	12.00 PM	12.30 PM	1.00 PM	1.30 PM	2.00 PM
DAY 1	30	48	68	94	112	124
DAY 2	29	51	69	97	108	132
DAY 3	27	47	64	92	109	128
DAY 4	29	50	66	95	110	130
DAY 5	28	47	68	96	107	127

From the table it is inferred that maximum temperature obtained is 132℃. Based on the temperature readings tabulated for different time at different days are plotted in the graph and the graph is shown. Also we plot the graph of amount of heat generated at different days.

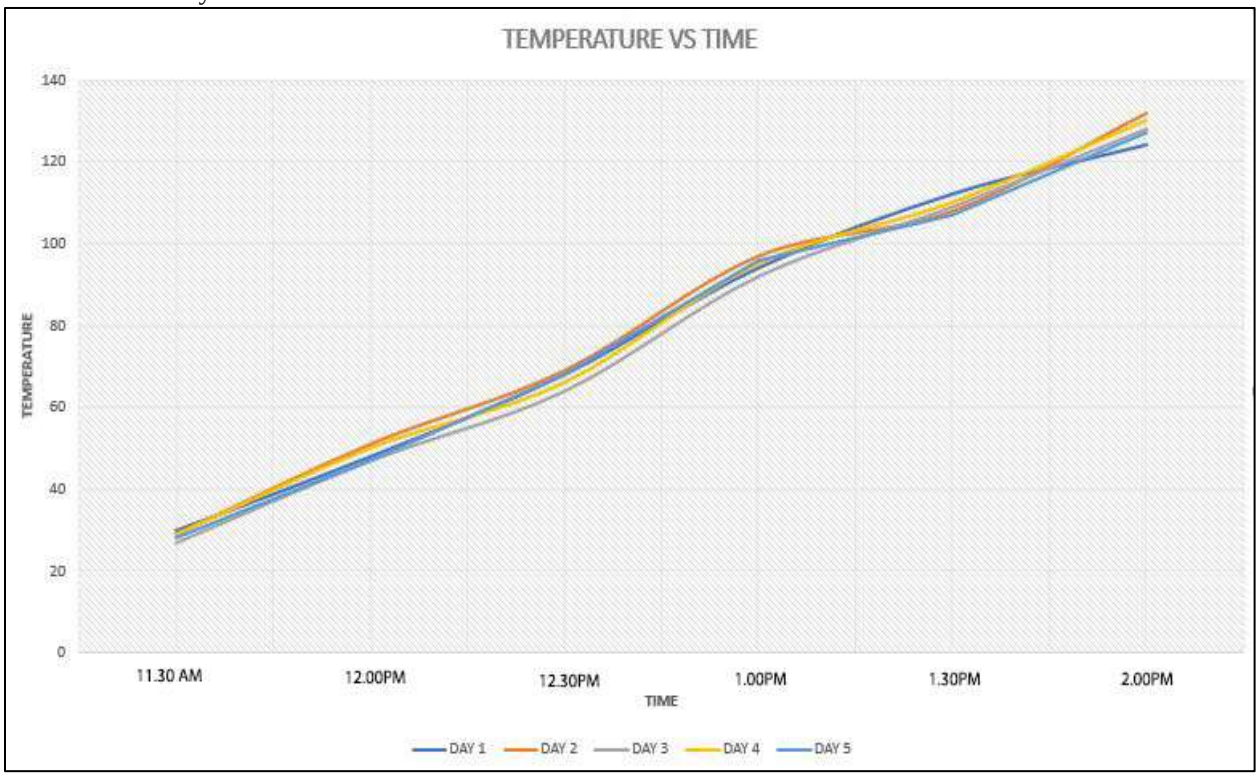

Fig. 4:

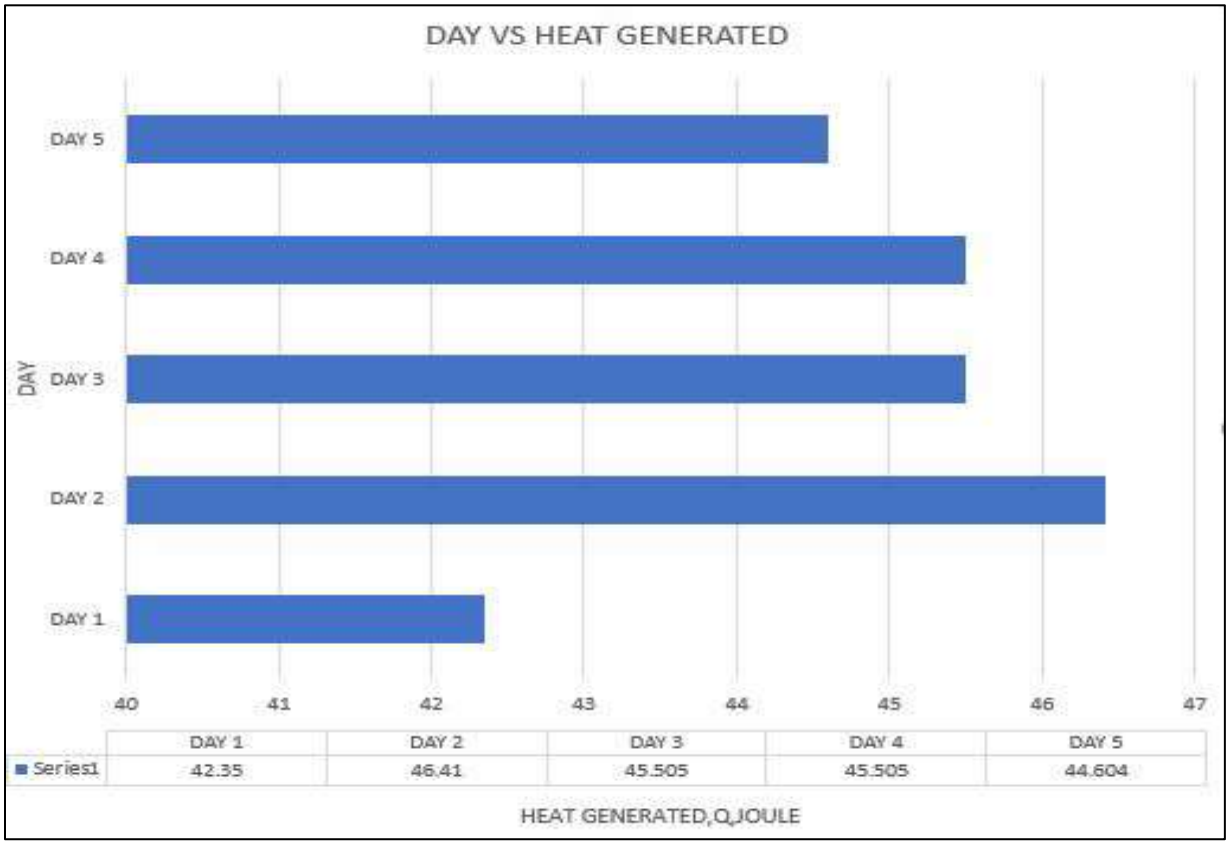

Fig. 5:

V. CONCLUSION

The project shows the potential of convex lens prototype to be used as one of the alternative solution for medical sterilization in future. Convex lenses enjoy considerable advantages for use in a solar concentrating collector as lesser space and cost, and portable. The project's aim was to generate steam at 121°C, a realistic goal that has been achieved.

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