International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Designing and Modeling of Solar Panel with Dish Reflector for Productive Improvement by Optimum Utilisation of Plant Area

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Abstract: ***In this paper, we propose a conceptual design to reduce the solar power plant area by using dish reflector and solar panel arrangement by placing the solar panel at 90° angle. The solar rays get redirected into the box with the help of parabolic dish reflectors which results reduced size requirement for the panel installation. The reflective surface increases both light intensity as well as power generation by the solar panel. Also, the usual factors associated with general installation method like dust or snow formation and bird dropping over the panels that affect the efficiency of solar panels are avoided in this light box concept.***

Keywords : Solar Panel, Solar box, Reflective dish, Panel performance.

I. INTRODUCTION

Solar energy is a clean, environment-friendly and abundant resource available everywhere almost all the year. Indeed, in just one hour, the solar energy intercepted by the earth exceeds the world's energy consumption for the entire year [1]. To utilise this energy completely, it is necessary to trap the energy as much as possible from sun, still solar energy conversion process is more expensive as compared to traditional electricity production from burnt fossil fuel [2]. Solar cells are electrically connected inside the solar panel as a module, it's protected with the glass on top of it to allow the light rays on the semiconductor wafers. The tilt angle of solar panel depends upon geological location and also depends on the weather. In India optimal tilt angle is 20° with ± 2° of variation depends on latitude [3].

Mirrors are used to boost the solar panel power output range. They deflect the solar rays from sun and project to the solar panel thereby the light illumination value gets amplified and it gives more illumination value to the solar panel, giving more efficiency for the solar panel [4]. The reflectivity of the mirror can provide more energy than traditional panel arrangement method [5].

Manuscript published on 30 September 2019
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The traditional methods of solar panel arrangement occupy more space and selection of land and cost of land for the solar plant is more compared to fossil fuel electricity production method. To reduce the area utilisation by solar panel in plant a new concept of solar box with parabolic dish design has been developed in this work. The experiments were aimed at productivity improvement with lesser utilization of plant area. Due to simplified arrangement the manufacturing cost is also low.

The construction and working procedure, the Laws of reflection of dish reflector and summary of results from the experiments conducted are outlined below.

II. CONSTRUCTION

A. The laws of reflection

The focusing point of the dish reflector is decided by referring the following Fig. 1. In this work, the curved dish is used to reflect the light rays from sun and its construction is as follows. The start point of the parabolic dish curve is denoted by y(x), over the x-y plane. The x-y plane is symmetry on the reflection area through the y axis of the curve therefore the y(-x) = y(x). The y-axis is thus the symmetry axis of the 2D curve profile y(x).

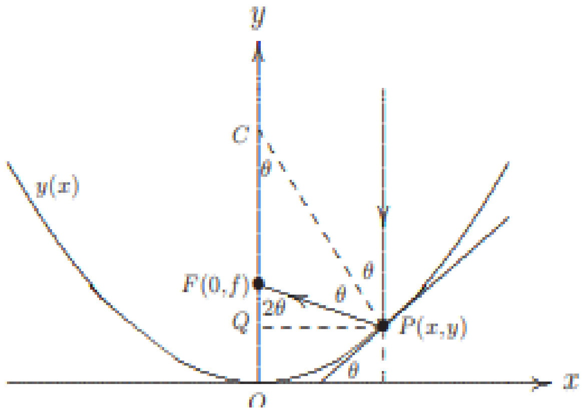

Fig. 1 Dish reflector focal point

The 3D curved dish surface is obtained by rotating the curved surface in the direction of y-axis, on the surface of curve corresponding to the surface of dish reflector, also termed as 'surface of revolution'. The projection of this surface over the x-y plane yields the original curve of y(x). Due to the symmetry of the three-dimensional surface, it is sufficient to examine the light ray's propagation in the x-y plane.

Consider two parallel light rays that strike a curved dish reflector. The very first ray is initially propagating in a direction parallel to the y-axis. It then strikes the mirror with an angle of incidence θ with respect to the normal to the curve y(x) at the point P, labeled by coordinates (x,y).

Using the law of reflection, the angle of reflection, of the resulting reflected ray is equal to the angle of incidence, θ. The second ray from the reflective dish heads down towards the y- axis, strikes the reflective surface at O and then it is reflected back to the same y-axis. Both reflected rays intersect at the single focal point F, labeled by coordinates (o,f), as shown in the above figure.

The tangent line to the curve at P is explicitly shown above. Simple geometrical considerations imply that, the angle made by the tangent line with the x-axis is also given by θ. Thus,

$$tan\ \theta = \frac{dy}{dx}$$

Where, the derivative of the curve y(x) is evaluated at the point P [6].

In addition, the angle of FCP is also equal to (as the two initial light rays are parallel), from which we conclude that the angle QFP is equal to 2θ, as indicated in the above figure. Thus, the distance of the line segment FQ is given by x/tan 2θ. Hence, the focal length f is given by

$$f = y + \frac{x}{tan2\theta}$$

Using the identity,

$$tan2\theta = y + \frac{2tan\theta}{1 - \tan^2\theta}$$

it follows that:

$$f = y + \frac{x(1 - tan^2\theta)}{2tan\theta}$$

From the above equation the focal length of the dish is found and the dish placed on the stand according to get the optimum height for the set up [6].

B. Design and development

The dish reflected solar panel system was constructed by using locally available raw materials to make cost effective. A frame for Solar panel is made and mounted on the Stand with help of shaft to provide rotation axis. The reflective dish is placed below the perpendicular to the solar panel. The adjustment screw was provided below the dish for height adjustment to find the optimal height. This setup was mounted on the shaft to provide rotation motion to the solar stand. At the top of the rotating shaft adjusting screw is provided for keeping the panel and dish in grip. Solar panel is placed in 90° angle frame in the form of triangle. Below the solar panel reflective dish is placed with help of frame.

III. EXPERIMENTAL METHODS

To run the experiment whole setup needs to be kept under the sunlight. The dish reflector is placed perpendicular to the solar panel and sunlight gets redirected by the dish inside the solar light box. Solar panel was connected in parallel connection and it is connected to multimeter to find the current and voltage flow rate of the solar panel as shown in Fig 2.

Fig. 2 Solar panel with dish reflector

Then the dish reflector is removed and the same experiment is then repeated as shown in Fig 3.

Fig.3 Solar panel without dish reflector

The current and voltage readings are taken by the multimeter for both the cases – with and without - dish reflector.

IV. RESULTS AND DISCUSSION

The experiment was conducted from morning to evening for about a week from 28-04-2019 to 05-05-2019 and the data collected on 04-05-2019 was tabulated in Table – I. The same are plotted in graphs for easy comparison of the performance of the solar panel arrangement with and without dish reflector as shown in Fig. 4 and Fig. 5.

Table - I Experimental readings

Time in hours	Reading with Dish Reflector		Reading without Dish Reflector	
	Voltage (V)	Current (A)	Voltage (V)	Current (A)
9	15.24	0.76	13.11	0.23
10	16.72	1.05	13.56	0.75
11	17.24	1.17	14.89	0.83
12	18.02	1.83	16.43	1.00
13	21.65	1.70	18.54	0.96
14	19.00	1.40	17.23	0.83
15	18.25	1.10	17.00	0.54
16	16.07	0.96	16.48	0.39
17	15.97	0.87	16.00	0.23

A. Voltage measurement

The voltage graph is plotted by keeping the hours along the X-axis and voltage along Y-axis. As seen from the graph, we note that the voltage generation value is higher with dish reflector set up when compared with that of system without dish reflector.

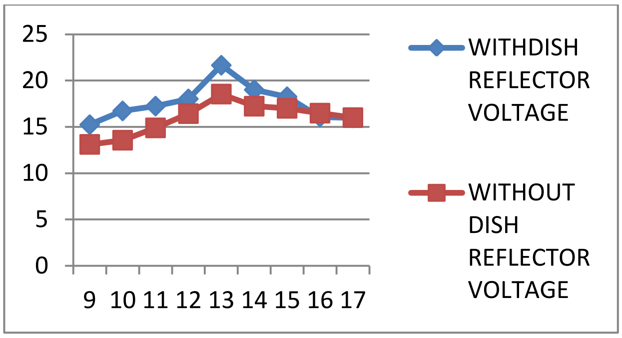

Fig.4 Voltage measurement

B. Current measurement

The graphical representation of the current generated in the solar panel for the experimental setup with and without dish reflector is shown below. The current plot is drawn keeping hours along X-axis and current in variable place marked along Y-axis. The current generation value is high with dish reflector set up in comparison to without dish reflector.

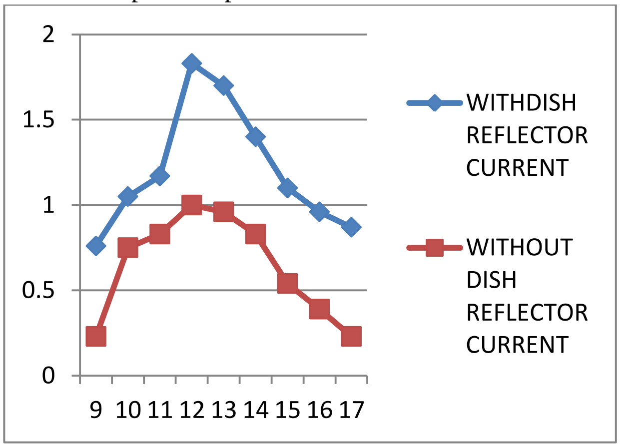

Fig.5 Current measurement

C. Power generation

A simple relation for electrical power generation is given by P = VI in Watts, where, V is voltage in V and I is current in A.

The values obtained for both the test are given in Table – II and the in graphical form in Fig. 6.

Table - II Comparison of Power generation

Time in hours	Power generation in Watts	
	With Dish Reflector	Without Dish Reflector
9	11.58	3.02
10	17.56	10.17
11	20.17	12.36
12	32.98	16.43
13	36.81	17.80
14	26.60	14.30
15	20.08	9.18
16	15.43	6.43
17	13.89	3.68

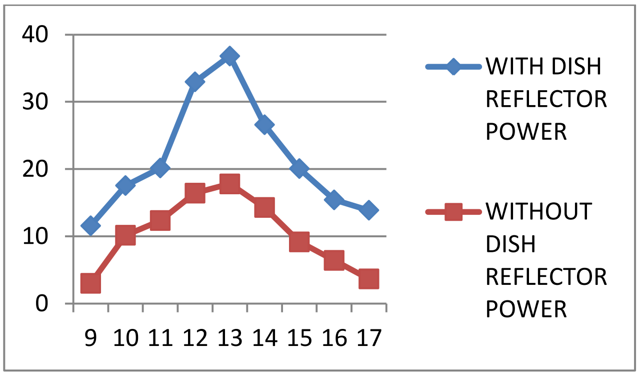

Fig.6 Comparison of Power generation

V. CONCLUSION

This dish type reflector solar panel is used to reduce the area utilization and reduce the existing drawbacks in common. By using dish reflector we get higher values for both current and voltage, which proves that solar panel with dish reflector results more power generation.

Area used in solar power plant also gets reduced by implementing the dish type reflector, this factor also improves the power generation.

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