IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 6, Issue 6 Ver. III (Nov.-Dec. 2014), PP 29-32
www.iosrjournals.org

Solar Radiation Concentrators Using Array of Plane Mirrors

[1]M. H. Ali, [2]Ibrahim. Isah
[1]*Department of Physics, Bayero University, Kano-Nigeria*
[2]*Department of Physics, Kano University of Science and Technology, Wudil. Nigeria*

Abstract: *Solar concentrators or reflectors enhance the efficiency of solar cookers or solar plants. Curved surfaces are better concentrators due to their abilities to direct rays to their focal point. This work is carried out to illustrate how an array of plane mirrors of a given surface area concentrate solar energy more efficiently compared to a single mirror (plane surface) of equal surface area. The performances of the two identical solar cookers with reflectors made from single mirror and array of smaller mirrors are carried out. The result shows that the rate of temperature rise in the cooker with the array mirror is always higher than the corresponding rate for the single mirror.*

I. Introduction

Solar energy is one of the most abundant sources of renewable energy especially for the regions near the equator [1][2]. Daily and sessional variation of solar irradiation flux is the most common disadvantage of any given solar system [3]. However, concentrators and reflectors are commonly used to increase the collection rate of the solar energy when and where it is available.

Despite the fact that the amount of solar energy of a given surface is fixed by its surface area and the location's Solar Constant value, concentrators are found to enhance the efficiency of the solar systems that employ them as collectors. This is due to their ability to concentrate all the collected

rays to a point, whereby high temperature rise is recorded at that point. This is the greatest advantage of curved surfaces compared to flat surfaces.

Even in ideal situations, the steady state temperatureof simple flat plate collectors rarely exceed 120^{o}C in practice. In very cold environments, operating temperatures are well below 90^{o}C because thermal losses to the surroundings limit the maximum possible output values. The smaller the overall heat transfer coefficient is to the surroundings the higher the temperature [4]. Because all the modes of heat transfer from a heated surface

are proposal to the area of the surface, a substanctial reduction of heat loss will result if this area is small. Thus if the intercepted solar power can be concentrated and directed on to a small area, a very high temperature will be achieved [4].

This work is intended to demonstrate that plane reflectors arranged in array would have some concentration features of curve surfaces whereby enhancing the concentrating capability of the plane mirrors.

II. Methodology

The material used for this investigation was wooden box type solar cooker with flat reflectors. One with a single mirror as reflector and the other with array of 9 small rectangular mirrors with surface area equal to that of the single mirror.

Two small identical containers of the same size and materials were inserted into the cooking vessel of the two solar cookers with ¾ volume of each container filled with water. A thermometer was then immersed into each of the two containers. The two cookers were simultaneously exposed to solar radiation at the same time for a period of three hours each day for three days. The two solar cookers were exposed to the sun at the same time being separated by a distance of 1.50m apart. The thermometer readings were recorded for the two solar cookers in the interval of 10 minutes for three hours each day.

Solar Cooker A:

The cooker is a Wooden box type with dimension 53cm x 48cm x 50cm, the inside (cooking vessel) was designed using corrugated aluminum sheet and painted black. A glass cover with a dimension of 50cm x 45cm was used as a cover for glazing purpose; a mirror (reflector) with a total surface area of 0.1935m^2 was used with a dimension of 43cm x 45cm as reflector.

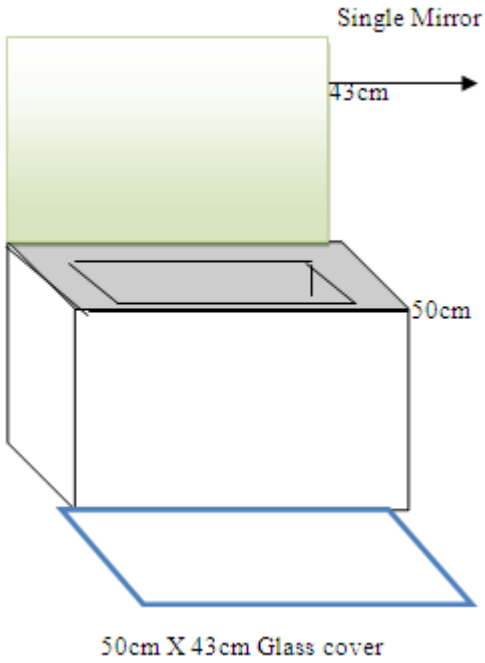

Figure 1 Cooker with Single Mirror Reflector

Solar Cooker B:
The concentrator is the same with A above but only differ in the design of the reflector. The mirror here was
divided into 9 identical smaller pieces and arraged in an array form. Each single mirror has a dimension of 43cm x 5 cm.

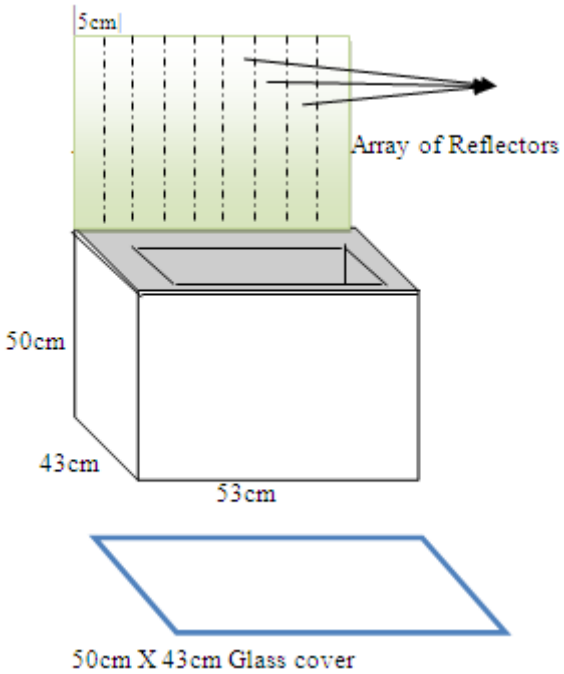

Figure 2 Cooker with 9-element Array of Mirrors

III. Results

The result of the investigation carried out in the previous section that is recorded as obtained during the experiment for one hour, two hours and three hours, and all the results were also presented in graph in

Figures 3 and 4.

The result was obtained based on the procedure as explained under the methodology;

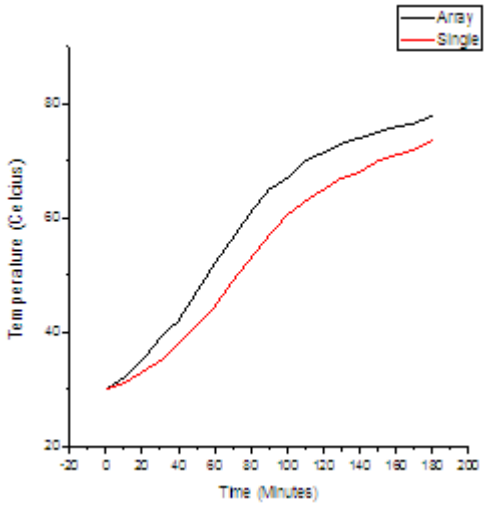

Fig. 3 Graph of Temperature Rise (^{o}C) with Time (s) for Array and Single Reflectors

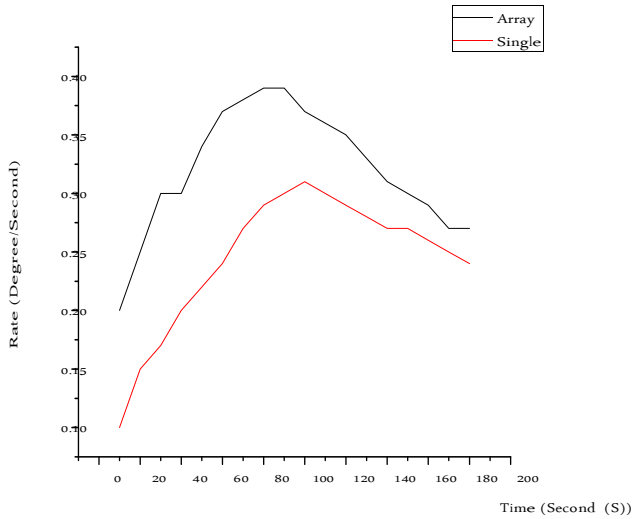

Fig 4. Graph of Rate of Temperature change with Time for the Single and Array Mirrors`

IV. Discussion

We found that the performance of the cooker with array of mirrors as its reflector is higher compared with the other one that has single mirror reflector. This is clearly illustrated by the two figures, 1&2 above.

This result implies that collection of solar energy with two or more mirrors is better than with a single mirror even though equal surface area collect equal amount of solar energy for a given environment/location. The improvement of the array collectors over the single one is due to the constructive interference of the reflected rays from the array mirror elenents.of the reflected rays from the array elements. This is true since constructive interference of two monochromatic waves sources produce higher intensity of the convined waves than a single wave of amplitude twice thaose of the smaller ones. [5][6]. The effect of this constructive interferences from the array of mirrors enhance the collecting capability of the array reflector when compared to the single element reflector.

When the reflected rays from the array mirros are focused on a given screen, regions of bright light equally spaced by darks ones similar to gratings were observed. Thus the constructive interfences occur in the bright regions while destructive ones occur at the dark regions.

V. Conclusion

In order to extract the solar energy for effective and efficient utilization, we need effective and efficient solar collectors/absorbers that will efficiently absorb significant amount of the incident solar energy.

This paper illustrates how an array of mirror of a given surface area can perform more efficiently compared to single mirror of same surface area. The mirror array concentrates more energy due to constructive interferences from the individual array element than the single continuos mirror.

References

[1]. Sayigh, A. A. (1977) "Solar Energy Engineering" Academic Press, New York, pp165
[2]. Kaplan, G. M.(1985) "Understanding Solar Concentrators" Volunteers Tecnical Assistance, VITA Publishers, 1600 WilsonBoulevard Suite 500.
[3]. Fish, M. J. and William, A.H. C. (1982) "Introduction to Solar Technology" Addison-Wseley Publishers, London
[4]. Rai, G. D.(2005) "Solar Energy Utilization" Khanna Publishers, New Delhi, pp200-205
[5]. Jenkins,F.A and White, H. E.(2001) "Fundamentals of Optics", McGraw-Hill Primis Custom Publishing. 4th Edition, pp261-265
[6]. Franco, C. Federico, R. and Andereca, N. (2011) " International Journal of Photoenergy, Vol. 2011 Retrieved from http.//dx.doi.org/10.1155/2011/843209 on 10th September,2011.