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Study of Solar Aqua Lens Concentrator and its Parametric Analysis

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Abstract: India is near to the equator, Country has large amount of solar energy with good intensity is available throughout the year. The sun's energy is intensely felt across India, due to the country's proximity to the equator. Solar Concentrator System can concentrate large amount of sunlight into a smaller one by applying lenses or curved and flat reflective mirror. The energy density from the sun is low for thermal utilization, light concentrator such Plano convex lens, Fresnel lens are needed. Approach is to develop a simple geometry curvature liquid lens concentrator fill with high refractive index liquid. A water lens can reduce the cost with trade off of concentration factor to some extent .It is easily prepared and operated with low cost material available in market. The effect of concentration ratio and diameter of focus area is studied and also is find significance of focus area .The concentrator creates positive effect for increasing the intensity of sun light. The circular plano convex lens that constitute the refractive power of lens. Refractive index of the liquid use as medium is the dominant parameter for having good spectrum of light.

Keywords: Concentration ratio, Focal point, solar intensity

I. INTRODUCTION

The sun's energy is intensely felt across India, due to the country's proximity to the equator. The average solar radiation incident over India varies from 4kwh/day to 7kwh/day. Every year, India receives nearly 3,000 hours of sunshine, which is equivalent to 5,000 trillion kWh of energy

Solar energy is an environment friendly resource that is utilized in many ways for application. The solar energy is highly dispersed so it can't be used as power generation directly. Today industrial development and environmental impact show that solar energy for solar power plant is most promising of the unconventional energy. Solar Concentrator System can concentrate large amount of sunlight into a smaller one by applying lenses or curved and flat reflective mirror. The energy density from the sun is low for thermal utilization, light concentrator such as Plano convex lens, Fresnel lens are needed. So high temperature collection at low cost is not possible as solar concentrator material and sun tracking mechanism is very costly. High temperature concentrator is 5 to 10 times the cost of flat plate collectors. The absorber temperature and the solar irradiance can be enhanced by using solar concentrator.

Solar Concentrator can increase the system efficiency for solar based energy conversion system. To develop an inexpensive method of producing liquid lenses for solar energy concentration basic material required are a mass of clear transparent liquid (such as water or glycerine) & clear transparent plastic sheet or plastic foil[1].

Properties of large scale water lenses for solar concentration were investigated. These lenses are built readily with available material, exposed to sunlight, the focal length & light intensity in the focal spot were measured &calculated [2].

A solar light concentrator composed of water & plastic transparent film has been designed .This flexible lens design can trace the solar movement through control of the tensile stress and around of water & concentrate the solar energy into thermoelectric module surface [3].

This paper presents one such effort to explore the potential of the convex lens to be used for water heating application. In this work manufactured using 6 convex lenses & copper receiver tube, many system are developed[4].

II. EXPERIMENTAL SET UP

An important feature of the design is the absence of environmental impact. If water is choose as liquid filter for the lenses. It has no hazard in case of leakage failure.

A water lens concentrator structure was made of mild steel ring thickness 5mm, and width 25mm with diameter 100cm of ring which has three square pin type welded on ring to hold detachable three legs stand of 5.5 feet long of square mild steel hollow bar of size 0.75"x 0.75".

The material of plastic foil of low density polyethylene (LLDPE) transparent to light. This material can stretch by the fluid or liquid load in circular form. The aqua lens is developed by two things, a transparent poly ethylene and the water mixture with higher refraction index liquid with sum ratio. A circular ring of metal of 100 cm diameter which is supported by three legs stands support the plastic film foil is spread over the ring. The film is fixed by clamps to the circular ring without any wrinkle on surface.

The reflected sun beam which passing through the curved liquid surface get focal to a circular spectrum spot at the focal point below the aqua lens which can be find by placing absorber plate in line of focal length.

Fig. 1 Experimental set up of solar lens concentrator

Experimental set up is shown in the fig.1 is used for experimental purposes and kept exposed to sunlight the mixture of water and liquid is measured and is pour in the plastic foil which form the shape of Plano convex lens curvature. Taking tap water as first liquid for experiment with measuring from 500ml to incremental of 500ml upto 2.5 litre in the aqua concentrator.

A special purpose instrument Tenmars solar power meter is used to measure solar intensity. First 500ml tap water is measured in measuring cylinder then pour in the solar aqua concentrator. It was find a good spectrum of hot spot at the focal point. Firstly measured the atmospheric solar intensity of sunlight by solar power measured. It was 150.7 watt/m^2, then also measured the solar intensity at focal point 161.5cm it was 2938 watt/m^2. A high intensity difference was found at the focal point.

The experiment was repeated by adding 500ml of tap water to the previous aqua water concentrator and again the reading by solar intensity power meter at the focal point is noted. At same time each aqua lens plane surface length is measured. Similarly the experiment was repeated up to 2.5 litre and different reading of solar intensity at focal point are noted. Also the length of lens surface is noted.

Similarly second liquid taken in concentrator was sugar solution of 30% by taking 750gm of sugar and 2liter of water. The experimental set up was kept in open sunlight on same day at 1:00 pm .Firstly measured 500ml sugar solution by measuring cylinder and poured in aqua concentrator kept in sunlight.

The solar intensity at focal point 124cm was 2730.2watt/m^2.It was found that the focal point length was reduced and also the solar intensity was reduced at the same aqua length of plane surface. Similar experiment was repeated by taking 500ml sugar solution an adding to previous aqua lens and reading for 1liter was noted. Similar experiment was repeated up to 2.5liter of sugar solution.

Similarly third liquid taken was pure honey. The experiment was repeated for pure honey500ml in the concentrator. The solar intensity measured at focal point length 70cm was 1447.8watt/m^2.It was found that the intensity reduced at focal point.

Similarly the experiment was repeated up to 2.5 litre and different reading of solar intensity at focal point are noted. Also the length of lens surface is noted.

Similarly second liquid taken in concentrator was sugar solution of 30% by taking 750gm of sugar and 2litre of water. The experimental set up was kept in open sunlight on same day at 1:00 pm .Firstly measured 500ml sugar solution by measuring cylinder and poured in aqua concentrator kept in sunlight. The solar intensity at focal point 124cm was 2730.2watt/m^2.It was find the focal point

III. FIGURES AND TABLES

Experimental work on 18/5/17 at 12:00pm
Atmospheric intensity of sunlight 150.7watt/m^2

First liquid–Tap water
Table 1

Sr.No	Quantity of water	Solar intensity at focal point in watt/m^2	Focal length/Point in cm	Length of plane surface of lens in cm	Concentration ratio
1	500ml	2938	161	29	0.05129
2	1liter	3539.2	142	32	0.04258
3	1.5liter	4108	132	36	0.03668
4	2liter	4534.6	122	40	0.03323
5	2.5liter	5056	120	42	0.02998

Second liquid –Sugar solution 30%
Table 2

Sr.No	Quantity of sugar solution	Solar intensity at focal point in watt/m^2	Focal length/Point in cm	Length of plane surface of lens in cm	Concentration ratio
1	500ml	2730.2	124	29	0.05519
2	1 liter	3043.08	121	32	0.04952
3	1.5 liter	3428.6	115	36	0.04395
4	2 liter	3728.8	110	40	0.04041
5	2.5 liter	3997.4	90	42	0.03769

Result and discussion:

The experimental was conducted by changing the liquid in the aqua lens the following result were being noted

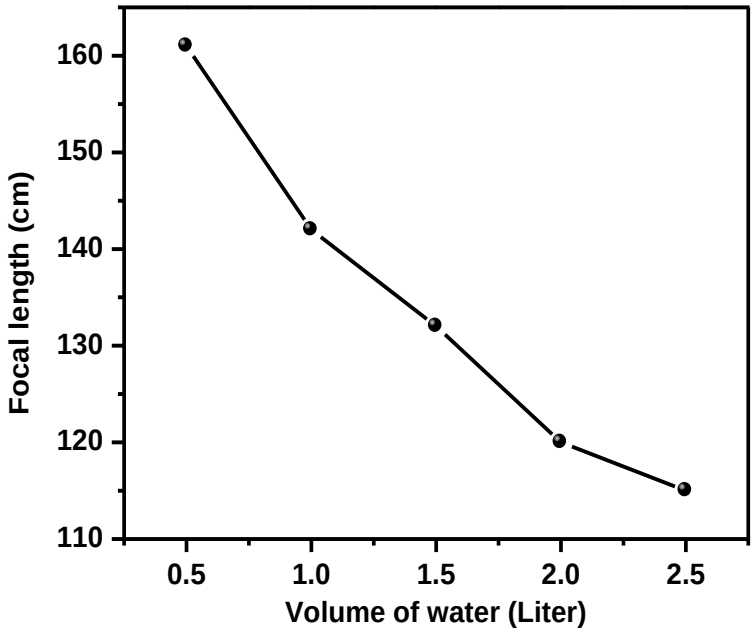

Fig. 2

From fig. 2, it has seen found that, as the volume of water is varied from 500ml to 2.5liter the shape of lens also change and the focal length or point changes from the graph its seems that as volume of water increases the focal length decreases this shows that size or diameter of aqua lens increases the focal length is inversely proportional to volume of water.

$$\text{Volume of water} \propto \frac{1}{\text{Focal length}}$$

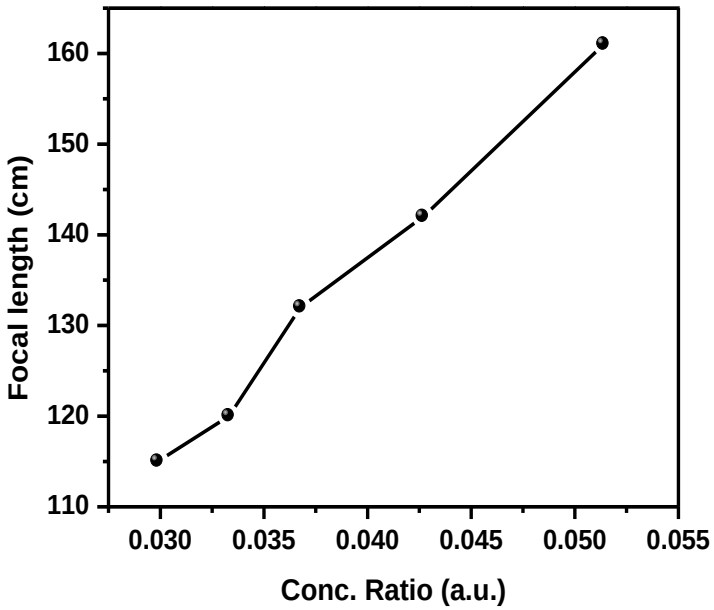

Fig. 3

From fig. 3, that is the graph of focal length v/s concentration ratio, ithas been foundthat as concentration ratio increases focal length increases. So concentration ratio is directly proportional to the focal length.

Mathematically,

Concentration ratio C ∝ Focal length

From fig.4, that is the graph of concentration ratio v/s the volume of water, ithas been found that, as volume of water increases the concentration ratio decreases. So concentration ratio is inversely proportional to volume of water.

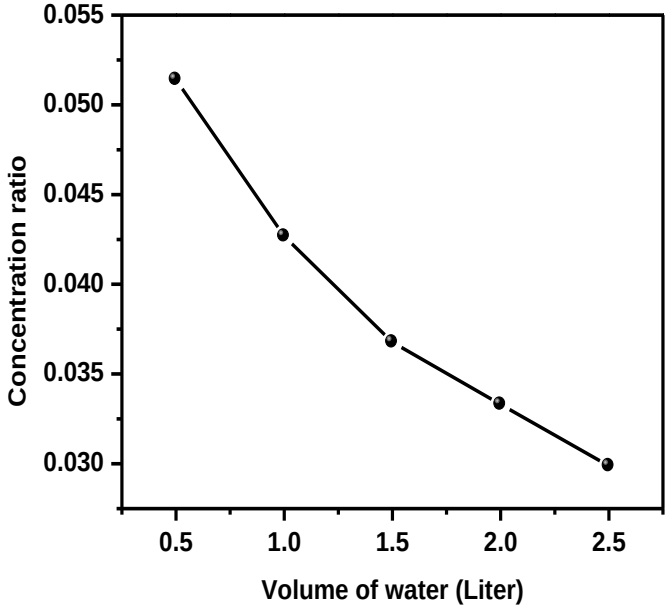

Fig. 4

$$\text{Concentration ratio C} \propto \frac{1}{\text{Volume of water}}$$

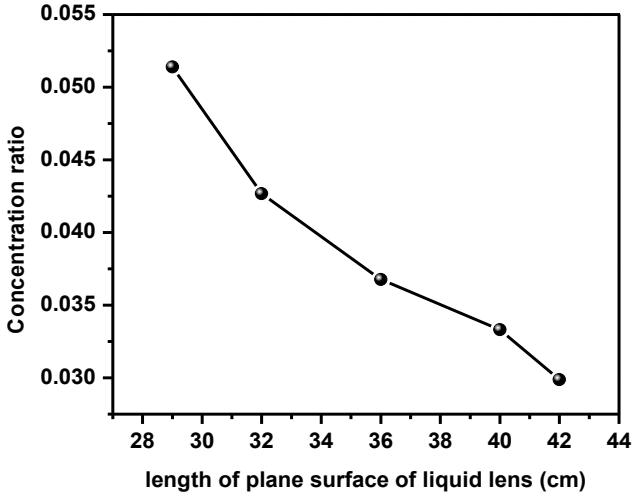

Fig. 5

From fig. 5 that is from the graph of concentration ratio v/s length of plane surface of liquid lens it has been found that as length of surface of water lens increases the concentration ratio decreases. So it is inversely proportional to each other.

$$\text{Concentration ratio C} \propto \frac{1}{\text{Length of plane surface lens}}$$

IV. CONCLUSION

The experimental study of operation performance of aqua concentrator is conducted. The Solar intensity at focus point is measured by intensity meter. The effect of concentration ratio and diameter of focus area is studied and also is find significance of focus area .The concentrator creates positive effect for increasing the intensity of sun light. The circular Plano convex lens that constitute the refractive power of lens. Refractive index of the liquid use as medium is the dominant parameter for having good focus of light. For different size lens by increasing the volume of liquid and the refraction is studied and optimize. The focal length and Solar intensity at the focal point are measured and compare with different liquid taken in the concentrator

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