EXPERIMENTAL ANALYSIS OF MULTI-PURPOSE CONCENTRIC SOLAR DISH

***D. KANAKARAJA[1], *K. NITHIN* [2], M. ADINARAYANA[3], D. ANAJAN KUMAR REDDY[4] ,P.BHASKAR[5]**

[1][3][4] [5] Department of Mechanical Engineering, Sir Vishveshwaraiah Institute of Science & Technology, Madanapalli, India,

[2] Department of Mechanical Engineering, Annamacharya Institute of Technology & Sciences, Tirupati, India.

ABSTRACT

The power generated using fossil fuels, emits carbon dioxide and other pollution every second. More importantly, fossil fuel will eventually run out. In order to make the development of our civilization sustainable and cause less harm to our environment, people are looking for new source of substitute clean energy. Because of the increasing demands in clean energy, the solar energy industry is one of the fastest growing forces in the market and there are several major directions for solar technology development. Solar Parabolic Dish is currently used for the Water heating and cooking applications. Generally Solar Parabolic Dishes are fixed focus point concentrators.

This report presents experimental platform based on the development and performance characteristics by non-tracking solar paraboloidal dish concentrating system. The system is fabricated with highly reflective materials (0.8 reflectance factor). The experimental setup is placed in open, and the tests were carried out. The experimental results are taken on summer and cloud free days. The results are encouraging to provide the data for rural application.

This paper not only gives a brief introduction about the fast developing solar technologies industry, but also may help us avoid long term switching cost in the future and make the solar systems performance more efficient, economical and stable.

Keywords: *Fossil fuels, solar energy, concentric solar dish, reflective material, Water heating.*

INTRODUCTION

Energy resources are classified as two types: renewable resources, including solar energy, wind power, hydraulic energy, geothermal energy and biomass energy, and non-renewable resources that cannot be restocked, such as petrol, nuclear energy, coal and natural gas. The world's energy usage from non-renewable properties adds up to 91.88% while 8.12% of the energy is produced from renewable resources [1]. Research involving inexpensive and fresh sources of energy such as solar energy, recently the use with solar energy for electricity generation, air conditioning and water heating has grown-up. **[2]** In the domestic applications, households consume energy by using air conditioning, heating, water heating, lighting and other uses. The aim of the project is to utilize the renewable energy unused in a large amount. One of the most important renewable-energy resources is the solar energy which sun emits to the earth. The solar energy can be utilized to a higher amount in areas having tough climatic conditions like India. The sun emits solar radiation as much as 1400 W/m2 to consume this energy solar collector is used **[3]**.

Over the last few decades, there have been significant changes in the way people use the world's energy sources. There has been an increasing effort from governments, industry and academic institutions to find alternative sources of energy and to improve energy efficiency. This, plus an ever growing pressure from different sectors of society to reduce carbon dioxide emissions, has motivates the development of emerging technologies to reduce the dependency on fossil fuels and the optimization of existing systems in order to minimize energy consumption. A lot of countries are now focusing more on renewable energy. In the US, for instance, President Barak Obama has chosen a group of people to run his Energy Department, hailed by the media as the "Green Team". Besides tackling the climate change, the team is also responsible to venture into new technologies. In 2008 alone, it is reported that the total global investment in renewable energy has reached approximately USD120 billion, led by the US, Spain, China and Germany. There are two ways to produce electricity from the sun. First is by using the concentrating solar thermal system. This is done by focusing the heat from the sun to produce steam. The steam will drove a generator to produce electricity. This type of configuration is normally employed in solar power plants.

The other way of generating electricity is through a photovoltaic (PV) cell. This technology will convert the sunlight directly into electricity. This technique is now being widely installed in the residential house and at remote places. It is also contributing to the significant increase in the development of Building Integrated Photovoltaic (BIPV) system. The sun emits solar radiation as much as 1400 W/m2 to consume this energy solar collector is used **[4]**.

Table 1: Power available from renewable resources

Energy source	**Max. Power(TW)**
Total surface solar	**85 000**
Desert solar	**7650**
Ocean thermal	**100**
Wind	**72**
Geothermal	**44**
River hydroelectric	**7**
Biomass	**7**
Open ocean wave	**7**
Tidal wave	**4**
Coastal wave	**3**

The aim of the project is to utilize the renewable energy unused in a large amount. One of the most important renewable-energy resources is the solar energy which sun emits to the earth. The solar energy can be utilized to a higher amount in areas having tough climatic conditions like India. The most financial and efficient solar collector is the parabolic collector which reflects the solar radiation to focal point and utilized, and the heat is conveyed over the water inside the receiver. Solar water heating (SWH) system comprises several improvements and many established renewable-energy technologies that have been well recognized until many years. SWH has been widely used in Australia, Austria, China, Cyprus, Greece, India, Israel, Japan and Turkey **[5]**.

CONSTRUCTIONAL PROCEDURE

This includes selection of collector type, Reflecting Material selection, Fabrication of dish along with stand, evaluation of Focal point for collecting the solar energy and to convert it to heat energy for various applications like Water heating

SELECTION OF COLLECTOR:

After reviewing of all the above literature of different surveys, it is decided that a concentric solar collector and concentric collectoris a metallic member looks like as a satellite dish for receiving the signals. It was constructed so that all the sun rays are reflected to a single point called as focal point. The specifications are as below.

Diameter of dish : 65 cm
Depth of dish : 8.3 cm
Focal point exists : 32 cm

MATERIAL SELECTION:

This includes selection of material for reflecting the solar rays to the focal point and sticking the reflective material to parabolic collector

REFLECTIVE MATERIAL:

Table 2: Commonly used materials and their lightning reflecting factors

Material	Reflection factor (%)
Aluminum, pure, highly polished	80 – 87
Aluminum, anodized, matt	80 – 85
Aluminum, polished	65 – 75
Aluminum, matt	55 – 75
Aluminum coatings, matt	55 – 56
Chrome, polished	60 – 70
Vitreous Enamel, white	65 – 75

Material	Reflection factor (%)
Lacquer, pure white	80 – 85
Copper, highly polished	70 – 75
Nickel, highly polished	50 – 60
Paper, white	70 – 80
Silvered mirror, behind glass	**80 – 88**
Silver, highly polished	90 – 92
Oak, light polished	25 – 35
Granite	20 – 25
Limestone	35 – 55
Marble, polished	30 – 70

. **Figure 1: Reflective material (Silvered mirror)**

ADHESIVE MATERIAL:

Silicone glue is a type of adhesive that contains silicon atoms, making it a good water-resisting solution. This structural adhesive is a versatile type of adhesive which can be used in an array of applications. Silicone glue is used in many areas because of its stability, chemically and thermally. It is also resistant to weathering and moisture, unlike other adhesives.

FOCAL POINT EVALUATION:

The focal length is one of the most important parameter of a lens. Sometimes the focal length is slightly different from the datasheet value given by the manufacturer, having an impact on the predicted optical system performances. Many methods have been elaborated to measure with more or less accuracy a lens's focal length. Some methods are easy to implement, other require more material and analyses, with more accurate measurements.

When a three dimensional parabola (i.e. a paraboloid)is aimed at the sun, all the light that falls upon its mirrored surface is reflected to a point known as the focus. If a black cooking pot is placed at the focus it will absorb the light's energy and become very hot. A satellite dish is an example of a parabaloid that can be made into a cooker. Parabolic Solar cookers heat up quickly and are used like a standard stovetop range to cook or fry foods, boil water, or even produce electricity. They can also be used to generate steam, power sterling engines, crack water to produce H2 gas, and even plasma matter. It is easy to see in today's world that this shape is successful in its use. The parabolic shape can be seen in satellite dishes, radio towers, and yes, even in solar cookers around the world.

A mirror is shaped like a paraboloid of revolution and will be used to concentrate the rays of the sun at its focus, creating a heat source called FOCAL POINT.

Steps to calculate focal point:

Use the following equation to determine the focal point. The formula for a parabola is **F=D^2/16X (or) F=R^2/4a**. To find the focal point of a parabola, follow these steps:

Step 1: Measure the longest diameter (width) of the parabola at its rim.

Step 2: Divide the diameter by two to determine the radius (R) and square the result i.e., (R^2).

Step 3: Measure the depth of the parabola (a) at its vertex and multiply it by 4 i.e., (4a).

Step 4: Divide the answer from Step 2 by the answer to Step 3 ($R^2/4a$). The answer is the distance

From the vertex of the parabola to its focal point.

The point at which all elements or aspects converge; center of activity or attention; the central or principal point of focus

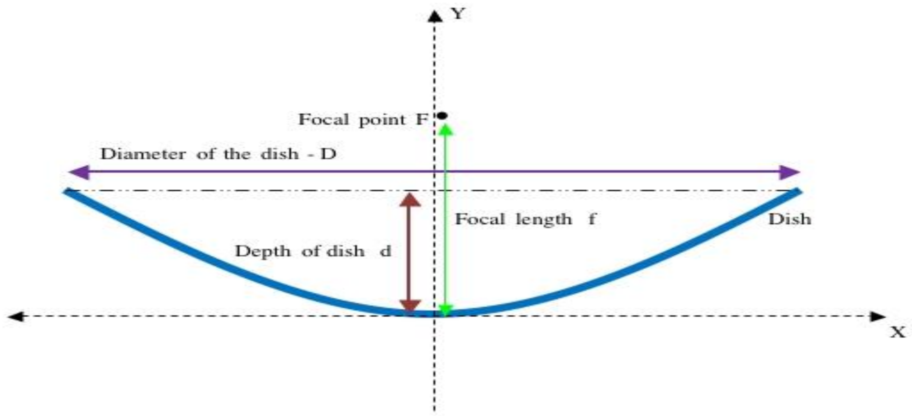

Figure 2: Focal point evaluation

Diameter of dish (D) = 65 cm

Depth of dish (X) = 8.3cm

Therefore the focal point = $D^2/16X$

= $65^2/16(8.3)$

= 4225/132.8

= 31.8

= 32 cms (approx.)

EXPERIMENTAL SETUP

It consists of Dish, Stand, Base board, Reflective material and Receiver.

DISH:

Figure 3: Dish Before adhesion of mirrors Figure 4: After mirrors adhesion

The dish is metallic plate made of aluminum and it should be fabricated so that it can withstand a minimum weight of 8 kgs. And here taken an aluminum dish and it is painted to avoid rusting.

The figure 3.2 is a normal picture of a satellite dish made of aluminum sheet which is used to receive the signals from the satellite.

The figure 3.3 represents the parabolic dish after attaching the silvered mirrors to get reflection.

BASE WHEEL SETUP AND A STAND FOR DISH:

Figure 5: Wheels and Stand arrangements

The stand is a supporting member for the parabolic dish as shown in figure 3.4, and it holds the entire setup.

RECEIVER:

Figure 6: basic receiver for heat energy

A receiver is heat absorbent and is used for different applications like as heating of water, cooking, etc. as shown in figure 3.5.

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FINAL SETUP:

The experimental setup consists of a solar parabolic dish system, receiver, and heat transfer fluid as water which is heated. Receiver is located in the focal point on the solar trace of parabolic dish. When the sunlight rays are incident on the reflective surface they are reflected and conveyed to the surface of the Receiver at the curve to heat the water and to take change phase. The parabolic dish made with highly reflective material (Silver coated mirrors) with 0.8 of reflectance factor. The reflector cut into small shapes and fixed parabolic which can be turned conveniently.

Figure 8: Parabolic dish concentrator experimental setup.

EXPERIMENTAL RESULTS AND ANALYSIS

Testing was done during the summer and clear sky with cloud free days during the month of April 2015 for about seven days. The tests were taken between 10 am to 4 pm in data were taken on each hour. The table 4.1shows the surface temperature of collector.

The experimental investigation of the performance of a thermosyphon V-through flat plate collector water storage system was performed at S.K.I.T. Campus, Jaipur (Rajasthan).

Measurements of the incident solar radiation and other system parameters were carried out at intervals of one hour from 9:00 A.M to 17:00 P.M every day. Tables 1-4 show the daily average values of global solar radiation, energy in water storage tank, heat losses and thermal efficiency for 12 January 2013 to 16 January 2013.

The observations of the 30 L capacity of the water tank and 5 L water continuously removed from the storage tank at one hour interval period. Temperature measurement of the set up was carried out for full day during whole study. Reflectors (mirror) are used to improve thermal efficiency of V-through solar water collectors.

OBSERVATIONS DURING EXPERIMENT

In this study, different observations are noted. All readings are surmised in a tabular form with necessary data. Nomenclatures are shown, used in the observation's tables:

T_1 Temperature of Receiver surface ^oC

T_2 Temperature of water inside Receiver ^oC

T_3 Temperature of inside the setup/ surface of Mirrors ^oC

T_4 Ambient Temperature ^oC

THERMAL ANALYSIS OF SOLAR WATER HEATER

In this section temperature measurements were done at various locations of experimental setup. And show these measurements in graphs for all experiments conditions. J-Type thermocouples are used for temperature recordings at 5 locations in Experimental Set-Up.
The results obtained after conducting the experiments were tabulated below and plots also drawn to show the variation.

The figure 9-12 are shown the temperature with time for each day. The table 3-6 are hourly measured parameters for water temperature on April 12, 2015 to April 15, 2015 between the time intervals of 10:00 am to 16:00 pm. the table are shown in below.

Table 3: Hourly Measured Parameters for water temperature on 12/04/2015

Time (Hr)	T1 (^OC)	T2 (^OC)	T3 (^OC)	T4 (^OC)
10	23.5	23.0	27.6	24.6
11	38.6	37.6	29.7	28.6
12	43.4	41.2	36.3	34.6
13	54.5	52.4	41.6	41.8
14	69.4	69.3	43.8	40.4
15	63.5	62.1	38.5	34.9
16	57.9	56.8	37.8	32.5
Average	50.11	48.91	36.47	33.91

Table 4: Hourly Measured Parameters for water temperature on 13/04/2015

Time (Hr)	T1 (^{O}C)	T2 (^{O}C)	T3 (^{O}C)	T4 (^{O}C)
10	26.2	25.0	25.2	23.2
11	36.5	32.7	30.2	29.3
12	45.2	42.5	36.7	32.1
13	54.4	53.6	45.2	40.5
14	68.6	67.2	43.6	40.3
15	62.7	60.1	40.6	32.8
16	54.9	50.8	31.9	31.2
Average	49.79	47.41	36.20	32.77

Table 5: Hourly Measured Parameters for water temperature on 14/04/2015

Time (Hr)	T1 (^{O}C)	T2 (^{O}C)	T3 (^{O}C)	T4 (^{O}C)
10	26.6	25.7	26.0	24.6
11	28.5	26.6	32.6	29.2
12	47.8	44.5	36.7	35.3
13	54.9	57.7	45.6	39.5
14	63.7	61.1	49.2	42.1
15	63.4	60.6	33.2	32.0
16	47.9	45.2	30.9	29.8
Average	47.54	45.91	36.31	33.21

Table 6: Hourly Measured Parameters for water temperature on 15/04/2015

Time (Hr)	T1 (^{O}C)	T2 (^{O}C)	T3 (^{O}C)	T4 (^{O}C)
10	29.7	26.5	27.5	25.2
11	36.5	33.6	30.6	28.6
12	43.6	39.6	32.2	30.3
13	54.7	47.6	46.2	42.1
14	63.8	55.8	45.9	40.8
15	59.0	55.1	39.0	36.8
16	53.3	49.0	33.8	31.7
Average	48.66	43.89	36.46	33.64

The following plots are drawn between various temperatures with respect to Time of the day from 10:00 am to 16:00 pm during Rain free days (in summer)

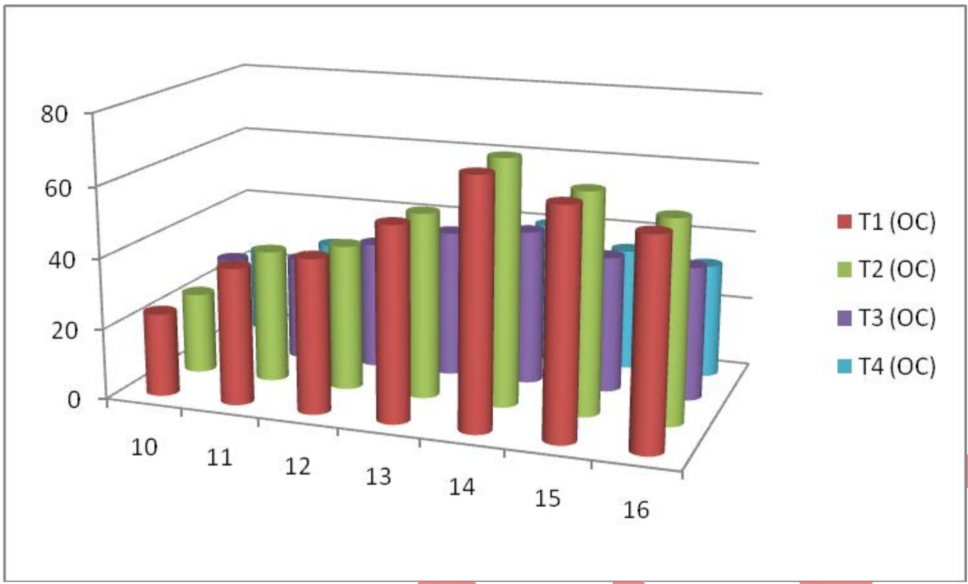

Figure 9: Temperatures with time of day per hr. on 12-04-2015

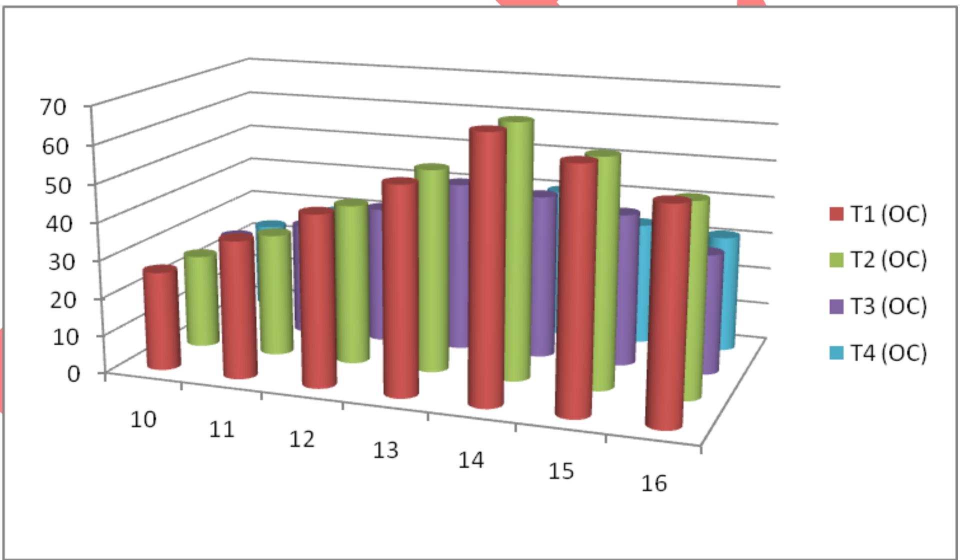

Figure 10: Temperatures with time of day per hr. on 13-04-2015

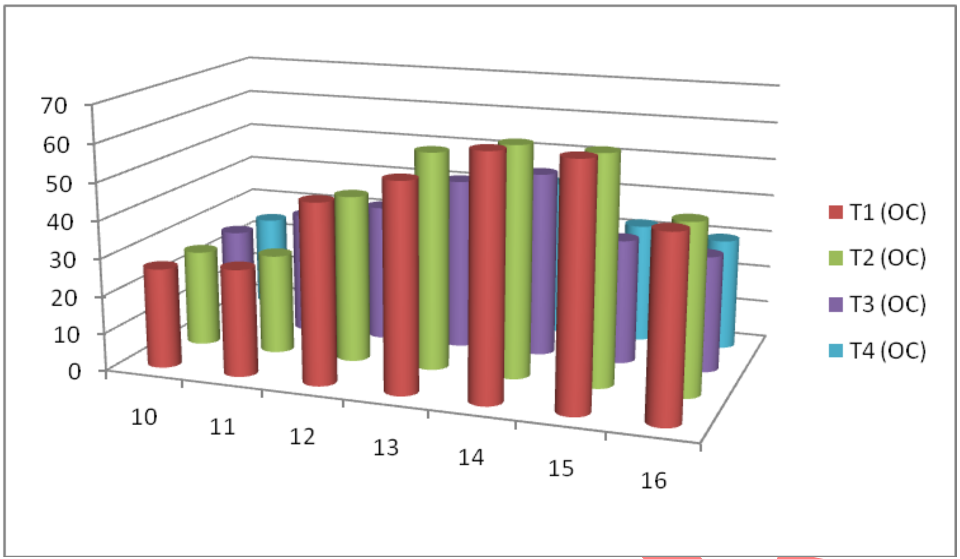

Figure 11: Temperatures with time of day per hr. on 14-04-2015

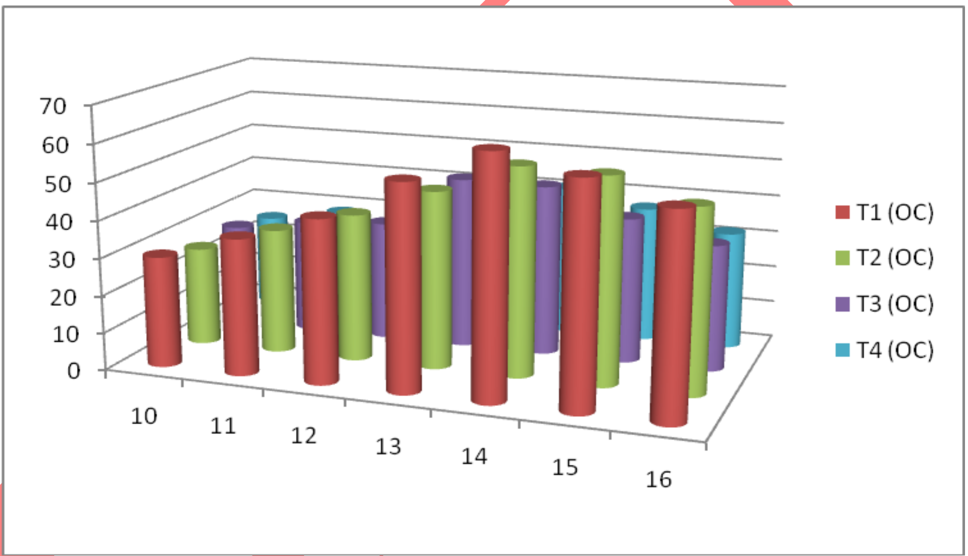

Figure 12: Temperatures with time of day per hr. on 15-04-2015

CONCLUSIONS & RECOMMENDATIONS

A. CONCLUSIONS.

On the basis of the results obtained from the experimental study, the following conclusions can be drawn:

The purpose of this project was to develop a low cost solar water heater. Specifically, a parabolic dish collector system constructed from home-grown materials and labour that would cost less than 3500 INR and deliver 1L of 50°C (Average) water within 10 min.

- Materials were selected based on cost, performance, and accessibility.
- Experimental measurements show that the water in the Receiver was heated by the solar energy being absorbed by the solar collector.

- All the thermo-physical properties of the absorber plate and the working fluid are computed in time dependent mode.
- The efficiency improvement by various changes in setup.
- This collector system is capable of achieving significant energy savings in hot climate countries. Particularly, in the present situation of acute energy short age and most suitable to supply the needs as a family.
- Results specify that the project of solar water heating system was a success.

B. RECOMMENDATIONS

- More experimental investigations are needed to confirm the efficiency of the proposed model by testing for different cases.
- By placing a Tracking system, it is easy to trace the sun over the entire day.
- By using a thermoelectric generator, can generate electricity.

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