"TO STUDY THE DESIGN AND PERFORMANCE OF FLAT PLATE COLLECTOR AND PARABOLIC COLLECTOR"

Maulik G Patel[1], Lect. Saumil C Patel[2]

[1]*ME scholar, Mechanical Department, LDRP-ITR, Gandhinagar, India*

[2]*Lecturer, Mechanical Department, LDRP-ITR, Gandhinagar, India*

ABSTRACT

In today's world of much more environmental problems, solar energy is the most abundant available energy by the use of which we can gain a promising outcome. So we are focusing our main attention on solar collector design and performance .This solar collector uses the solar irradiation and generally used for various heating purposes, cooking, and so on. I did the detailed study of flat plate collector and sk-14 (parabolic dish type collector) is made along with the fabrication of flat plate and complete setup (assembly and installation) of sk-14 collector. After installation of both collectors, temperature readings are taken at different time interval, also the graphs are plotted of time versus temperature range for surface (steel) and fluid (water). The efficiencies are also calculated on these bases.

Keywords: - Flat plate collector, parabolic dish type collector, solar concentration, solar thermal

1. INTRODUCTION

At present the problem of pollution is troubling the local inhabitant of this planet earth. It is just like a curse to this planet and its inhabitant. Moreover the uses of more and more conventional resources like petrol, diesel, coal etc are adding worries to this problem.

Therefore it's a great concern to turn towards the use of non-conventional resources like solar, wind, hydro energy. Also the greatest source of non-conventional energy is solar energy and it is available freely and in abundant quantity, but efficiency of solar power plant has not much enough to work with such valuable energy which is freely available. Now here my concern will be comparative study and improvement in existing design of solar collector which is the input of solar power system so that output can be improved.

My project will be on solar energy system and comparative studies of solar collector which is the main component (input device) of any solar energy system. Moreover we will be doing experimental study on collector's performance and finding their efficiency and also we will try to design new solar collector using magnifying glass in order to improve performance of collector and will conclude which one is the best.

2. OBJECTIVE OF PRESENT WORK

To study and design performance of Flat Plate collector & Parabolic collector

Flat Plate collector and Parabolic dish type collector is made along with the fabrication of complete setup (assembly and installation) of both collector.

Temperature readings are taken at different time interval, also the graphs are plotted of time versus temperature range for surface (steel) and fluid (water).

The efficiencies are also calculated of flat collector and parabolic dish type collector.

3. EXPERIMENTAL SETUP

Parabolic dish type collector

Parabolic shaped reflector to direct sunlight to a small area in order to generate heat for cooking. They are able to Reach high temperatures, 350 °C (662 °F), which allows them to be used for grilling and frying.

Parabolic dish type collector one type of solar cooker. These temperatures are significantly higher than what Can be reached by a solar box cookers or solar panel cookers and allow the cooking times on a parabolic cooker to be comparable to a conventional Stove, such as an electrical or gas burner.

Sk-14 is a durable although light, cost effective to build and easy to use. Now here maximum amount of energy is desired, the dish must only be moved every 15-25 minutes to face the new position of the sun.

The heated area is located within the dish, therefore burning and blinding are easy to avoid. When the food is too bestirred, the reflector dish is simply rotated over the pot, so that the pot is in the shade.

It should be place on a level surface without any obstacles in the immediate cooking area.

In windy conditions it needs to secure by tying some little bags of sand to the frame to stop it blowing over and being damaged. Or by putting some steel pins pushed into the ground

The SK 14 is now normally sold in a kit form now called K14 the benefit of this kit is that it can be assembled where it will be used. No damage of misshape of the parabolic can take place during transport.

The SK14 is a very versatile solar cooker. In the rural areas it can take to the field where the farmer can cook his food while attending to his chores, then have Piping hot food for lunch.

It can be used for much other work where heating is necessary. Like ironing clothes, food processing such as making jam pickles snacks for packing etc.

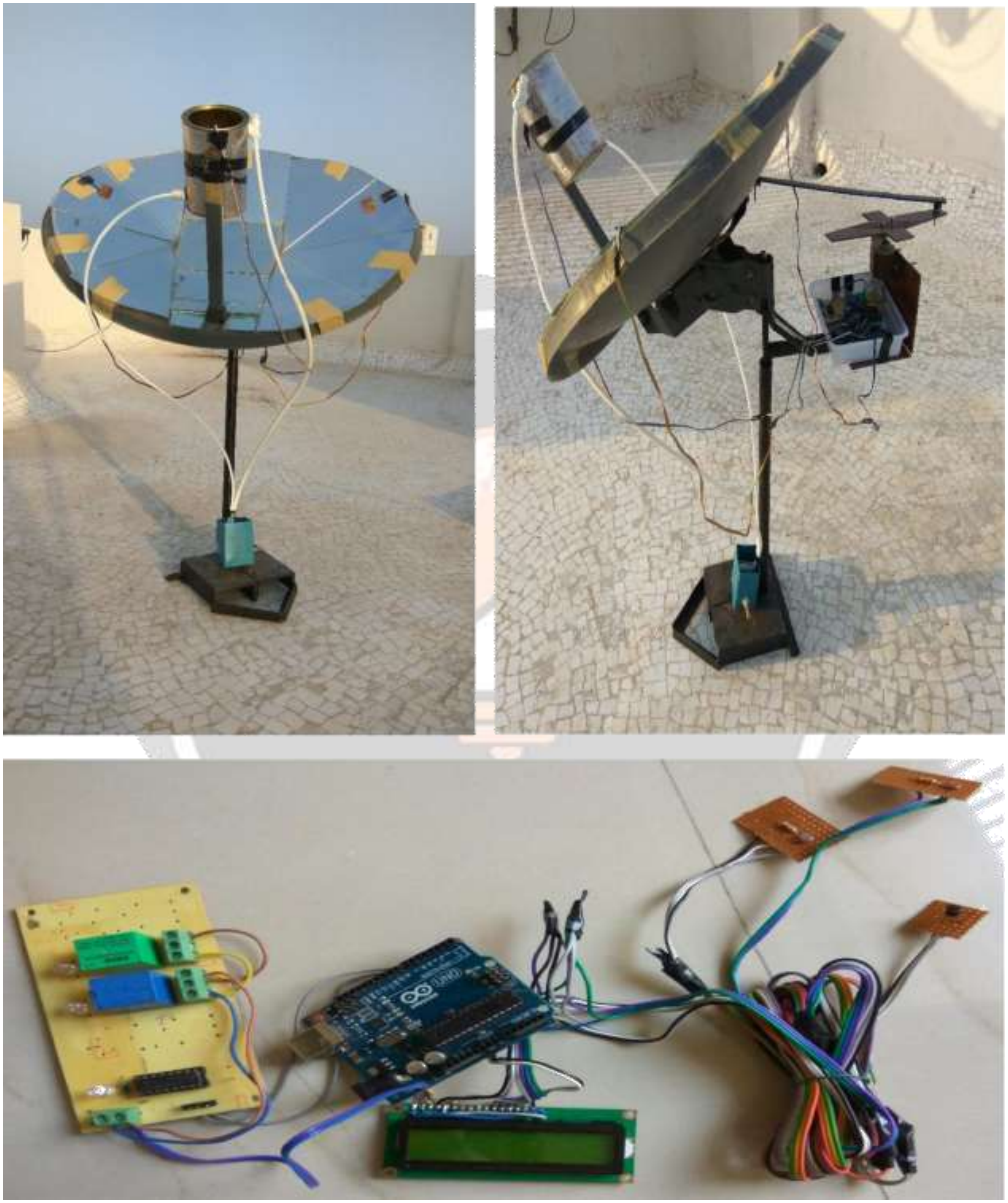


Fig: Final Model Setup of Parabolic Collector



Advantages:

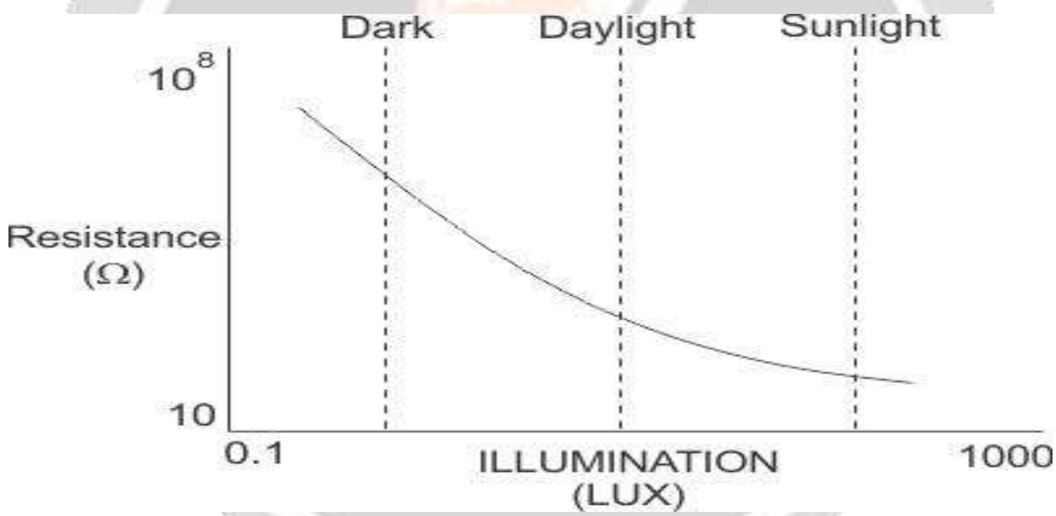
- It is point focusing type collector
- Required less area compare to flat plate collector
- High temp.
- Flexibility obtain
- Low maintenance
- Easy to assemble

LDR Sensor

A light dependent resistor is a light-controlled variable resistor. The resistance of a LDR decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A LDR can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

Fig: LDR Sensor (Light dependent Resistance)



LN35 Sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

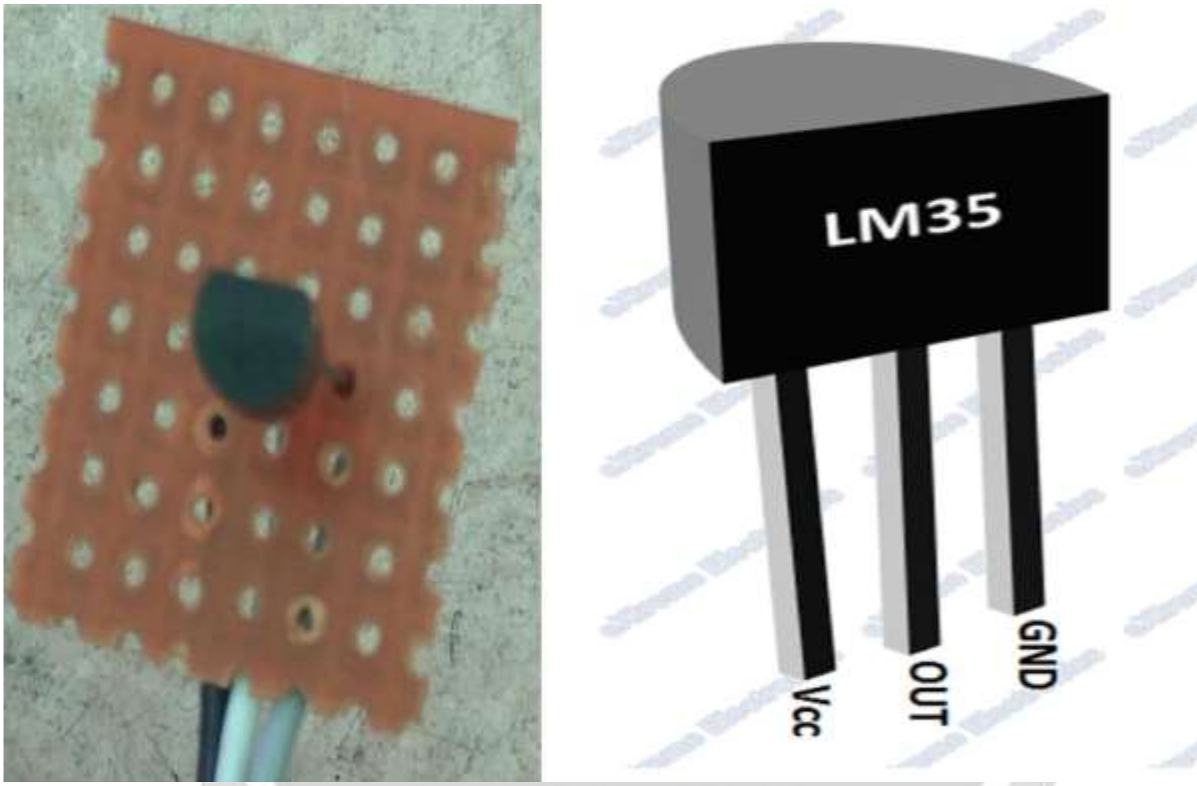


Fig: LN35 Sensor

Feature

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

Relay Board

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

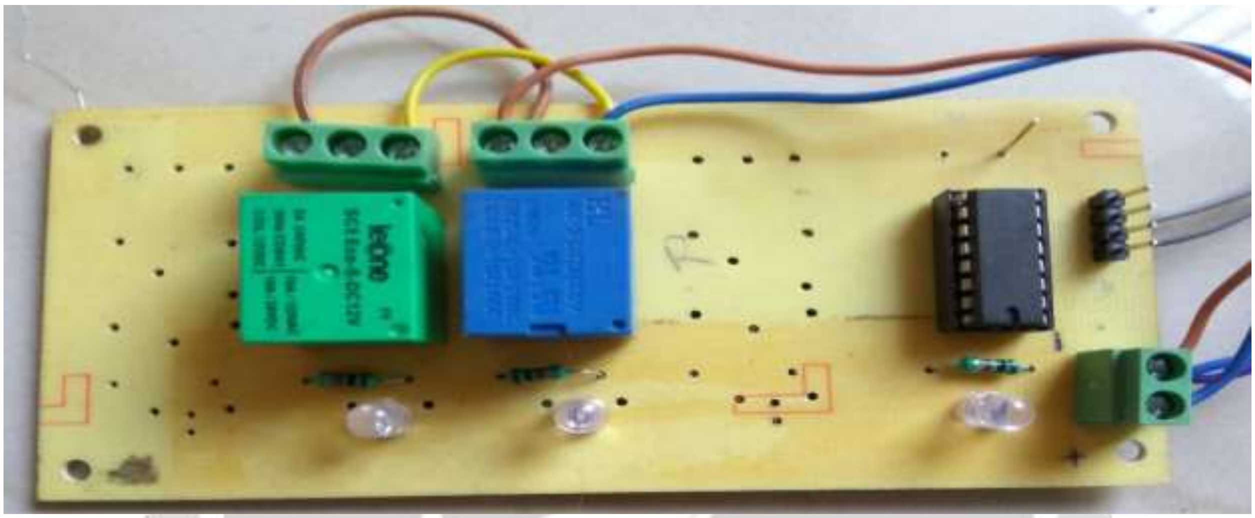


Fig: Relay Board

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

ARDUINO

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

Fig: ARDUINO

Flat Plate Collector

Of the many solar collector concepts presently being developed, the relatively simple flat plate solar collector has found the widest application so far. Its characteristics are known, and compared with other collector types, it is the easiest and least expensive to fabricate, install, and maintain.

Moreover, it is capable of using both the diffuse and the direct beam solar radiation. For residential and commercial use, flat plate collectors can produce heat at sufficiently high temperatures to heat swimming pools, domestic hot water, and buildings; they also can operate a cooling unit, particularly if the incident sunlight is increased by the use of a reflector. Flat plate collectors easily attain temperatures of 40 to 70ºC. With very careful engineering using special surfaces, reflectors to increase the incident radiation, and heat-resistant materials, higher operating temperatures are feasible.

The main components of a flat plate solar collector are:

Absorber plate made of any material, which will rapidly absorb heat from sun's rays and quickly transfer that heat to the tubes or fins attached in some manner, which produces a good thermal bond.

Tubes or fins for conducting or directing the heat transfer fluid from the inlet header or Duct to the outlet.

Glazing, this may be one or more sheets of glass or a diathermanous (radiation transmitting) plastic film or sheet.

Thermal insulation, which minimizes downward heat loss from the plate.

Cover strip, to hold the other components in position and make it all Watertight.

Container or Casing, which surrounds the foregoing components and keeps them free from dust, moisture, etc.

Flat plate solar collectors are classified into:

Water-type (hydraulic) collectors, using water as the heat-transfer fluid,

Air-type collectors, using air as the heat-transfer fluid

Diathermanous Materials (Glazing)

The term "diathermanous" is applied to materials capable of transmitting radiant energy, including solar energy. From the standpoint of the utilization of solar energy, the important characteristics are reflection (ρ), absorption (α), and transmission (τ). The first two should be as low as possible and the latter as high as possible for maximum efficiency. According to the law of conservation of energy, the relationship between the absorbed, reflected and transmitted energy is:

$$\alpha + \rho + \tau = 1$$

Where, α is the solar absorptance, i.e. the fraction of the incident solar radiation absorbed by a Substance. ρ is the solar reflectance, i.e. the fraction of the incident solar radiation reflected by a surface.

τ is the solar transmittance, i.e. the fraction of the incident solar radiation transmitted through a Non-opaque substance.

Absorber Plates

The primary function of the absorber plate is to absorb as much as possible of the radiation reaching through the glazing, to lose as little heat as possible upward to the atmosphere and downward through the back of the container, and to transfer the retained heat to the circulating fluid.

In general, absorption of solar energy impinging on an absorber plate should be as high as possible, but re-emission (loss) outward from the collector should be minimized.

Thermal Insulation

Flat-plate collectors must be insulated to reduce conduction and convection losses through

The back and sides of the collector box. The insulation material should be dimensionally and chemically stable at high temperatures, and resistant to weathering and dampness from condensation.

Usually, glass-wool insulation 10 cm thick is recommended. it would be between if the insulation also could contribute to the structural rigidity of the collector, but more rigid insulating materials are often less stable than glass-wool. Temperatures in flat-plate solar collectors can be high enough to melt some foam insulations, such as Styrofoam. And some foam give off corrosive frames at high temperatures, which could damage the absorber plate.

Fig: Final Model Setup of Flat Plate Collector

Design for Flat Plate collector

Dimension: length = 150 cm

Width = 100 cm

Height = 5 cm

No. of tubes = 9

Tubes material = Aluminum

After coating the base of collector joining (fixing) them together with nails. After fixing the base, the pipes joined together with elbows and adhesive solution and packed in the rectangular box which is the result of fitting various base components.

A. Tubes : Aluminum (Dia. 2.5cm)
B. Cover : Glass
C. Base : Wood
D. Insulation : Glass wool
E. No of elbows used =18
F. No of clamps =18
G. Adhesive

4. EXPERIMENTAL READING

Table 4.1: Readings Taken for Parabolic dish type collector (For water)

Time	Water temperature(^oC)
11:16	22
11:59	40
12:30	74
12:51	85
13:00	92
13:04	95

Table 4.2: Readings Taken for Parabolic dish type collector (For Surface)

Time	Surface temperature(^oC)
11:16	26
11:59	98
12:30	145
12:51	160
13:00	200
13:04	240

Table 4.3: Readings Taken for Parabolic dish type collector (For Reference)

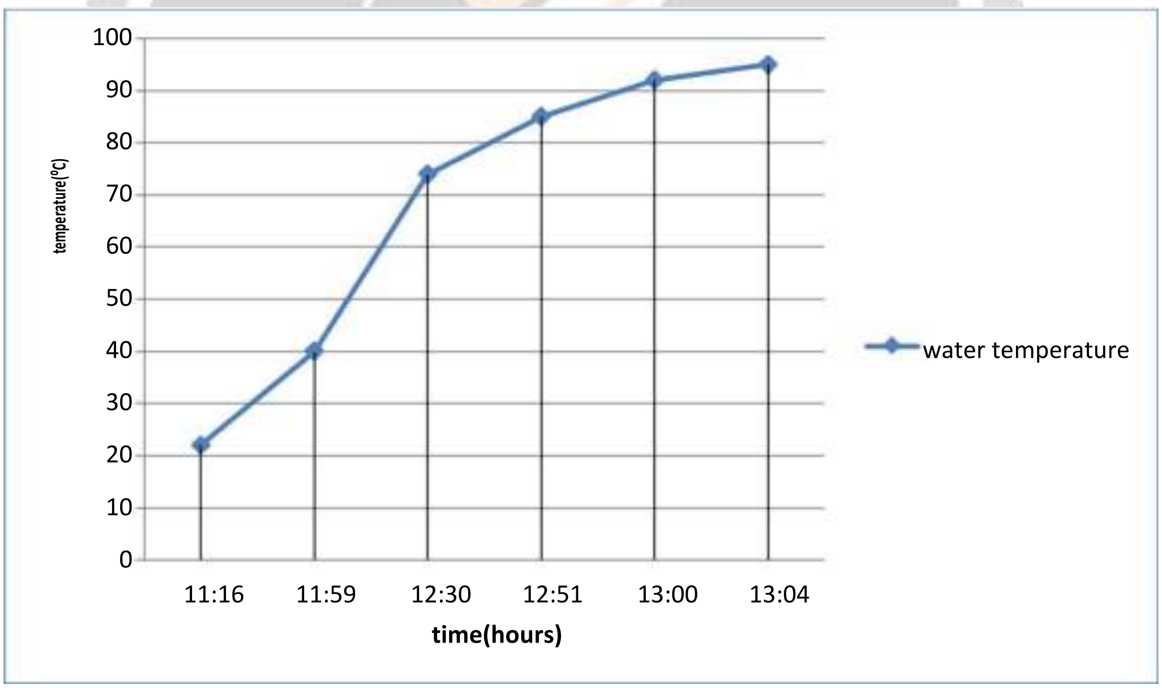
Time	Temperature(^oC)
11:16	17.3
11:59	43.3
12:30	74.7
12:51	89.3
13:00	94.7
13:04	96

Table 4.4: Comparison of reading with reference data

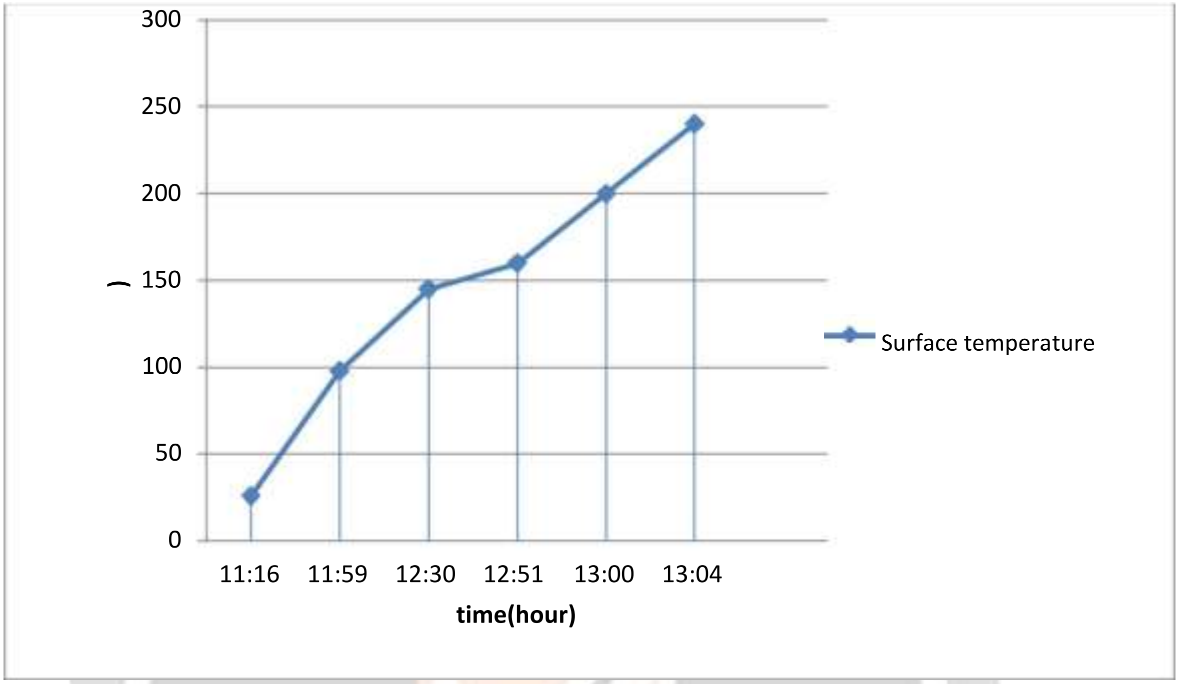
Time	water temperature	water temperature(reference data)
11:16	22	17.3
11:59	40	43.3
12:30	74	74.7
12:51	85	89.3
13:00	92	94.7
13:04	95	96

5. RESULT AND DISCUSSION

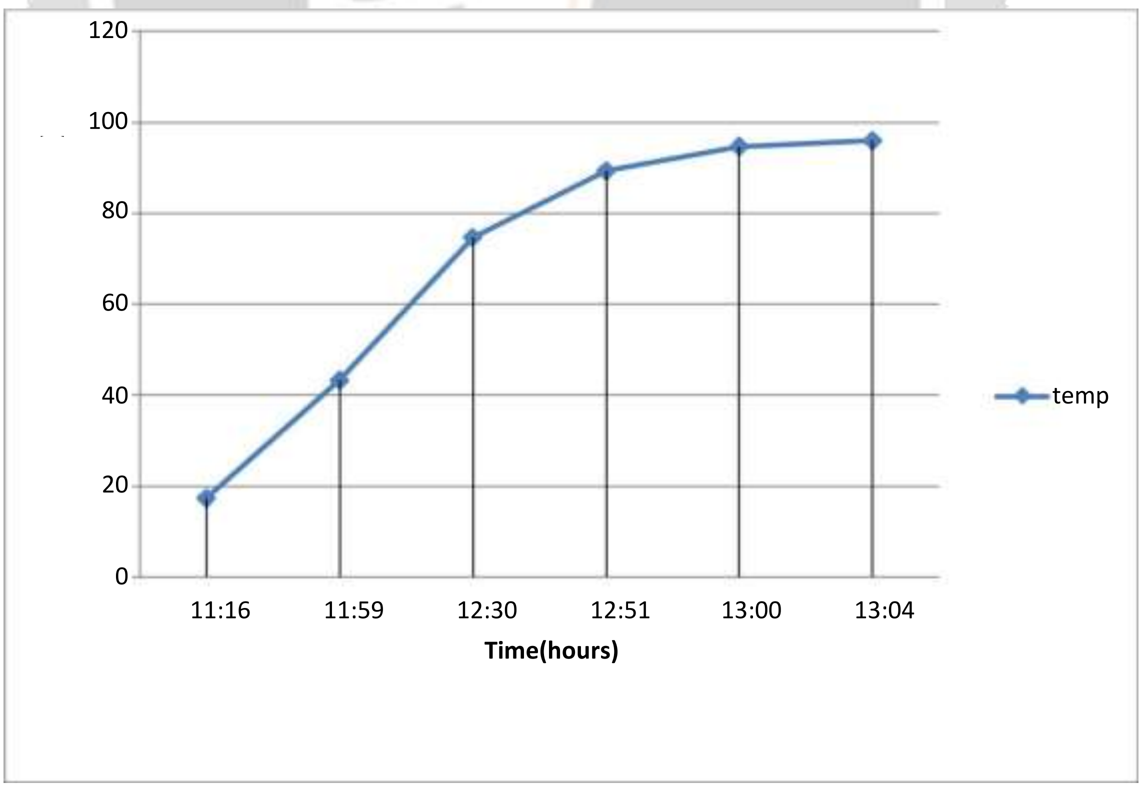
5.1 Water temperature graph



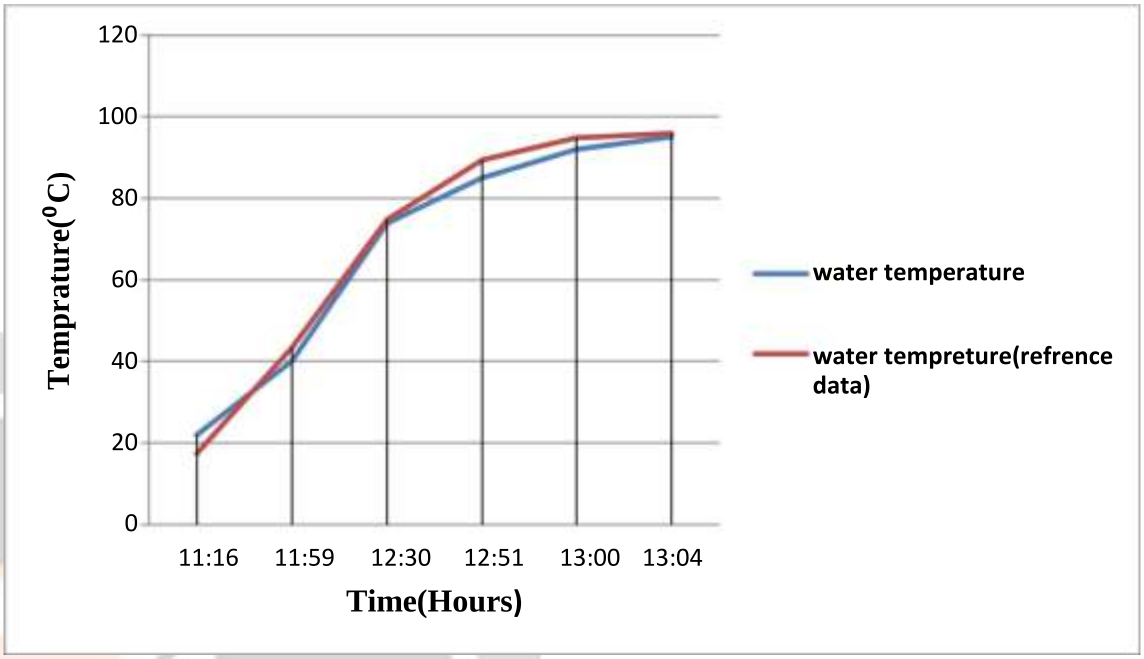
5.2 Surface temperature graph



5.3 Time vs. fluid temperature graph



5.4 Comparison Table



Efficiency calculation of parabolic dish type collector

Average Solar radiation received by earth in terms of energy I = 900 W/m2/Hr.

Solar radiation received by earth in 7 hours in terms of energy I_T= 900*7 W/m2/day

I_T = 6300 W/m2

I_T= 226800000W Sec/m,

Where,

A = Area of Sk14 in m2

T1 = Temperature of water at initial in ºC

T2 = Temperature of water after some interval in ºC

Mass of water taken in the storage tank M = 100 kg

Specific heat of water Cp = 4.182 KJ/KG ºK

Heat gained by water,

Q = M*Cp*(T2 – T1)

= 100*4.187*10^3*(95–24)

= 29727700 Joules Collector

efficiency is given by

$$\eta_i = \frac{q_u}{A_C I_T}$$

=87%

I_T -the amount of solar radiation falling on the collector

A_C- area of the collector (m2)

Efficiency calculation of flat plate collector

Average Solar radiation received by earth in terms of energy R = 900 W/m2/Hr.

Solar radiation received by earth in 7 hours in terms of energy R = 900*7

W/m2/day R = 6300 W/m2

R = 22680000 W Sec/m,

Where,

A = Area of Flat plate collector in m2

T1 = Temperature of water at inlet in ºC=24

T2 = Temperature of water at outlet in ºC=36 Mass

of water taken in the storage tank M = 100 kg

Specific heat of water Cp = 4.182 KJ/KG ºK

Area of the flat plate collector,

A = L*W m2
= 1.4m2

Radiation receive by collector,

R1 = R*A

= 22680000*1.4

= 34020000Joules

Output of the Stationary Collector

Q = M*Cp*(T2 – T1)

= 100*4.187*103*(36–24)

= 5024400

Efficiency of fixed flat plate collector

η = Output of the collector / Input Radiation

η = M*Cp*(T2 – T1) / R*A

= 6699200Joules / 34020000Joules

= 14.7%

6. CONCLUSION

- Temperature range of parabolic collector (sk14) is more than the flat plate collector.
- Reading taken by us are matching the reference reading as compared in chart

Comparison:

Flat plate collector	Sk-14 (parabolic type)
1. Non concentrating type.	Point focusing type.
2. Absorber area of collector is more than parabolic type and thus insolation intensity is less.	Absorber area is less compared to flat plate, thus more solar insolation.
3. The working fluid attains low temperature than parabolic type.	The working fluids attain high temperature in comparison to flat plate.
4. Overall efficiency is around14.7%	Overall efficiency is around 87%
5. More maintenance.	Less maintenance.

“Thus we can conclude that the sk-14 type parabolic collector is more efficient than flat plate type of similar configuration.i.e. We have taken same aperture area for both collectors and on that basis we compared them

7. REFERENCES

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This paper gives information as under:

Collector Description

Advanced Flat-plate Collectors
Evacuated Tube Collectors
CPC Collectors
Parabolic dish Collectors
Linear Concentrating Fresnel Collectors
Concentrating Collectors with Stationary Reflector

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