Experimental Analysis of Double Glazing Cover Solar Flat Plate Collector

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Abstract- Solar Flat Plate Collector is a well-known solar collector now days in the market for water heating and many more application both in rural and urban areas. The low maintenance and simple design and easy to operate made a focused in domestic home applications. The ideology in flat plate collector is to achieve the radiation energy received from the sun by heat absorption. In the present work a solar flat plate collector is fabricated to determine the performance of collector when it is fabricated using doubled glazing cover and also determine the heat gain and efficiency of the collector by maintaining constant flow rate of water when tested in a location at Hyderabad.

Key Words: Solar Flat Plate Collector, Absorber Plate, Glazing Cover, Radiations, Efficiency, Constant flow rate, Energy.

I. INTRODUCTION

Solar energy is the energy available from the sun. The sun radiates a huge amount of energy in the form of light and heat consequential commencing nuclear fusion reaction. Heat energy received from sun can be utilizes as heat energy for water heating, space heating and some energy can converts sun-light energy to electrical energy. Solar energy is one form of non-conventional energy source which are inexhaustible in nature. Solar energy that receives from the sun into space eternally reaches the earth, but only very amount can be extracted which is enough to supply all needs of energy both domestic and industrial applications. The sun constantly delivers 1360j/s/m^2 to the earth [2]. Solar energy is mostly used in heating builds and water and also to generate electricity. The suitable device for collecting this energy is Flat Plate Collector (FPC). FPC absorbs the solar radiation receiving from the sun and converts it into heat by absorbing surface, and transmits the same heat to a working fluid passing through the collector. The amount of warm water collected from collector can either directly be used as hot water or can store and can be reused whenever required i.e. at night and on unclear days. Collectors are two types one is Flat plate collector and another is concentrating collector. This are differentiate based on their application of usage. The main part of a solar collector is absorber, which are thin metal sheets arranged side-by-side. The working fluid used intended for transfer of heat usually passes throughout a metallic pipe, linked with absorber.

A. *Components of FPC*

a. Absorber plate: It is made of copper material, and can be black coated for maximum absorption of sun radiations declining on to the surface.
b. Tubes or fins: These are used for directing the heat to transfer to the working fluid from the inlet duct to the outlet.
c. Glazing: This is a glass sheet which is placed on the top of the collector for transmitting the radiation to the absorber. The material used is either plastic film or sheet.
d. Thermal insulation: This is used to minimize heat loss from the plate.
e. Cover strip: These are used to hold the components in their respective position.
f. Container or Casing: These are surrounded around the collector to prevent it from dust and moisture.

II. LITERATURE SURVEY

Solar water heater for domestic and industrial purpose is designed [1], the device is compared with unconventional energy source by considering the cost and capacity. The design was focused on absorber plate, material used for plate, glass cover i.e. top cover and coating of the top cover and insulating material used. Later it was disused about the installation location of the collector. This paper is focused on the thermal efficiency of the solar flat plate collector and instantaneous efficiency of the collector in a day[2]. The major application of solar energy is water heating and industrial purpose. Fixed collector has low effectiveness due to its nature sources of energy. To overcome this tracking mechanism is introduced with flat plate collector to increase the performance of the collector. To predict the performance a test rig is fabricated for experimental study. The efficiency was increased to 21% when compared with non tracking sola flat plate collectors.

Solar collector for heating space having the standard dimensions [3] of window is fabricated as flat plate solar air collector. Absorber plate is coated with black paint to absorb more energy from the sun. Glass wool insulating material is used for protecting from heat losses. The experiment was carried out one week based on the climatic conditions; a uniform data was collected to determine the collector efficiency using natural convection and forced convection at different inlets and outlets in addition to average air speed. An average 21% of air is collected using forced convection over natural convection. KOLEKTOR 2.2 software tools [4] based on mathematical model is designed to validate the experimental results of performance of solar thermal flat plate collector using various parameters which influence on the performance. This software was helped in determined the performance of solar collector. Computational fluid dynamic (CFD) was simulates to understand the heat transfer capacity of solar collector. Solar collector is used for household application based on inside and outside climatic conditions. The water is heated using crude oils is a common procedure which are more costly than the non conventional energy sources. In this present works [5] numerical simulation of flat plate collector is designed and controlled. 3D model of collector and absorber plate is modeled using Solidworks and simulated using Ansys Fluent software. The propose of the project is to understand the temperature distribution within the collector, future the designed is optimized to improve the efficiency of the collector.

Demonstration project in Europe was present in monitoring the performance of solar thermal field of meat factory. The paper focused on performance of solar collector efficiency and transient effect [6] on the measure fields. A bin method is applied to analysis of July month of 2014. Finally medium performance was investigated throughout the decay. Solar flat plate collector is one of the most commonly used devices for space heating and water application required for temperatures less than 100ºC. Absorber plate, top cover and heating pipe are the major components of the flat plate collector. The objective of the study is evaluating the performance of SFPC [7] using various geometric absorber configurations. Thermal efficiency of the collector is obtained. Cost of FPC can be reduced to enhance the efficiency. To determine the performance collector is fabricated using IS standards and tested in laboratories. Solar energy collected from sun emphasis to develop the active solar energy system for integrating it for heat storage, heat exchange, control system, and fluid system [8]. The major components involved are absorbing surface, insulator and glazing covers. These devices are usually used in transferring or converting the amount of energy received from the sun in useful form. Many factors were discussed to formulate mathematical model to determine the efficiency of the collector in cloudy days. Flat plate collector is major and foremost solar collector works under the temperature range of 60oC to 100oC [9]. In the present work a series of circular cross sectional tubes are bonded to absorber plate for absorbing the heat and transfer it to working fluid. Flat plate with trapezoidal shape was fabricated. The heat has increased by an efficiency of 45.79% with maximum outlet temperature of 56oC and 69.3oC of absorber plate temperature with 25 kg/hr mass flow rate.

CFD analysis was used to predict the performance of the solar collector for many applications [10]. In this present work a 3D solar collector is modeled and analyzed sing Ansys Fluent to indicate the temperature distribution of the temperature throughout the collector. The key purpose of present design of solar flat plate collector by CAD software [11] is performed for thermal analysis in the month of March at 11am, 12, 1pm & 2pm by keeping mass flow rate as constant. The same was modeled using GAMBIT 2.4 and analyzed in ANSYS FLUENT used. Mathematical modeling was made for describing the performance of solar thermal [12] collector drawn in night and cloudy days. The working fluid used in this work is water. The energy received from sun was absorbed and converted in useful form of heat.

III. FABRICATION OF COLLECTOR

Collector is fabricated using wood as blocks as container. Absorber plate made of aluminum sheet is placed inside the container and coated with black paint for more absorption of heat from the sun. GI pipes are welded to the absorber plate where the working fluid passes through the pipe line to absorber the heat absorbed by the absorber. Two glass covers maintaining 10mm distance between each is placed on the top of the contained and insulated by thermocol as shown in fig.1 to 2.

Fig.1: Fabrication of Solar Collector

Fig.2: Experimental Set for testing the collector.

IV. RESULTS AND DISCUSSION

A. Flat Plate Collector Efficiency

The efficiency of flat plate collector can be estimated by an energy that determines the portion of the incoming radiation delivered as useful energy to the working fluids for flat plate collector, the useful heat gain (Q_U) can be calculated by the formula below.

$$Q_u = mcp(t_o - t_i)$$

Where

Q: the useful heat gain (watts)
m: Mass flow rate (kg/s) = 0.277kg/sec
c_p: Heat capacity at constant pressure (kJ/kg.K)
t_o: Fluid outlet temperature (°C)
t_i: Fluid inlet temperature (°C)

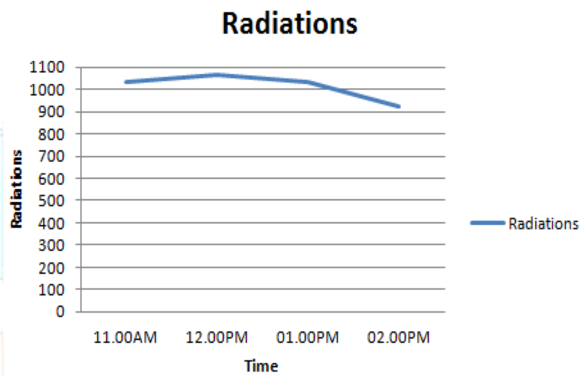
After obtaining the useful heat gain, (Q_u), the efficiency of the flat plate collector can be calculated by using;

$$\eta = \frac{Q_u}{A * I_T}$$

I_T: Energy gain from solar radiation(W/m^2)
A_C:Collector absorber area(m^2)
Q_u:Energy absorbed by the flat plate collector(W)

Table 1: Efficiency of FPC at slope 10° on 10th May 2017 (Minimum Temperature in the Month)

Slope	Hour Angle	Radiation (W/m²)	Inlet Temp	Outlet Temp	Heat Gain (W)	Efficiency %
10°	11.00AM	1029.72	34	44	12	3.28
10°	12.00PM	1066.49	36	54	21	5.71
10°	01.00PM	1029.72	35	46	13	3.61
10°	02.00PM	923.24	33	41	9	2.93



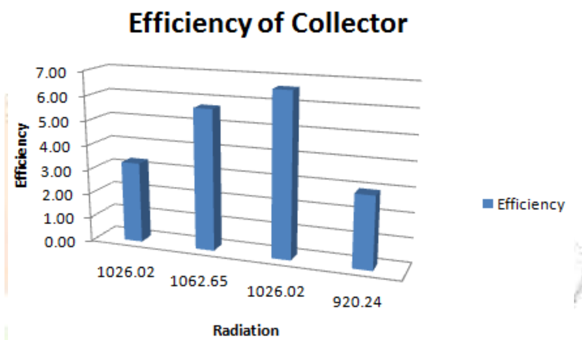
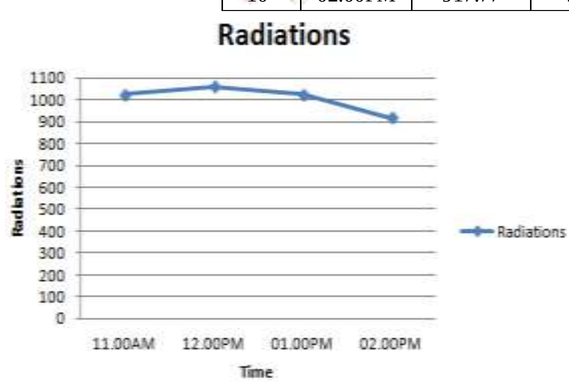


Fig.3: Time Vs Radiation Graph on 10th May 2017 **Fig.4: Efficiency of Collector based on Available Radiation on 10th May 2017**

Table 2: Efficiency of FPC at slope 10° on 19th May 2017 (Maximum Temperature in the Month)

Slope	Hour Angle	Radiation (W/m²)	Inlet Temp	Outlet Temp	Heat Gain (W)	Efficiency %
10°	11.00AM	1023.25	42.5	54	13	3.80
10°	12.00PM	1059.62	43	65	25	7.02
10°	01.00PM	1023.25	42	53	13	3.63
10°	02.00PM	917.77	41	51	12	3.68



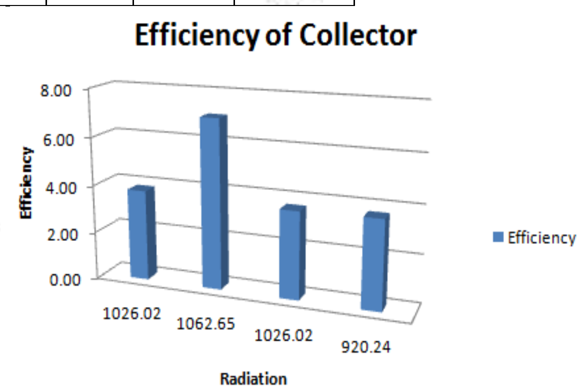


Fig.5: Time Vs Radiation Graph on 19th May 2017 **Fig.6: Efficiency of Collector based on Available Radiation on 19th May 2017**

Table 3: Efficiency of FPC at slope 10° on 15th May 2017 (Average Temperature in the Month)

Slope	Hour Angle	Radiation (W/m^2)	Inlet Temp	Outlet Temp	Heat Gain (W)	Efficiency %
10°	11.00AM	1026.02	38	49	13	12.06
10°	12.00PM	1062.65	39	59	23	21.18
10°	01.00PM	1026.02	37.5	49	13	12.61
10°	02.00PM	920.24	36	45	10	11.07

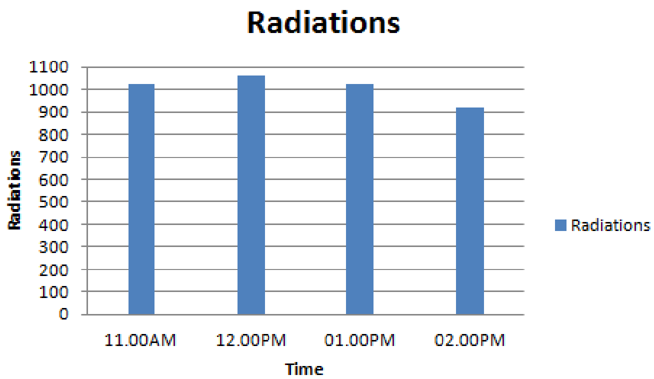


Fig.7: Time Vs Radiation Graph on 15th May 2017

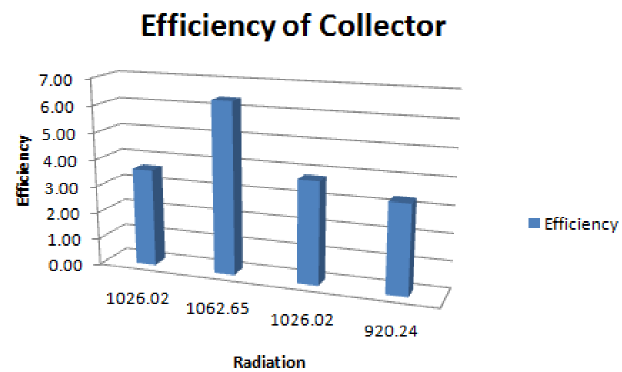


Fig.8: Efficiency of Collector based on Available Radiation on 15th May 2017

V. CONCLUSION

Based on the results obtained the following are the conclusions made

1. Maximum temperature of 43°C found to be on 19th may 2017; the average energy gained is 15.75W Minimum temperature of 36°C on 10th May 2017; the average energy gained is 13.5W and average temperature of 39°C on 15th May 2017; the average energy gain is 14.75W.
2. Radiations are calculated by using the calculation obtained from [13, 14, and 15] and considering slope angle of 10°. Maximum radiations of 1066.49 W/m^2 is obtained at 12.00PM on 10th May 2017.
3. Collector having dimensions of area $0.342m^2$ and 1m long, and $0.277kg/m^3$ constant flow rate have the average efficiency of 4.54% on 19th May 2017 when compared with all other days calculated in the same month.
4. Maximum water temperature is 65°C at 12.00PM on 19th May 2017 and Minimum water temperature is 41°C at 02.00PM on 10th May 2017. The heat gain at this temperatures is 25W at 12.00PM and 9W at 02.00PM.

Solar Flat Plate Collector is one of the suitable device for water heating application that has to be followed both in rural and urban areas to overcome the power problem and to save energy.

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