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Fabrication of low cost solar flat plate collector

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ABSTRACT

Flat plate collector is a device which is used to collect the sun radiation and convert it into thermal energy. The main parts of the flat plate collector (solar geyser) are the glazing, pipes, heat collecting absorber flat and insulating body. In this research an effective flat plate collector has been fabricated for solar geyser, which is low cost, simple design, and easier installation for heating purposes. More focus has been given to the heating loss and collecting solar radiations. Controlling the heat loss, the fluid can absorb more thermal energy which increases the efficiency. A different technique has been employed to enhance the efficiency of solar geysers. Effect of using double glazing to control the heat losses, because the temperature between glass covers and the absorber is not equal to environment. Increasing the length and reducing the diameter of the pipe improved the heat harvesting and observes more heat from absorber sheet.

1. INTRODUCTION

The burning of fossil fuels increase air pollution, the level of CO2 has increased more than 30%, and surface temperature increased about 0.8 ^{o}C, causing climate change [1-2]. On the other side much energy is required to industries due to increase in population. The renewable energy concept can solve this problem. It is the energy obtain from natural processes which refilled constantly. The energy is collected from renewable resources are naturally refilled by wind, rain, tides, sunlight (sun irradiation) and geo heat. This energy cannot be collected without proper systems such as wind turbine, photovoltaic (PV) panel and solar thermal collector, which may provide the best way to get energy without air pollution, low cost and with high yield [3].

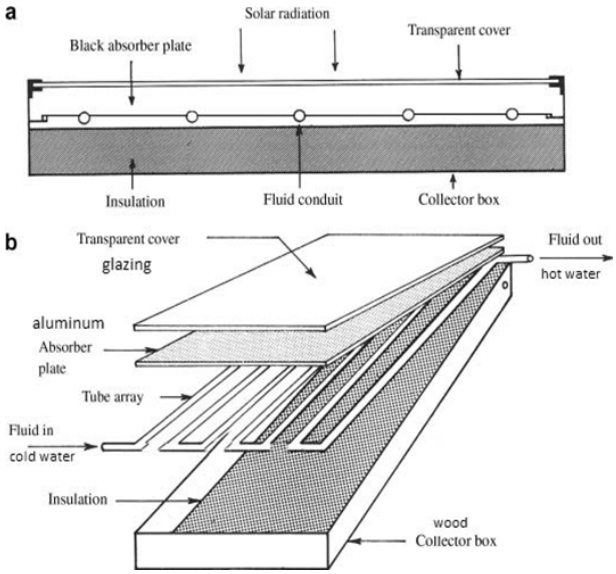

Fig. 1. *Schematic of flat plate collector*

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The sun is the closest and a large energy source for the earth, a large amount of energy is received from the sun to the earth. The earth receives light and heat from the sun and receive enough energy in the form of heat. Solar energy has great potential and zero carbon emission [4]. In renewable energy solar energy is one of the most common and outstanding source of energy. This energy is low cost and environment friendly.

We can get solar energy in different ways. Here in this work solar thermal collecting method is represented. Solar collector can be classified in two types, concentrating and non-concentrating. Non-concentrating is further divided more in evacuated tube collector and flat plate collector. Flat plate collector plays a key role in solar energy. It is a type of heat exchanger between source and liquid flow in it [5]. When the sun radiations fall on it, it converts sun irradiation into thermal energy and transfer it to liquid by using the well-known greenhouse effect. Typically, Collector refer the device which collect sun radiation. This radiation is in the form of electromagnetic radiation (long and short wavelength).

Flat plate collector is more effective due to low cost, simple design, and easier installation compare to other form collecting solar radiation system. This controls the building owner's bill for energy to heat water.

Flat plate collector is an insulated box with glass cover (glazing) which does not absorb sun radiation and a large absorber sheet of metal typically aluminum or copper, because these metals are good heat conductor. Copper is best conductor but aluminum has low cost. This absorber sheet is made blackened which absorb more sun radiation and on absorber sheet the copper pipe is attached in zig zag arranged which contain the heat transfer liquid or fluid (specially water). When the sun radiation falls on absorber sheet and it increase the temperature of absorber surface and as the sheet get hooter it transfers it heat to copper pipe and the fluid absorb the heat from copper pipe, which is then used in heating application, such as room heating, water heating and many other industrial applications. If user need hot water day and night so an insulated tank is used to store hot water during the day and use as owner needed. This may be direct or indirect. 13% Use of hot water in home is the 2nd essence energy demand of Scotland [6]. The coper pipe and absorber are enclosed in a wood box and glazing on the top. To control heat losses a rigid foam is used on the sides and bottom by Hottel and woertz in 1942 and hollet and whiller in 1958 [7-8].

Many researchers reported different development and analysis technique to increase the performance of flat plate collector in USA [9-10]. They describe the way to increase the efficiency and can collect more radiation of the sun.

In the solar collector some of heat is lost into environment. These thermal losses include, (a) heat lost from glazing due to wind, (b) heat lost due to radiation back to sky, (c) heat lost due to air between absorber and glazing. The heat is lost through the glass cover (glazing) because the temperature in between glass covers and the absorber is not equal to environment, so the heat is lost though the glass cover. To minimize the heat losses by increasing the number of glazing, instead of single glassing by using double glassing which can improve the efficiency of the flat plate collector. In between these glassing there will be vacuum which help to control the heat losses. if once we control heat losses, it will increase the efficiency of the flat plate collector and get more heat on absorber which transfer these heat to fluid

In development of pipe designing which is zigzag shape and also by decreasing the width of the pipe and increasing the number of the pipe which gave better performance because it covers more area of the absorber and can get more heat from absorber plate.

2. METHODOLOGY

As we know that solar flat plate collector is a system for heating liquids, this system is commonly used in houses, offices and industries. This increase the temperature of liquids to several degrees by trapping the solar radiations coming from the sun. The system is designed in such a way in which the sun radiations are easily trapped and increase the temperature of liquid.

Flat Plate collector have some main parts such as Transparent Glazing, Absorber plate (Aluminum plate), the Riser (tubes for liquid passage), and a casing box for these parts.

2.1. Transparent Cover (Glazing)

The materials of glazing cover are transparent to solar short wavelength radiation. The water white glass which is purely transparent is more suitable material, instead of using any other plastic materials. As we know that a portion of heat is losses from the heated cover by a convection and reflection, so the heat loss is controlled by increasing the number of glazing. The space between first glazing and absorber is equal to 1.5 inch.

2.2. Black Absorber Plate

Absorber plate of a solar water geyser is a metal, usually the aluminum or copper, we use an aluminum plate. Aluminum has very low density therefor it is very lightweight. It is a very good conductor of heat and electricity, so due to best conductivity we use Aluminum or copper plate as an absorbing material. The liquid tube is attached on the top of the plate. The aluminum plate is coloured dark with black paint; the black paint should be thin. The coatings have high absorptivity to short wavelength radiations. The length of the plate is 4.5 ft, and its width is 3 ft.

2.3. Heat Transport system and fluid

Actually the liquid which is used here is mostly water because the water is very effective heat transport medium, but some un fever conditions are caused due to water. as the water may be get freeze in tubes under some conditions such that during cold nights or in winter weathers the atmospheric temperature decreases which may cause the water freeze, once the water is freeze in the tubes then it might be very difficult to be heated soon. another problem of passing water through tubes is of corrosion of metal by water, due to this situation the leakage may be happened. So instead of using water we can also use fluids (Ethylene glycol), Ethylene glycol is an organic compound with the formula $(CH_2OH)_2$. its boiling point is 197.3 ^oC and its density is 1.11 g/cm^3. For better heat transfer the tubes are arranged in such a way in which the liquid rotates in zig zag rotation to get the solar heating continuously. The length of the tube is 35ft long.

2.4. Heat Losses Control components

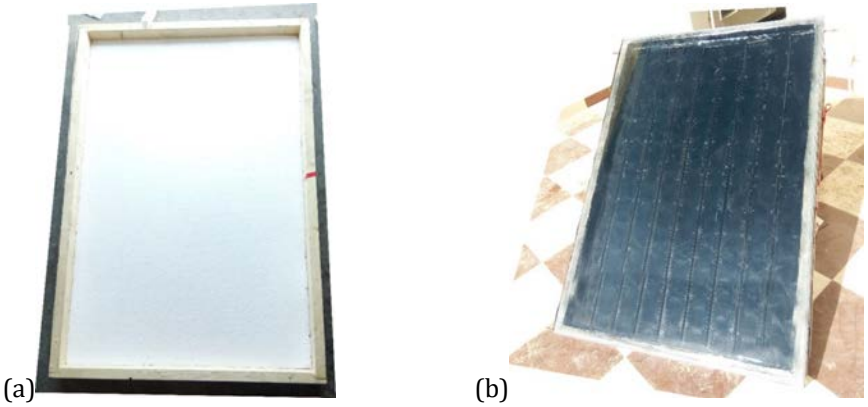
To the efficiency of solar geyser can be increased by controlling the heat losses. As discussed above that a way to control heat losing is by glazing, the glazing may be given single or double but the best way to control heat losing is to give double glazing. but some other components are also used to control heat loss, the foam with a thickness 1.5 inch is fixed in the casing (Frame), behind the absorber, and the double hardboards of wood are also fixed over the foam in the casing. There is a vacuum between the absorber and foam which may be a good way to control heat losing.

2.5. Casing (Frame)

The casing or frame is a nonfunctional component. Which control heat losing from the side and also give support to all other components of the flat plate collector and protection. The casing of the flat plate collector is a frame made of wood with a length equal to 4.9 ft and width equal 3.3 ft. the wooden frame is covered with an iron plate sheet.

Table 1. *Specifications of the flat-plate collector*

Specifications	flat collector	Unit
Dimensions of frame	135×99	cm
Absorber area	122×92	cm
Glazing thickness	4	mm
Absorber thickness	1.5	mm
Frame (aluminum)	-	-
Piping	D=6.2, t=1.1	mm
Piping length	35	ft
Weight	34	kg
Insulation (polystyrene and wood)	3.8	cm



(a) (b)

Fig. 1. *Casing of the flat plat collector and assembled flat plate collector*

3. RESULTS AND DISCUSSIONS

The assembled flat plate collector was installed with the water supply take placed on the top of the roof and obtained the data as shown in the table 2. The data was taken between 10.30 am to 2.25pm with the initial ambient temperature 21°C.

Table 2. *Observations and calculation between time and varying temperature of solar geyser*

S.No	Timing (t)	Ambient Temperature (T_1) ^{0}C	Temperature of water before observation (T_2)	Temperature of water after observation (T_3)	Water Flow rate (liter/30 sec)
1	10:30 am	21	17	22	0.5
2	10:40 am	23	17	31	0.5
3	10:50 am	24	17	33	0.5
4	11:03 am	24	17	41	0.5
5	11:13 am	24	17	43	0.5
6	11:24 am	25	17	44	0.5
7	11:34 am	27	17	44	0.5
8	12:30 pm	26	18	44	0.5
9	12:40 pm	26	18	43	0.5
10	12:50 pm	27	18	44	0.5
11	01:00 pm	28	18	44	0.5
12	01:55 pm	27	17	41	0.5
13	02:05 pm	26	17	39	0.5
14	02:15 pm	24	17	37	0.5
15	02:25 pm	23	17	35	0.5

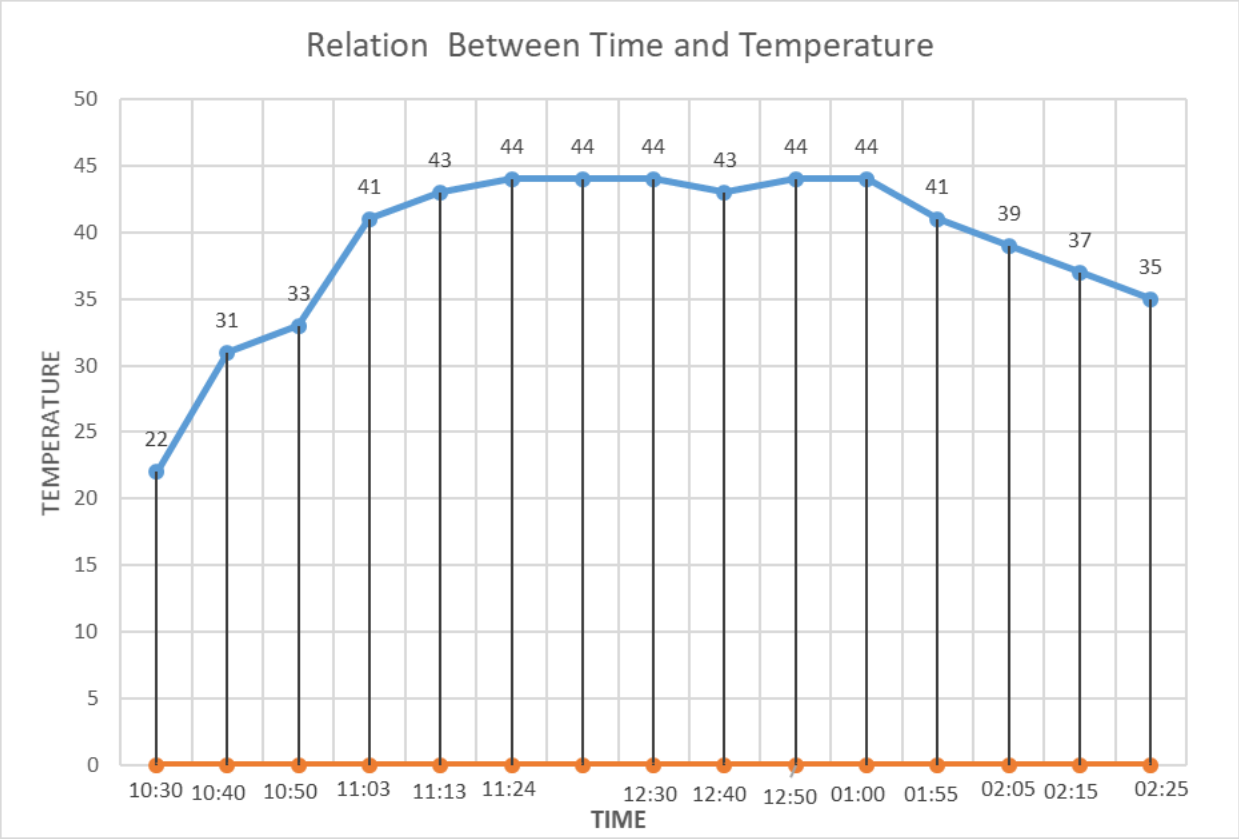


Fig. 3. *Temperature obtained by the flat plate collector in different timings*

Figure 3 shows the graphical results between time and temperature of ambient and flat plate collector. In the beginning on 10:30 am the result shown was 22 °C, after waiting for 10 minutes at 10:40 am the temperature of outlet water reached to 31 °C, from 11:13 am to 11:24 am the temperature of water raised to 44 °C. and remain constant as shown in the curve diagram till 12:30 pm, but then suddenly ambient temperature decreased due to which water's temperature also

decreased at 12:40 pm for one degree, and reached to 43 ^{o}C. it is all because of blowing of air in the atmosphere. After 10 minutes at 12:50 pm the temperature again raised for one degree, and reached to 44 ^{o}C, and remain constant till 01:55 pm. And on 01:55 pm the temperature decreased and came down to 39 ^{o}C. Gradually after each 10 minutes it is observed that temperature becoming down as shown in the curve diagram.

4. RESULTS AND DISCUSSIONS

In this research a simple low cost solar thermal flat plate collector was fabricated which can be used as solar geyser. To control the heat losses double glasses glazing was used.

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