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Fabrication and Testing of Solar Heat Collector by using alternative Absorber and Glaze Materials

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Abstract: Now a days we are using the solar water heaters as source of renewable energies in order to harvest the heat energy from sun for our daily proposes. In the solar water heaters, the main component which harvest the heat energy is the collector. The solar heat collectors we are using today are very highly engineered in order grab the lot of heat but due to the engineering and designing with particular materials is raising cost of collector so much extent.

In order to reduce the cost and we want to create a solar collector which is so basic in design and selection of materials and can able to perform nearly best to some of the efficient collectors out there. For that we are replacing the engineered glaze with regular window glass and the absorber plate is shift down to the pipes which is coated with the aluminium foil sheet in order maximize the reflection. By this we want to make it possible to a middle-class person to use the solar water heaters in their homes so that he can also put his contribution towards leaving the fossil fuel world.

Keywords: Solar heat collector, Absorber, Glaze materials, Autodesk Fusion 360, and Experimental Analysis.

I. INTRODUCTION

Solar thermal collector is a fascinating device which works only based on the solar gain and gives the unimaginable temperatures and the world is moving to the non-conventional energy sources day by day. This solar thermal collector is taking their part in solar water heaters to giving from hot water to steam. It is everyone are spending lots of money on solar water heaters in which the collector is taking major cost which has so much scope to optimise for cost efficiency.

II. FABRICATION OF SOLAR HEAT COLLECTOR

A. Components Required

In order the make the fabrication possible we need to take a list of components needed here are they.

1) A Hard copper pipe of ¾ ‘diameter – 2m long
2) A Soft copper pipe of ¼ ‘diameter – 15.4m long
3) Two CPVC ball valves of ¾ ‘diameter
4) Two CPVC dummies of ¾ ‘diameter
5) A Sealing pastes
6) A ply wood sheet of 1000x1000x17 mm
7) A G.I sheet of
8) An aluminium foil sheets
9) Some glue
10) A frame work that holds all this equipment

B. Fabrication Process

In order make the fabrication process smooth we started the process with copper. As the copper is one of the best conducting metals genre after gold and silver. So, we have chosen copper as perfect match between cost and conductivity. First we have taken a ¾ ‘diameter pipe of length 2m and we’ve cut it in two equal parts. Our design is a parallel tube collector as shown below. The software we have employed to design the project is Autodesk Fusion 360.

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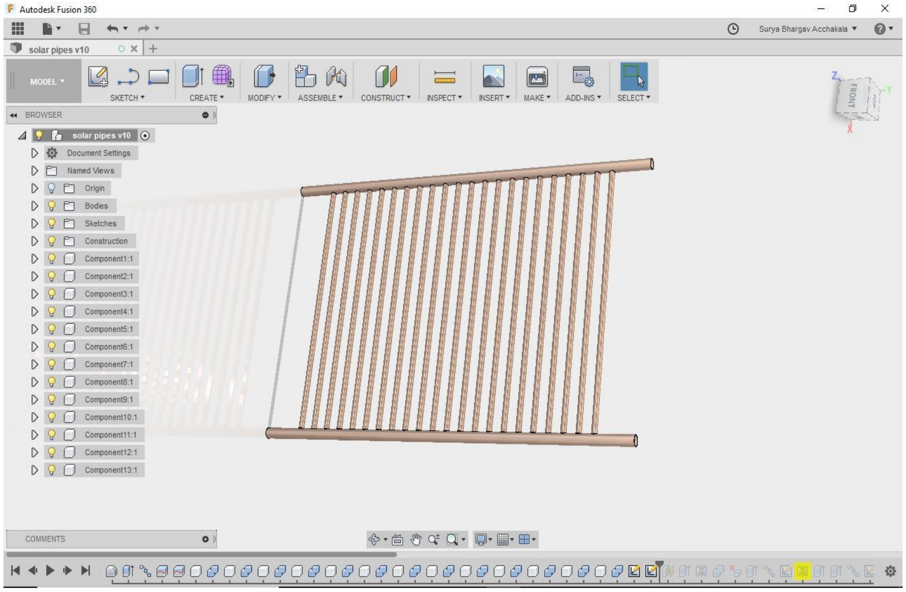

Fig. 2. 1: The design of parallel tube copper collector

Fig. 2. 2: the complete virtual design of collector

To make design possible we need to make around of total 22 holes for each ¾ copper pipe segment. So, we've drawn a straight ling throughout the pipe and then drilled the holes.

Fig. 2. 3: holed copper pipes

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The we have welded the ¼ ‘diameter pipes using oxyacetylene gas welding with copper filler material. Then we have got this.

Fig. 2. 4: welded pipe

Then we have grinded it to remove the burrs and rust on it. Then we started to assemble the setup first we have got a ply wood and cut down it to the desired measurement of 800X700 and supporting planks 4-inch height for supporting glass and then we have nailed it and then we had painted it.

Fig. 2. 5: Painting wooden frame

We have asked for a drawing table flame which has an inclination angle of 130.Our generous management has grated it to us we are so thankful to them, we have screwed the wooden frame to iron frame. In order to increase the reflectiveness, we have added a GI sheet on which we pasted an aluminium foil. Then we have assembled the copper pipes with wooden frame and made a grove and installed the glass on it the final device shown in below.

Fig. 2. 6: aluminium foiled frame

Fig. 2. 7: The fabricated heat Collector

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III. EXPERIMENTATION

A. *Observation No. 1*

All the time we had fabricated the system, now it's time for us to test it weather it is reaching the expectations or not
It is conducted on 08/03/2018. It is a clear spring day with a maximum atmospheric temperature of 35.3^{0}C. we have tested it without water on this day.

Table 3. 1: Test Case-1

Date: 8/3/18

Time	Atmospheric temperatures(^{0}C)	Chamber temperature(^{0}C)
9:45	28.1	35.8
10:15	29.8	63.8
10:45	32.3	74.2
11:15	32.4	77.4
11:45	32.5	77.8
12:15	33.3	78.3
12:45	33.3	79.3
13:15	34.2	81.9
13:45	35.2	81.9
14:15	34.1	82.0
14:45	33.7	78.2
15:15	34.2	76.8
15:45	33.1	70.9
16:15	31.9	68.7
16:45	31.1	63.9
17:15	31.0	56.8

B. *Observation No. 2*

All the time we had fabricated the system, now it's time for us to test it weather it is reaching the expectations or not
It is conducted on 10/03/2018. It is a clear spring day with a maximum atmospheric temperature of 35.3^{0}C. we have tested it without water on this day.

Table 3. 2: Test Case-2

Date: 10/03/18

Time	ATM temperature(^{0}C)	Chamber temp. (^{0}C)	Water temp.(^{0}C)
10:45	31.6	38.1	28.6
11:15	31.2	4.3	3
11:45	32.5	61.5	61.5
12:15	32.3	67.1	72
12:45	32.7	68.8	73
13:15	32.6	68.9	68.3
13:45	33.3	68.9	67.8
14:15	32.9	79.3	78
14:45	32.7	68.7	72
15:15	32.2	62.6	71
15:45	31.	60.3	62
16:15	30.8	56.5	53.7
16:45	30.5	52.7	47.2
17:15	30.5	50.8	44.1
17:45	30.5	46.8	40.3
18:15	29.8	39.6	30.2

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IV. EFFICIENCY CALCULATION

If I am the intensity of solar radiation, in W/m^2, incident on the aperture plane of the solar collector having a collector surface area of A, m^2, then the amount of solar radiation received by the collector is:

$$Q_i = I.A$$

I intensity of solar radiation, W/m^2
A collector area, m^2
Q_i collector heat input, W

As the collector absorbs heat its temperature is getting higher than that of the surrounding and heat is lost to the atmosphere by convection and radiation. The rate of heat loss (Q_o) depends on the collector overall heat transfer coefficient (UL) and the collector temperature.

$$Q_0 = U_L A(T_c - T_a)$$

Q_O heat loss, W
U_L collector overall heat loss coefficient, W/m^2
T_C collector average temperature, °C
T_a inlet fluid temperature, °C

The instantaneous thermal efficiency of the collector is:

$$\eta = 1 - \frac{Q_0}{Q_i}$$

Calculations:

The Heat input for collector $Q_i = I \times A$ =6580× 0.089=292.81W

Case-1: T_c=68.1^{0}C, T_a = 30.3^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$
$$=51.2\times 0.089 \times (68.1°C - 30.3°C)$$
$$=172.247W$$
$$\eta = \frac{Q_i - Q_O}{Q_i}$$
$$\eta = \frac{292.81 - 172.247}{292.81}$$
$$\eta = 41.1\%$$

Case-2: T_c=80.5^{0}C, T_a = 33.1^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$
$$=51.2\times 0.089 \times (80.5°C - 33.1°C)$$
$$=215.99W$$
$$\eta = \frac{Q_i - Q_O}{Q_i}$$
$$\eta = \frac{292.81 - 215.99}{291.81}$$
$$\eta = 26.2\%$$

Case-3: T_c=50.9^{0}C, T_a = 32.2^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$
$$=51.2\times 0.089 \times (50.9°C - 32.2°C)$$
$$=85.212W$$
$$\eta = \frac{Q_i - Q_O}{Q_i}$$
$$\eta = 1 - \frac{85.212}{292,81}$$
$$\eta = 70.8\%$$

Case- 4: T_c=70.2^{0}C, T_a = 33.3^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$
$$=51.2\times 0.089 \times (70.2°C - 33.3°C)$$
$$=168.14W$$

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$$\eta = \frac{Q_i - Q_O}{Q_i}$$

$$=1 - \frac{168.14}{292.81}$$

$$\eta = 42.5\%$$

Case-5: T_c=54.3^{0}C, T_a = 31.2^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$

$$=51.2 \times 0.089 \times (54.3°C - 31.2°C)$$

$$=105.262W$$

$$\eta = \frac{Q_i - Q_O}{Q_i}$$

$$\eta = 1 - \frac{105.262}{292.81}$$

$$\eta = 64.05\%$$

Case- 6: T_c=52.7^{0}C, T_a = 30.8^{0}C

$$Q_O = U_L \times A \times (T_C - T_a)$$

$$=51.2 \times 0.089 \times (52.7°C - 30.8°C)$$

$$=99.793W$$

$$\eta = \frac{Q_i - Q_O}{Q_i}$$

$$\eta = 1 - \frac{99.793}{292.81}$$

$$\eta = 65.9\%$$

V. RESULTS

A. As we seen above in observations we have reached a maximum temperature of 82.2^{o}C without water in it. By including water, we have reached temperature of 79.3^{0}C of chamber temperature and 78^{0}C of water temperature has achieved.

B. The efficiency has been affected heavily by the atmospheric and chamber temperatures under heavy fluctuations anyway we have achieved a maximum efficiency of 70.8%. for fabricated solar heat collector.

VI. CONCLUSIONS

A. As we seen above in the results which are looking some much fascinating under standard assumptions. We have achieved our objectives of project to see how flat plate collectors works in practical by fabricating and testing them and to give cost efficient flat plate collector and to give a device for further future research work to excel the science of flat plate collectors.

B. This is cost efficient flat plate collector, cost is Rs. 6000/-, which can make a big difference for a middle-class person and help him to grant his wish to give his hand in the future of non-conventional energy source.

VII. FUTURE SCOPE

As we have prepared a flat plate collector and made primary analysis on it. It needs in depth analysis in order to figure out what the collector is capable off. It can undergo slight and costless modifications like creating a concentric for every pipe in the circuit inserting some copper plates to increase heat conduction area of fluid and many more there huge scope to enhance this project make it more efficient and affordable as well.

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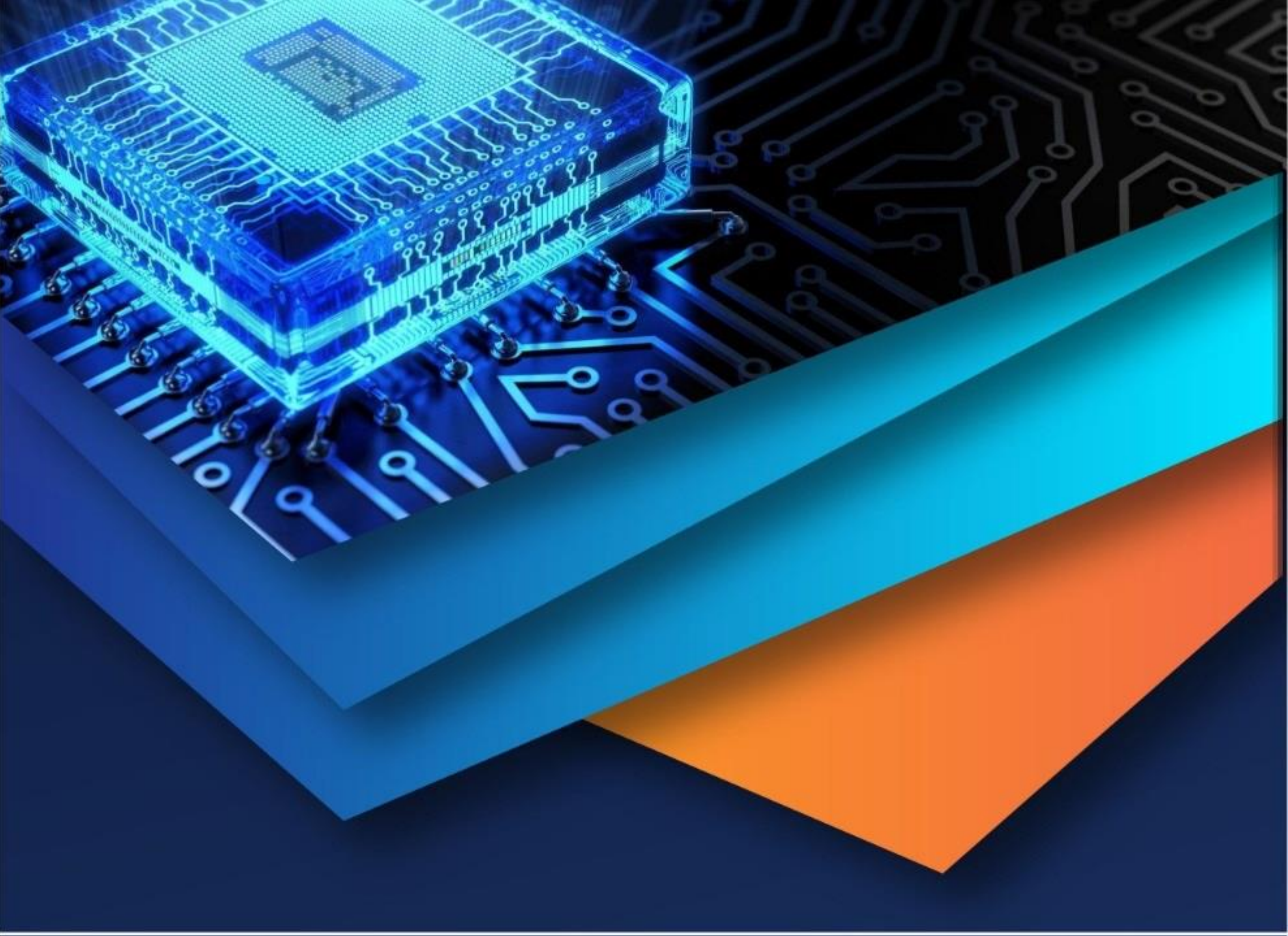

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