# Experimental Investigation of Double Pass Solar Air Heater with Different Arrangements Using Aluminium Material

[1]Maulik Sukhadiya, [2]Kaushik Savaliya, [3]Krunal Parikh
[1]M.E Scholar, [2]Assistnat Professor,
[1]Department of Mechanical Engineering,
[1]Gandhinagar Institute of Technology, Gandhinagar, Gujarat, India

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***Abstract* - solar air heaters are used for applications at low and moderate temperatures such as; crop drying, timber seasoning, and space heating. This method substantially improves the collector efficiency by increasing the fluid velocity and enhancing the heat-transfer coefficient between the absorber plate and air. These types of collectors had been designed as a proposal to use an absorbing plate made of aluminium cans into the double-pass channel in a flat-plate to build absorber plates of SAHs at a suitable cost. In the first type (Type I), cans had been staggered as in order on absorber plate, while in Type II they were arranged in zigzag. Type III is a flat plate arrange with baffles. For the same flow rate, the efficiency of the double pass is found to be higher than the single pass. An efficiency test was used to find the best fin arrangement of the receiver. Air enters the upper channel and lower channel of the air heater flows to outside in the parallel direction. If 2-10 m/s speed limit of air in piping system is assumed, proposed some arrangement fin technology enables an efficiency improvement in relation to the smooth pipe arrangement of the solar collector with black paint.**

***Index Terms* - Introduction, Experimental setup, Thermal performance, Result and Discuss**

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## I. Introduction

The main applications for SAHs are space heating, drying and paint spraying operations. Numerous SAH devices have been developed and used experimentally [1]. A glass or transparent cover is fixed above the absorber plate and the system is insulated thermally from the back and from the sides. SAHs are simple in design and maintenance. Corrosion and leakage problems are less severe compared with liquid heater solar systems. The main drawback of an SAH is that the heat-transfer coefficient between the absorber plate and the air stream is low, which results in a lower thermal efficiency of the heater. However, different modifications are suggested and applied to improve the heat-transfer coefficient between the absorber plate and air [2]. There are different factors affecting the SAH efficiency, e.g. collector length, collector depth, type of absorber plate, glass cover, wind speed, etc. Increasing the absorber plate shape area will increase the heat transfer to the flowing air, but on the other hand, will increase the pressure drop in the collector; this increases the required power consumption to pump the air flow crossing the collector [3]. Several configurations of SAHs have been developed in literature. Various designs, with different shapes and dimensions of the air flow passage in plate type solar air collectors were tested. The double-flow type SAHs have been introduced for increasing the heat-transfer area, leading to improved thermal performance. The increases of thermal energy between the absorber plate and the air, which clearly improves the thermal performances of the solar collectors with obstacles arranged into the air channel duct. Sahu and Bhagoria [4] planned to investigate the effect for different pitch of 90 degree broken wire rib roughness on the enhancement of thermal performance of SAH. Ghoneim [5] investigated the effects of gap thickness on the performance of compound honeycomb using the solar collector. Sadasuke are made on the performance of a collector with a flow in the upper channel on the absorber plate as well as in the lower channel. Njomo [6] examined the unsteady state heat exchanges governing the functioning of an unglazed one-pass SAH utilizing a non-porous selective absorber. The mathematical model developed is then used to predict the thermal performances of such a collector.

## II. Experimental Setup And Measurement

A model of the constructed double-flow SAH system of collector is shown in Fig. 2, and photographs of the three different absorber plates of the SAH collector and the view of the absorber plate in the collector box are shown in Fig.3, Fig.4, and Fig.5 respectively. In this study, three types of absorber plates were used. The absorbers were made of aluminium sheet with black selective coating. Dimension and plate thickness for all three collectors were 1 m, 1 m and 2 mm, respectively. Normal window glass of 4 mm thickness was used as glazing. Single cover glass was used in all three collectors. Thermal losses through the collector backs are mainly due to the conduction across the insulation (thickness 3 cm) and those caused by the wind and the thermal radiation of the insulation are assumed negligible.

The absorber surface which is the most important part of the SAH consisted of 3 circular cross section air flow channels made of 32(16 _2, upper and bottom surfaces) aluminium cans painted in black in type I and the SAH consisted of five circular cross-section air flow channels made of 50(25_ 2, upper and bottom surfaces) aluminium cans painted in black in type II. Each aluminium can was opened on the top and bottom, their surface was cleaned using water. Thermocouples were positioned evenly, on the top surface of the absorber plates, at identical positions along the direction of flow, inlet and outlet air temperatures were measured by two well insulate thermocouples [10, 11, 12 and 13]. The output from the thermocouples was measured in degrees Celsius by temperature indicator. The total solar radiation incident on the surface of the collector was measured with a solar power meter. This meter was placed adjacent to the glazing cover, at the same plane, facing due south. The experimental setup was situated at Latitude 23˚ 09‟ 52""N and Longitude 72˚ 26‟ 27""E. The measured variables were recorded at time intervals of 30 min and include isolation, inlet and outlet temperatures of the working fluid circulating through the collectors, ambient temperature, absorber plate temperatures at several selected locations and air flow rates (HTCAVM-07 digital anemometer). The air was provided by a blower with a maximum capacity of rpm 16,000 and that can regulate by AC veriacmeter. The blower placed at the outlet of the collectors sucked in the air. All tests began at 10:00 AM and ended at 4:00 PM.

**(a) Type – I**

In this case the solar air heater conventionally manufactures. The temperature at the inlet and outlet are measure also the intermediate air temperature measure by the thermocouple. The mean plate temperature calculates. The air is first pass in series type from the inlet of the air heater as shown in Figure: 1 also the wind velocity is changing from 2 to 10m/s.

Figure: 1 Experimental setup Type – I

**(b) Type - II**

In this case the solar air heater conventionally manufactures. The temperature at the inlet and outlet are measure also the intermediate air temperature measure by the thermocouple. The mean plate temperature calculates. The air is first pass in series type from the inlet of the air heater as shown in Figure: 2. also the wind velocity is changing from 2 to 10m/s.

Figure: 2 Experimental setup Type – II

**(c) Type - III**

In this case the solar air heater conventionally manufactures. The temperature at the inlet and outlet are also the intermediate air temperature measure by the thermocouple. The mean plate temperature calculates. The air is first pass in series type from the inlet of the air heater as shown in Figure: 3 also the wind velocity is changing from 2 to 10m/s.

Figure: 3 Experimental setup Type – III

## III. Procedure For Experimental Setup

Here in this experiment I will work with the following different conditions: Double pass solar air heater with the aluminium can place in series form.[Type-I] Double pass solar air heater with the aluminium can place in zigzag form.[Type-II] Double pass solar air heater with the aluminium baffles place in offset as zigzag form.[Type-III] Taking the readings for air suction from the outlet of this arrangement by thermocouple.

Here all the conditions are further work with the varying the wind velocity of the air flowing through the air heater. In case of all above four conditions the wind velocity is changed with the values 2, 4, 6, 8 and 10 meters/seconds [14, 15, 16, and 17].

Table 1 Experimental specifications

| Double pass solar air heater with aluminium cans | | | |
|---|---|---|---|
| **Arrangement** | **Type - I** | **Type - II** | **Type - III** |
| Velocity | V = 2 m/s | V = 2 m/s | V = 2 m/s |
| | V = 4 m/s | V = 4 m/s | V = 4 m/s |
| | V = 6 m/s | V = 6 m/s | V = 6 m/s |
| | V = 8 m/s | V = 8 m/s | V = 8 m/s |
| | V = 10 m/s | V = 10 m/s | V = 10 m/s |

## IV. Calculate Thermal Efficiency

The thermal efficiency of the solar collectors (η) is defined as the ratio between the energy gain and the solar radiation incident on the collector plane [18, 19 and 20].

$$\eta = \dot{m}C_p\left(T_{a,out} - T_{a,in}\right)/(IA_C). \qquad (1)$$

Where,

m is the mass of air [kg/s],
$C_p$ is specific heat of air [k j/kg k],
$T_{a,}$ out is temperature at outlet of air [· C],
$T_{a,\,in}$ is temperature at inlet of air [· C],
*I is* solar isolation intensity [w/m2],
$A_c$ is collector area [m2],

## V. Results

An experimental investigate on DPSAH (double pass solar air heater) with alluminium cans the results as discuss below with graph of efficiency with respect to time. For each operating condition there are five comparative readings were taken for changing the velocity of the air flowing from the air heater. The change in the wind velocity changes the mass flow rate of the air heated by the air heater. The wind velocity is changed in order of 2, 4, 6, 8, 10 m/s for each operate conditions. From the equation 3.4.1 we can get the value of the air heater efficiency.

Table 1 as below which shows the efficiency versus time of DPSAH of Type 1 as respectively different velocity to 2, 4, 6, 8, and 10 m/s.

Table: 1 Efficiency of DPSAH Type -I arrangement

| Type – I | | | | | |
|---|---|---|---|---|---|
| Time | Date: 12-6-2014 to 16-6-2014 | | Velocity: - 2/4/6/8/10 m/s | | |
| Min | 2 m/s | 4 m/s | 6 m/s | 8 m/s | 10 m/s |
| 10:00 | 6.24 | 12.4 | 18.55 | 16.19 | 16.24 |
| 10:30 | 6.7 | 13.48 | 19.09 | 16.92 | 16.51 |
| 11:00 | 6.76 | 13.73 | 20.28 | 18.41 | 16.86 |
| 11:30 | 6.86 | 14.29 | 21.41 | 19.21 | 18.54 |
| 12:00 | 6.91 | 14.83 | 21.57 | 20.01 | 18.51 |
| 12:30 | 7.18 | 14.93 | 22.37 | 20.71 | 19.78 |
| 13:00 | 7.45 | 15.05 | 22.95 | 21.24 | 19.45 |
| 13:30 | 7.63 | 16.49 | 24.61 | 22.35 | 20.23 |
| 14:00 | 7.36 | 15.51 | 23.94 | 21.31 | 19.03 |
| 14:30 | 6.96 | 15.01 | 23.19 | 20.01 | 18.75 |
| 15:00 | 6.81 | 14.74 | 22.88 | 19.28 | 18.43 |
| 15:30 | 6.6 | 14.41 | 22.28 | 18.01 | 16.51 |
| 16:00 | 6.46 | 14.08 | 21.42 | 17.11 | 16.14 |

Table 2 as below which shows the efficiency versus time of DPSAH of Type 2 as respectively different velocity to 2, 4, 6, 8, and 10 m/s.

Table: 2 Efficiency of DPSAH Type -II arrangement

| Type – II | | | | | |
|---|---|---|---|---|---|
| Time | Date: 19-6-2014 to 23-6-2014 | | Velocity: - 2/4/6/8/10 m/s | | |
| Min | 2 m/s | 4 m/s | 6 m/s | 8 m/s | 10 m/s |
| 10:00 | 6.59 | 13.81 | 18.67 | 17.35 | 17.99 |
| 10:30 | 6.72 | 14.16 | 20.97 | 18.75 | 18.13 |
| 11:00 | 7.39 | 14.42 | 21.23 | 19.21 | 18.24 |
| 11:30 | 7.16 | 14.82 | 21.35 | 19.07 | 18.36 |
| 12:00 | 7.42 | 15.41 | 21.69 | 20.01 | 18.55 |
| 12:30 | 7.43 | 15.44 | 22.42 | 20.71 | 19.84 |
| 13:00 | 7.48 | 15.58 | 23.84 | 21.78 | 20.82 |
| 13:30 | 8.09 | 16.51 | 26.45 | 22.46 | 21.49 |
| 14:00 | 7.64 | 16.62 | 25.36 | 21.22 | 20.36 |
| 14:30 | 7.52 | 16.51 | 24.76 | 20.01 | 18.77 |
| 15:00 | 7.13 | 16.49 | 24.55 | 19.21 | 18.45 |
| 15:30 | 6.92 | 16.27 | 24.31 | 19.01 | 17.94 |
| 16:00 | 6.87 | 15.45 | 23.79 | 18.51 | 16.27 |

Table 3 as below which shows the efficiency versus time of DPSAH of Type 3 as respectively different velocity to 2, 4, 6, 8, and 10 m/s.

Table: 3 Efficiency of DPSAH Type -III arrangement

| Type – III | | | | | |
|---|---|---|---|---|---|
| Time | Date: 23-6-2014 to 30-6-2014 | | Velocity: - 2/4/6/8/10 m/s | | |
| Min | 2 m/s | 4 m/s | 6 m/s | 8 m/s | 10 m/s |
| 10:00 | 5.12 | 10.28 | 14.26 | 13.26 | 12.56 |
| 10:30 | 5.63 | 10.84 | 14.85 | 14.24 | 13.04 |
| 11:00 | 5.83 | 11.29 | 15.49 | 14.69 | 13.88 |
| 11:30 | 5.94 | 11.56 | 16.06 | 15.78 | 14.21 |
| 12:00 | 6.08 | 11.71 | 16.72 | 15.76 | 14.48 |
| 12:30 | 6.23 | 12.01 | 17.21 | 15.75 | 14.88 |
| 13:00 | 6.38 | 12.27 | 17.25 | 16.33 | 15.16 |
| 13:30 | 6.51 | 12.74 | 18.8 | 16.88 | 15.43 |
| 14:00 | 6.36 | 12.49 | 18.11 | 16.17 | 15.4 |
| 14:30 | 6.16 | 12.25 | 17.71 | 15.74 | 14.78 |
| 15:00 | 5.94 | 11.85 | 17.89 | 14.85 | 14.51 |

| | | | | | |
|---|---|---|---|---|---|
| 15:30 | 5.72 | 11.29 | 17.82 | 14.28 | 13.88 |
| 16:00 | 5.68 | 11.24 | 17.14 | 14.13 | 13.81 |

## VI. CONCLUSION

In the present work the conventional solar heater is modified by using double pass with aluminium cans to increase heat transfer rate. The performance of double pass air heater is investigated. The heat loss from the top cover is reduced in case of double pass solar air heater for the entire different range of mass flow rate. The efficiency of double pass solar air heater is further increase by adding aluminium can son both the channels. The path of the air travel is increased in case of double flow solar air heater resulting higher outlet temperature of the same mass flow rate. This collector minimizes the heat losses to the ambient and maximizes the heat transfer to the air stream. In these arrangements Type 2 is higher efficient with compare to other Type 1 and Type 3 arrangements. Increasing wind velocity increases the mass flow rate. As we increase the mass flow rate it the outlet temperature decreases due to decreasing the time for heat transfer process from absorber to air.

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