Comparative Experimental Performance Evaluation of Longitudinal and Transverse Four-Pass Soda Can Solar Air Heaters

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Abstract
Comparative experimental performance evaluation of longitudinal and transverse four-pass soda can solar air heater has been studied. The aluminum soda can was used as the absorber plate of the solar air heater. Two design configurations, transverse and longitudinal arrangements, of the solar air heater's absorber plate were studied. The tests were carried out at different tilt angles of 0^o, 7^o, 14^o, 21^o and 28^o between May and June 2019 and readings were taken on daily basis from 8:00 hrs. to 17:00 hrs. The outlet velocity, inlet and outlet temperature of each arrangement were measured. Parametric plots were made with the measured parameters and the efficiencies were computed and compared. Even at a low insolation value, the transverse arrangement recorded a 10% more useful energy gain and 15% higher cumulative efficiency than the longitudinal arrangement. Temperatures of about 105.4^{o}C and 103.1^{o}C at a mass flowrate of 0.019 kg/s, suitable for industrial and agricultural applications, were recorded for the transverse and the longitudinal arrangement, respectively.

Keywords:

Solar air heaters, aluminum soda cans, temperature difference, thermal efficiency, discarded soda cans

1. Introduction
The world faces a greater challenge on energy management, economic waste and environmental pollution caused by disposal of used materials. It can never be overemphasized that recycling and reusing waste materials will save the environment and provide raw materials for production. Beverage (soda) cans (which are mainly made of aluminum) are not biodegradable and millions of them are discarded daily in the world. A typical soda can is an alloy containing 92.5% to 97% aluminum, 5.5% magnesium, 1.6% manganese, 0.15% chromium and some trace amounts of iron, silicon and copper (Alcoa Inc., 2012). These end up clogging up the waterways and littering the environment with disastrous consequences. As part of a waste to wealth program, aluminum cans (which were usually recycled into products of lower value) are recycled. It has been found that due to its high thermal conductivity, aluminum soda cans can serve as absorber of solar air heaters which is of higher importance in the value chain (Mgbemene et al. 2017, Alvarez et al. 2004 and Sperry 2011). The use of soda cans as a component of solar air heating system is not yet very popular. However, the usage provides a cheap way of making solar air heating system. The aluminum soda cans, when used as the absorber plate of a solar air heater, are economically cheaper than aluminum flat plate and with the sun as the heat source, the whole system becomes even more economical. The use of recyclable materials in making absorber plates of solar air collector therefore implies the production of cheaper solar air heaters and cleaner environment.

Solar air heating refers to the use of solar energy directly for heating purposes. The energy from the sun (solar insolation) is captured by an absorption medium and used to heat air for buildings or process heat applications. It is also applied for air conditioning or heating in buildings or for other different processes (Omojaro and Aldabbagh, 2010). Solar air heaters are the most cost-effective solar technologies and are widely used due to their simplicity. It is employed in space heating, drying of timber and agricultural products and for re-generating dehumidifying agents. Also, solar air heaters are utilized as preheaters in industries and as auxiliary heaters in buildings to save energy during winter-times (Mahmood and Aldabbagh, 2013).

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Application of solar air heaters are most useful for agricultural purposes in regions close to the equator. Enibe, 2002 investigated the performance of a natural circulation solar air heating system with phase change material energy storage in Nigeria. The results showed that the system can be operated successfully for crop drying applications and other agricultural purposes.

Nomenclature

A_c	collector absorber surface area (m^2)
A_o	area of outlet duct (m^2)
C_p	specific heat capacity of air (kJ/kgK)
D_h	hydraulic diameter (m)
F_R	heat removal factor
F'	collector efficiency factor
H	overall heat transfer coefficient (W/m^2K)
I_c	solar radiation absorbed by collector per unit area of the absorber (W/m^2)
k	thermal conductivity of air (W/mK)
$\dot{m}$	mass flow rate of air (kg/s)
Q_i	collector heat input
Q_o	overall heat loss
Q_u	useful energy gain (W)
Q_u'	useful energy gain per unit length of soda can (W)
t	time period (s)
ΔT	temperature difference $(T_o - T_i)$ (°C)
T_a	ambient temperature (°C)
T_{fi}	inlet fluid temperature (°C)
T_{fo}	outlet fluid temperature (°C)
T_{av}	arithmetic average fluid temperature (°C)
T_i	inlet air temperature (°C)
T_o	outlet air temperature (°C)
T_p	absorber plate/soda can temperature (°C)
T_s	sky radiation exchange temperature (°C)
U_L	overall heat loss coefficient (W/m^2K)
V_o	outlet air velocity (m/s)

Greek symbols

$\overline{\eta}$	average collector efficiency
Δ	change parameter
η'	cumulative efficiency of the collector
ρ	density of air (kg/m^3)
η	instantaneous efficiency of the solar air heater
μ	viscosity of the air at absorber temperature
$(\tau\alpha)$	transmittance-absorptance product

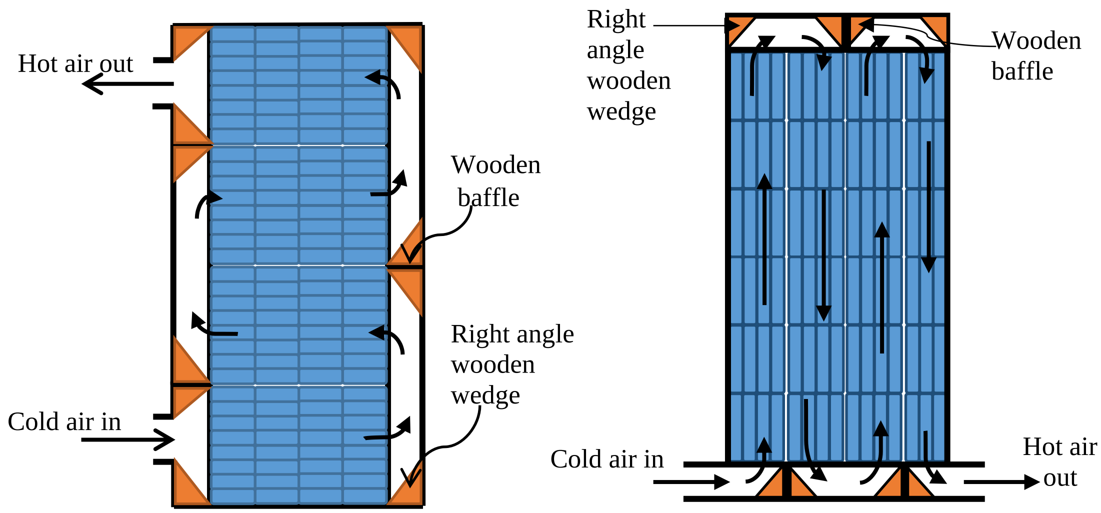
Subscripts

a	ambient
c	collector
g	glass
i	inlet
o	outlet
p	absorber plate
s	sky

Parameters affecting the solar air heater efficiency include collector length, collector depth, type of the absorber plate, glass cover, wind speed (passive systems), inlet temperature, etc. Among all, the absorber plate area and heat transfer coefficient are two important factors affecting thermal efficiency of the solar collector. The rate of heat transfer of the flowing air increases when absorber plate area is increased. This leads to an increase in pressure drop inside the collector and more pumping power is required (Aravindh and Sreekumar, 2016). The thermal efficiency of a solar air heater is significantly low because of the low value of the convective heat transfer coefficient between the absorber plate and the flowing air leading to high absorber plate temperature and greater heat losses to the surroundings (Mgbemene et al. 2017). It has been discovered that the main thermal resistance to the heat transfer is due to the formation of a laminar sub layer on the absorber plate heat transferring surface (Bhagoria et al. 2002).

Various solar air heater configurations have been designed and implemented by researchers to enhance collector efficiency compared to a simple flat-plate device consisting of glass covers, an absorber plate and air flow channels (Romdhane, 2007; El-Sebaii et al. 2011 and Chen et al. 2010). Different types of absorbers and modifications have been suggested and applied on single pass, double pass and multiple pass solar air heaters to increase the heat transfer coefficient between the absorber plate and the air stream. Other methods include allowing the air to spend more time inside the collector and artificially creating turbulence or disturbing the laminar sub-layer to increase the collector efficiency (Yeh, 2014; Gupta et al. 2013 and Aldabbagh et al. 2010). Modifications of the flat plate absorber with fins and baffles (Alta et al. 2010; Maheshwari et al. 2011; Vishwakarma and Jaurker, 2014) and wire mesh with fins and baffles (Prasad et al. 2009; Nowzari et al. 2014; Omojaro and Aldabbagh, 2010) to increase collector efficiency have been studied. These modifications have improved the efficiency of solar air heaters but to a certain level. In all these scholarly studies, none to the knowledge of the authors has been on using soda cans as the absorber for the solar air heater.

Soda can air heater (SCAH) is a system which makes use of black absorptive soda can as the heat absorber. The solar thermal energy is captured using an absorptive black painted soda can (absorber) and the heat is transferred to an adjacent layer of air flowing through it, thereby heating it up. It consists of a soda can tube absorber, a transparent cover that reduces convectional heat losses, a working fluid (air) to remove heat from the absorber and an insulating backing. It has been presented as Do-It-Yourself things in most published items (Sperry 2011). However, few researchers have been able to show that recent solar air heaters with aluminum soda cans as absorber were built as active systems and they exhibited relatively high efficiency (Ozgen et al. 2009; Murali et al. 2019; Mgbemene et al. 2017; Alvarez et al. 2004). They have found usage in space heating and drying of agricultural products (Kishk et al., 2019). To the best of our knowledge, SCAH have not been evaluated and characterize properly in this part of the world around the equator. Hence, this work tends to evaluate and characterize the thermal performance of a soda can air heater in terms of adequate design of multiple pass airflow and absorber configuration.



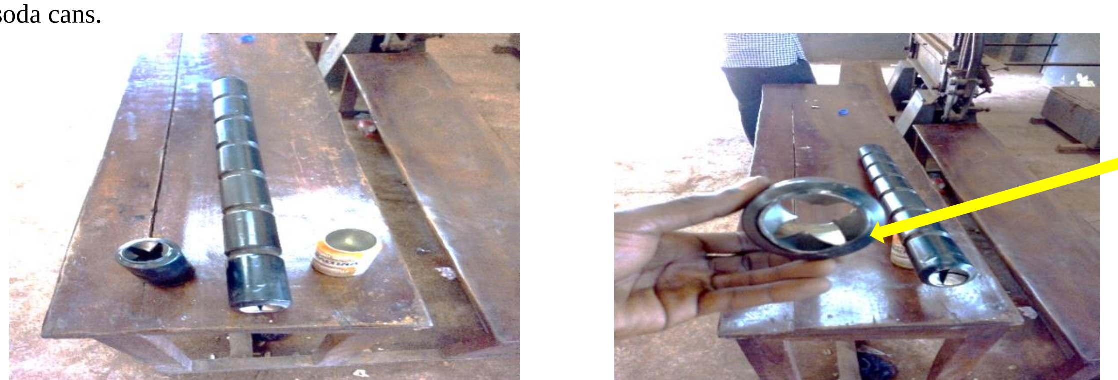
(a) Transverse arrangement (b) Longitudinal arrangement

Fig. 1: Four Pass Soda Can Air Heater

The present investigation is aimed at studying the performance of a four-pass soda can solar air heater arranged longitudinally and transversely and to compare their results for effectiveness. To do that, two soda can air heaters, whose absorbers were arranged in longitudinal and transverse pattern were constructed and studied (Fig. 1). The objective of this paper therefore, is to experimentally determine which arrangement can give the higher temperature and also determine the thermal/collector efficiency of each of the systems in order to find out the better configuration under active conditions.

2. The Experimental Set up

The soda can collectors (longitudinal and transverse arrangement) were designed and fabricated. The solar air heater box was made of mahogany wood. Wood was chosen over metal because it is cheaper and has low thermal conductivity and greater workability. Both arrangements had the same collector area and contained the same number of soda cans.



(a) (b)

Fig. 2 (a) & (b): Aluminum soda cans perforated in star pattern at the bottom (arrowed) and joined end to end.

The aluminum soda cans were cut open at the top side and perforated in star pattern at the bottom side into four equally spaced fins and joined end to end with a silicone glue as shown in Fig. 2. The perforation helps to create turbulence in the flow in order to increase the rate of heat transfer to the working fluid. A cross section of the arrangements of the soda cans are as shown in Fig. 3. Glass wool were used for the thermal insulation at different times. A 4 mm ceramic glass with a solar energy transmittance of 0.85 was used as the cover glass. Fig. 4 shows the actual collectors being studied.

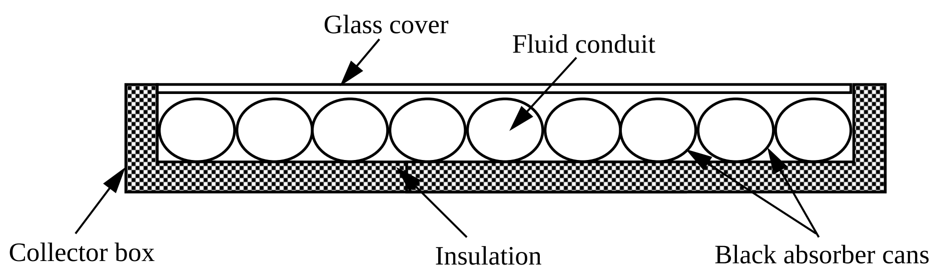


Fig. 3: Cross section of the collector showing the arrangement of the cans.

The collector area for the transverse and longitudinal arrangement were made up of 240 aluminum soda cans. Transverse arrangement consists of 8 columns and 30 rows as shown in Fig. 4(a) while the longitudinal arrangement consists of 15 columns and 16 rows soda cans as shown in Fig. 4(b).

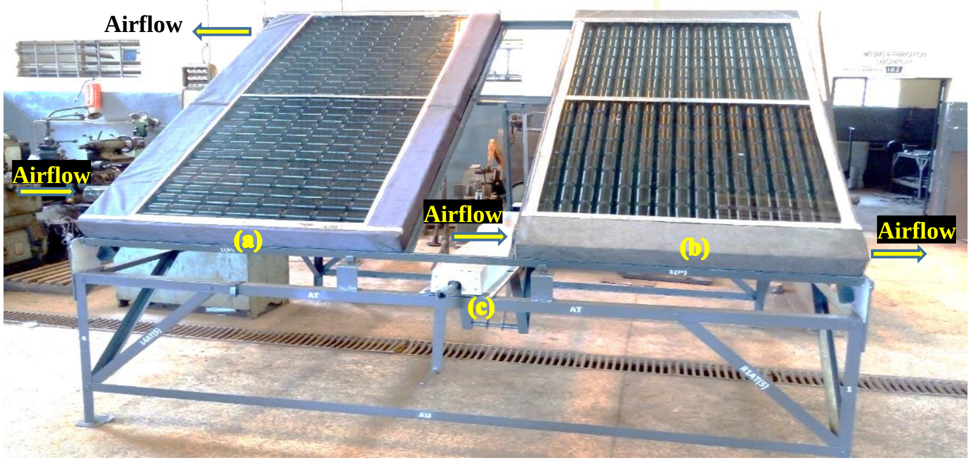


Fig. 4: Arrangement of the Soda Can Air Heater
(a) Transverse arrangement (b) Longitudinal arrangement (c) Solar test bed.

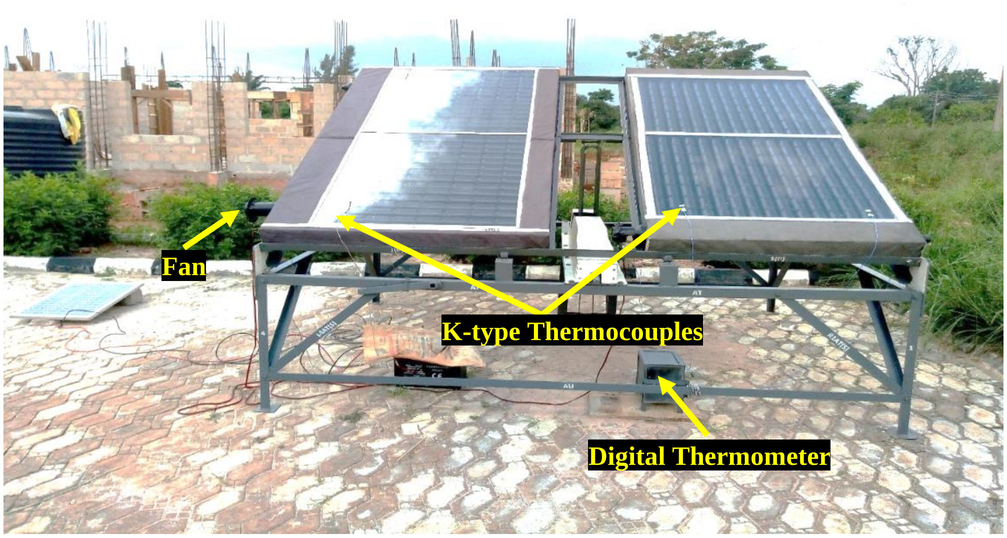


Fig. 5: Experimental setup of the longitudinal and transverse arrangement of the soda can air heater.

The solar air heater was an active system thus a 12V DC fan with model number: AZ8025MS with a flow rate of 25CFM (Cubic Feet per Minute) was used for forced circulation of air. The fan was mounted on the inlet duct manifold.
K-type thermocouples with standard accuracy of 0.85% for temperatures up to 400ºC was inserted in the collector's inlet and outlet duct for measuring the air temperatures and also on the cover glass for temperature reading. The temperatures were displayed and logged with a Multi-Channel Temperature Meter (Applent Instrument, Model: AT4208) capable of reading 8 (eight) different temperatures with accuracy: ± 0.1ºC. A Kestrel 3000 digital meter capable of measuring air velocity, temperature, and humidity was used for measuring the properties of the air. The solar radiation was measured with a Dr. Meter ® SM206 Digital Solar BTU Power Meter.

3. Experimental Procedure

The experiments were carried out in Nsukka, Enugu State of Nigeria located at a latitude of 6°51′24″N and longitude of 7°23′45″E. The solar collectors (both longitudinal and transverse absorber configuration) were placed on a manually operated solar test bed and the experimental setup facing south and tilted at angles 0º, 7º, 14º, 21º and 28º to the horizontal surface. The experiments were performed from 8.00 am to 5.00 pm, the theoretical useful sun period for Nsukka location. The intensity of solar radiation and air velocity (at the inlet and outlet ducts) were measured and recorded in 15-minute intervals while the temperatures were measured and recorded in 1-minute interval with a data logger. The experiments were repeated at the different tilt angles over a period of days (from May to June). Both Soda can air heaters were placed at the same angle and tested at the same time under the same condition as shown in Fig 5.

4. Theoretical analysis

Fig. 6 shows the general description of the collector for the analysis. The thermal performance of a solar collector can be evaluated by carrying out an energy balance of the system. This helps to determine the portion of the incoming radiation delivered as useful energy to the working fluids.

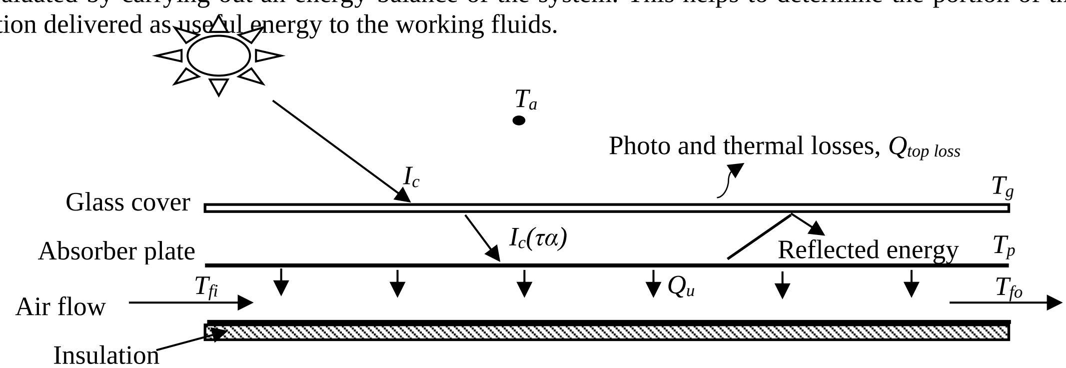


Fig. 6: General description of the collector for the analysis.

The thermal energy lost from the collector to the surroundings by conduction, convection, and infrared radiation can be represented as the product of the heat transfer coefficient, U_L multiplied by the difference between the mean absorber plate temperature, T_p and the ambient temperature, T_a (Duffie and Beckman, 2013).

In steady state, the useful energy gain, Q_u of the collector area, A_c is the difference between the absorbed solar radiation and the thermal loss (Eq. 1).

$$Q_u = Q_i - Q_o = I_c A_c - U_L A_c \left(T_p - T_a\right) \quad (1)$$

$$Q_u = \dot{m} C_p (T_o - T_i) \quad (2)$$

$$\dot{m} = \rho A_o V_o = \text{mass flow rate of the fluid in kg/s} \quad (3)$$

Thermal efficiency of the collector was calculated using the heat gained, collector area and the solar radiation value. However, since the experiment was carried out over some specified time period, the average value of the efficiency will be more useful. Hence the average efficiency is given as:

$$\overline{\eta} = \frac{\int_0^t Q_u \, dt}{\int_0^t A_c I_c \, dt} \qquad (4)$$

where t is the time period over which the performance is averaged. The instantaneous thermal efficiency of a solar heater is the ratio of the useful energy delivered to the incoming solar energy. This is given as:

$$\eta = \frac{Q_u}{A_c I_c} \qquad (5)$$

Alternatively, the instantaneous efficiency of a solar air collector can also be expressed as (Duffie and Beckman, 2013)

$$\eta = F_R(\tau\alpha) - \frac{F_R U_L (T_{av} - T_a)}{I_c} \qquad (6)$$

where $T_{av} = \frac{T_o + T_i}{2}$ (7)

For a constant value of U_L, F_R and $(\tau\alpha)_n$, if the instantaneous efficiency, η is plotted against temperature-insolation function, $\frac{(T_{av} - T_a)}{I_c}$, a straight line will result. The instantaneous efficiency of solar air collector can also be determined in terms of the mass flow rate through the collector from

$$\eta = \frac{\dot{m} C_p (T_o - T_i)}{A_c I_c} \qquad (8)$$

The cumulative efficiency of the solar air heating system is the ratio of the cumulative useful energy gained by the heated exit air to the cumulative energy absorbed by the solar collector from the sun's radiation. It is expressed as

$$\eta' = \frac{Q_{u,cum}}{Q_{i,cum}} \qquad (9)$$

4.1 Heat Transfer Analysis of the Air Flowing Through the Absorber Soda Can

Fig. 7 depicts the heat transfer through an arrangement of cans. Let us analyze the flow through a single can. The airflow through the can in the collector is assumed to be turbulent because of the disruption of the flow by the star patterned, equally spaced fins at the bottom of each soda cans. The airflow's Reynolds number is expressed as follows:

$$\mathrm{Re} = \frac{\rho V D_h}{\mu} = \frac{\rho V}{\mu}\left(\frac{4 \times flow\,area}{wetted\ perimeter}\right) = \frac{4\dot{m}}{\pi D \mu} \qquad (10)$$

and the Prandtl number is given as:

$$\mathrm{Pr} = \frac{\mu C_p}{k} \qquad (11)$$

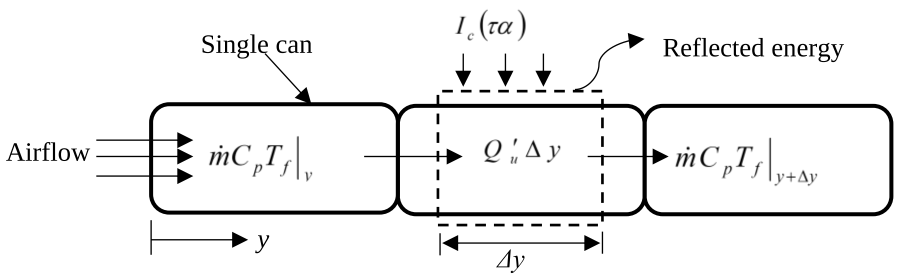


Fig. 7: Heat transfer to the air flowing through the soda can.

On the assumption that the flow through the soda can is fully developed, the Nusselt number for a fully developed turbulent flow for smooth surfaces is obtained from Dittus-Boelter equation (Cengel, 2002).

$$Nu = 0.023\mathrm{Re}^{0.8}\mathrm{Pr}^{0.4} \quad \mathrm{Re} > 10,000 \tag{12}$$

But the heat transfer coefficient from the soda can to air is given by:

$$h = \frac{k \times Nu}{D_h} \tag{13}$$

where $$D_h = \frac{4 \times \textit{flow area}}{\textit{wetted perimeter}} = \frac{4\pi D^2/4}{\pi D} = D \tag{14}$$

5. Results and discussion

The analysis of the results obtained from the experiments is mainly on the comparative performance and efficiency of the transverse and longitudinal SCAH (soda can air heater). The average mass flowrate used in calculating the useful energy gain was obtained from Eq. (3). This was done for each day of the experiment. The average mass flow rate calculated for 15th May 2019 was 0.019 kg/s. The Reynolds numbers for the airflow through the soda cans were calculated using Eq. (12). Values obtained varied from 16,122 to 18,249 and 14,946 to 18,547 on the transverse and longitudinal arrangements, respectively. From Eqs. (14) and (15), the calculated heat transfer coefficient varied from 20.66 to 22.11 W/m^2 for collector A (transverse arrangement) and 20.63 to 20.71 W/m^2 for collector B (longitudinal arrangement). The variations were due to the transient conditions of the system. Temperatures varied with time during the test period. Reynolds number, Nusselt number and heat transfer coefficient strongly depend on the fluid temperature consequently, they vary as temperature of the air varies. The average heat transfer coefficient for both collectors - transverse and longitudinal arrangement were 21.4 W/m^2 and 20.7 W/m^2, respectively.

Five tilt angles namely 0^o, 7^o, 14^o, 21^o and 28^o were used for the test. The plots of temperature against time for the angles were similar in their patterns (Figs. 8 - 12). The 21^o tilt angle gave the best results for the Nsukka location (6°51′24″N 7°23′45″E). This agrees with the other experimental works on solar collectors in Nsukka, Nigeria which state that the best tilt angle ranges from 14^o – 35^o facing south (Enibe, 2002 and Mgbemene et al, 2017). Since that of 21^o tilt angle gave the best output, the plots for the analysis are for the 21^o tilt angle. The results of the experiment are plotted as shown in Figs. 12 – 18. The results presented here are for both the transverse (A) and longitudinal (B) arrangements of the system. The air inlet temperature approximately equaled the ambient temperature. Hence,

$$T_i \approx T_i(A) \approx T_i(B) \approx T_a \tag{15}$$

Fig. 12 shows the variation of temperatures for both arrangements at 21^o collector tilt angle as recorded on 15th May, 2019. The temperature of the air at the outlet was greater than that at the inlet thus, a high temperature difference was observed between the inlet and outlet air temperatures. The rise in air outlet temperature was due to the absorbed energy from the solar radiation received by the collector. From the plot, it can be observed that the maximum air outlet temperature was attained around the noon. A maximum temperature of above 100^{o}C was recorded for both SCAHs (Soda can air heaters) on 15th May 2019. The month of May falls within the rainy season in Nigeria. The average insolation for that day was 717.2 W/m^2. The maximum air outlet temperatures of 105.4^{o}C and 103.1^{o}C were recorded at 12:38 hours at insolation of 1150 W/m^2 for transverse and longitudinal arrangement respectively at 21^o tilt angle.

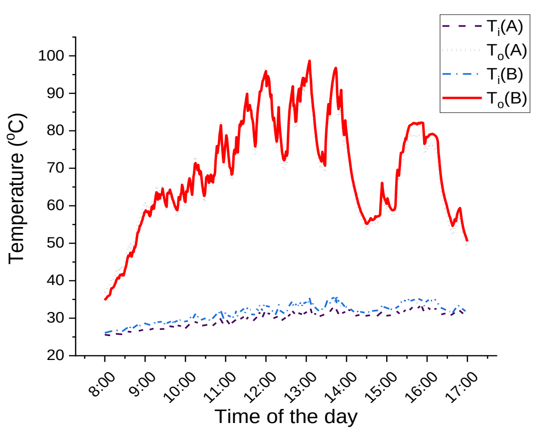


Fig. 8: Variation of Temperatures for both Collectors at 0^o collector tilt angle Date: 19th June 2019

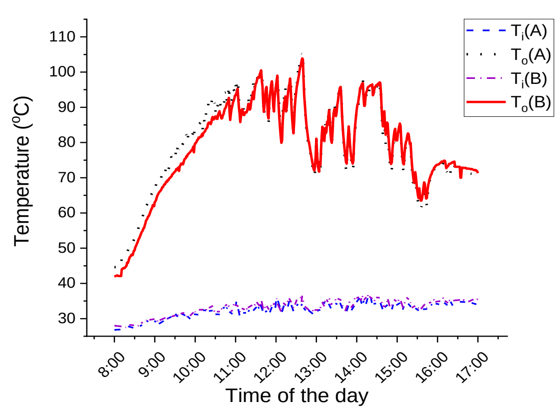


Fig. 9: Variation of Temperatures for both Collectors at 7^o collector tilt angle Date: 10th May 2019.

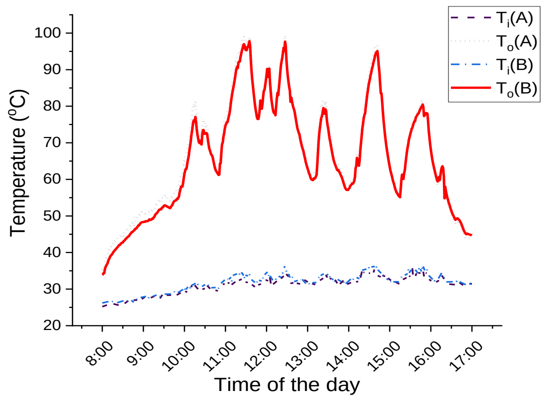


Fig. 10: Variation of temperatures for both arrangements at 14° collector tilt angle. Date: 14th May 2019.

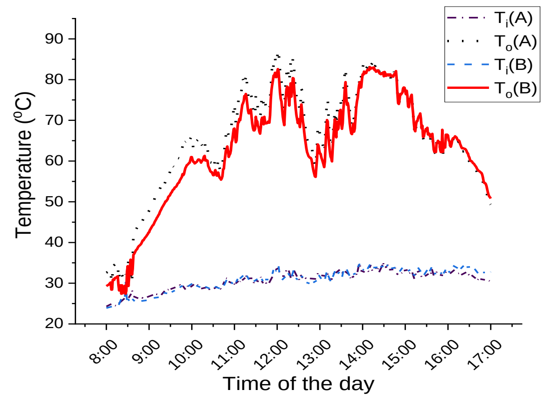


Fig. 11: Variation of temperatures for both arrangements at 28° collector tilt angle. Date: 27th May 2019.

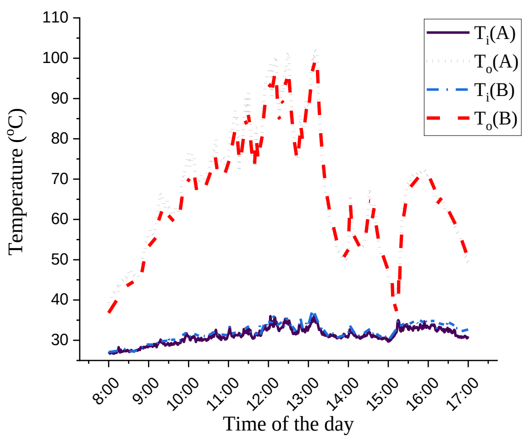


Fig. 12: Variation of temperatures for both arrangements at 21° collector tilt angle

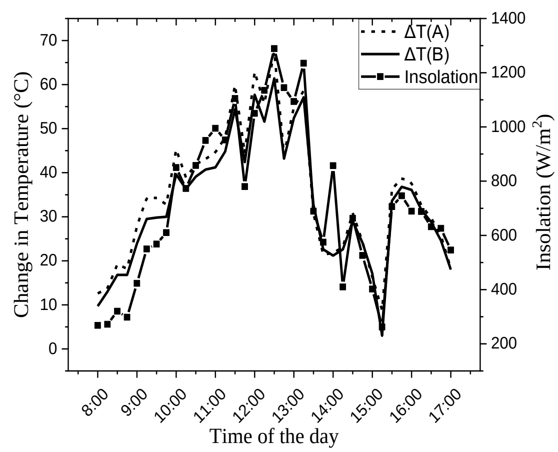
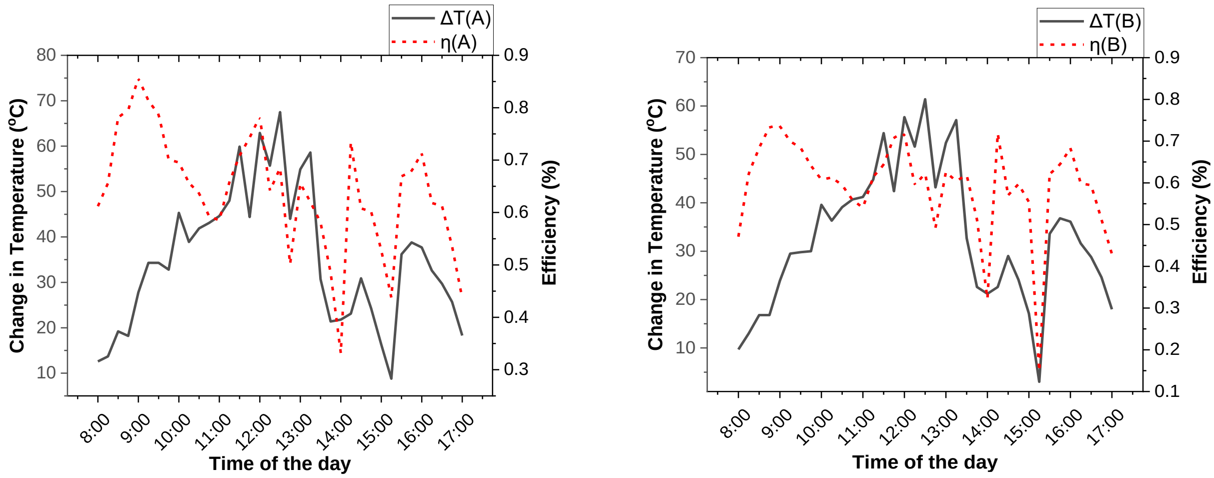


Fig. 13: Temperature difference and insolation for both arrangements at 21° collector tilt angle.

(A) Transverse arrangement

(B) Longitudinal arrangement

Fig. 14: The temperature readings of outlet air recorded on 12:30 hours at insolation of 1089 W/m² on 15th May 2019.



(A) Transverse Arrangement **(B) Longitudinal Arrangement**

Fig. 15: Variation of Temperature rise and Efficiency at 21° collector tilt angle.

Fig. 13 shows a plot of temperature difference, ΔT, between inlet air and outlet air and insolation against time of the day for both SCAHs. The plot shows that the temperature difference is directly proportional to the insolation. As the insolation increases, the temperature difference, ΔT, increases, and vice versa. Thus, the outlet air temperature of both collectors increases as the intensity of the sun increases and decreases as the intensity of the sun decreases. This demonstrates that the outlet air temperature depends on the insolation.

Fig. 14 shows the digital thermometer reading of the outlet air temperature for both arrangements at about 12:30 hrs. Fig. 15 shows the plot of temperature difference, ΔT, and collector efficiency against time of the day for both collectors. It shows that there is a strong relationship between the temperature and collector efficiency. The temperature difference, ΔT, which in turn depends on the insolation, has a significant effect on the efficiency of the collector. As the insolation increased, the temperature of the absorber increased. The insolation increased till the noon period while efficiency was higher at the beginning of the day despite low insolation. As the absorber cans become hotter, heat loss from the top surface of the absorber cans increases too reducing the efficiency of the collector. The instantaneous efficiency of the transverse arrangement is significantly higher than that of the longitudinal arrangement with about 16%. The temperature difference of the transverse arrangement is nearly 6% higher than that of the longitudinal arrangement.

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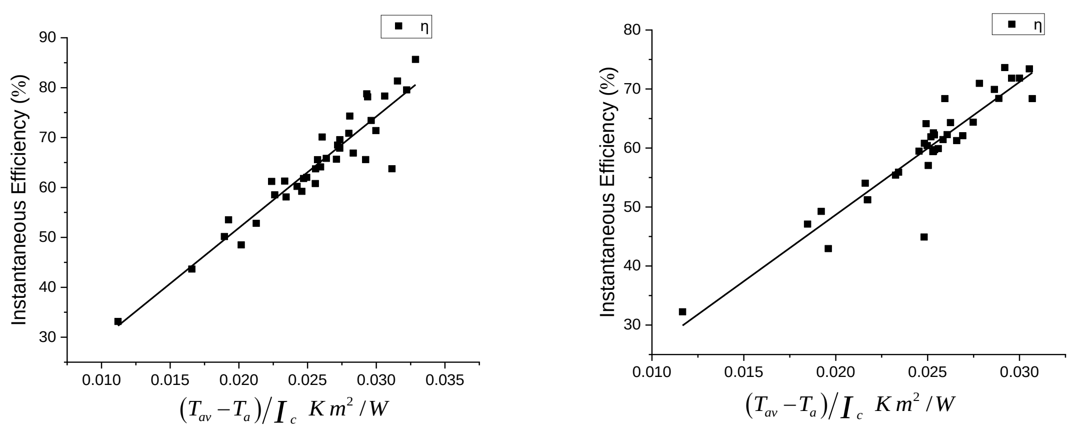

(A) Transverse Arrangement **(B) Longitudinal Arrangement**

Fig. 16: Variation of instantaneous efficiency to temperature-insolation function at 21° collector tilt angle

Fig. 16 shows a plot of instantaneous efficiency against temperature-insolation function. The plots show that a characteristic curve (a straight-line plot) was obtained between efficiency and temperature-insolation function. By calculating the slope of the line of best fit, the value of $F_R U_L$ (a strong parameter that describes how the solar collector works) can be obtained from the plot (Fig. 16). A linear least square fit of the data using OriginPro 2018 gave the following correlations

$$\eta_A = 7.30 + 2230.16((T_{av} - T_a)/I_c) \text{ for transverse arrangement} \quad (17)$$

$$\eta_B = 3.65 + 2251.61((T_{av} - T_a)/I_c) \text{ for longitudinal arrangement} \quad (18)$$

A positive slope was obtained for both collectors because the experiment was carried out on a transient mode. Overall heat loss coefficient, U_L varies with the operating temperature of the collector and the ambient weather condition causing some deviations from the straight-line relation. Thus, the scatters in the data plots are to be expected, because of temperature dependence, wind effects, and angle-of-incidence variations

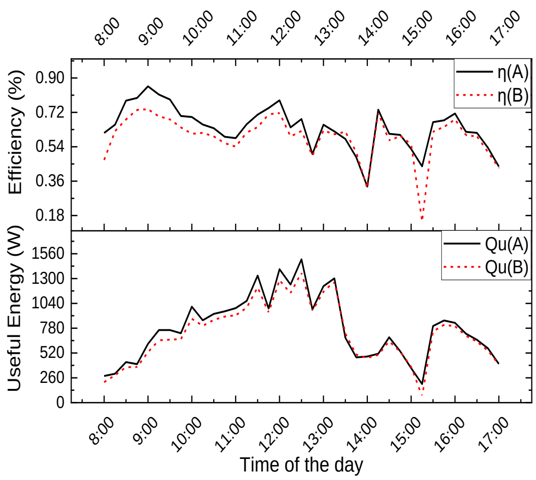

Fig. 17: Variation of useful energy gain and efficiency on both collectors at 21° collector tilt angle.

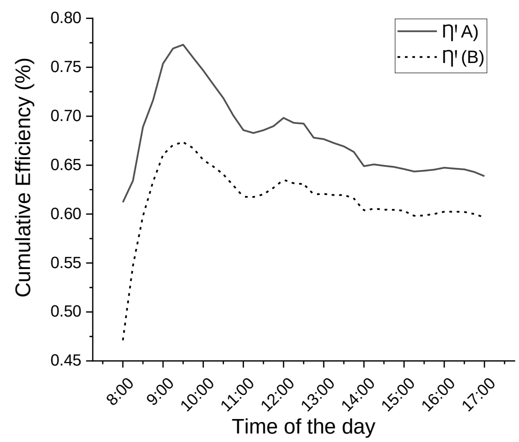

Fig. 18: Cumulative Efficiency of both arrangements at 21° collector tilt angle.

Fig. 17 is a plot of the variation of useful energy gain against efficiency on both collectors at 21° collector tilt angle. The efficiency of both SCAHs increased in the morning within the first hour of the tests to the maximum values of about 86% for the transverse arrangement and about 74% for the longitudinal arrangement. However, as the absorber cans become hotter, the useful energy gains increase but the efficiency of the collector drops due to high overall heat loss. With respect to the insolation, a rise in the insolation resulted in a rise in the useful energy gain and a decrease in collector efficiency. This is in agreement with Eqs. (1) and (6). This occurred in both arrangements. However, the useful energy gain of the transverse arrangement is about 5% more on the average than that of the longitudinal arrangement. Fig. 18 shows that the cumulative efficiency of both collectors is higher in the morning hours and reduces as the day progresses. The result shows that the transverse arrangement has a higher cumulative efficiency (about 15%) than the longitudinal arrangement.

Table 1: Summary of the performance of the two air heater arrangements on 15th May 2019 with average insolation of 717.2 W/m².

S/N	Parameter	Transverse arrangement	Longitudinal arrangement	Percentage difference
1.	Maximum temperature achieved (°C)	105.4	103.1	2.2
2.	Maximum temperature rise (°C)	72.4	68.5	5.7
3.	Maximum instantaneous efficiency (%)	86	74	16.2
4.	Overall daily efficiency (%)	64	59	8.5
5.	Maximum cumulative efficiency (%)	77	67	14.9
6.	Maximum useful energy gain (W)	1501	1365	10
7.	Average heat transfer coefficient (W/m²)	21.4	20.7	3.4

Comparing the results of the transverse and longitudinal arrangements of the four-pass solar aluminum soda can air heater, it could be seen that a reasonable maximum rise in temperature difference reaching 72.4^{o}C and 68.5^{o}C were established in the flow despite the low insolation. Even at the low insolation value, the transverse arrangement recorded a 10% more useful energy gain than the longitudinal arrangement with values at 1501 W and 1365 W, respectively. Table 1 presents the summary of the performance of the two air heater arrangements on 15th May 2019 with average daily insolation of 717.2 W/m^2. Comparing the efficiency of both arrangements, it can be seen that the transverse arrangement performs better than the longitudinal arrangement in both instantaneous efficiency and cumulative efficiency. This must have been as a result of absorber configuration and less pressure drop in transverse arrangement.

Conclusions

The performance of the longitudinal and transverse arrangement of a four-pass soda can air heater has been studied. The results of both arrangements showed that the four-pass soda can air heater can give an outlet temperature of 105.4^{o}C and 103.1^{o}C respectively in rainy reason. Such a temperature is high enough for industrial use. The lower temperatures are good for home heating and agricultural drying purposes. The configurations of the system (transverse and longitudinal absorber arrangement) that will give the best performance have also been determined. The results were consistent in all the modes. They show that even in the rainy season, when sky is mostly cloudy, both SCAH configurations would still be able to establish a good temperature difference in the fluid. This shows that the aluminum soda cans can serve as good absorber materials for air collectors. However, the mass flow rate is a factor to be considered in the design and decision to use the SCAH.

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