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"Comparative Study of Double Pass Solar Air Heater with Solar Air Heater with Baffles & With Longitudinal Fins"

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***Abstract*:** Solar air heater is a most popular device in the space heating and industrial processes applications. But solar air heater has lower heat-transfer coefficient between the absorber plate and the air stream, which results in a lower thermal efficiency of the heater. The solar air heaters efficiency can be affected by various parameters such as collector length, number of channels, depth of channels, type of absorber plate, number and material of glass covers, air inlet temperature and air velocity. Comparative study of double pass solar air heater with fins, baffles and porous material's effect has been carried out in this research study. Also, mass flow rate at the outlet of the double pass solar air heater in the metallic wiry sponge is significantly improve as compared to the other double pass solar air heater. So that, the maximum efficiency as been gained in the double pass solar air heater with metallic wiry sponge as compared to the other.

Keywords: *Double pass solar air heater, Fins, Baffles, porous media, mass Flow rate, and Thermal efficiency.*

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I. INTRODUCTION

Solar air heater is a device, which covert solar radiation into the heat energy. This research study has been carried out for increasing the performance of the double pass solar air heater. Day by day industries and societies accepted the solar systems because of its eco friendly nature and less maintenance cost and long life products. This research study has been focused on the metallic wiry sponge used in the double pass solar air heater. Metallic wiry sponge is the greatest metallic porous media which provided the high conductive large contact surface area to the air. The productivity output parameters will comes better as compared to the baffles, and longitudinal fins. This research study is a comparative study of metallic wiry sponge to the baffles and longitudinal Fins inserted inside the double pass solar air heater.

II. METHODOLOGY

To apply the concept of double pass solar air heater with metallic wiry sponge, with fins, with baffles, prepare models of it and manufacture two units of double pass solar air heater. These two solar air heater mounting on the stand with bolts and nuts. Put these both at same angle of inclination 23° to the horizontal. To receive a maximum solar radiation put a solar Air heater system towards the North direction. Record a data during the typical day of the month with two different units at same time.

[1]**Chii Dong Ho, Hsuan Chang et al.** worked on new solar air heaters with using an absorbing plate with fins and baffles, which facilitate the recycling of flowing air. They gained Significant improvement in heat-transfer efficiency with the baffle and fin design due to the recycling heating and the extended heat transfer area. [2]**Maulik Sukhadiya, Kaushik Savaliya et al.** performed to improve the collector efficiency by increasing the fluid velocity and enhancing the heat-transfer coefficient between the absorber plate and air.

In these design they 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 these arrangements Type 2 was 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. [3]**Raj Kumar, Ranchan Chauhan et al.** worked on artificial roughness in different shapes and sizes used to enhance the convective heat transfer coefficient of solar air heaters and heat exchangers. it can be provided in the form of ribs / wires of different shapes, dimples / protrusions, wire mesh, delta winglet, baffles etc. very near to the heat transferring surface.[4] **Sanda Budea et al.** worked on space heating, this experiment gives results of a solar collector air, in climatic conditions from South Eastern Europe. It was shown that after maximum 50 minutes, solar air collectors, with baffles and double pass of air can reach 50 % efficiency for solar irradiation of 900-1000 W/m2. [5]**J. Mahmood and L. B. Y. Aldabbagh et al.** worked on counter flow solar air heaters with four transverse fins and wire mesh layers. From this study they observed that, for air mass flow rate range between 0.011-0.036kg/s, the thermal efficiency increased with increasing the air mass flow. The maximum efficiency obtained is 65.6% for the mass flow rate of 0.036kg/s. [6]**Salah abdallah, mazen abu khader et al.** worked with coated and uncoated porous media of metallic wiry sponges and black volcanic rocks as absorber material in the solar still. Experimental Results shows that the **uncoated sponge has the highest water collection during day time**, followed by the black rocks and then coated metallic wiry sponges. The overall average gain in the collected distilled water taking into the consideration with the overnight water collections were 28%, 43% and 60% for coated and uncoated metallic wiry sponges and black rocks respectively.

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III. EXPERIMENTAL SETUP

There are two double pass solar air heaters have been manufactured for better comparison of the results and observe the significant difference. The experimental setup has been made up of galvanized iron sheet of 1.6mm thick, which is coated inside with black oil paint. Thermal conductivity of black paint is in between 0.94-0.98 W/m K to absorb the maximum solar radiation during the day period. Inclination to the air heater collector has been provided to receive the maximum solar radiation during the day period. Clear glass has been provided to allow transmitting the maximum solar radiation and the glass cannot allow the low grade radiation outside and it is help full to store the solar heat energy inside the system. It is fitted and tight with the help of clamp and LN-key bolts. Fully easily foldable stand, which has been fully assembled and disassembled with welded bolts and nuts. Draft and induced exhaust type fan has been provided at the outlet of the experimental setup.

Three different types of absorber plate have been manufactured to observe the significant changes in the results. In first absorber plate baffles has been attached horizontally to obstruct the flow of air and increase the heat transfer rate. Baffles used in this experimental setup to divert the flow of working fluid air and increase the air contact period with absorber which has been useful to increase the heat transfer rate. In the second absorber plate linear fins has been attached vertically to maximize the heat transfer rate. And in third absorber plate new concept has been applied such as metallic wiry sponge has been attached to the absorber plate without coating, and compared with each other.


Figure 3.1. Experimental Setup Metallic Wiry Sponge Vs Baffle Type Solar AIR Heater

Figure 3.2. experimental setup metallic wiry sponge Vs Fins attached Type Solar Air Heater

Table 3.1: Table of dimensions of Experimental Setup

SR NO.	PRODUCT	DIMENTIONS	Thermal Properties
1	Absorber Area / 0.5m2	500 X 1000 X 150- Height	Galvanized iron 1.6mm thick basin
2	Glass	540 X 1200 X 4-Thick	Conductivity = 0.8W/mK
3	Ceramic class wool	10- thick insulation to negligible heat loss	Conductivity = 0.048W/mK
4	Baffles	(400X65)-8No.s / (200X65)-16No.s	Alternative arrangement
5	Fins	900X65 – (4+3=7No.s)	Galvanize material
6	Metallic wiry sponge	75 – diameter and 75- height	Alternative in raw and Colum

IV. THERMAL PERFORMANCE ANALYSIS

The theoretical model used to study solar air collector that works in non-stationary regime is

described by the balance equation (1):

$$Q_u = I_0 - \dot{Q}_P \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: Q_u - heat output of collector, kW; I_0 - absorbed solar radiation, kW; $\dot{Q}_p$- heat lost, kW.

Heat output of collector is expressed by the balance equation (2):

$$Q_u = \dot{m}C_p(T_{a,out} - T_{a,in}) \ldots\ldots\ldots\ldots\ldots.. (2)$$

where: $\dot{m}$ – air mass flow rate, (kg/s); c_p – air specific heat at constant pressure (kJ/kg·K); Ta,in - air temperature at collector inlet (K); Ta,out – air temperature at collector outlet (K).

Solar radiation absorbed by collector is given

$$I_0 = \eta_0 . I. A_c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where, η_o – optical efficiency; I – solar radiation (kW/m^2); Ac – area of collector absorber (m²)

Lost heat is described by Eq. (4):

$$\dot{Q}_P = U_c A_c(T_{p,med} - T_{amb}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where: Uc - coefficient heat losses by convection (kW/m2K); Tp,med – average temperature of collector (K); Tamb- ambient average temperature (K). Equation (1) can be re-written using the equations (2)-(4) as Eq. (5):

$$\dot{m}C_p(T_{a,out} - T_{a,in}) = \eta_0 . I. A_c - U_c A_c(T_{p,med} - T_{amb}) \ldots. (5)$$

Optical efficiency (ηo) and heat loss coefficient (Uc) are parameters that characterize the behaviour of the solar collector. Optical efficiency is the fraction of solar radiation absorbed by the collector and depends basically on the transmittance of transparent cover and absorbance.

The heat loss coefficient includes losses through transparent cover, lateral and bottom sides of collector. The thermal efficiency of the solar collector (η) is defined as the ratio of energy collected (useful energy) and solar radiation incident on the collector plane (Eq. 6):

$$\eta = \frac{\dot{m}C_p(T_{a,out} - T_{a,in})}{I. A_c} \ldots\ldots\ldots\ldots\ldots (6)$$

V. RESULT & DISCUSSION

All resultant data for this concept of metallic wiry sponge used in solar air heater has been carried out in typically sunny days in month of May. Where in Maximum Solar Radiation arrived at 1050W/m^2 and The Experiment has been carried out from 10:00 AM in morning to 05:00PM in Evening. All data has been measured with required Instrumentation. Solar Radiation has been measured with the help of Pyrano-meter bulb type digital solar meter. Wind velocity and mass flow rate of air outlet has been measured with the help of anemometer, all Temperatures has been measured with the help of J-type Thermocouple and value has been indicated in the j-type digital indicator.

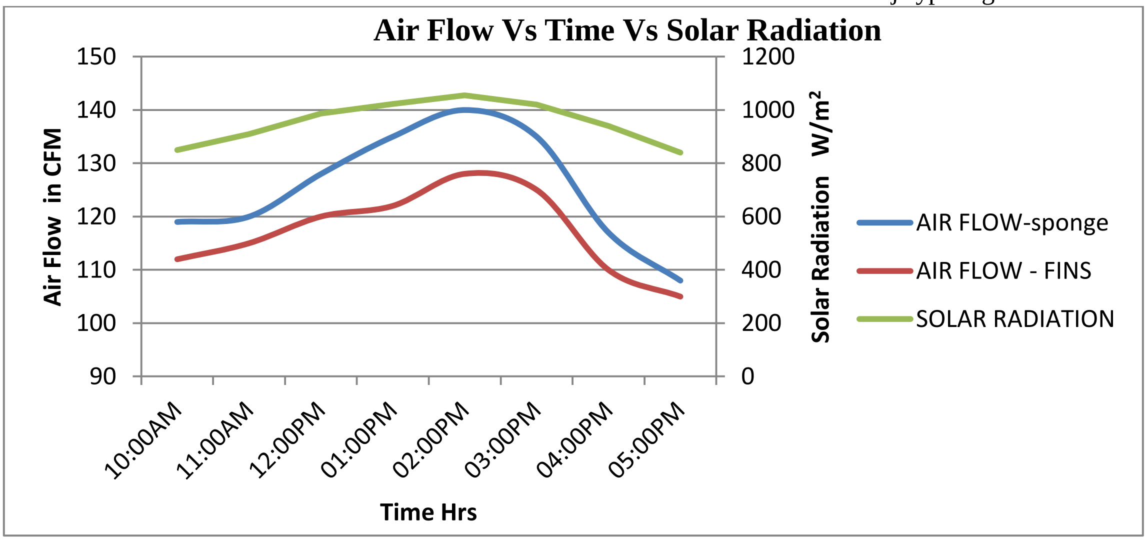

Figure 5.1 Effect of Solar Radiation on air flow Vs Time in with Longitudinal FIN and Metallic Wiry Sponge Type Solar Air Heater

From the above chart Figure 5.1, it has been observed that the Air flow in the outlet increases with solar Radiation up to 02:00PM and it has been decreased after 02:00PM gradually. From this chart it has been observed that the density of air is affected on the flow at the outlet. It has been observed that when temperature of air increases the flow of air at the outlet has been increased and when temperature decreases the flow of air at outlet is decreased. This graph shows that the air outlet flow has been higher in metallic wiry sponge as compared to the longitudinal Fins attached in the solar air heater.

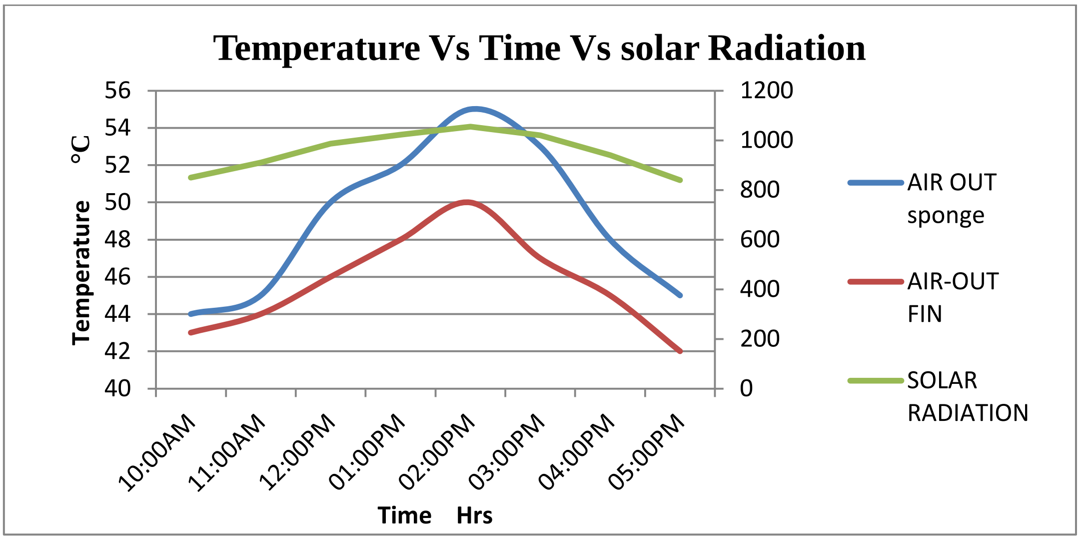

Figure 5.2 Variation in Temperatures of Air outlet for Fin and Sponge Type

Solar Air Heater Vs Time

The above chart shows the effect of solar radiation on the temperature of the air outlet during the day period from 10:00AM to 05:00PM. From the above chart it has been observed that the solar radiation has been gradually increased with increasing in time up to 02:00PM and after that it has been gradually decreasing. In this case when the solar radiation has been increased the temperature of the air outlet in both solar air heaters has been increased and when the solar radiation has been reduced the temperatures of the air outlet in both the solar air heaters has been decreased. From the above measurement it has been observed that metallic wiry sponge gives the higher temperature at outlet as compared to the Longitudinal Fins mounted inside the solar air heater.

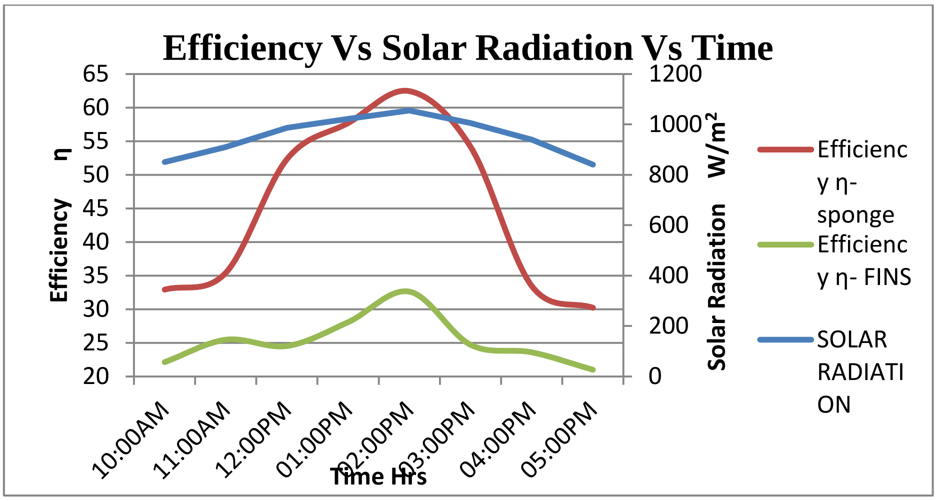

Figure 5.3 Effect of Solar Radiation on the Efficiency Vs TIME in LONGITUDINAL FIN and Metallic Wiry Sponge Type Solar Air Heater

The above chart has been shows the effect of solar radiation on the efficiency of the solar air heater with respected to the time. From the above chart it has been observed that the efficiency of the both solar air heater has been increased with increase in solar radiation and it has been decreased with decrease in solar radiation. It has been observed that the efficiency of solar air heater with metallic wiry sponge inserted has higher efficiency as compared to the efficiency of solar air heater with Longitudinal Fins inserted.

VI. CONCLUSION

From the above Experiment it has been conclude that,

- Temperatures of the double pass solar air heaters has been increase with increase in solar radiation and decreases with decrease kin solar radiation
- The maximum solar radiation obtained in the metallic wiry sponge type double pass solar air heater as compared to the solar air heater with baffles and solar air heater with Longitudinal fins
- Also, mass flow rate at the outlet of the double pass solar air heater in the metallic wiry sponge is

significantly improve as compared to the other double pass solar air heater.

- So that, the maximum efficiency as been gained in the double pass solar air heater with metallic wiry sponge as compared to the other.

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