Experimental Analysis And Optimization Of Variable Parameter Of Solar Air Heater By Using Of Extended Surface On Absorber Plates

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Abstract - *In practice different kinds of solar air heaters are available for domestic heating and industrial air heating purposes, Advantage of this system to use of renewable energy source that is free in cost and eco-friendly.*

[Accumulated energy]+[Energy gain]= [Absorbed energy]+[Lost energy]   (2.1)

For each term of Eq. (2.1) the following expressions are formulated

But problem associate with this system is low heat transfer Accumulated Energy $= M_p C_p (dT_{p,ave} / dt)$ (2.2)
coefficient between the absorber plate and the air stream, which results in a lower thermal efficiency of the heater. There are so many research are going on to improve the efficiency using extended or longitudinal fins attached, baffles, metallic

$= m_p C_p (T_{out} - T_{in})$

$= \eta \ IA$

Energy Gain

(2.3)
wiry sponge, absorbent material, angle of inclination of glass cover, recycling of air etc. This research focuses to improve the Absorbed Energy $_0$ $_c$

(2.4)
efficiency of the double pass solar air heater by using the wiry sponge or extended surface on absorber plate. This research is carried out of experiment with and without wire sponge and Lost Energy
$= U_c (T_{p,ave} - T_e) A_c$

(2.5)
extended surface to increase heat transfer area and turbulence in the fluid and Compare the experiment result.

Key Words: Solar, Absorber Plate, Fins, Collector & Radiation Intensity.

By combining Eq. (2.2)–(2.5), the thermal energy balance equation necessary to describe the solar collector functioning is obtained:

$M_p C_p (dT_{p,ave} / dt) + m_p C_p (T_{out} - T_{in}) = \eta_0 IA_c +$

1. INTRODUCTION
$U_c (T_{p,ave} - T_e) A_c$

(2.6)

Energy crisis and global warming was lead to find an alternative way to overcome the above worsening situation. Renewable energy plays a major solution and thereby meets our energy demand and reduces the CO2 emission which reduces the greenhouse effect. And also reduce fossil fuel. In the renewable energy side, Sun is the mother for all sources and harnessing the solar energy in proper ways can eliminate the energy crisis of the world. Collectors are used and for low temperature application side flat plate collectors are used. In solar air heater, solar energy's collected by means of an absorbing plate and the collected heat energy is transferred to heat transferring medium such as air.

2. Working Principal of ThermoacousticRefrigeration System

2 Thermal analyses:

The optical yield (η_0) and the energy lose coefficient (U_c) are the parameters that characterize the behavior of the solar collector. Note that (η_0) represents the fraction of the

solar radiation absorbed by the plate and depends mainly ontransmittance of the transparent covers and on the absorbance of the plate.

Thermo-hydraulic behavior of flow inside solarheater duct

In [9] introduced a more realistic performance parameter that shows relative value of thermal gain than that of hydraulic loss, called thermo-hydraulic performance parameter, expressed

$$[{}^{Nu_r}]$$ ——

The theoretical model employed for the study of the solar collector that operates in unsteady state is made using a thermal energy balance.

$$\eta = \frac{Nu_x}{[\frac{f_r}{F_x}]^{1/3}}$$ ———— ——

(2.7)This factor shows the enhancement of heat transfer due to application of roughness over the smooth surface for the same pumping power requirements

The Nusselt number for roughened surface (Nur) can be estimated by using the mean heat transfer coefficient (h) as:

$$\left(\right) Q - W + \quad m\,\psi \qquad\qquad \sum 1 - \frac{T_e}{}\qquad \sum$$

$$-\sum m \quad \psi \quad = E$$

$$Nu_r = \frac{hd}{k}$$

(2.8)
Where

$$\left(T_s\right)$$

$$_s \qquad\qquad _{in}\;\;_{in} \qquad\quad _{out}\;\;_{out} \qquad _{x,dest}$$

(2.15)

Here over bar indicates time average, brackets h i indicate averaging in the y direction, and Ag is the cross-sectional theThe Nusselt number for smooth duct can be obtained by using the Dittus-Boelter Equation given as:

$$\psi_{in} = (h_{in} - h_e) - T_e(s_{in} - s_e)$$

$$\psi_{out} = (h_{out} - h_e) - T_e(s_{out} - s_e)$$

(2.16)

(2.17)

$$Nu_s = 0.23 \mathrm{Re}^{0.8} \, \mathrm{Pr}^{0.4}$$

(2.9)

If Eq. ((2.16) and (2.16) are substituted in Eq. (18), it isarranged that

Pressure drop for fully developed turbulent flow throughroughened duct is obtained by friction factor (fr) as:

$$\left(1 - \frac{T_e}{\quad}\right) Q$$

$$-m[(h$$
$$-h\ ) - T\ (s$$
$$-s\ )] = E \qquad\qquad\qquad \left|\quad T \quad\right|$$
$$\Delta p$$

$$\text{s} \qquad\quad \text{out} \quad \text{in} \quad\ \text{e} \quad \text{out} \quad \text{in} \qquad \text{x,dest}$$

$$f_r = \frac{2[\ ]D}{\rho v^2} \quad \frac{I}{}$$

(2.10)

$$\left(_s\ \right)$$

(3.18)

Exergy Analysis

Where Qs is solar energy absorbed by the collector absorbersurface and it is evaluated by the expression
This article focuses on the combination of the two laws of

$$Q_s = H(\tau\alpha)A_c$$

(3.19)

thermodynamics, which are described in the concept of exergy analysis. The assumptions made in the analysis presented in this study are:

The enthalpy and entropy changes of the air in the collectorare expressed by

a) Steady state, steady flow operation,
b) Negligible potential and kinetic energy effects and

$$\Delta h = h_{out} - h_{in} = c_p(T_{f,out} - T_{f,in})$$

(2.20)

no chemical or nuclear reactions,

c) Air is an ideal gas with a constant specific heat, andits humidity content is ignored

d) The directions of heat transfer to the system and

$$\Delta s = s_{out} - s_{in} = c_p$$

$$\ln \frac{T_{f,out}}{T_{f,in}} - R \ln \frac{P_{out}}{P_{in}}$$

(2.21)

work transfer from the system are positive.

The mass balance equation can be expressed in the rate form

$$m \qquad\qquad -T \qquad\qquad -mRT \ln_{out} = F_x$$

Substituting Eq. (2.19) – (2.20) in Eq. (2.18) it may berewritten as
as

$$\sum m^{in} =$$

$$\sum\nolimits_{out}$$

(2.11)

$$\left(\frac{T}{T} \right) \qquad\qquad \left| 1 - {}^{e} \right| H(\tau\alpha)A - mc\ (T$$

$$c \quad p \quad f,out \quad f,in \qquad p\ e$$

$$\frac{T_{f,out}}{T} \qquad\qquad\qquad) + mc\ T \ln$$

$$e \quad \frac{P}{P} \qquad dest$$

Where m is the mass flow rate, and the subscript in stand

$$\left({}_{s} \right)$$

$$f,in \qquad\qquad in$$

(3.22)

for inlet and out for outlet.

If the effects due to the kinetic and potential energy changesare neglected, the general energy and exergy balances can be

The irreversibility Ex_{dest} can be directly evaluated from thefollowing equation

expressed in rate form as given below

$$\sum E_{in} = \sum E_{out}$$

$$Ex_{dest} = T_e S_{gen}$$

The second law efficiency is calculated as

(3.23)

$$\sum E \quad - \sum E \quad = \sum E$$

(2.12)

$$\eta_{II} = 1 - \frac{T_e S_{gen}}{}$$

(3.24)

$$in \qquad out \qquad dest$$

(2.13)

$$\sum Ex_{heat} - \sum Ex_{work} + \sum Ex_{mass,in} - \sum Ex_{mass,out} = \sum E_{dest}$$

(2.14)

All physical properties of air were selected according to thefollowing bulk mean temperature:

Using Eq. (2.12), the rate form of the general exergy balancecan also be written as

$$\Delta T_m = (T_{in} + T_{out}) / 2$$

(3.25)

3. Instrumentation Setup

The experimental setup has been fabricated from the galvanized iron sheet of 16" gauge (1.6mm), the reduced draft has been provided to the equally air distribution at theinlet and outlet section. The absorber M.S. plate is put at themiddle of the solar air heater and all inner surfaces with absorber plate coated black paint to absorb the maximum solar radiation. Adjustable inclination stand has been designed to measure the effect of different inclination anglesof solar air heater. For batter comparison there are two setup will fabricated of same dimensions. Absorber plate area isdesigned to measure the effect is 0.5m2. Forced draft fan isplaced at the inlet of the DPSAH. 4mm clear glass is placed atthe top of the air heater to reduce the heat loss.
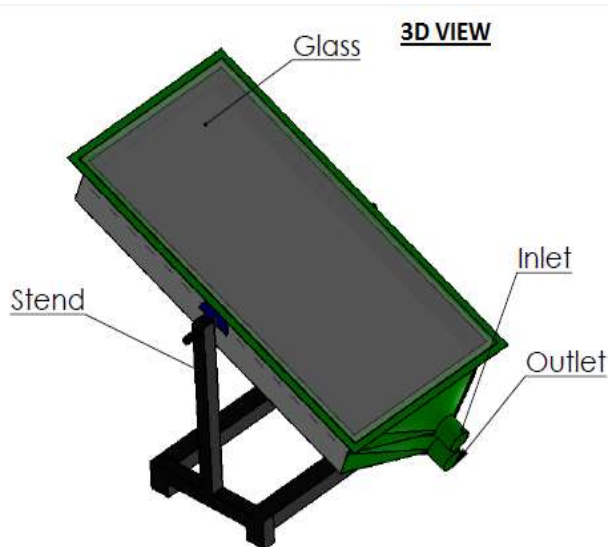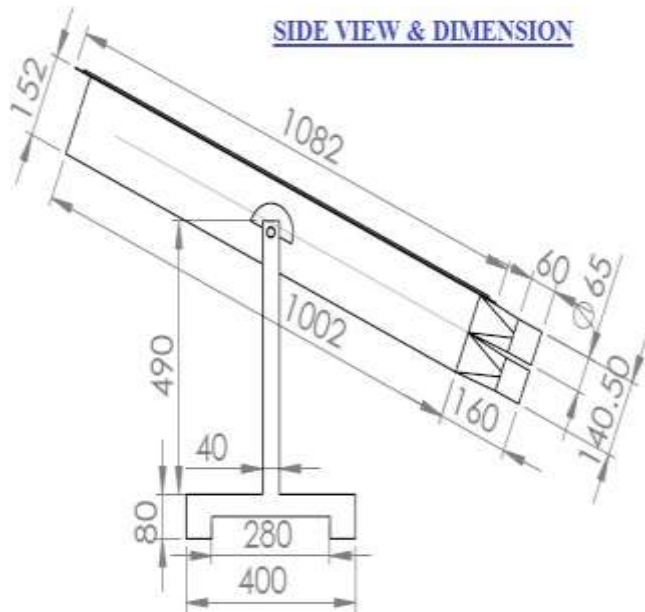

Figure 3.1 Experimental Setup CAD Design

Figure 3.2 Experimental Setup Dimensions

Figure 3.3 Experimental Setup

4. Result & Discussion

All resultant data for this concept of fins used in solar air heater has been carried out in typically sunny days in month of April. Where in Maximum Solar Radiation arrived at 910W/m2 and The Experiment was conducted from 10:00AM in morning to 04:00PM in Evening. All data has been measured with defined Instrument. Solar Radiation has been measured with the help of digital solar meter. Wind velocity and mass flow rate of air outlet has been measured with the help of anemometer, all Temperatures have been measured with the help of J type Thermocouple and value has been indicated in the j-type digital

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indicator. Flow rate has been regulated with the help of control valve at 10 mm. 20mm, 25mm & 30mm pressure difference

Temperature variation of air in Simple DPSAHwithout fins with 10dp

The maximum solar radiation is observed at 2:00PM. The maximum temperature has been observed at 2:00PM 83 °C.lowest temperature recorded in air inlet of 38°C. the maximum temperature of air inlet is recorded at 43 °C. from10:00am to 2:00PM it has been gradually increased and after3:00PM it has been gradually decreased with respected to the solar radiation. Air outlet maximum temperature has been observed is 63 °C.
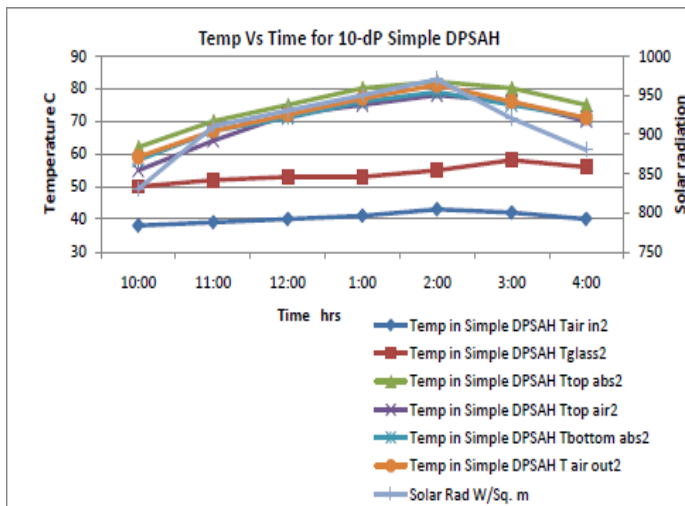

Figure 4.1 Temperature Vs Time Vs Solar Radiation for10mm dp & Simple DPSAH

Temperature variation of air in Simple DPSAHwith fins with 10dp

From the Above Figure 4.2, it has been observed that the alltemperatures have been increased with respected to the time by attaching the fins. The maximum solar radiation inboth type of solar air heater has been observed at 02:00PM.The maximum Temperature has been achieved with 10mmpressure difference in the Top absorber plate at 02:00PM forfinned obserber plate in case of finned and without fin obserber plate, The Temperatures has been gradually increased with respected to the time up to 02:00PM and it has been decreases gradually after 02:00PM.
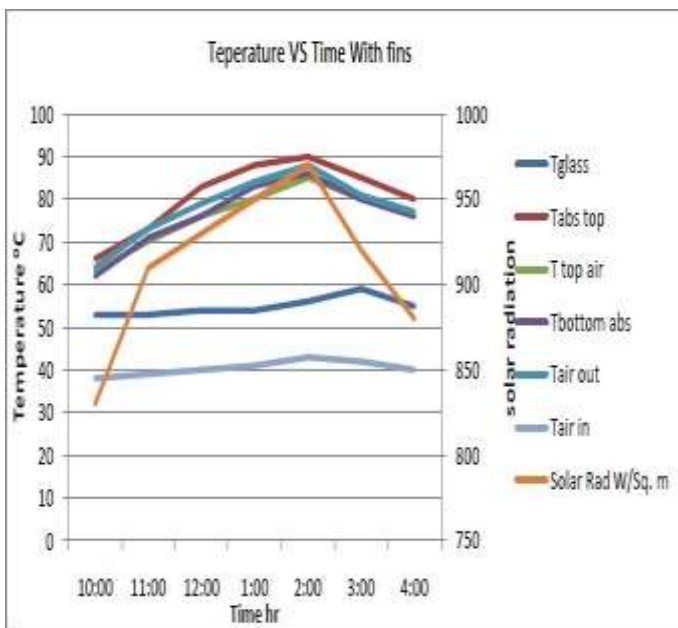

Figure 4.2 Temperature Vs Time Vs Solar Radiation for10mm dp with fins

Temperature variation of air in Simple DPSAHwithout fins with 20dp

We can the see the result in the fig-4.3. Result show that a small change in mass flow rate changes the maximum temperature of air and plate. The maximum solar radiationis observed at 2:00PM. The maximum temperature has beenobserved at 2:00PM 86 °C. lowest temperature recorded inair inlet of 27°C. the maximum temperature of air inlet is recorded at 35 °C. from 10:00am to 2:00PM it has been gradually increased and after 2:00PM it has been graduallydecreased with respected to the solar radiation. Air outlet maximum temperature has been observed is 69 °C.
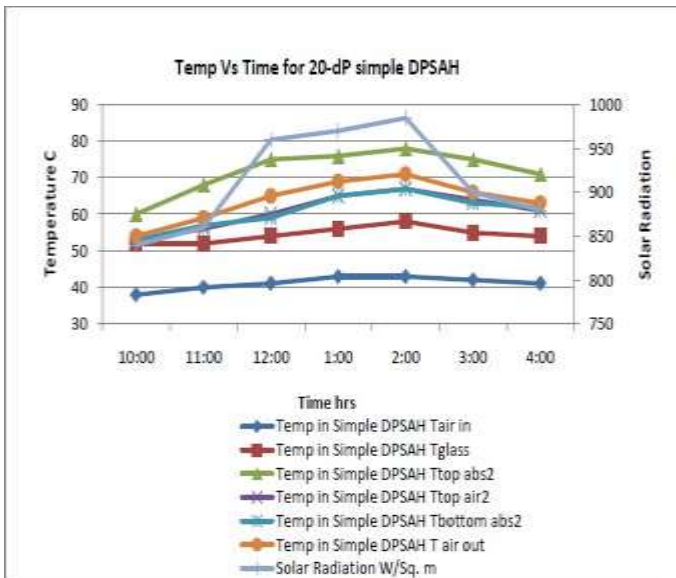

Figure 4.3 Temperature Vs Time Vs Solar Radiation for20mm dp & Simple DPSAH.

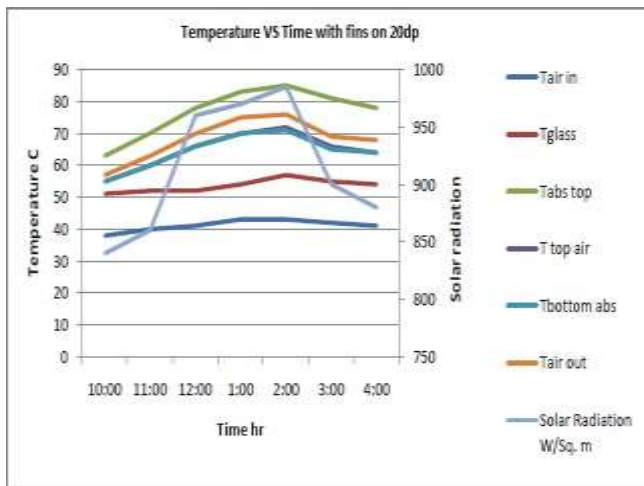## Temperature variation of air in Simple DPSAHwith fins with 20dp

Figure 4.4 Temperature Vs Time Vs Solar Radiation for20mm dp with fins

Attaching the fins on lower surface of observer plate is enhancing the heat transfer rate AS we seen that small change in mass flow rate is increase the maximum and minimum temperature of obserber plat and air. The maximum solar radiation is observed at 2:00PM. The maximum temperature has been observed at 2:00PM 84 °C.lowest temperature recorded in air inlet of 26°C. the maximum temperature of air inlet is recorded at 35 °C. from10:00am to 2:00PM it has been gradually increased and after2:00PM it has been gradually decreased with respected to the solar radiation. Air outlet maximum temperature has been observed is 64 °C.

Temperature variation of air in Simple DPSAHwithout fins with 25dp

By increase the mass flow rate pressure drop is increases and maximum temperature of air and observer plate decreases. The maximum solar radiation is observed at 2:00PM. The maximum temperature has been observed at 2:00PM 80 °C. lowest temperature recorded in air inlet of 26°C. the maximum temperature of air inlet is recorded at 34°C. from 10:00am to 2:00PM it has been gradually increasedand after 2:00PM it has been gradually decreased withrespected to the solar radiation. Air outlet maximum temperature has been observed is 63 °C.
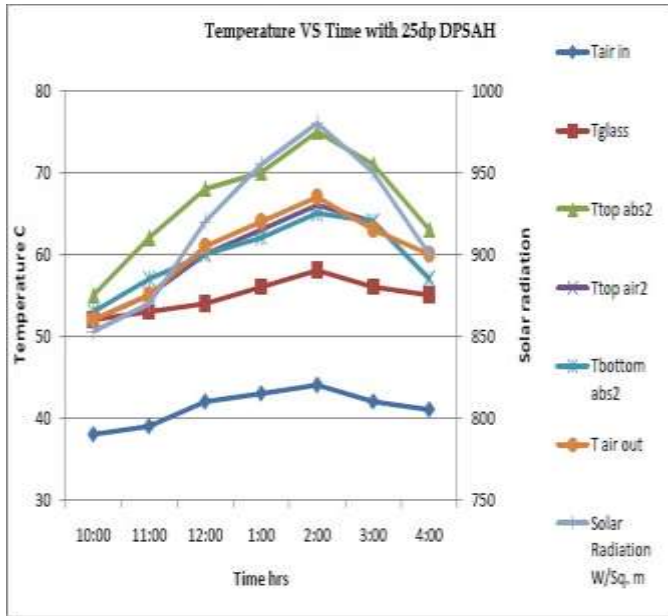

Figure 4.5 Temperature Vs Time Vs Solar Radiation for25mm dp & Simple DPSAH

Temperature variation of air in Simple DPSAHwith fins with 25dp

From the Above Figure 4.6, it has been observed that the alltemperatures have been increased with respected to the time. We get the optimum parameter if concern the pressure drop and temperature gradient. It also helps to reduce the external irreversibility of the system. The Temperatures and solar radiation have been gradually increased with respectedto the time up to 02:00PM and it has been decreases gradually after 02:00PM. From the charts it has been observed that Temperatures glass temperature, absorber top surface temperature, and Air temperature in uppersection, temperature of absorber bottom surface, air-in, andair-out increases with time gradually and it decreases after02:00PM gradually. From the charts Top surface of absorberplate has been observed the largest temperature 78 ˙C in Solar Air Heaters and then after Top absorber plate, Bottomabsorber plate, air outlet, Top Air, glass temperature and Air-In Respectively From Higher to Lowest direction. The maximum out let air temperature has been observed 75 ˙C.

Figure 4.6 Temperature Vs Time Vs Solar Radiation for25mm dp & with fins
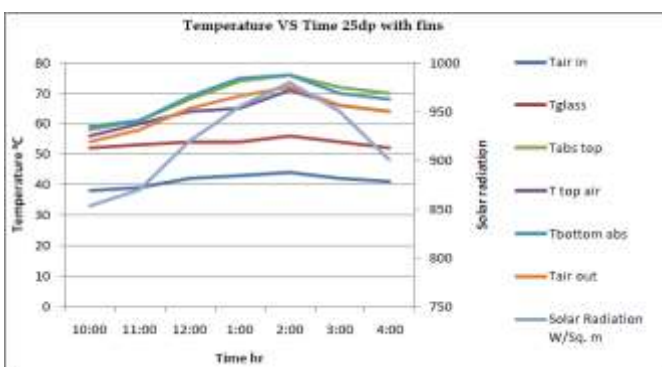
5. CONCLUSIONS

The pressure drop along the collector increases as the collector length increases for the all mass flow rates. At the lower mass flow rate of 0.0073kg/s the pressure drop for the fin solar air heater is 4.01% whereas it increases by around 15.4 % for the maximum mass flow rate 0.132kg/s without fins. And it is increased by around 19.60% at maximum mass flow rate with finned surface Also, increasing the collector length became ineffective beyond the mass flow rate of 0.017kg/s for the fin solar air heater. The thermal efficiency decreases as pressure drop increases. To overcome this and enhance the heat transfer from SAH heater finned is more significant. It increases the heat transfer rate with minimum pressure drop so thermal efficiency of the system is increase.

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