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Research paper

Experimental Investigation of Solar Room Heater for Commercial Purpose

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Abstract:

According to the present era the requirement of the energy is continuously increasing. At the earth surface abundant quantity of heat is available but not in useful form, one of the main source of this energy is Solar which is available free of cost. On the basis of this theory we have designed a solar room heater by using tin cans soldered with spiral wire for increasing heat transfer between air and solar heat present in the collector. After designing the experimental set up experiment will be carried out for finding the outlet temperature, velocity of air for calculating heat transfer and pressure drop, heat transfer characteristics across the solar air heater. In this study, we have concluded the temperature of inlet air will improve around 17^0C to 20^0C without using any external device like blower and fans.

Keywords: *Solar Room Heater, Tin Cans, Thermocots, Heated Air, Thermometer.*

1 Introduction

In these day world is started move towards the renewable energy resources due high depletion of the fossil fuels and increasing rate of petrol, diesel and lot of environment and health problem faced by human being. The total energy from the fossil fuels is only 1% of the energy coming on the earth by sun in one day. **Sukhatme S.P. in 2003** concluded that wider spacing tube had higher efficiency than lesser spacing tube. **M.K. Mittal et.al.2005** the roughened solar room heater performed better than conventional smoother solar room heater. He alsoconcluded that increase in efficiency due to use of inclined roughened rib in pipe of solar heater**.Varun et. al. (2007)** determined the heat transfer, friction factor by taking the inclined and transverse ribs over the absorber plate in between the range of reynolds number of 2000 to 14000 at defined relative roughness pitch, relative roughness height.**R.P. Saini and JitendraVerma (2008)** improved the heat transfer rate by providing roughness underside to the absorber plate duct in the range of reynolds number from 2000 to 12000 with relative pitch 8 to 12 and relative height 0.018 to 0.037.**S.V. Karmare and A.N. Tikekar (2008)** have been investigated the effect of producing artificial roughness on pumping power and thermodynamic performance parameter in the range of Reynolds number from 3600 to 17000 at different-2 ralativepich, relative height **Santosh B. Bopche andMadhukar S. Tandale (2009)**have been determined the heat transfer coefficient, fiction factor in the U shaped roughened surface by making roughened wall heated and other three walls insulated. The experiments conducted on the range of Reynolds number 3800 to 18000 at different-2 hydraulic diameter. **R.S. Gill et. al. in 2012** concluded that ambient temperature, stagnation temperature , solar radiation variation though out the day in single glazed, double glazed and packed bed air heater**.**He also concluded that single glazed room heater give better performance in summer and double glazed room heater performed well in winter. **Vijay et.al.(2018)** experimental investigations was related to the artificial roughened solar heater. In this experiment he observed the effect of different variable of roughness (height, width, angle, pitch etc) on the heat transfer coefficient and friction factor for calculating the efficiency of collector, exergetic efficiency of air flow out of collector. **M. Ansari et.al.(2018)** in his experiments set developed the rib type solar model in which optimized height of the rib is find out and concluded that taller height rib will produce the high turbulence at low mass flow rate**. Deep Singh Thakur et. al.(2016)** done the 2D CFD analysis over artificial roughened solar air heater with novel hyperbolic ribs. The performance of novel hyperbolic ribs are also validated with rectangular, triangular and semicircular ribs performance at different-2 reynolds number and checked upto the 10000. **M. Cuzminschiet. al.(2017)** done the experimental and CFd analysis on solar air heater for residential purpose.It is fully depends on the natural convection phenomena and can be used for drying the seed, nuts, fruits.**SimarpeetSingh(2017)** done the numerical simulation on ANSYS FLUENT(16.2) and getting the pressure field, velocity field, temperature field to determine the pumping power, nusselt number and heat transfer at solar constant of 500W/m2 in range of Reynolds number from 3800 to 14000. He also see the variation of nusselt number with Reynolds number and found that 10000 reynold number the nusselt number is significantly improved. **Ali Heydariaet. al.(2018)** design a model of solar air heater in which air is flowing at helical path through a triangular section. After designing the apparatus experimental and numerical experimentation investigation is done and same results is compared for finding the better designine**. A.E. Kabeel et.al.(2018**) compared the performance of conventional air heater, baffled glazed-bladed entrance air heater (BGBSAH) at the same operating conditions. In addition he found that baffeled glazed blade efficiency is increased from 29.91 to 51.69% with 800 baffled compared to conventional solar air heater. **Inderjeet Singh et.al.(2018)** used the roughened surface for breaking the laminar sub layer at the absorbing surface in turbulent layer for improving heat transfer characteristics and improve overall efficiency.

2.Experimental Set UP.

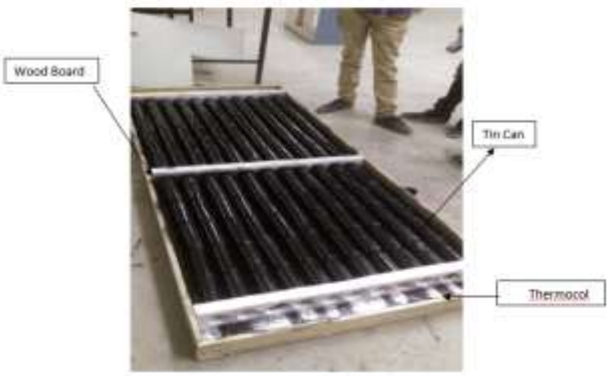

Figure-1: Experimental Set up of Solar Air Heater

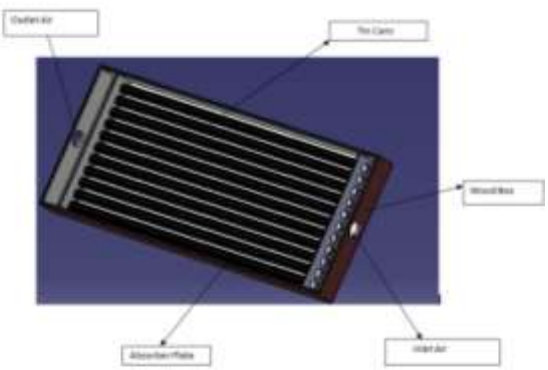

Figure-2: Model of Experimental Set Up

Figure-3: Measurement of Temperature at outlet of solar air heater

3. The experimental set up contain following parts

Tin can (10 cm diameter): used for movement of air from inlet to outlet. The air is moved due to pressure difference occur due to inclination of solar air heater at window of the room.
Wood board: is used to support whole frame the dimensions of 225cm*95cm. The front end of board contains the hole for entrance for the inlet air.
Thermocol: It is located at both side of the board have the 11 hole support the tin can painted with black color.
Transparent Glass Plate: A glass sheet 5mm thickness is provided to trap high wavelength of radiation coming from the top glass plate. It works like as the green house chamber.
Absorber Plate: it is the 1mm thick copper sheet black paintedso that its absorvity is around 100%.
Insulation: Mineral wool of 8cm is used for the perfect insulation from bottom site for stopping heat transfer by convection, conduction.

4. Mathematical Equation

Heat energy from Sun passes through the cover plate reached on the absorber plate. The absorber plate are black painted so most of the energy is absorbed by it rest of the energy is reflected back to atmosphere some part of it is transmitted to the bottom plate. Therefore for writing the model equation we have write the energy balance among absorber plate, cover plate, bottom plate , atmosphere present around the solar air heater. These equation taken from book of solar energy written by **S.P. Sukhatame[4].**
Solar energy absorbed by Absorber Plate= Heat transfer to atmosphere by convection + Heat transfer to fluid air by convection+ heat transfer to bottom plate by radiation

$$SL_2dx = u_tL_2dx(T_{pm} - T_{bm}) + \square_{fp}L_2dx(T_{pm} - T_f) + \sigma L_2dx(T_{pm}^4 - T_{bm}^4)/(\frac{1}{\epsilon_p} - \frac{1}{\epsilon_b} - 1) \quad (1)$$

For bottom plate

$$\frac{\sigma L_2dx(T_{pm}^4 - T_{bm}^4)}{\frac{1}{\epsilon_p} - \frac{1}{\epsilon_b} - 1} = \square_{fb}L_2dx(T_{bm} - T_f) + u_bL_2dx(T_{bm} - T_a) \quad (2)$$

For Air stream

$$m^{\cdot}c_pdT_f = \square_{fp}L_2dx(T_{pm} - T_f) + \square_{fb}L_2dx(T_{bm} - T_f) \quad (3)$$

Radiation Heat transfer Coefficient

$$h_r = 4\sigma Tav^3/(\frac{1}{\epsilon_p} + \frac{1}{\epsilon_b} - 1) \quad (4)$$

$$T_{av} = \frac{T_{pm} + T_{bm}}{2} \quad (5)$$

Useful heat gain

$$q_u = F_R A_p [S - U_l^{II} (T_{fi} - T_a) \tag{6}$$

Heat Transfer

$$F_R = mC_p / U_l^{II} A_p [1 - e^{\left\{-\frac{F^I U_l^{II} A_p}{mC_p}\right\}}] \tag{7}$$

Kays Equation

$$N_u = 0.0158 R_e^{0.8} \tag{8}$$

Malik and Buelow Equation

$$N_u = 0.\frac{01344\, R_e^{0.75}}{1 - 10586 R_e^{-0.125}} \tag{9}$$

Equivalent Diameter

$$d_e = \frac{4A}{p} \tag{10}$$

Blausius Equation

$$f = 0.079 R_e^{-0.25} \tag{11}$$

5. Experimental Reading

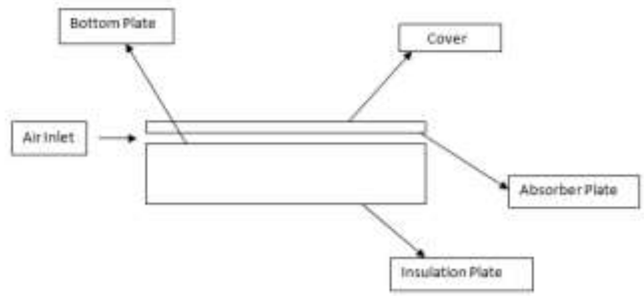

Figure-4: Arrangement of Absorber plate, Cover plate, Bottom Plate

Table-1: Experimental reading

S.No.	Inlet Temp (°C)	Outlet Temp(°C)	ΔT (°C)	velocity	Mass flow rate Of airKg/sec
1	40	57 °C	17 °C	0.4246	0.040
2	35	50 °C	15 °C	0.478	0.045
3	33	46 °C	13 °C	0.5626	0.053
4	30	40 °C	10 °C	0.6263	0.059

Table-2: On the basis of experimental reading calculation of heat transfer, pressure Drop

Reynold Number ($\rho V d_e / \mu$)	Friction Factor $f = 0.079\, R_e^{-0.25}$	Pressure Drop $\delta P = 2 f \rho L V^2 / d_e$	Nusselt Number $N_u = 0.0158 R_e^{0.8}$
2567	0.011098	0.108	8.437
2887	0.01078	0.133	9.2686
3401	0.010344	0.1767	10.56
4544	0.009622	0.2	13.323

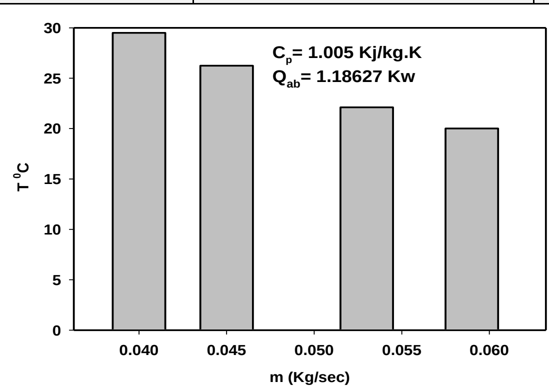

Figure-5: Variation of Outlet Temperature with Mass flow rate.

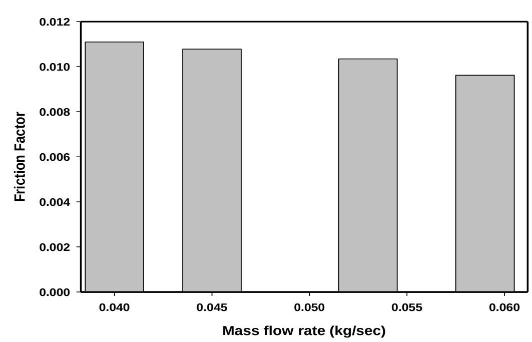

Figure-7: Variation of Friction Factor with Mass flow

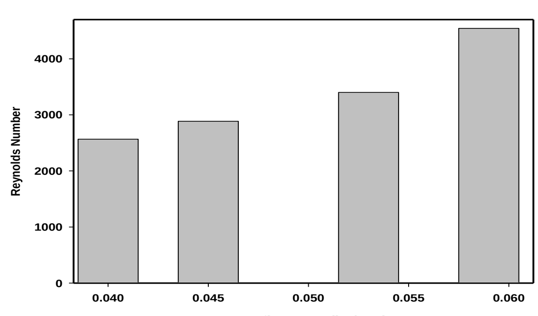

Figure-6: Variation of Reynolds Numaber with Mass flow rate.

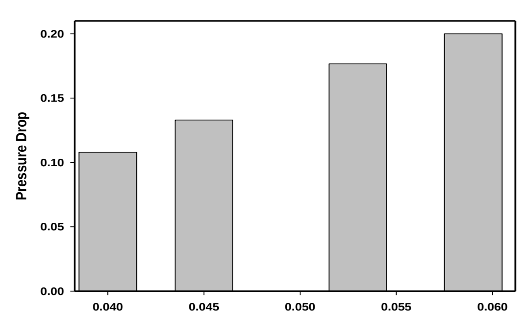

Figure-8: Variation of Pressure Drop with Mass flow rate.

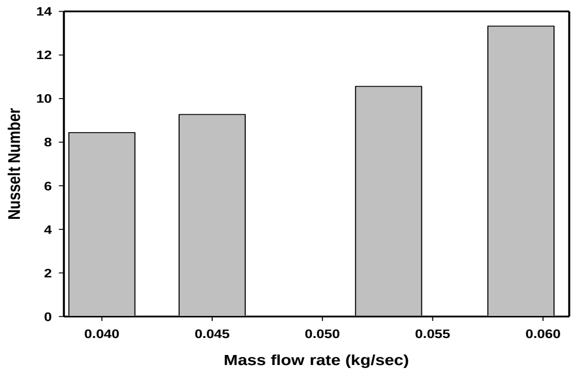

Figure-9: Variation of Nusselt Number with Mass flow rate.

6. Conclusion

In this paper we have concluded the following observation at the time of experimentation.

1- Figure-5 concluded that the temperature at outlet reduced due to incensement of mass flow rate because most of the heat absorbed by solar plate is transmitted to the air flow through the spiral tin can pipe.
2- Figure-6 shows the variation of Reynolds number significantly by small increment of mass flow rate.
3- Figure-7 shows that when mass flow rate increase friction factor little bit improve but in figure-8 pressure drop increased significantly due to increment in velocity.
4- Figure-9 shows the increment of nusselt number with mass flow rate. So we can concluded that due to increase in nusselt number heat transfer coefficient also improved result in several times heat transfer.

The only demerit of solar energy in winter season is reduced because sun rays are slanting in the northern hemisphere so intensity of heating on earth is less. The running cost of solar heating is very less only maintenance cost is there.

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