Performance Analysis Of Solar Air Heater By Extended Heat Transfer Surfaces

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Abstract

The power from the sun intercepted by the earth is approximately 1.8 x 10^{11} MW, which is many thousands of times larger than the present consumption rate on the earth of all commercial energy sources. Thus, in principle, solar energy could supply all the present and future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources.

In this study, the effect of longitudinal fins on heat absorbing media in air type solar collector is studied experimentally. In the solar air heater, the value of the heat transfer coefficient between the absorber plate and the air is low and this result in a lower efficiency ranging 40% to 50%, to overcome this problem, the surfaces are sometimes roughened or longitudinal fins are provided in the air flow passages. The addition of continuous longitudinal fins to the upper or bottom side of the absorber plate improves the heat transfer rate. This is desirable because it increases the overall efficiency of the air heater.

Heat transfer is strongly base upon the area of contact of sun radiations, by using this criteria the maximum total radiation is collected and is used to heat the air by solar energy. By changing the collector tilt angle for at least three positions (as above 5ºC and 10ºC to the latitude angle) and checked the performance of the air heater, also the effect of varying air mass flow rate on the heat transfer is studied. It is found that effective heat transfer coefficient is maximum for the smallest pitch of the longitudinal fins, in addition the friction factor and pressure drops are found lowest with largest Reynolds number.

Keywords :- Solar energy**,** Solar Air Heater , Heat Transfer, Longitudinal Fins, Forced Convection.

Nomenclature

hc- convection heat transfer coefficient ,W/m^{2}K

hr – radiation heat transfer coefficient, W/m^{2}K

L – Length of collector, m

v – Velocity, m/s

μ – Coefficient of viscosity, kg/m-s

m – Mass flow rate , kg/s

ρ – Density of the air , kg/m^3

w- Spacing between two fins , m

L_f-fin height, m

L_1, L_2 – Length and width of the collector, m

L – Depth of the collector, m

ΔP – pressure drop

σ - Stefan-Boltzman constant , W/m^{2}K^4

ti – inlet temperature, °c

ta – Ambient temperature, °c

to – outlet temperature , °c

Dimensionless numbers

Nu – Nusselt number

Re – Reynolds number

f – friction factor

1. Introduction

Air solar heater is a specific type of heat exchanger which transfers heat energy, which is obtain by absorbing solar radiation to air. Basically in heat exchanger heat transfer from fluid to fluid occurs by conduction and convection, on other hand, in air-type solar heater heat transfer occurs from an energy source which spreads radiation to air.

Air solar heater are used in food industry to dry agricultural products, textile industry to dry fabrics and space heating, drying grains, fruits, vegetables, tea are examples of food industry, greenhouse heating and hospital heating to obtain fresh air are example of space heating.

One of the method of improving the performance of solar air heater is the addition of longitudinal fins on the absorber plate which increases the surface area and hence the collector performance increases. An important application of solar energy is to supply hot air for drying of agriculture products and for the heating of buildings, there are various configuration of solar air heater which may be employed for this purpose among these, one of the simplest and most commonly used this type which is easy to manufacture and relatively cost effective.

2. Literature Survey

Several designs have been proposed in the literature, to increase the heat transfer coefficient between the absorber plate and the flowing air, these include the rectangular fin plate, fin heat exchanger, finned absorber air heater, co-regulated absorber air heater for rectangular fined plate the length of the absorber plate plays important role in improving the efficiency of solar air heater, increasing the length of absorber plate increases the efficiency and is higher for shallower duct depth [2] .

The analytical study on rectangular longitudinal fins [8] shows a significant increase in the effective heat transfer coefficient, as surface emissivities of the absorber plate and bottom plate increases also for strong radiation the effective heat transfer coefficient is highest and as the spacing between two fins (w) increases the effective heat transfer coefficient decreases.

The comparative study [9] on selective and non-selective absorber plate shows the lowering of forward heat loss by radiation to the environment for the selective absorber.

The use of porous media in the solar air heater improves the heat transfer from the absorber to the air stream because of high volumetric heat transfer coefficient [10].

Theoretical analysis [7] on finned solar air heater shows the increase in outlet air temperature and efficiency with the increase in number of fins.

3. Present Work

However the experimentation on longitudinal finned solar air heater has not been touch before so to check the performance of the longitudinal finned solar air heater, this area is taken for experimentation.

For experimental set up, the length and width of the collector are 700 mm and 400 mm respectively.

Primary duct size =(240 *240) mm
Secondary duct size = (240 *240) mm
Depth of the collector = 150 mm
Distance between cover plate to absorber plate
= 50mm.
Distance between absorber plate to bottom plate = 75 mm
Number of fins = 16
Spacing of the fins = 25mm
Height of the fins = 30 mm
Material of the absorber plate, Aluminum, 1mm
Thickness of the cover plate, glass, 5mm

Due to manufacturing constraint and easy availability and high thermal conductivity of aluminum, the absorber plate made of Aluminum sheet and connected to the fins to increases the heat transfer area.

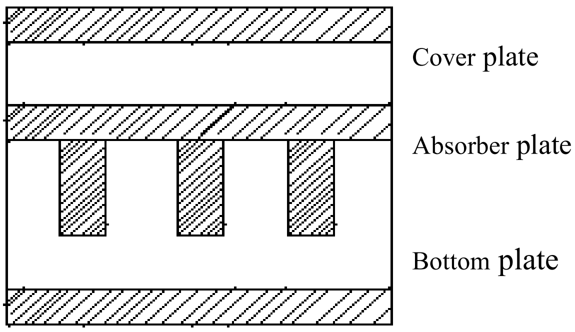

Fig 1 : Constructional features of Solar Air Heater

4. Experimental Setup And Procedure

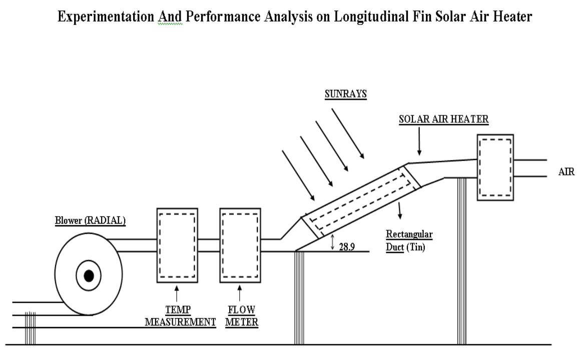

Fig 2: Schematic of longitudinal fin Solar Air Heater

Experimental setup, which consists of rectangular fins with duct manufacture by casting or fabrication. The radial fan and air ducts, The absorber plate is metal sheet about 1mm in thickness usually made of GI or steel or aluminum.(IS 12933) Continuous longitudinal fins extend to bottom side of the absorber plate.

Set up consist of vane anemometer (flow meter) and thermocouples. Glass of thickness 5 mm (IS277) is used as cover material. Insulating material of thickness 5 mm is used for the bottom and side insulation. Insulation is also provided at the back.

The whole set is placed in the clear sunny day at Nagpur (79°.10'E, 21°.8'N) and mass flow rate is controlled by the control valve. The tilt angle of collector is set at 21.8^0 Once the steady state is reached the inlet temperature of air (ti) ,ambient temperature (ta), and outlet temperature of air (to) is recorded at an interval of 30 minutes.

The procedure is repeated for different mass flow rates and collector tilt angle of 26.8^0 and 31.8^0

5. Result and Discussion

1) Increases the performance of the collector:

With the longitudinal finned absorber plate the increase in efficiency of the collector is found to be 10 to 18 %. Experimentally obtained value of collector efficiency is 61.58% whereas the recommended value of the maximum efficiency of collector without finned absorber plate is 56.88%

2) Friction factor and pressure drop in solar air:-Variations of friction factor with Reynolds numbers, as Reynolds number increases, the friction factor decrease in the channel formed between two longitudinal fins.

3) The effect of ambient temperature, temperature difference between inlet and outlet of air type solar heater and wind speed are investigated. wind speed does not affect efficiency directly for measured value, on other hand, ambient temperature performs significant effect on the thermal performance of air heater.

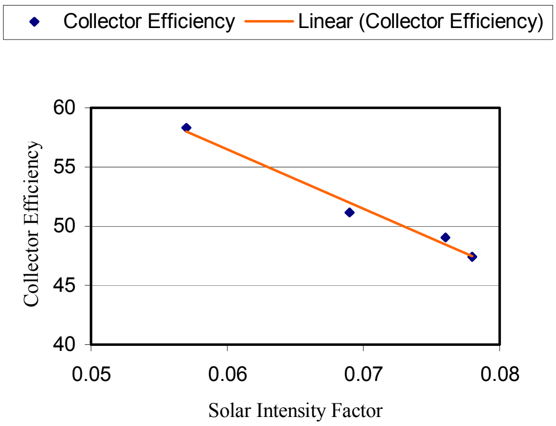

Fig. 3 Collector performance curve

Fig. 3 shows that the ratio of temperature difference to the total radiation intensity decreases, the collector efficiency increases .this curve also known as collector performance curve.

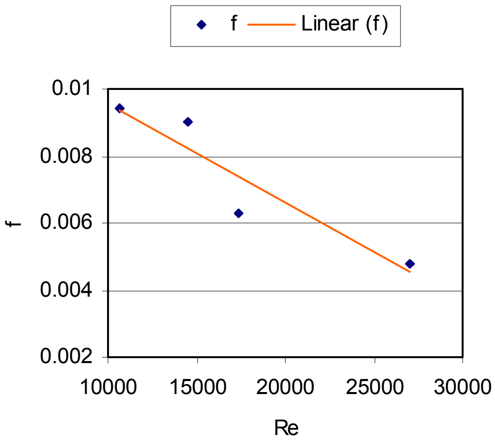

Fig. 4 Variation of friction factor with Reynolds number

Fig. 4 shows that the Reynolds number increases the friction factor decreases, however the friction factor depends on the Reynolds number and depth of the collector and fin height.

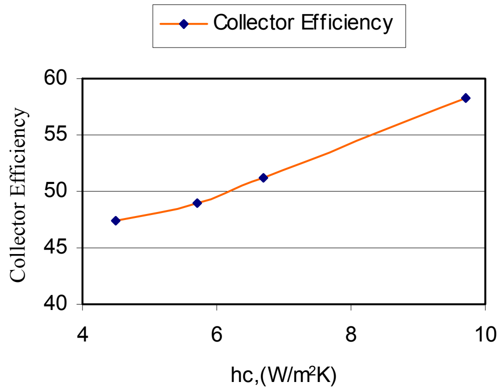

Fig. 5 Variation of collector efficiency with convective heat transfer coefficient

Fig 5 shows that the convective heat transfer coefficient increases, the collector efficiency also increases therefore the performance of the collector increases.

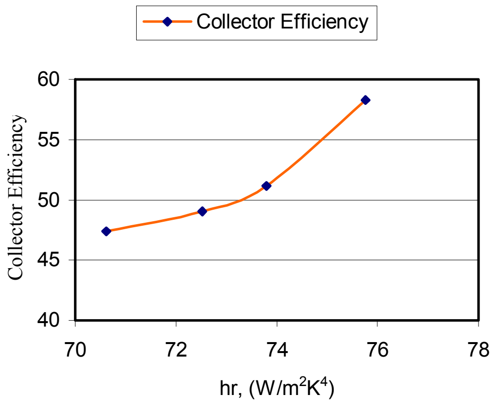

Fig. 6 Variation of collector efficiency with radiation heat transfer coefficient

Fig 6 shows that the radiation heat transfer coefficient increases, the collector efficiency also increases that is collector efficiency strongly depends on the radiation heat transfer coefficient.

6. Conclusion

1] The friction factor decreases as Reynolds number increases.

2] As friction factor increases the pressure drop increases and so heat transfer rate also increases.
3] With the longitudinal finned absorber plate the increase in efficiency of the collector is found to be 10 to 18 %.
4] As the ratio of temperature difference to total radiation decreases the collector efficiency increases. It shows that the performance of solar air heater is strongly depend upon the solar radiation and ambient temperature.

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