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Performance Analysis of Solar Air Heater

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Abstract—*Double pass counter flow solar air collector is one of the important and attractive design. Absorber plate of this collector is a critical part of design on which performance of collector depends. Flat absorber plate is the simplest design. For performance improvement different variations of absorber plate can be used. This paper presents experimental analysis of double pass solar air collector with flat and wavy shape absorber plate. Effects of various parameters on the thermal performance and pressure drop characteristics have been discussed.*

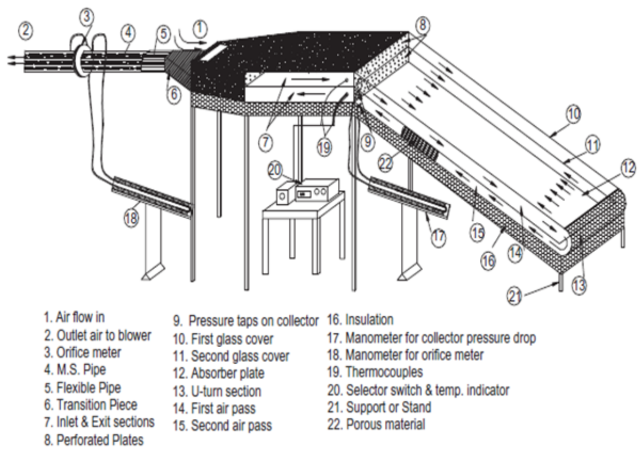
1. INTRODUCTION

Solar energy is converted into thermal energy in a solar collector. Solar collector basically is a device used to trap solar energy to heat a plate and transfer the heat to a fluid flowing under or above plate. When sun light falls onto a plate, solar radiations reach the plate at lower wavelength and heat it up. Then the heat is carried away by either water or air that flows under or above the plate. Solar collector used to heat up air is called solar air heater (SAH). Air is much lighter and less corrosive than water. Heated air can be used for moderate-temperature drying, such as harvested grains or fish. Since the solar air heater has less convective heat transfer coefficient, some researchers tried to increase this convective heat transfer coefficient. A popular type of solar air heaters is the flat plate SAH, which has a cover glass on the top, insulation on the sides and bottom to prevent heat transferred to the surrounding, a flat absorber plate that makes a passage for the air flowing with sides and bottom plate. Usually, the passage or channel has a rectangular cross-section. The absorber plate will transfer the heat to the air via convection. Unfortunately, the convection coefficient is very low. To increase the convection coefficient from the absorber plate, v-corrugated plate is used instead of a flat plate. Tao et al.(2007) stated that a solar air heater with a v-grooved absorber plate could reach efficiency 18% higher than the flat plate on the same operation condition and dimension or configuration. Karim dan and Hawlader (2006) found that a solar collector with a v-absorber plate gave the highest efficiency and the flat plate gave the least. The results showed that the v-corrugated collector is 10–15% and 5–11% more efficient in single pass and double pass modes, respectively, compared to the flat plate collectors. Choudhury dan and Garg (1991) made a detailed analysis of corrugated and flat plate solar air heaters of five different configurations. For the same length, mass flow rate, and air velocity, it was found out that the corrugated and double cover glass collector gave the highest efficiency. According to Naphon (2007) the corrugated surfaces give a significant effect on the enhancement of heat transfer and pressure drop.

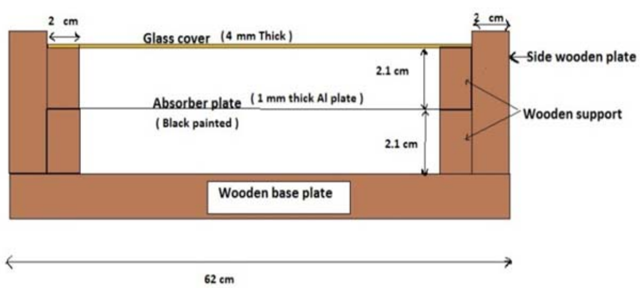
2. EXPERIMENTAL SET UP

Experimental set up has been designed for external data collection. Two identical air heater set up are designed and fabricated one with flat absorber plate and another with wavy shape absorber plate. Both are double pass arrangement. One pass is made between glass cover and absorber plate and second pass is made between absorber plate and wooden base. Second pass has air flow in reverse direction. Both the passes has same length that is 210 cm. Width of both the passes is kept 60 cm and depth 2.1 cm. These collectors are fixed on iron base inclined at 30 degree due south to maximize the incident solar radiation on collector for year round application. Absorber plate of both set up is made of 1 mm thick aluminum plate. Absorber plate is painted by black board paint which is assumed to have high absorptivity value. Below absorber plate there is 20 mm thick wooden plate which act as insulation and supportive base. Transparent glass cover of 4 mm thickness is kept as a cover which is transparent for short wavelength and opaque for longer wavelength. Gap between absorber plate and glass cover is 2.1 cm. Two passes are connected by smooth U turn. Sides of both collectors are made by 20 mm thick wooden plates. These collectors are supported on iron base of size 25*25*5 mm. Entrance and exit duct are provided at inlet and outlet to stabilize the flow. These are made from plywood of thickness 20 mm and having cross section same as test section. This is done on basis of ASHARE Standard 92-77(1997). Two perforated aluminum plates of 1 mm thickness and equal to cross section area of the passage are placed perpendicular to flow direction to allow mixing of the air at entrance and exit of test section and to facilitate measurement of air temperature after mixing at entrance and exit of solar air collector. Exit section is connected to blower through G.I. pipe and flexible pipes. A centrifugal blower of 2.2 kW capacity is used to draw ambient air into collector through the entrance section. Measurement of mass flow rate of air through each collector is accomplished by two separate orifice meters. Temperature is measured by calibrated copper constantan thermocouples. The pressure drop across the collector has been measured using a standard manometer with manometric fluid as kerosene. The intensity of solar radiation has been measured by means of a

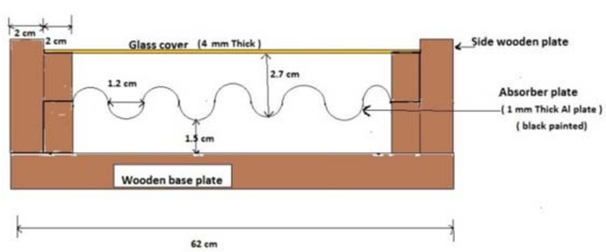
Pyranometer (PSP Model supplied by The Eppley Laboratory Inc., USA) having a calibrated constant of 8.0 *10^6 volts per watts/m2.



Dig- Line diagram of set up



Dig- Cross section of flat plate collector



Dig- Cross section of wavy plate collector

Dig- Actual set up of air heater

3. PERFORMANCE PARAMETERS

The experimental data have been used to determine desired parameters. All the properties of air, i.e. viscosity, density, specific heat, used in the calculations, are evaluated at the arithmetic mean of the inlet and the outlet temperature of air. The useful heat gain, Qu is given as under

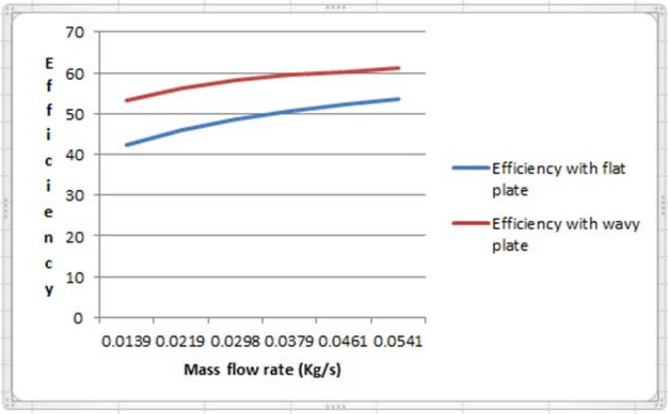
$$Q_u = mc_p\{T_{fo} - T_{fi}\}$$

Thermal efficiency of double pass solar collector is determined from following equation:

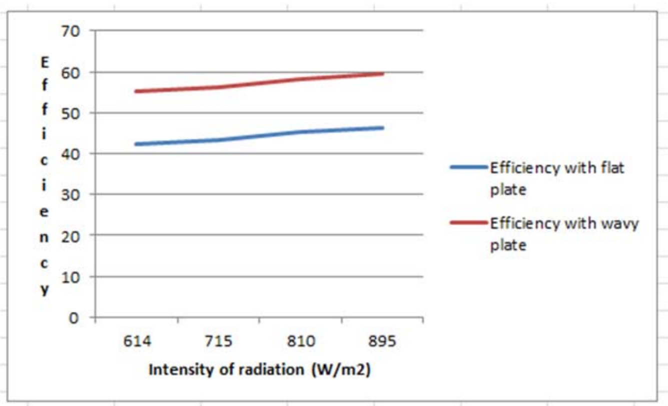
$$\eta = \frac{Q_u}{A_c I} = \frac{mc_p\{T_{fo} - T_{fi}\}}{A_c I}$$

4. RESULT AND DISCUSSION

Double pass counter flow solar air collector with wavy shape absorber plate gives higher thermal efficiency in comparison to double pass counter flow solar air collector with flat plate. This can be due to the fact that the porous material absorber plate. Because wavy shape absorber plate provides very large surface area for heat transfer and hence the volumetric heat transfer coefficient is high.



Dig- Variation of efficiency with mass flow rate



Dig- Variation of intensity with intensity of radiation

REFERENCE

1. Tao, L., Wen, X.L., Wen dan, F.G., Chan, X.L., 2007. A Parametric study on the termal performance of a solar air collector with a V-groove absorber. Int. J. Green Energy 4, 601–622.

2. Karim dan, Hawlader, M.N.A. 2006.Performance investigation of flat plate, V-corrugated and finned air collector. Energy 31, 452–470.

3. Choudhury dan, C., Garg, H.P., 1991. Design analysis of corrugated and flat plate solar air heaters. Renew. Energy I (5/6), 595–607

4. Abhishek Saxena, Varun, A.A. El-Sebaii(2014),"A thermodynamic review of solar air heaters", Renewable and Sustainable Energy Reviews 43(2015)863-890

5. Naphon, P., 2007. Heat transfer characteristics and pressure drop in channel with V corrugated upper and lower plates. Energy Convers.Manage. 48, 1516–1524.