THERMAL PERFORMANCE OF SOLAR AIR COLLECTOR BY COMPARING SINGLE GLASS COVER WITH DOUBLE GLASS COVER: EXPERIMENTAL INVESTIGATION

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ABSTRACT

Solar energy is that energy which is rapidly gaining acceptance as an energy saving measure in various applications. It is preferred as an alternative source of energy. The thermal performance of the air collector is investigated experimentally at various different operating parameters. Air is used as the working fluid in this experimental set-up. The aim of the experiment is the production of hot air by using the aluminium tubes with single glass sheet and double glass sheet. Air Collector efficiency in between these single and double glass sheet is been found. The temperature difference and the collector efficiency are studied with different flow rates of air. It is observed that the air collector containing single glass sheet has higher efficiency when compared to the double glass sheet air collector. The maximum efficiency in case of single glass sheet air collector is 72.1% which is higher when compared to the efficiency of the double glass sheet air collector which is found to be 58.8%.

Keywords: Solar Air Collector, Single and Double Glass Sheet, Air Collector Efficiency

I. INTRODUCTION

A solar collector is a device which converts the solar energy into the useful heat energy in the most efficient way. As we all know that our conventional energy resources are decreasing day by day. It is mainly due to the prolonged use of the electricity which is produced by coal, gas, diesel, etc. The emissions and the byproducts of these fuels are effecting the environment very badly which is resulting in the global warming, depletion of ozone layer, causing acid rain, etc which is very harmful for all the living beings. So, we need to find an alternative method by which we can reduce consumption of the electricity. Solar energy is the best non-conventional energy resource which can be use as an alternative method. Solar energy can be utilized directly in two ways. (I) by collecting the radiant heat and using it in the thermal systems. (II) By collecting and converting it directly to electrical energy using a photo-voltaic system. The solar air heating is pollution free and the running cost is also very low. It is environment friendly. But, the initial cost for set-up is very high and works in day time. It does not work properly on the cloudy or foggy days. This paper will present the comparison of thermal performance of the solar air heating consisting of aluminum tubes with single and double glass sheet.

A review of literature suggests that the considerable effects have been invested in research and development of solar air heating technology. **R Perez et al (1995)** developed a radiation model for evacuated collector with tubular absorber [1]. **L Qin (1999)** investigated the tube geometry and panel design of evacuated tube solar

collector [2]. **G L Morrison (2004)** measured the typical performance of the water in glass evacuated tube solar water heater [3]. **Young Kim (2007)** investigated the thermal performance of glass evacuated solar collector numerically and experimentally [4]. **Louise Jivan Shah (2007)** investigated heat transfer and flow structures inside the glass evacuated tubes for different flow operating conditions by computational fluid dynamics [5]. **Liangdong Ma (2010)** investigated the thermal performance of the individual glass evacuated tube solar collector by analytical method [6].

II. EXPERIMENTAL SETUP

The main objective of this experiment is to study the thermal performance of solar air collector and to produce hot air. The experimental setup is shown in Figure 1. The setup consists of 10 aluminium tubes, the length and diameter of each aluminium tube is 73cm and 2.54 cm respectively. The surface area of solar air collector is 1.40 m^2. The open ends of aluminium tubes are connected to the manifold channel and closed end is supported by frame. Blower is used to blow the air in the tubes.

Figure 1. Solar Air Collector

The experimental setup consists of the following parts:

(I) Aluminium tubes - Ten number of aluminium tubes are being used. Air is allowed to flow inside the aluminium tubes.

(II) Manifold channel – It supports one end of the aluminium tube.

(III) Screen - It is made up of toughened glass. It is a type of safety glass processed by controlled thermal or chemical treatments to increase its strength compared with normal glass. Thickness of both glass sheets is same i.e 5 mm.

(IV) Fan - It is a mechanical device which is used to direct the air flow inside the air collector.

(V) Frame - It is the outer boundry of the air collector which support the other end of the aluminium tubes.

2.1 Measuring Instruments or Devices

The various parameters which are to be measured in this experiment:

Figure 2. Temperature Sensor

(I) Inlet and Outlet temperatures – The inlet and outlet readings are taken with the help of a temperature sensor. It gives the digital display reading in degree Celsius (^oC).

(II) Solar Intensity – The reading of solar intensity is taken with the help of a solar power meter.

(III) Air flow rate – The readings of the velocity at the outlet of the air is taken with the Anemometer.

III.CALCULATION AND RESULT

3.1 Formulae Used

Thermal performance of the solar air collector can be estimated by the collector efficiency which is defined as the ratio of output to the input. Output in this case is the heat gain by air flowing through the manifold channel and input is the energy of the solar radiation falling on aluminium tubes:

$$\eta = P_{out} / P_{in}$$

Where;

$$P_{out} = \dot{m} C_{pa} (T_{out} - T_{in})$$

$$P_{in} = I_o A$$

$$\dot{m} = \rho AV$$

Area of the solar collector is given by (A) = Number of tubes × 2DLe.

3.2 Nomenculature

T_{out}: Outlet temperature of air, ^oC

T_{in}: Inlet temperature of air, ^oC

C_{pa}: Specific heat of air, J/kg K

$\dot{m}$: Mass flow rate of air, kg/hr

A: Area of solar air collector, m^2

I_O: Solar radiation intensity, W/m^2

η: solar air collector efficiency.

Table 1. Data Obtained in Experiment

WHEN SINGLE GLASS SHEET IS USED AS COVER

Time	Outlet Temperature of air, T_{out} (^oC)	Inlet temperature of air, T_{in} (^oC)	Mass flow rate of Air, $\dot{m}$ (Kg/sec)	Solar Intensity, I_o (W/m^2)	Temperature difference, ΔT (^oC)	Efficiency, η (%)
10:00 AM	30	20	.017498	450	10	27.9
10:45 AM	34	20	.017498	480	14	36.6
11:30 AM	38	20	.017498	510	18	44.4
12:15 PM	46	20	.017498	540	26	60.4
1:00 PM	52	20	.017498	555	32	72.1
1:45 PM	45	20	.017498	530	25	59.2
2:30 PM	40	20	.017498	500	20	50.2
3:15 PM	33	20	.017498	470	13	34.7
4:00 PM	29	20	.017498	440	9	25.6

Table 2. Data obtained in experiment

WHEN DOUBLE GLASS SHEET IS USED AS A COVER

Time	Outlet Temperature of air, T_{out} (^oC)	Inlet temperature of air, T_{in} (^oC)	Mass flow rate of Air, $\dot{m}$ (Kg/sec)	Solar Intensity, I_o (W/m^2)	Temperature difference, ΔT (^oC)	Efficiency, η (%)
10:00 AM	28	20	.017498	450	8	22.3
10:45 AM	32	20	.017498	480	12	31.4
11:30 AM	36	20	.017498	510	16	39.4
12:15 PM	42	20	.017498	540	22	51.1
1:00 PM	46	20	.017498	555	26	58.8
1:45 PM	41	20	.017498	530	21	49.1
2:30 PM	37	20	.017498	500	17	42.3
3:15 PM	30	20	.017498	470	10	26.7
4:00 PM	25	20	.017498	440	5	14.2

Table 3.Comparison between single glass and double glass cover

No of glass sheet used as cover	Maximum effieciency (η)(%)	MaxTemperature difference ΔT (°C)
Single	72.2	32
Double	58.8	26

IV.CONCLUSION

From the experimental analysis the following conclusion is been obtained:

(1) The maximum temperature difference of single glass sheet is found to be 32 ^{0}C at air flow rate of 0.017498 Kg/sec.

(2) The maximum temperature difference of double glass sheet is found to be 26 ^{0}C at air flow rate of 0.017498 Kg/sec.

(3) The efficiency obtained in case of single glass sheet is found to be 72.2 %.

(4) The efficiency obtained in case of double glass sheet is found to be 58.8%.

(5) Thus, the efficiency in case of the single glass sheet air collector is higher when compared to that of double glass sheet air collector.

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BIOGRAPHICAL NOTES

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