EXPERIMENTAL INVESTIGATION OF SOLAR AIR COLLECTOR BY COMPARING GLASS WOOL AND FOAM AS AN INSULATION MATERIAL

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ABSTRACT

The Sun is the most powerful heat generator, which neither of the heat sources created by mankind can compete with. Solar energy is that energy which is rapidly gaining acceptance as an energy saving measure in various application. In this experimental set up the thermal efficiency of the air collector containing aluminium tubes is been found out by using two different insulating material. Glass wool and Foam are used as the insulating material. The temperature difference and efficiency are studied at constant air flow rate. The main aim of this paper is to compare the thermal efficiency between the glass wool insulated air collector to the foam insulated air collector. The maximum efficiency in the case of the glass wool insulated air collector is found to be 63.9% and in case of foam insulated air collector is 70.16%. Thus the efficiency of the foam insulated air collector is higher.

Keywords: Air Collector, Thermal Efficiency, Glass Wool and Foam Insulation

I. INTRODUCTION

Solar energy is preferred as another alternative sources of energy because it is abundant, inexhaustible and non-polluting. So if more people used solar energy to heat the air and water in their homes, our environment would be cleaner. Over the past century, fossil fuels provided most of our energy, because they were much cheaper and more convenient than energy from alternative energy sources. The limited reserves of fossil fuels cause situation in which the price of fuels will increase as the reserves are decreased. Solar air heaters are simple devices to heat air by utilizing solar energy. A solar collector has two functions: (1) Absorb solar radiation and (2) transfer the heat from absorber plate to the transport fluid (Air is the fluid in this case). In all air type collectors the flow of the transport fluid should be restricted so as to create a high flow velocity against the solar absorber plate. The performance of solar air heaters is mainly influenced by meteorological parameters (direct and diffuse radiation, ambient temperature and wind speed), design parameters (type of collector, collector materials) and flow parameters (air flow rate, mode of flow). The principal requirements of these designs are a large contact area between the absorbing surface and air.

Chiou, El-wakil, Duke in the year **1965** and **Hachemi** in the year **1999** proposed that the Collectors performances depend on the collector materials [1-2]. **Binodi P, Circala L, Farina G** in the year **1988** and **Gupta D, Solanki SC, Saini JS** in the year **1993** said about the technology used in the manufacturing of the collector [3-4]. **El sawi AM, Wifi AS, Younam MY, Elsayeded EA** in the year **2010** and **Lanjewar A, Bhogoria** in the year **2011** said that the Solar collectors performance depends, on their operating parameters: the global solar irradiance, air-flow velocity and air-flow rate discharged through the solar collector, and operating

time [5-6]. **Krzaczek M, Kowalczuk Z** in the year **2011** and **Chan HY, Riffat SB, Zhu J** in the year **2010** proposed that the improvement in the energy performance of solar heat collectors is important, both for their use in space heating, and also in natural ventilation systems integrated in the technology of building passive houses [7-8]. Thus, there are two technologies to consider regarding solar air collectors: in a closed loop system, when the air is circulated from the house to the collector and back to the house—for heating; and in an open loop system, when the air is taken from outside, flows through the panel, is circulated into the building, and goes back outside—for ventilation, to improve indoor air quality [9].

II. EXPERIMENTAL SETUP

In this experiment we will be comparing the thermal efficiency between the air collector containing different insulating material. Glass wool is used in one case and foam is used in another case as an insulating material. The objective of the experiment is to study the performance of solar air collector and to produce hot air. The set up consists of 10 aluminium tubes , each having diameter of 2.54 cm and length 73 cm. The surface area of solar air collector is 1.40 m^2. The one end of the aluminum tube is connected to the manifold channel and the other end is supported by frame. Fan is used to blow the air into the aluminium tube.

Figure 1. Solar Air Collector For Space Heating

Experimental set up consists of the following

(I) Aluminium Tubes – Aluminium tubes are used in this air collector through which the air is passing. Number of aluminium tubes used in this experiment are ten .

(II) Screen – The screen 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. Toughened glass sheet of 5mm thickness is used.

(III) Glass wool insulation – Glass wool is an effective insulation material whose main function is to prevent the heat losses. Thickness of glass wool is 2cm.

(IV) Foam insulation – Foam insulation is a very good air barrier but does not provide any type of water vapor barrier. It is much more sponge like in appearance. It is often used for interior walls because it provides sound reduction. Thickness of Foam used is 2cm.

(V) Frame – It is the outer most boundry of the setup. This frame is made up of wood. One side of the aluminium tubes are supported by this frame.

(VI) Fan - A small fan is used to direct the air flow into the collector system.

Figure 2. Fan

2.1 Measuring Instruments

These are the various parameters which are to be measured in this experiment:

(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 ;

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

$$P_{in} = I_o A$$

$$\dot{m} = \rho A V$$

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 GLASSWOOL IS USED AS AN INSULATION

THICKNESS OF GLASS WOOL USED IS 2CM

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 (%)

10:15 AM	30	21	.016387	455	9	23.2
11:00 AM	34	21	.016387	485	13	31.5
11:45 AM	38	21	.016387	515	17	38.8
12:30 PM	45	21	.016387	545	24	51.8
1:15 PM	52	21	.016387	570	31	63.9
2:00 PM	43	21	.016387	535	22	48.3
2:45PM	39	21	.016387	505	18	41.9
3:30 PM	34	21	.016387	490	13	31.2
4:15 PM	29	21	.016387	445	8	21.1

Table 2. Data Obtained in Experiment

WHEN FOAM IS USED AS AN INSULATION

THICKNESS OF FOAM USED IS 2CM

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 (%)
10:15 AM	32	21	.016387	455	11	28.4
11:00 AM	36	21	.016387	485	15	36.3
11:45 AM	40	21	.016387	515	19	43.3
12:30 PM	48	21	.016387	545	27	58.2
1:15 PM	55	21	.016387	570	34	70.1
2:00 PM	46	21	.016387	535	25	54.9
2:45PM	42	21	.016387	505	21	48.9
3:30 PM	36	21	.016387	490	15	36.0
4:15 PM	31	21	.016387	445	10	26.4

Table 3.Comparison Between Glass Wool and Foam Insulation

Type of insulation material	Maximum effieciency (η)(%)	MaxTemperature difference ΔT (°C)
Glass wool	63.9	31
Foam	70.16	34

IV.CONCLUSION

From the experimental analyisis the following conclusion have been obtained :

(1) The maximum temperature difference in case of glasswool as an insulation material is found to be 31^0C and air flow rate is 0.16387 Kg/sec.

(2) The maximum temperature difference in case of foam as an insulating material is found to be 34^0C and air flow rate is 0.16387 Kg/sec.

(3) The efficiency in case of the glasswool as an insulating material is found to be 63.9 %.

(4) The efficiency in case of the foam as an insulating material is found to be 70.16 %.

(5) Thus, the efficiency in case of the foam insulating material is found to be higher when compared to the glasswool insulating material.

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BIOGRAPHICAL NOTES

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