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Experimental study of thermal effect of a solar air heater with different stage

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Abstract- In the first type (Type I), cans had been staggered as zigzag on absorber plate, while in Type II they were arranged in order. Type III is a flat plate (without cans). Experiments had been performed for air mass flow rates of 0.03 kg/s and 0.05 kg/s. The highest efficiency had been obtained for Type I at 0.05 kg/s. Also, comparison between the thermal efficiency of the SAH tested in this study with the ones reported in the literature had been presented, and a good agreement had been found

Key Word- Thermal efficiency ,Experimental process, three stage temperature

1 -Introduction-

Solar air heating is a renewable energy heating technology used to heat or condition air for buildings or process heat applications. It is typically the most cost-effective out of all the solar technologies, especially in commercial and industrial applications, and it addresses the largest usage of building energy in heating climates, which is space heating and industrial process heating.

Solar air collectors can be commonly divided into two categories:

- Unglazed Air Collectors or Transpired Solar Collector (used primarily to heat ambient air in commercial, industrial, agriculture and process applications)
- Glazed Solar Collectors (recirculating types that are usually used for space heating)

2-Experimental set up & procedure

PV solar is not particularly efficient, converting only around 12-14% of the 'insolation' into electricity for polycrystalline cells, and maybe up to 18% for monocrystalline cells. Insolation is just a word abbreviated from 'incident solar radiation', i.e. the amount of energy from the sun received at a particular location, and is usually expressed in terms of watts per square metre. As a rough guide the insolation is generally around 1,000 W/m2 at the earth's surface, although it does vary by location. The 1,000 W/m2 value is also the basis on which the rated Watt-peak outputs of commercial PV solar panels are determined. Thermal solar panels can be much more efficient, when the intention is to convert the sun's energy to heat and not directly to electricity.

I watched a few YouTube videos on making solar air heaters (or solar furnaces, as they're called across the pond), and reasonable results seemed achievable from home-made versions mostly using aluminium drinks cans. However, the techniques used all seemed a little fiddly and time-consuming, in that the cans required cutting of both their ends and then sticking together to form a stack, although undoubtedly it's a cheap way to try it. Instead, I decided to use 80mm flexible aluminium HVAC ducting. This 'slinky' is reasonably cheap, comes in one continuous length and seemed ideal for the job. It has an irregular 'crinkly' surface which has two distinct advantages :-

1.a greater external surface area per unit length than a smooth tube or drinks can, to collect more of the sun's energy

2.a rougher internal surface than a drinks can, which causes the air to be more turbulent within the slinky and pick up more heat.

So, I bought a 10 metre length of flexible ducting from eBay and an 8'x4' sheet of insulation board from Wickes. This 'Celotex' insulation material is what's used in the cavity walls in new build projects, and comprises a lightweight closed-cell insulation material backed on both sides with aluminium foil.

I dug out some timber from the shed, and initially made an outer frame which fitted inside one of my ex-caravan window frames – see my earlier PV solar post.

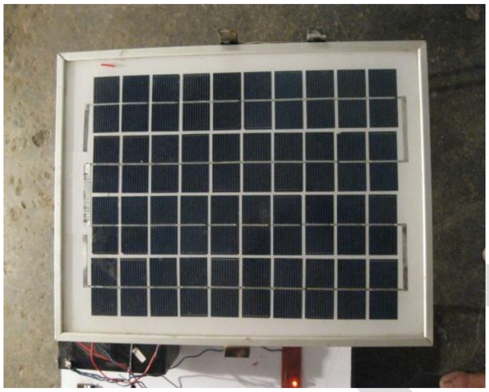

Figure .1. PV cell

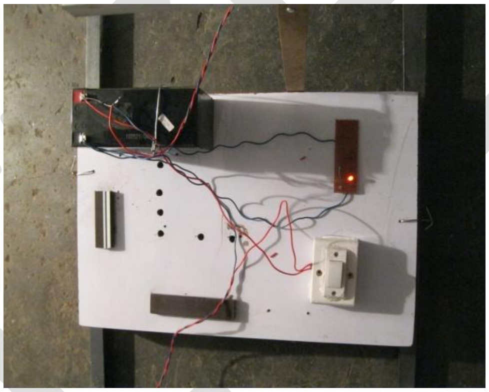

Figure .2. Control panel

The absorbers were made of stainless steel with black chrome selective coating. Dimension and plate thickness for all three collectors were 2.14 m, 0.84 m and 1 mm, respectively. Normal window glass of 5 mm thickness was used as glazing. Single cover glass was used in all three collectors. Thermal losses through the collector backs are mainly due to the conduction across the insulation (thickness 3 cm) and those caused by the wind and the thermal radiation of the insulation are assumed negligible.

Each aluminium can was opened on the top and bottom, their surface was sanded and cleaned using water. After installation, the three collectors were left operating several days under normal weather conditions for weathering processes.

Figure .3. Experimental set up

The ambient temperature was measured by a mercury thermometer placed in a special container behind the collectors' body. The total solar radiation incident on the surface of the collector was measured with a Kipp and Zonen CM 3 Pyranometer integrated to a computer based-CR510 Datalogger. This meter was placed adjacent to the glazing cover, at the same plane, facing due south. The measured variables were recorded at time intervals of 30 min and include: insolation, inlet and outlet temperatures of the working fluid circulating through the collectors, ambient temperature, absorber plate temperatures at several selected locations and air flow rates .The air was provided by a radial fan with a maximum 0.537 kW power. The radial fan placed at the outlet of the collectors sucked in the air. All tests began at 9 AM and ended at 4 PM.

3-- Result and discussion

Table.1. Inlet Temperatures of Solar air heater (T_1 =35°C)

Sr. No.	Time	Temperatures
1	09:00	35°C
2	10:00	45°C
3	11:00	55°C
4	12:00	62°C
5	13:00	64°C
6	14:00	61°C
7	15:00	54°C
8	16:00	46°C

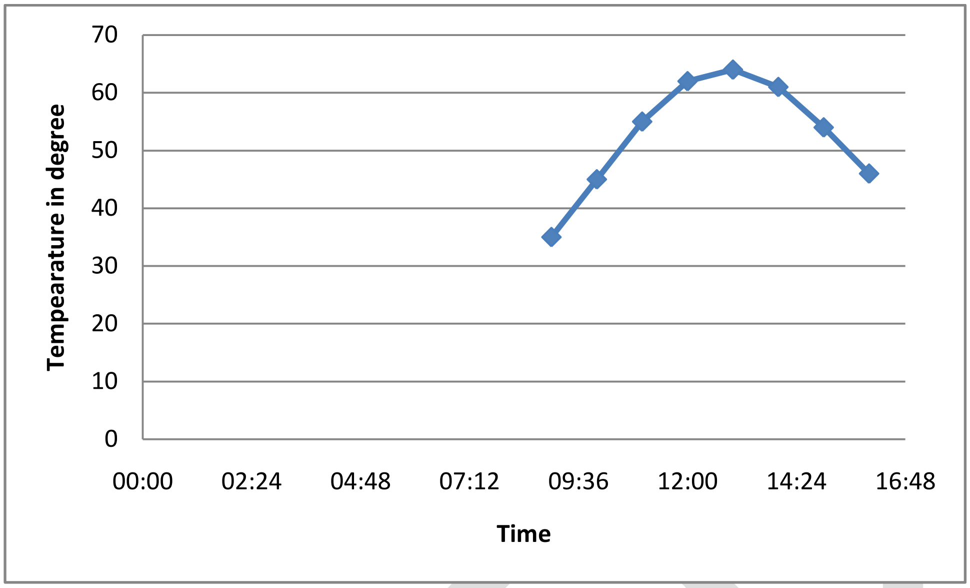

Figure .4. Graph

Efficiency:

Temperature at inlet =35 °C

Max.. Temperature at outlet =64°C

ή= (Max. Temperature at outlet -Temperature at inlet) / Temperature at inlet

= (64-35)/35 =82.85%

Table.2. Inlet Temperatures of Solar air heater (T_2 =38°C)

Sr. No.	**Time**	**Temperatures**
1	**09:00**	**38°C**
2	**10:00**	**48°C**
3	**11:00**	**57°C**
4	**12:00**	**64°C**
5	**13:00**	**66°C**
6	**14:00**	**63°C**
7	**15:00**	**57°C**
8	**16:00**	**49°C**

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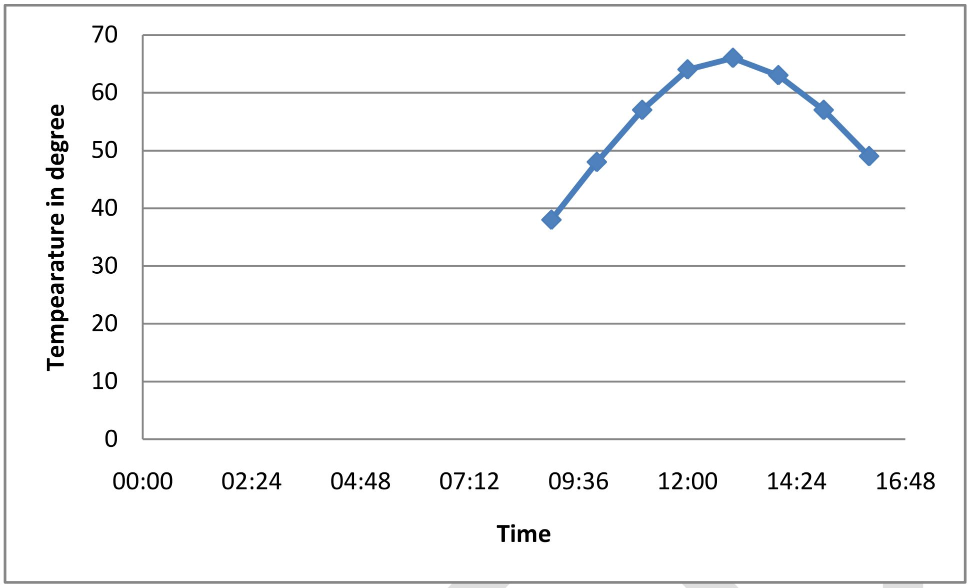

Figure .5. Graph

Efficiency:

Temperature at inlet =38 °C

Temperature at outlet =66°C

ή= (Max. Temperature at outlet -Temperature at inlet) / Temperature at inlet

= (66-38)/38 =73.68%

Table.3. Inlet Temperatures of Solar air heater (T_3 =40°C)

Sr. No.	Time	Temperatures
1	09:00	40°C
2	10:00	51°C
3	11:00	60°C
4	12:00	66°C
5	13:00	70°C
6	14:00	67°C
7	15:00	56°C
8	16:00	51°C

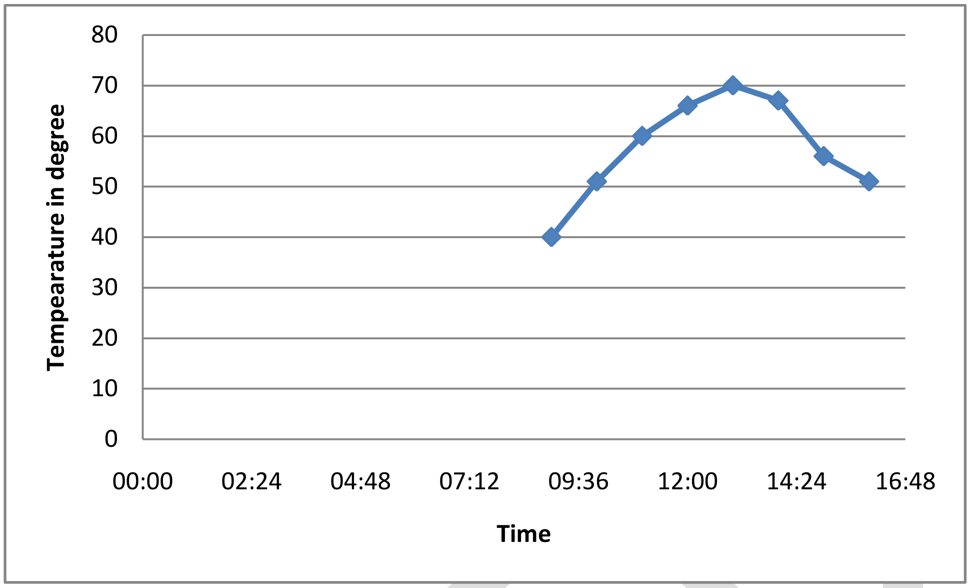

Figure .6. Graph

Efficiency:

Temperature at inlet =40 °C

Temperature at outlet =70°C

ή= (Max. Temperature at outlet -Temperature at inlet) / Temperature at inlet

= (70-40)/40 =75.00%

Table.4. Inlet Temperatures of Solar air heater (T_1 ,T_2 , T_3)

Sr. No.	Time	Temperatures at T_1	Temperatures at T_2	Temperatures at T_3
1	09:00	35°C	38°C	40°C
2	10:00	45°C	48°C	51°C
3	11:00	55°C	57°C	60°C
4	12:00	62°C	64°C	66°C
5	13:00	64°C	66°C	70°C
6	14:00	61°C	63°C	67°C
7	15:00	54°C	57°C	56°C
8	16:00	46°C	49°C	51°C

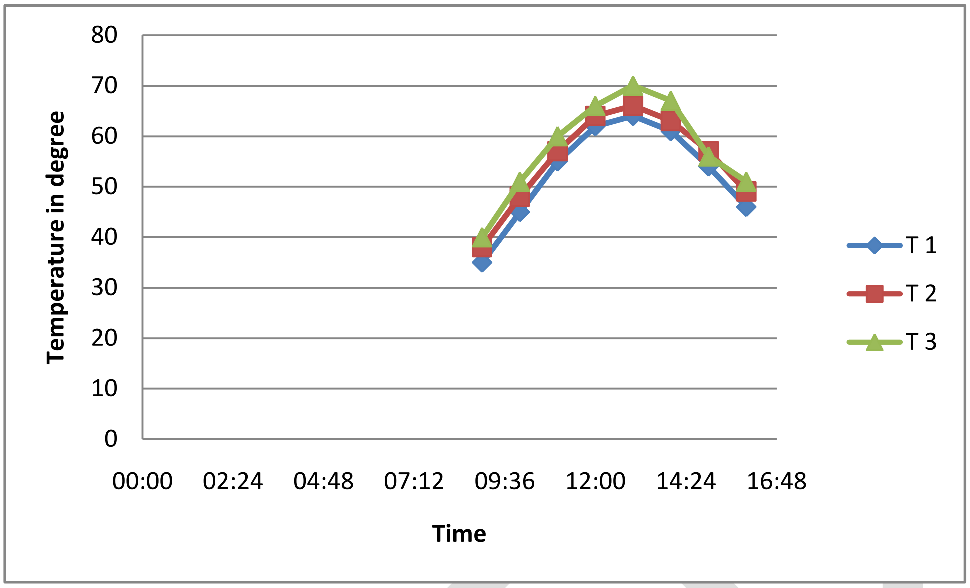

Figure .7. Graph

Max. Efficiency at T_1:

Temperature at inlet =35 °C

Max.. Temperature at outlet =64°C

ή= (Max. Temperature at outlet -Temperature at inlet) / Temperature at inlet

= (64-35)/35 =82.85%

4. Conclusion- According to the results of the experiments, the double-flow type of the SAHs with aluminum cans has been introduced for increasing the heat-transfer area, leading to improved thermal efficiency. The performance of double-flow type SAHs, in which air is flowing simultaneously over and under absorbing plate, is more efficient than that of the devices with only one flow channel over or under the absorbing plate because the heat-transfer area in double-flow systems is double. Find out the maximum efficiency at T_1 are 82.85% .

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