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ANALYSIS OF HEAT TRANSFER RATE IN EVACUATED TUBE TYPE SOLAR WATER HEATER BY GREEN HOUSE EFFECT

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Abstract— Energy crisis has been a major problem due to growing population and growing needs. This crisis can be met with solar energy, which is also known as renewable energy and which cannot be depleted. There is a lot of applications available using solar energy. One such promising application is the solar water heater. Solar water heaters save electricity and thus money. They could even turnout to be more reliable than electric power supply. They are clean and green and thus reflect one's commitment for preservation of environment. They are even safer than electric geysers as they are located on the roof top. The objective of this project is to design such an evacuated type solar water heater that could possibly use industrial gases like helium, nitrous oxide as the working medium. This involves selection of materials needed for various components like tank, Frame, collector tube and it is done through literature survey. Further theoretical calculations are done to evaluate various parameters and dimension. Material selection and calculation come under the design phase. The work also involves fabrication of experimental setup which is done to analyze the temperature obtained from different gas setups. Analysis work was done for the entire day. The fabricated setup was kept under solar radiation and the temperature observations were done during particular time interval. Analysis started at 10:00 a.m. and it was done till 4:00 p.m. The various temperature readings are then plotted as graph and conclusions were made.

keywords: Evacuated type solar water heater, Renewable energy,.

I. INTRODUCTION

The solar energy is the most capable of the alternative energy sources. Due to increasing Demand for energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is considered an attractive source of renewable energy that can be used for water hearing in both homes and industry. Heating water consumes nearly 20% of total energy consumption for an average family. Solar water heating systems are the cheapest and most easily affordable clean energy available to homeowners that may provide most of hot water required by a family. Solar heater is a device which is used for heating the water, for producing the steam for domestic and industrial purposes by utilizing the solar energy.

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SWH systems are generally very simple using only sunlight to heat water. A working fluid is brought into contact with a dark surface exposed to sunlight which causes the temperature of the fluid to rise. This fluid may be the water being heated directly, also called a direct system, or it may be a heat transfer fluid such as a glycol/water mixture that is passed through some form of heat exchanger called an indirect system.

1.1 COMPONENTS OF SOLAR WATER HEATING SYSTEM

Solar Water Heating generally consists of a solar radiation collector panel, a storage tank, a pump, a heat exchanger, piping units, and auxiliary heating unit. Some of important components are described in the next sections.

1.2 Solar Collector

The choice of collector is determined by the heating requirements and the environmental conditions in which it is employed. There are mainly three types of solar collectors like flat plate solar collector, evacuated tube solar collector, concentrated solar collector.

1.2.1 Evacuated Tube Collector

Evacuated-Tube Collectors are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube, or absorber, covered with a selective coating that absorbs solar energy well but inhibits radiative heat loss. The air is withdrawn (“evacuated”) from the space between the tubes to form a vacuum, which eliminates conductive and convective heat loss. They are most suited to extremely cold ambient temperatures or in situations of consistently low-light. They are also used in industrial applications, where high water temperatures or steam need to

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be generated where they become more cost effective. Fig. 1.1 represents the Evacuated Tube Collector.

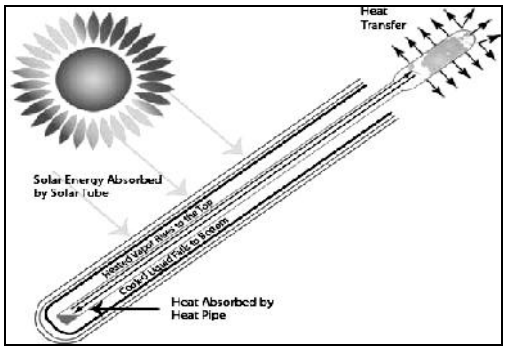

Fig. 1.1 Evacuated Tube Collector

Technical grade fiber will be send to our German Subsidiary Hemp Flax Deutschland GmbH, where it will be processed to non-woven fleece material. The core is cleaned and deducted in a sophisticated cleaning system and transported by a high pressure air piping to the packing department. There it will be packed in 14kg, 3kg and 1kg packing.

2. OBJECTIVES AND METHODOLOGY

2.1 OBJECTIVES

The main objective of this project is

- To find out the suitable green house and inert gases to carry out the analysis with the green house effect.
- To design a solar water heater with proper geometry and dimensions.
- To fabricate the solar water heater to carry out the experimental test.
- To conduct the experiment with the selected gases at the same day simultaneously.
- To carry out the comparative study of heat transfer with different gases and to select the best one.

2.2 METHODOLOGY

The above objective have been achieved by the following methodology

- Thermal conductivity of the green house gases was checked and suitable gases were found to be helium and nitrous oxide.
- The diameter for the collector tube is chosen from the different diameter tubes available in the market. The remaining calculations were made from the design procedure stated in the literature survey.
- The fabrication of each component by suitable machining process with suitable materials and dimensions mentioned during the designing stage.
- The Fabricated tubes were kept simultaneously under the solar radiation for one complete day.
- The output temperature was noted for each separate collector tube and tube with best gas is thus found. The comparative study can be effectively carried out by different Graphs drawn with extracted experimental data.

3. COMPONENTS

The important components of the experimental setup are as follows

1. Dimensions of the tube (Standard dimensions).
2. Material that can withstand high temperature.
3. Types of gas to be used inside the collector.
4. Operating temperature of the tube (design calculation)
5. Heat Transfer fluid (water).

3.1 SELECTION OF GLASS TUBE

Tube consists of two glass tubes made from extremely strong borosilicate glass with high chemical and thermal shock resistance. The outer tube is transparent allowing light rays to pass through with minimal reflection. The outer side of the inner tube is coated with a sputtered solar selective coating (Al-N/Al or AlN/AlN-SS/Cu) which features excellent solar radiation absorption and minimal reflection properties.

Borosilicate is a glass with silica and boron trioxide as the main glass-forming constituents. Borosilicate glasses are known for having very low coefficients of thermal expansion (~3×10^{-6} K^{-1} at 20 °C), making them resistant to thermal shock, more so than any other common glass. Such glass is less subject to thermal stress and is commonly used for the construction of reagent bottles. Borosilicate glass is sold under such trade name as Simax, Borcam, Borosil, Suprax, Kimax, Heatex , Pyrex , Endural , Schott, or Refmex, Kimble

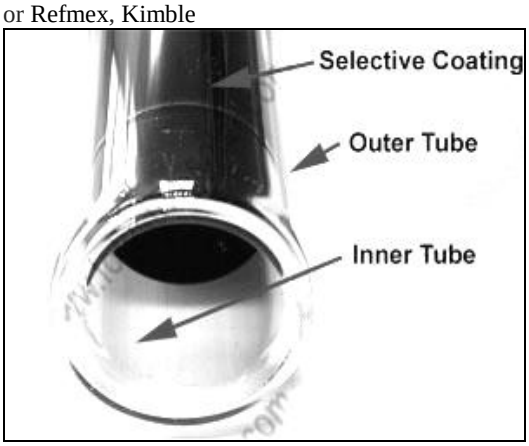

Fig 3.1.0 Borosilicate Glass Tube

3.1.1 Chemical Composition

The Borosilicate tube is composed of the following materials which are described in the table as follows:-

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Table 3.1.2 Physical Properties

Parameters	Range
Coefficient of Expansion	32.5 x 10^{-7}cm/°C
COMPOSITION	**PERCENT APPROX**
Strain Point	510°C
SiO_2	80.6%
Anneal Point	560°C
B_2O_3	13.0%
Soften Point	821°C
Na_2O	4.0%
Density	2.23 g/cm^3
$A1_2O_3$	2.3%
Young's Modulus	6.4 x 10^3 kg/mm^2
Miscellaneous Traces	0.1%
Refractive Index	1.474 @ Sodium D Line
Temperature Limits	490°C (Extreme Service)
Maximum Thermal Shock	160°C

3.2 TYPES OF GAS

A greenhouse gas (sometimes abbreviated GHG) is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. The primary greenhouse gases in earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Out of these gases carbon dioxide and nitrous oxide are used in the project because of their low thermal conductivity.

3.3 SELECTON OF STORAGE TANK

It is a tank which stores the water and come from external water source like water tank. It is mainly consist of two tank i.e. inner tank and outer tank. The inner tank is placed inside the outer tank. The gap is maintained between two tanks. This gap is filled by high tech insulating material (Rock Wool or mineral wool) in order to reduce the heat losses from the heated water exist inside the inner tank heated by the evacuated tube solar water heater. Rock wool is a manmade fiber and has many excellent characters like non-combustible, non-toxic, low thermal conductivity, long service life and so on. Storage tank is placed at the top of frame and tubes. The top open end of the tubes is connected to the storage tank. The bottom end of tubes is placed in a holder provided at bottom of the frame.

3.4 EMISSIVITY OF ABSORBING COATING

The emissivity of absorbing coating of all-glass evacuated tube changes greatly with the coating layer temperature and it cannot be seen as a constant. The value of emissivity directly affects the radiation loss energy of the solar heater system. Since the maker proposed only the emissivity data in low temperature range for water heating, therefore, an experiment is conducted to measure the emissivity of absorbing coating (Black Coating) in the temperature range from 20°C to 250°C. And the experiment result reveals that the emissivity and temperature have a linear relationship within the temperature range of 0 - 250°C.

3.5 FABRICATION OF GLASS TUBE

The tube is made of up of borosilicate material. It is cylindrical in shape and entirely transparent to allow the solar radiation to pass through. The Manufacturing of Glass tube is show in Fig.3.5.1.

Fig. 3.5.1 Fabricated Glass Tube

Thus the fabricated experimental setup have been fabricated and assembled successfully. The whole fabricated experimental setup is shown below in Fig 3.5.2

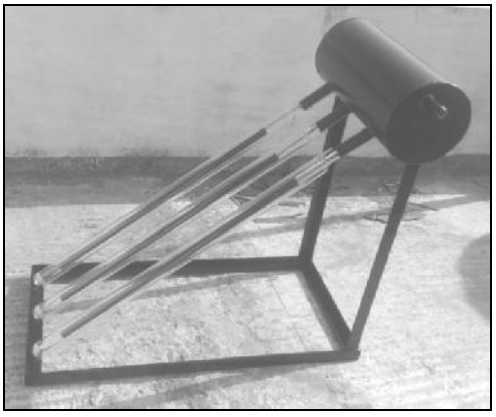

Fig. 3.5.2 Fabricated Experimental setup

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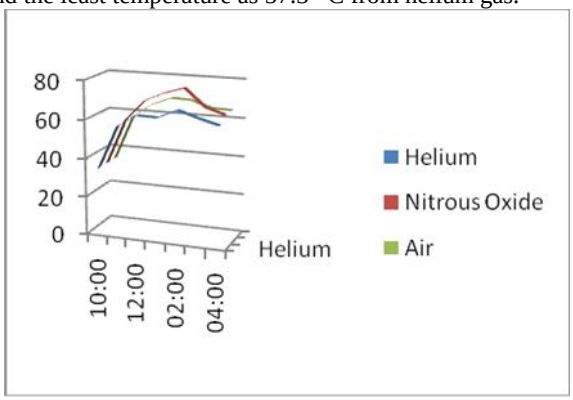
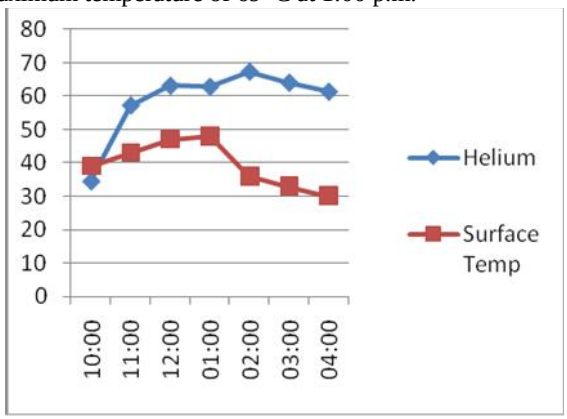
4. COMPARISON OF TEMPERATURE GASES AND AIR

The following comparison graph shows the variation of various parameters like time, temperature for the gases like helium, nitrous oxide and air. From inference from the graph we can find the peak temperature as 76.5 ^{0}C from helium gas and the least temperature as 57.3 ^{0} C from helium gas.



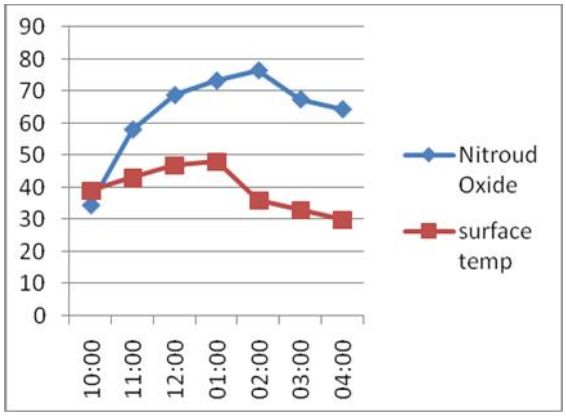
Graph. 4.1.1 Temperature variation for all Gases

Graph. 4.1.2 is about the surface temperature of tube vs. outlet water temperature of Helium setup. The surface temperature was initially 39^{o}C.The surface temperature was found to be increasing till 1:00 p.m and then it was found to be decreasing. The least surface temperature was found to be 30 ^{0} C at 4:00 p.m. The highest surface temperature was 48^{0}C. The water inside the helium gas filled tube was reached to the maximum temperature of 69^0 C at 1:00 p.m.



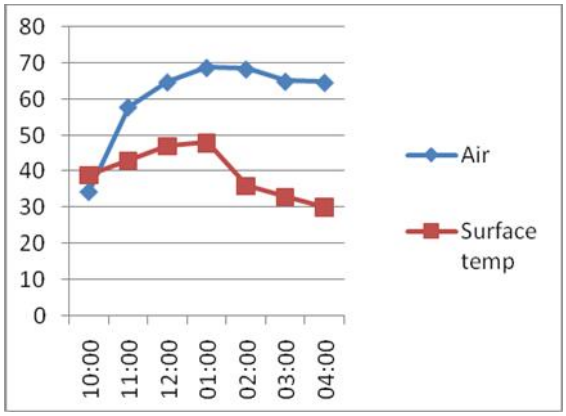
Graph. 4.1.2 Surface Temperature vs. Temperature of Helium Filled Tube

The surface temperature of tube vs. water outlet temperature of Nitrous oxide setup is shown in graph 4.1.3.The surface temperature was initially at 39^{o}C. The highest surface temperature was to be 48^{0}C. The water inside the nitrous oxide gas filled tube was reached to the maximum temperature of 78^0 C at 2:00 p.m.



Graph. 4.1.3 Surface Temperature vs. temperature of N_2O Filled Tube

Graph 4.1.4 shows the variation of surface temperature of tube vs water outlet temperature of Air setup. The surface temperature was found to increasing till 1:00 p.m. and then it was found to be decreasing. The highest surface temperature was to be 48^{0}C. The water inside the air filled tube was reached to the maximum temperature of 70^0 C at 1:00 p.m.



Graph. 4.1.4 Surface Temperature vs. Temperature of Air Filled Tube

Fig. 6.12 is known as mid day graph. It shows various temperature readings between time intervals of 11:00 a.m. to 2:00 p.m. and concludes which is the best gas that can be used. From the graph we can conclude nitrous oxide shows the peak temperature of about 76.5^0 C and hence it the most suitable gas satisfying the objective.

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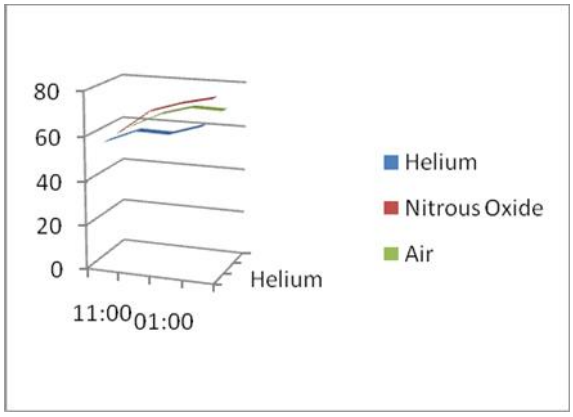

Graph. 4.1.5 Mid Day Graph

5. CONCLUSION

- Thus the thermal conductivity of the green house gases was checked and the most suitable gases were found to be Nitrous Oxide.
- Assumptions were made and theoretical calculations were done.
- Thus from market survey the available dimensions for the collector tube, frame and tank were found. From the literature survey, the various materials needed for the fabrication was correspondingly chosen.
- Fabrication was done as per the design, successfully.
- Then the fabricated tubes were kept simultaneously under the solar radiation for a complete day. The readings were taken using pencil type thermometer.
- The output temperature was noted for each separate collector tube and tube with best gas was thus found.
- Since, CO_2 gas is found to be highly expandable during heat; it could not be used in the glass tubes.
- So, Nitrous oxide gas is suitable instead of using CO_2 gas.
- Since, Nitrous oxide gas produce more heat similar to vacuum, Vacuum could be replace by Nitrous oxide gas.

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