Design of Serial Connected Vacuum Tube Solar Air Collector

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Abstract

Solar collectors are systems that convert solar energy into heat energy and transfer it to a fluid (liquid or gas). In practice, systems using for produce hot water and hot air. Solar liquid heaters aim to produce the hot water for houses and facilities (such as hotels, sports halls, etc.), while hot air generating systems are widely used for heating living spaces, heating greenhouses and drying agricultural products.

Vacuum tubes are now used in liquid heated solar collectors. The thermal efficiency of the vacuum tubes is higher than the flat plate collectors. However, there is no design for the use of vacuum tubes as air heating manifolds. In this study, it was aimed to design an air heating collector using vacuum tubes. In the designed collector, vacuum tubes are connected serial. Thus, it will be ensured that air is produced at high temperature from vacuum tubes.

Keywords: Solar collector, vacuum tube. Solar air heater

Introduction

The most common water heating systems is solar collectors in hot climate region. Solar water and hot water preparation systems vary according to the circulation and purpose of the water in the system, rather than the type of water to be prepared. Solar water heating systems (GESIS) are technologically well known and new developments are being made (Hepbaşlı and Utlu, 2004).

Today, solar air heater collectors are produced on a flat plate absorber surface. The planar air solar collector is a flat plate that acts as a black object for absorbing heat, and a structure consisting of one or more layers of glass or a permeable cover placed on the plate. All collector parts, except the permeable cover, must be thermally well insulated to reduce energy losses as much as possible. The permeable cover used reduces the transport and radiation losses to the atmosphere while allowing it to pass through the solar radiations and be held in the space between the planar plate and the

permeable cover or absorbed by the black body. The resulting heat is then transferred to the air passing through a duct located between the absorbent surface and the permeable cover (Duffie, J. A. and Beckman, W. A 1991.)

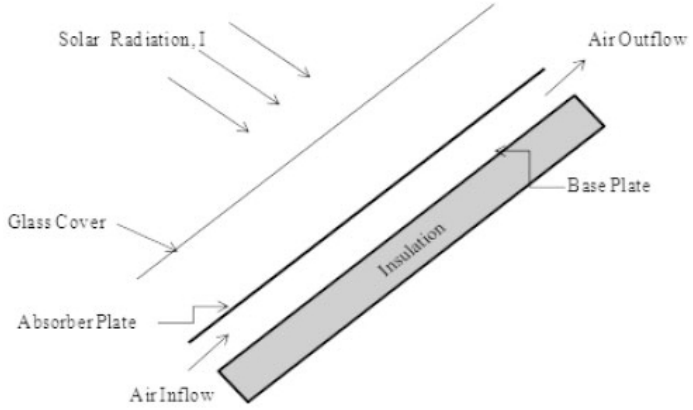

Figure 1. Flat Plate Collectors

Because the air used as heat carrier fluid in air heating collectors has low heat transfer ability, the efficiency of these collectors is lower than water heating collectors. For this reason, different applications are being made to increase the thermal performance of the collectors used to produce hot air. These applications include; replacement of the absorbent panel profile, development of different air flow patterns, and increase of heat transfer surface area and heat storage capability in the collector.

Vacuum tube collectors

Vacuum tube collectors have recently using as solar water collectors. The reason for this is that the efficiency of vacuum tube collectors is higher than that of flat plate collectors and that they can operate without antifreeze under cold climatic conditions. The reasons for the high efficiency of vacuum tube collectors are summarized below.

The vacuum tube has a structure in which the air between the lower and upper surfaces of two inner glass tubes is merged. Due to the fact that the air between two pipes is vacuumed, the heat losses by convection are low (Figure 2). This is the most important factor that increases the efficiency of vacuum tube solar collectors.

Figure 2. Vacuum Tube

Absorbent surfaces of vacuum tubes are in cylindrical form. For this reason, at every hour of the day, an area is formed that takes the rays of the sun vertically. The inclined arrival of solar rays in flat plate collectors increases losses through reflection. The cylindrical absorber surface allows vacuum tubes to more effectively utilize the solar radiations (Figure 3).

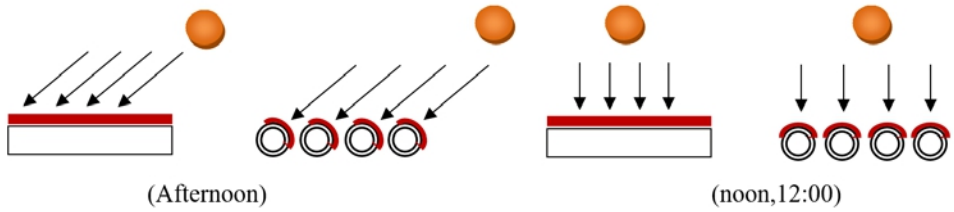

Figure 3. The position of the absorbing surfaces of vacuum tubes and flat plate collectors relative to the incident angle of solar radiation

There are many studies in the literature about determining the efficiency of vacuum tube solar water heating systems. In these studies, different efficiency values have been achieved due to the ambient conditions, the temperature of the ambient air, the radiation levels and the structural characteristics of the system used.

Öz et al. (2007) have experimentally compared the performance and efficiency of vacuum tube solar water heating system with standard flat plate water heating collectors. Experimental results show that vacuum tube solar water heating system has higher performance and efficiency than other systems. The yield values vary in the range of 48-58% for vacuum tube collectors, while for flat plate surface collectors under the same conditions this value remains within the range of 37-47%.

Koçer et al. (2015) by comparing them to the F-Chart method, which is widely used in evaluating the thermal performances of flat plate and vacuum tube solar collectors. The F-Chart parameter obtained by using this method gives a percentage value about the usability of the system and the

value approaching 100% means that the thermal success of the system is also high. The researchers calculated the F-Chart values for planar solar collectors by 64%, 50% and 39% for vacuum solar collectors, 77%, 62% and 50% respectively for 40, 50 and 60 ° C water temperatures.

Due to their high efficiency, the use of vacuum tube collectors in our country is increasing rapidly in recent years. Vacuum tubes are composed of two closed glass pipes (Uyarel and Öz, 1987). Because of the circular structure of the abrading plate in glass tubes, the yields are higher than other planar collectors due to the continuous vertical angle of sunlight (Bulut, et al., 2006).

Design of Vacuum Tube Solar Air Heater

In this Study, it is aimed to design an air heated solar collector using vacuum tubes. For this purpose, a structure is designed to provide air flow from vacuum tubes. Vertical air ducts are placed in the vacuum tube in the designed collector. The air flow diagram of the collector is shown in Figure 4. Air enter into the system with channel 1. Air comes out of channel 2 on the channel. Air is out of section 2 and moving upwards. The warming air passes through the No. 3 duct. The temperature of the air in the vacuum tube is further increased. The temperature of the output air can be increased according to the number of series connected vacuum tubes used in the system.

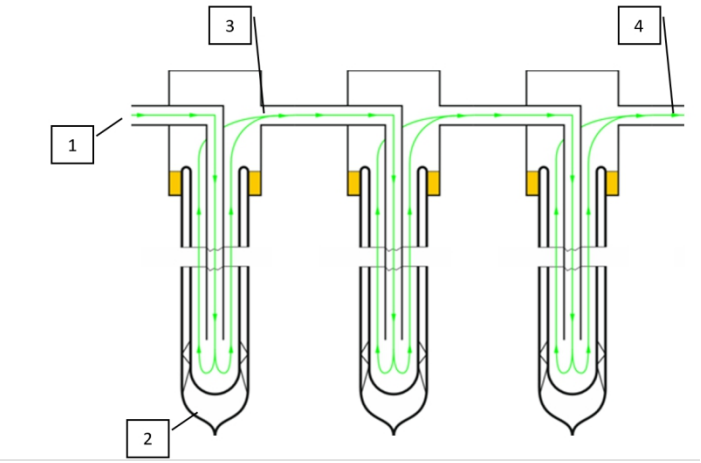

Figure 4. Schematic of the designed collector

The 3d model of the collector designed in the scope of the study is shown in figure 5. The exterior view of the collector is water-heated. The junctions of the air vents are in the upper chamber. The upper chamber has cold air inlet and outlet channels.

Figure 5. 3d model of the designed collector

The 3d model showing the internal structure of the designed collector is shown in Figure 6. The air entering the collector with blue troughs passes through the connected vacuum tubes and emits from the red channel. As the number of vacuum tubes to be used in the system increases, the temperature of the air taken from the exit channel will also increase.

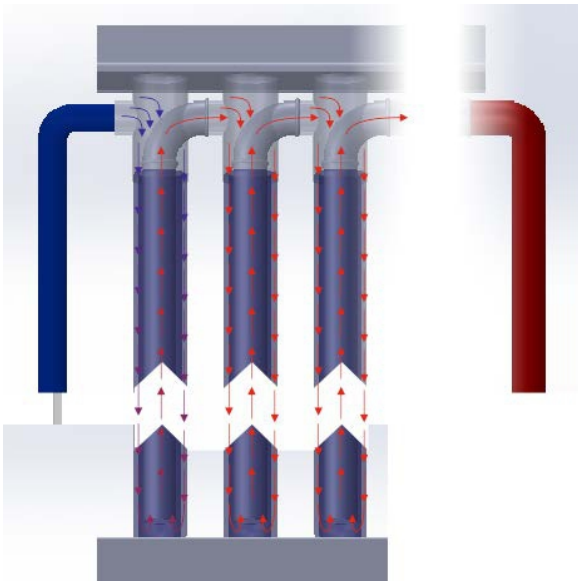

Figure 6. Internal structure of the designed collector

Conclusion

In the scope of the study, the vacuum tube solar air heater was designed. The most important features of the designed collector were the use of vacuum tubes and the serial connection of vacuum tubes. Vacuum tubes are more efficient than conventional collectors. The use of these collectors in air heating will increase efficiency. In addition, serial connection of the tubes will ensure that the outlet air temperature is raised. Designed collectors can be used in space heating and agricultural product dryers.

References:

Bulut, H., Şahin, H., Karadağ, R. Güneş Enerjili Su Isıtma Sistemlerinin Tekno-Ekonomik Analizi. TMMOB Makina Mühendisleri Odası, Tesisat Mühendisliği Dergisi, 101, 23-33, 2007.

Duffie, J. A. ve Beckman W. A. Solar engineering of thermal processes, John Wiley and Sons, New York, 1991.

Hepbaşlı A., Utlu Z. Evaluating the energy utilization effiency of Turkey's renewable energy sources during 2001. Renewable and Sustainable Energy Reviews, 8:237–255, 2004.

Kocer, A., Atmaca, I., Ertekin, C. A Comparison of Flat Plate and Evacuated Tube Solar Collectors With F-Chart Method. Isı Bilimi ve Tekniği Dergisi, 35, 1, 77-86, 2015.

Öz, E. S., Özbaş, E., Dündar, R. Vakum Tüplü Güneşli Su Isıtma Sistemi İle Standart Düz Kollektörlü Güneşli Su Isıtma Sistemlerinin Performans Ve Verimlerinin Deneysel Olarak Karşılaştırılması. VIII. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2007.

Uyarel, A.Y., Öz, E.S. Güneş Enerjisi Uygulamaları Emel Matbaacılık, Ankara, 1987.