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Ali Etem Gürel
Doğu Çamur
Alper Ergün
Karabuk University
etemgurel@gmail.com
Karabuk-Turkey

EXPERIMENTAL EXAMINATION ON THE USE OF HEAT PIPE AND VACUUM TUBE IN THE SOLAR ENERGY WATER HEATING SYSTEMS UNDER THE CONDITIONS OF KARABÜK

ABSTRACT

In this study, for the purposes of comparing heat pipe and vacuum tube applications in solar energy water heating systems, a collector which has the surface area of totally 0.7 m² of surface area is divided into equal parts and one end is placed with vacuum tube on and the other and is placed with heat pipe on which is manufactured by us and both of these systems were installed on the stores with the volume of 10 liters. For five days, the temperature of store water of the systems, external ambient temperature and sun radiation values were measured and recorded. According to the calculations made in accordance with the data, while vacuum tube system provided 40% efficiency under Karabük conditions, heat pipe increased up to 31% efficiency. On the other hand, the amount of energy which can be converted to usable energy was determined to be 68 W for heat pipe system and 85 W for vacuum tube system.

Keywords: Solar Energy, Heat Pipe, Vacuum Tube, Efficiency, Energy

GÜNEŞ ENERJİLİ SU ISITMA SİSTEMLERİNDE ISI BORUSU VE VAKUM TÜPÜ KULLANIMININ KARABÜK ŞARTLARINDA DENEYSEL OLARAK İNCELENMESİ

ÖZET

Bu çalışmada, güneş enerjili su ısıtma sistemlerinde ısı borusu ve vakum tüpü uygulamalarının karşılaştırılması amacıyla, toplam 0.7 m² yüzey alanına sahip bir kollektör eşit iki bölüme ayrılarak bir kısmına vakum tüpü, bir kısmına ise tarafımızdan imal edilen ısı borusu yerleştirilmiş ve her iki uygulama 10 litre su hacmine sahip depolara monte edilmiştir. Beş gün boyunca sistemlere ait güneş radyasyonu, depo suyu sıcaklıkları ve dış sıcaklık değerleri kaydedilmiştir. Bu veriler doğrultusunda yapılan hesaplamalara göre, Karabük şartlarında vakum tüplü sistem ortalama %40'lık bir verim sağlarken, ısı borusu %31'lik bir verime ulaşmıştır. Sistemler tarafından kullanılabilir enerjiye çevrilen enerji miktarı ise, ısı borulu sistem için ortalama 68 W, vakum tüplü sistem için ise 85 W olarak belirlenmiştir.

Anahtar Kelimeler: Güneş Enerjisi, Isı Borusu, Vakum Tüp, Verim, Enerji

1. INTRODUCTION (GİRİŞ)

The demand for the energy in our country and in the works has been gradually increasing. This situation drives some international institutions and companies to make researches in energy production, efficient use of energy and new energy resources. The researches which have been recently conducted indicate that fossil energy resources will be consumed by 2030. When taking this fact into account, it become obligatory to develop alternative energy resources which may replace fossil-based energy resources and the systems where they are used [1 and 2]

Alternative energy resources may be listed as wind, hydraulic, solar, geothermal, biomass and nuclear energy today. Among them, solar energy which is infinite warm and light resource is utilized mostly. In our days, solar energy system is considerably used in meeting the need of the houses for hot water, warming the buildings and many more application. Turkey has a quite good place on the globe in term of solar energy. Therefore, solar collectors used in order to meet the need of houses for hot water also become more and more common even in rural areas [3].

Among the main methods which have been frequently used in the solar energy water heating systems for the last years are the vacuum tube and heat pipe collector applications. Such kinds of systems are preferred by their users due to their high efficiency; thus, the studies on determining the performance of such types of systems and increasing their existing performances are speeded up.

Öz et al. (2007) has examined the efficiency of the vacuum tube and natural circulated planar solar water heating system comparatively and determined that vacuum tube solar water heating system have more efficiency as a result of the experiments they have conducted [4]. Bulut et al. (2007) has made technical and economical analysis of the solar energy water heating systems. Considering the average costs of the system presented to market in Turkey for the economical analysis, repayment periods are calculated. A computer program which projects the solar energy water heating systems and makes economic analysis of them was developed [5]. Yılmaz et al. (2005) used T-22 as a cooling fluid in heat pipe systems in heat pipe and natural circulated hot water manufacturing systems they designed and researched the impact of this fluid on the efficiency of the system. As a result of the experiments, using R-22 as cooling fluid has been determined to increase the system performance [6].

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

In this study, the impacts of heat pipe and vacuum tube applications on the system efficiency in the solar energy water heating systems have been examined comparatively under the conditions of Karabük.

3. EXPERIMENT SYSTEM (DENEYSEL ÇALIŞMA)

The main topic of the study consists of a comparison between vacuum tube which is divided into two parts in a collector and a heat pipe which has pure water as fluid in it under the same conditions. For this purpose, collector which is manufactured by us is seen in Figure 1.

A collector which has 0.7m^2 of surface area is divided into two equal parts and one end is placed heat pipe on which was manufactured by us by using two copper pipes with the sizes of 28mm and 42mm and the other end is placed with vacuum tube on. Collector area where heat pipe was placed was covered with galvanized sac and a surface in the shape of conduit where heat pipe could be placed very well. In order to increase the amount of sunbeams which would be absorbed in the system, the surface of collector was painted with black color. After making the required insulations in order to eliminate heat loss of the system, heat pipe and vacuum tube were installed on the stores at the equal volume. Thanks to this, the aim was to compare two different applications under the same conditions.

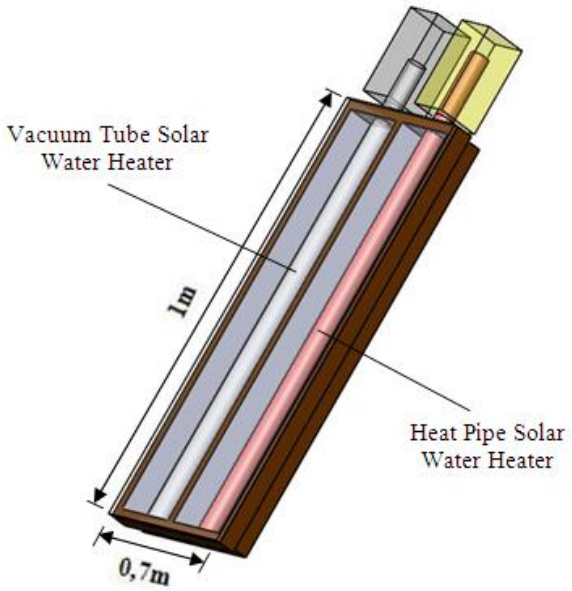

Figure 1. The Collector designed to compare heat pipe and vacuum tube systems
(Şekil 1. Isı borusu ve vakum tüp sistemlerinin karşılaştırılması için tasarlanan kolektör)

Technical details of experiment arrangement composed for comparing heat pipe and vacuum tube systems are provided in Table 1.

Table 1. Technical specifications of experiment system
(Table 1. Deney sisteminin teknik özellikleri)

The System Used	Heat Pipe System	Vacuum Tube System
Working Fluid	Pure water	Water
Store volume	10lt	10lt
Heat pipe and vacuum tube dimensions	28 mm(internal pipe dimension) and 42mm (external pipe dimension)	47mm
Collector surface area	0.35m^2	0.35m^2
Pipe Heights	150cm	150cm
Insulation Materials	Extruded Polystyrene	Extruded Polystyrene
Transparent Surface	4 cm glass	-
Bevel	40˚	40˚

4. SYSTEM EFFICIENCY (SİSTEM VERİMİ)

Collector efficiency is defined as the solar energy arriving at the collector of the solar energy which is converted to usable energy by transferring the heat to the carrying fluid in the collectors. System efficiency depends on the amount of energy amount which can be achieved from the system. The amount of energy which can be achieved from the system is expressed as in the equitation following:

$$Q_s = m.c_p.\Delta T \quad (1)$$

Where the energy amount which can be achieved from the system is represented with (Q_s), total mass of the water is represented with (m) and the difference between the initial and final temperatures of the store water is represented with (ΔT) [6-7].

On the other hand, the total radiation coming to the collector (TRA) is calculated with the following equitation considering the collector surface area (A) and the sunlight radiation on the unit surface area (I):

$$TRA = A.I \quad (2)$$

Bots of the values achieved are correlated one another and system efficiency is achieved. System efficiency is found with the following equitation:

$$\eta = \frac{Q_s}{TRA} = \frac{m.c_p.\Delta_t}{A.I} \quad (3)$$

5. EVALUATION OF THE EXPERIMENT RESULTS (DENEY SONUÇLARININ DEĞERLENDİRİLMESİ)

Measurements were taken for five days in order compare the productivities of heat pipe and vacuum type systems. The experiments were started in the morning and continued up to 16:00 for seven hours. In order to measure the temperatures of store water, 12-channelled heat measurement device of Elimko firm was used. Solarmeter was used in order to measure the sun radiation coming overt the system. The features of the experiments devices are provided in Table 2.

Table 2. Measurement devices used in the experiment system
(Table 2. Deney sisteminde kullanılan ölçüm cihazları)

Measurement Devices	Features
Air speed and temperature measurement device	Testo, temperature -20,+70°C, speed 0-20m/s measurement accuracy 0.01m/s, 0.1°C heated wire, NTC sensor.
Solarmeter	Haenni brandname -130model, the maximum measurable value 1500W/m², measurement accuracy ±1.5%
Temperature Measuring Device	Elimko, Type E-6700-12, type J, measurement range 0-400°C, 12-channeled electronic temperature measurement device.

The amounts of the systems to convert the solar energy into usable energy display the same change as the efficiency curves. Figure 2 indicates the amounts of sun radiation velocity coming on the both of the systems which can be converted by the systems. Energy amount which is converted by the systems to the usable energy is determined to be 68W for the heat pipe system on average and 85W for vacuum tube system.

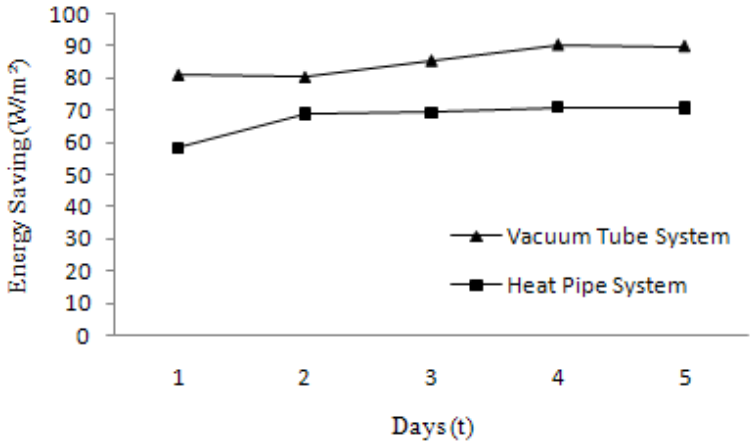

Figure 2. Usable energy amounts provided by the systems.
(Şekil 2. Sistemler tarafından sağlanan kullanılabilir enerji miktarları)

Daily system efficiency of the heat pipe and vacuum tube applications are provided in Figure 3. It is seen in Figure 2 that the efficiency value of the vacuum tube system is more than the heat pipe system. While the vacuum tube system has 40% efficiency on average for the experiment period of five days, heat pipe systems have 31% efficiency under the same conditions.

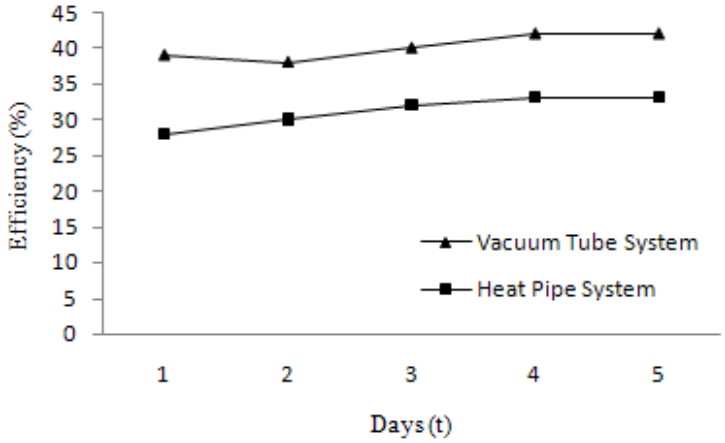

Figure 3. Daily average efficiency curves of the systems in the experiments
(Şekil 3. Deneylerde sistemlere ait günlük verim eğrileri)

Store water temperature has a great importance in the solar energy water heating systems and is accepted by the consumers as the largest indicator of the efficiency. In Figure 4, the variance of store water temperatures measured for heat pipe and vacuum tube applications depending on the time are provided. In both of the applications, the store water temperatures display similar tendency in the first hours of the day, whereas the store water temperature of the vacuum tube application accelerates in the noon when the sun lights come to the world directly and this increase is maintained until the end of the experiment.

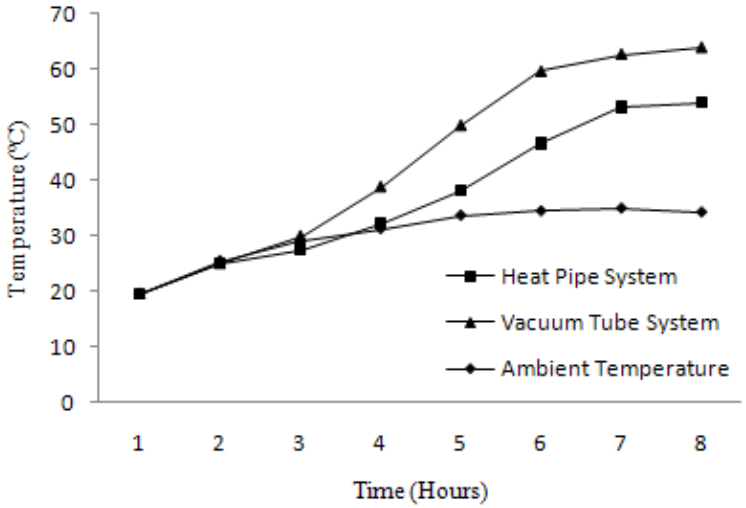

Figure 4. Change of store water temperature depending on the time
(Şekil 4. Depo suyu sıcaklıklarının zamana bağlı değişimi)

6. CONCLUSIONS (SONUÇLAR)

The fact that fossil-based energy sources will become extinct in a very near future and the environmental problems occurring during the time when such types of energy resources have caused the general demand for the alternative energy resources to increase in the world. Particularly due to its advantages such as efficiency and not producing any waste, solar energy, which is the infinite energy resource, constitutes the base for the applications of alternative energy resources. Solar energy water heating systems are used for preparing the hot water economically, particularly in the houses. However, determining the most productive and the most economical one among these systems which have a wide range of application area will certainly increase the success of the applications.

In the study conducted, use of heat pipe and glass tube under the conditions of Karabük has been examined experimentally. At the end of the study, the system productivities and usable energy amounts are determined. While these values are found to be 31% and 68W for the heat pipe system respectively, the same is found to be 40% and 85W for vacuum tube system respectively.

SYMBOLS AND ABBREVIATIONS (SEMBOLLER VE KISALTMALAR)

A	Collector surface (m^2)
c_p	Water specific heating temperature (kJ/kg °C)
I	Sun radiation coming on the unit surface area (W/m^2)
m	Mass (kg)
TRA	Solar energy coming to the collectors (W_S)
T_b	Water initial temperature of the experiment (°C)
T_s	Water temperature which can be reached at the end of the experiment period (°C)
Q_s	Energy which can be achieved from the system (kJ)
η	Efficiency
ΔT	Heat Difference (°C)

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