ICAT'19

8TH INTERNATIONAL CONFERENCE ON ADVANCED TECHNOLOGIES

PROCEEDINGS BOOK

E-ISBN : 978-605-68537-4-6

Editors
Ismail SARITAS
Omer Faruk BAY

August 26-30, 2019
Sarajevo, Bosnia and Herzegovina
www.icat2019.com

International Conference on Advanced Technologies

8th International Conference, ICAT'19
Sarajevo, Bosnia and Herzegovina, August 26-30, 2019

Proceedings

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Saday Mühendislik Sertifika No: 35542

www.snbt.com.tr

SN Bilgi Teknolojileri

Kürden Mh. Temizciler Sk. No:5/3 Meram / KONYA
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August – 2019

PREFACE

8th International Conference on Advanced Technologies (ICAT'19) has been organized in Sarajevo, Bosnia and Herzegovina on August 26-30, 2019.

The main objective of ICAT'19 is to present the latest research and results of scientists related to Computer Sicences, Electrical & Electronics, Energy Technologies, Manufacturing Technologies, Mechatronics and Biomedical Technologies. This conference provides opportunities for the different areas delegates to exchange new ideas and application experiences face to face, to establish business or research relations and to find global partners for future collaboration.

All paper submissions have been double blind and peer reviewed and evaluated based on originality, technical and/or research content/depth, correctness, relevance to conference, contributions, and readability. Selected papers presented in the conference that match with the topics of the journals will be published in the following journals:

- International Journal of Intelligent Systems and Applications in Engineering (IJISAE)
- International Journal of Applied Mathematics, Electronics and Computers (IJAMEC)
- International Journal of Energy Applications and Technology (IJEAT)

At this conference, there are 227 paper submissions. Each paper proposal was evaluated by two reviewers. And finally, 124 papers were be presented at the conference from 17 different countries (Algeria, Bosnia and Herzegovina, Bulgaria, Czech Republic, France, Japan, Kosovo, Libya, Macedonia, Malaysia, Palestine, Saudi Arabia, Serbia, South Africa, Turkey, United Arab Emirates, United Kingdom).

In particular we would like to thank Prof. Dr. Mustafa SAHIN, Rector of Selcuk University; International Journal of Intelligent Systems and Applications in Engineering (IJISAE); International Journal of Applied Mathematics, Electronics and Computers (IJAMEC); International Journal of Energy Applications and Technology (IJEAT) and Zenith Group. They have made a crucial contribution towards the success of this conference. Our thanks also go to the colleagues in our conference office.

Looking forward to see you in next ICAT.

Ismail SARITAS - Omer Faruk BAY
Editors

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Experimental Investigation of the Storage of Solar Energy in Natural Stones

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***Abstract*— The depletion tendency of fossil fuels and the irreversible effects of environmental pollution have led to alternative energy sources in the world. It has become imperative that externally energy dependent countries should develop different solutions to meet the energy needs and reduce their energy consumption. Although the use of renewable energy sources is constantly increasing, there are some disadvantages of these systems. The biggest problem encountered in the use of renewable energy is the discontinuity and disruption of energy. Thermal energy storage technologies can be an important solution for energy efficiency and sustainability in energy use. In this study, thermal energy storage properties of pebbles, Urfa stone and basalt stone at different geometric shapes were investigated experimentally under Şanlıurfa climate conditions. Şanlıurfa province located in south-eastern Turkey has a high potential in terms of solar energy. For this purpose, an experimental setup including an insulated box where the stone is placed inside, an air solar collector, a fan and the measuring devices have been used. Solar radiation, inlet and outlet air temperatures, stone temperatures and ambient temperature were measured with thermocouples and recorded by using a data logger for the analysis and calculations. Charge and discharge times, and the thermal energy storage potentials of the stones were determined according to the measurements carried out for different days and the time dependent temperature changes were examined. As a result of this study, it was determined that the thermal storage capacity of the basalt stone is higher than other stones. It has been observed that solar air collectors and natural stones can be used together in thermal storage applications such as heating and drying systems in terms of energy efficiency.**

***Keywords*— Heat storage, Solar energy, Air solar collector, Natural stones**

I. INTRODUCTION

Energy has always played an important role in human history, since the development of countries depends on energy and the availability of energy resources. Today, one of the main problems is the irreversible destruction of nature and environment caused by the energy resources used in addition to trying to meet the increasing energy needs with limited energy resources. Among the energy sources, the most consumed fossil fuels tend to be depleted and they are one of the main causes of environmental pollution. So, this has led the world to seek alternative energy sources. These alternative energy sources are renewable energy sources such as solar energy, hydraulic energy, wind energy, geothermal energy, biomass energy and wave energy. The use of renewable energy sources brings many advantages. For example, the countries that are dependent on foreign sources in energy supply their energy needs with domestic resources and they do not have environmental damages which is one of main advantages.

Increasing energy demand in the world increases the need for conventional resources. Coal, natural gas and petroleum are the main sources of these conventional or non-renewable energy sources, which is the most of the world's energy needs are met. The use of conventional fuels increases greenhouse gas emissions and is also the main reason for global warming. Renewable energy sources are environmentally friendly and sustainable energy sources [1].

As solar energy is a clean and renewable energy source, it can be easily used in low temperature applications such as housing, food, textile and chemical industry, which does not require any cost other than the first investment. [2]. Solar energy has many techniques and applications such as thermal and electrical applications. In the world and in Turkey, there is a huge increase in the use of solar air collectors which is one of thermal solar energy applications in recent years [3].

Among the renewable energy sources, solar energy has the greatest potential; has many advantages in terms of use. The most important of these is that it does not cause environmental pollution, does not require superior and complex technology and can be applied locally. Because of these advantages, solar energy; it has been a subject of intensive studies. Heating, cooling of buildings, air conditioning applications, industrial studies, food drying and electricity generation are the areas where solar energy is widely used [4]. In the heating applications made by using solar energy, especially hot water production takes the lead. Other thermal applications are not at the desired level [5,6]

Comprehensive research is carried out by researchers about energy storage. There is a need to store energy in order to use energy wherever it is needed and when we want it. This is called

energy storage. There many paramaters in energy storage; high storage capacity, high charge / discharge efficiency, low self-discharge and capacity losses, long life, cheapness, energy intensive (kWh / kg or kWh / liter). It is desirable that the warehouse to be used in these systems is able to store the energy in minimum volume and weight. Therefore, thermal, mechanical or electrical energy storage methods are available in different forms [7].

In the study on the thermal storage properties of pebbles and paraffin, the use of high heat energy potential during the daytime hours was stored and their use in the evening and night hours was investigated [8].

In another study, thermal energy storage for heating applications and chemical, sensible, latent and mechanical energy storage processes are technologically reviewed [9].

Heat energy is stored using the change in the internal energy of the substance. Heat energy can be stored in the form of sensible heat, latent heat and reaction heat.

In sensible heat storage, heat energy is stored by changing the temperature of a storage medium such as water, air, oil, rock beds, bricks, sand, or soil. The amount of energy input to heat storage by a sensible heat device is proportional to the difference between the storage final and initial temperatures, the mass of the storage medium, and its heat capacity. Thermal capacities of some heat storage materials at 20 °C is shown in Table 1.

Table 1. Thermal capacities of some heat storage materials at 20 °C

Material	Density (kg/m^3)	Specific heat (J/kg K)	Volumetric thermal capacity (10^6 J/kg K)
Clay	1458	879	1.28
Brick	1800	837	1.51
Sandstone	2200	712	1.57
Wood	700	2390	1.67
Concrete	2000	880	1.76
Glass	2710	837	2.27
Aluminium	2710	896	2.43
Iron	7900	452	3.57
Steel	7840	465	3.68
Gravelly earth	2050	1840	3.77
Magnetite	5177	752	3.89
Water	988	4182	4.17

In this study, thermal energy storage properties of pebbles, Urfa stone and basalt stone at different geometric shapes were investigated experimentally under Şanlıurfa climate conditions. Thermophysical properties of natural stones used in this study are shown in Table 2.

Table 2. Thermophysical Properties of Natural Stones [10]

Material	Density (kg/m^3)	Coefficient of heat conduction (W/mK)	Specific heat (J/kgK)	Coefficient of Thermal Diffusivity (10^{-6} m^2/s)	Heat Capacity ($10^6 J/m^3K$)
Urfa Stone	2570	1.42	1041	0.66	2.68
Basalt Stone	2800	1.513	1500	0.36	4.20
Pebble Stone	2050	1.730	1840	0.46	3.77

II. METHOD

The main purpose of this study is to determine the thermal storage properties of Sanliurfa in an adiabatic volume by using an air type solar collector heating system and to investigate its applicability. The experimental system consists essentially of an adiabatic volume and a solar air collector. Fig. 1 shows the solar air collector system consisting of fan, insulated circular air duct, air inlet and outlet hoods and solar air heater with jet impingement.

Fig.1 Solar air collector system

Fig. 2 schematically shows the experimental setup with solar air collector and adiabatic thermal storage volume with measurement points. Experiments were carried out in Harran University Faculty of Engineering, Mechanical Engineering Department, Solar Energy Laboratory.

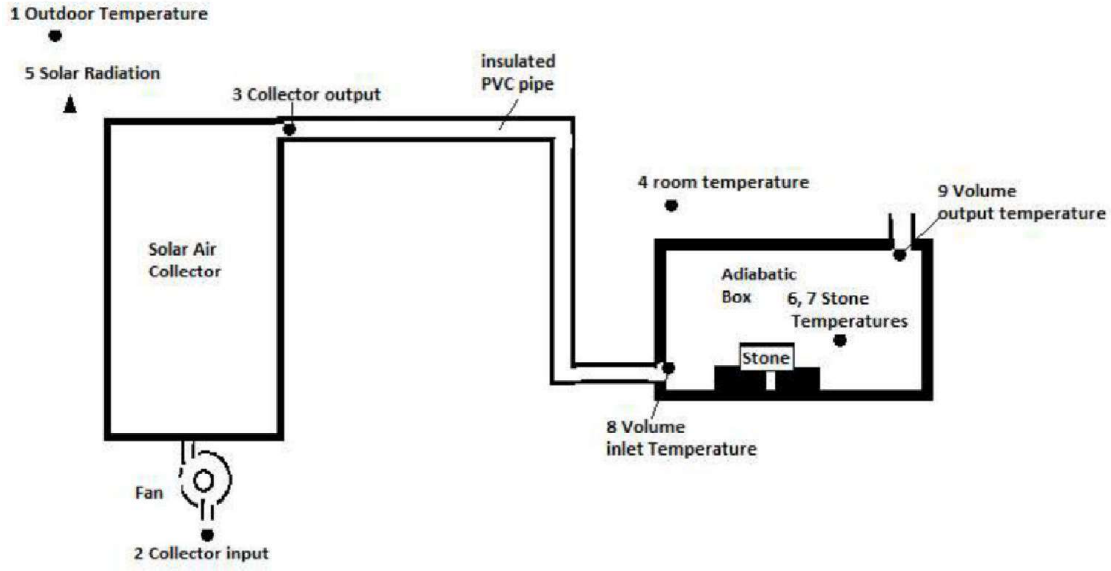

Fig. 2. Experimental setup and measurement points

The basalt stone used in the study is the non-porous basalt stone located on the Siverek side of Şanlıurfa. In the experiments basalt stones of different geometries (plate 30x30x3 cm, cube 10x10x10 cm, 7x7x7 cm, 5x5x5 cm and cylinder 6 cm diameter x 10 cm height) were used (Fig. 3).

Fig. 3 Basalt stones

In the experiments, Urfa stones were used in different geometrical shapes as cubes (10x10x10 cm, 7x7x7 cm, 5x5x5 cm), cylinders (6x10 cm) and spheres (5 cm) (Fig. 4). The stones were obtained from the quarries in Şanlıurfa.

Fig. 4 Urfa stones

Fig. 5 shows the pebbles used in the study. Pebbles were collected from the Euphrates river. The average diameter of pebbles varies between 2 cm and 6 cm.

Fig. 5 Pebbles

III. RESULTS AND DISCUSSIONS

A. Basalt Stone Results

Fig. 6 shows the basalt stone volume input-output temperature and solar radiation change over time with different sizes of basalt stones and velocity at maximum level. It is seen from the figure that the solar radiation and temperature show similar changes for different phase shifts. A phase shift of 150 minutes was detected at the volume inlet temperature. After 14:50, it was observed that the basalt stone was transferred to the discharge position and the volume outlet temperature was higher than the inlet temperature. As seen in the figure, the slopes of all stones are almost equal and it is observed that the heating and discharge of the cylindrical basalt stone is later than the other stones.

In the experiment, it was found that basalt cylindrical stone has better heat storage than other stones. 5x5x5 cm better heat and cool more quickly.

It was found that the temperature of basalt stone was given to the air until late at night.

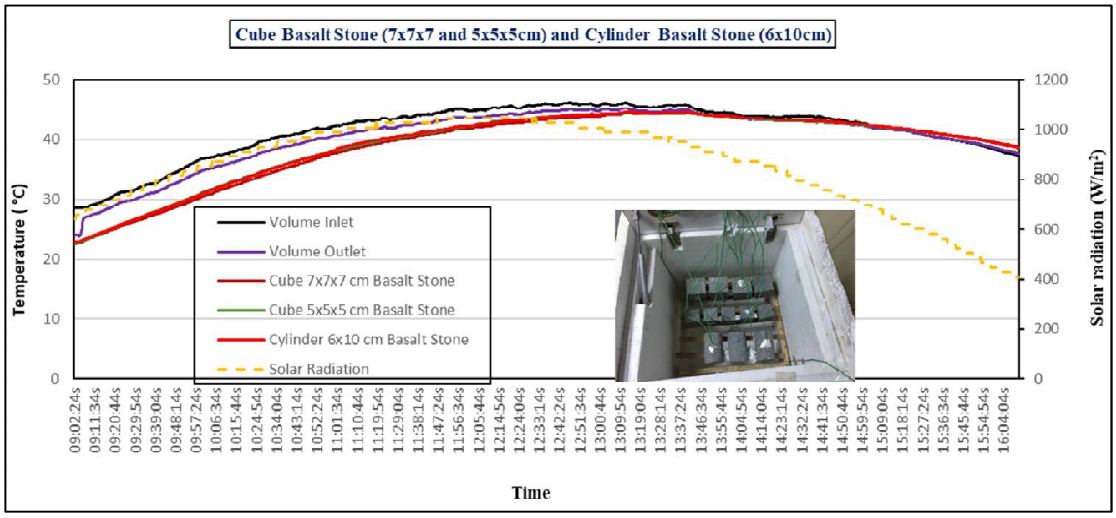

Fig. 6 Variation of inlet and outlet air temperature of volume, basalt stone (cube and cylinder) temperature and solar radiation with time

Fig. 7 shows basalt stones of varying sizes and the volume input-output temperature and solar radiation change over time with a velocity of 2.6 m/s. Due to the low solar radiation and cloudy weather conditions, the discharge time is early. After 13:10, the basalt stone moves to the discharge position and the volume inlet temperature is higher than the outlet temperature. As seen in the figure, it is seen that the slopes of all stones are almost same and that the plate basalt stone is heated and discharged later than the cube. Basalt plate stone has been found to store heat better than cube stones. It is observed that the temperature of the basalt stone is given to the air until late.

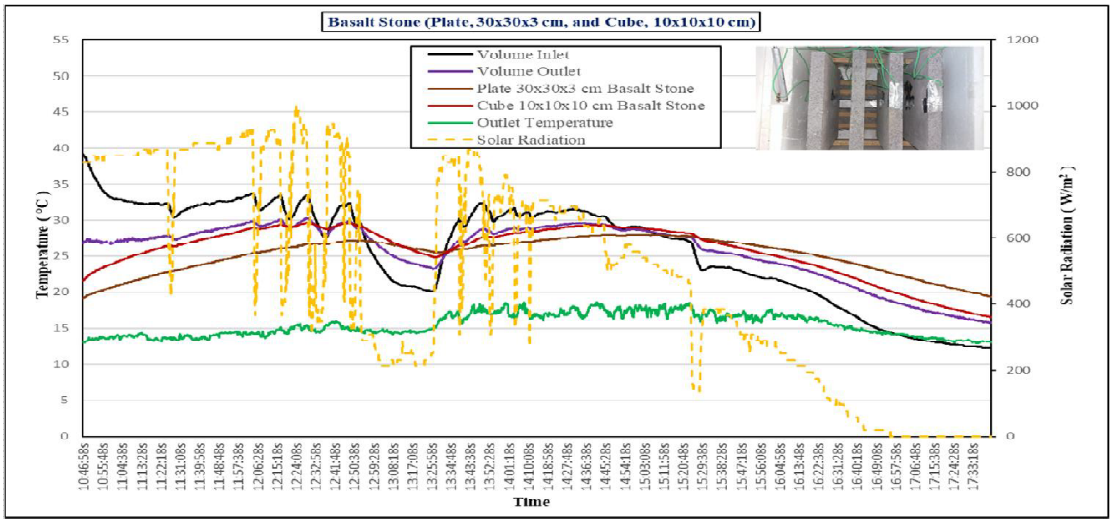

Fig. 7. Variation of inlet and outlet temperature of volume, basalt stone (plate and cube) temperature and solar radiation with time

B. Urfa Stone Results

Fig. 8 shows the variation of Urfa stone temperatures, volume inlet-outlet temperatures and solar radiation with time. The figure shows that solar radiation and temperature show similar changes for different phase shifts. A phase shift of 120 minutes was detected at the volume inlet temperature. After 14:00, the Urfa stone moves to the discharge position and the volume outlet temperature is higher than the inlet temperature. As seen in the figure, it was found that the slopes of all stones were almost equal and the heating and discharge time of the cylindrical basalt stone was later than the other stones. Urfa

cylindrical stone has been found to store heat better than other stones.

It is seen that the stones heat up 5x5x5 better and cools more quickly.

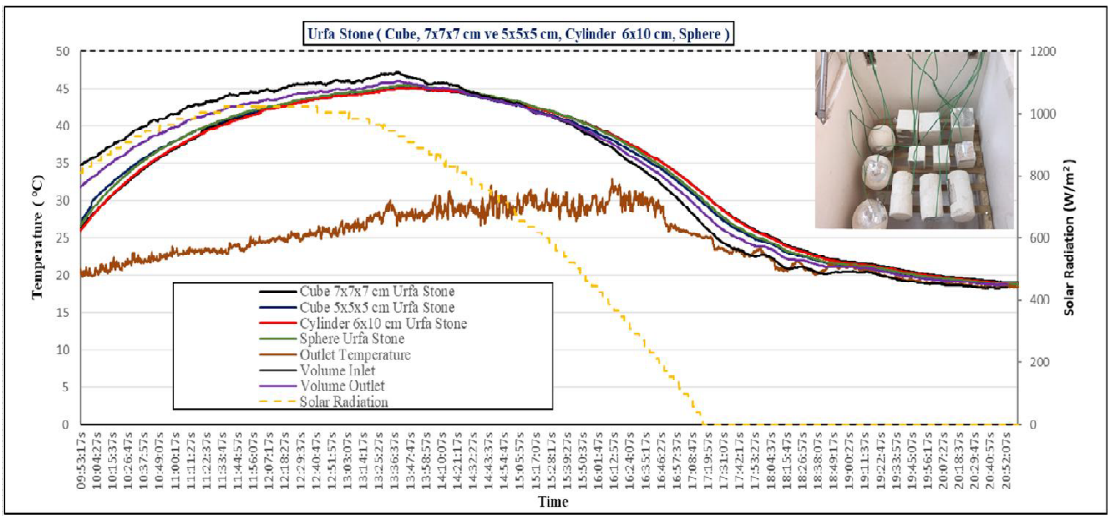

Fig. 8. Variation of inlet and outlet air temperature, Urfa stone (cylinder, cube and sphere) temperature and solar radiation with time

C. *Pebble Stone Results*

The effect of variable solar radiation on the outlet air temperature and thermal storage during the day is shown in Fig. 9. In the experiment carried out on a cloudy day, the fluctuation in solar radiation was similar to the change in air outlet temperature but did not cause a significant change in pebbles temperature.

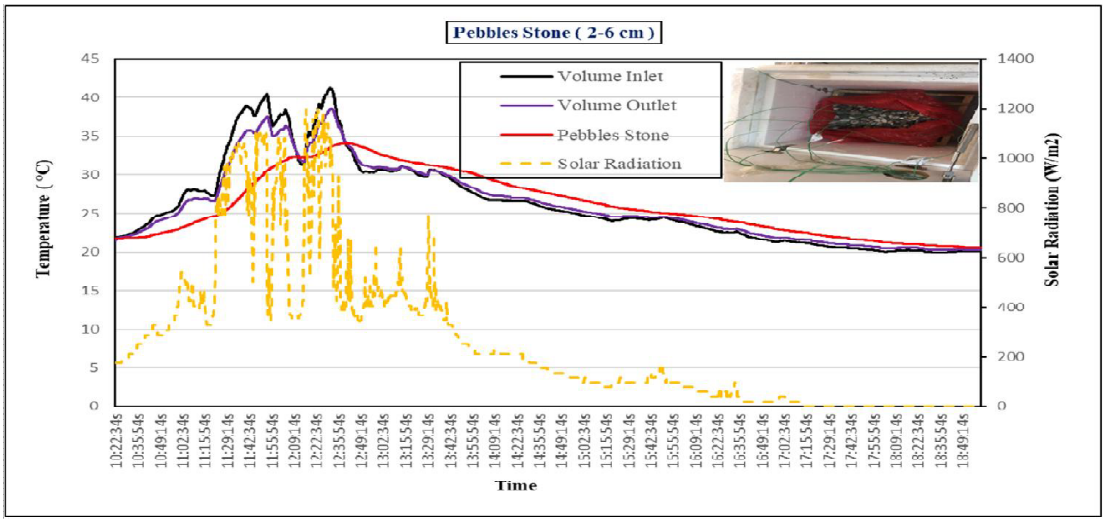

Fig. 9. Variation of inlet and outlet air temperature of volume, pebbles stone (2-6 cm) temperature and solar radiation with time

IV. CONCLUSIONS

In this study, the experimental analysis of the storage of solar energy as a renewable energy source as thermal energy in different natural stones has been carried out. Basalt, Urfa and pebble stones have thermal storage properties as natural stones in Şanlıurfa. In order to compare the thermal storage properties of these stones, experimental thermal storage capacities were calculated and compared. Charge and discharge conditions under variable temperature conditions were investigated. The following results were obtained from the experimental study:

-The effect of climate conditions and solar energy on thermal energy storage is important,

-Solar energy can be stored in stones with solar air collectors,

-Stone temperatures can reach above 45 ºC with solar energy,

-The effect of solar radiation is a time shift to the system,

-When the results of the experiment were examined, it was observed that basalt stone had higher thermal storage properties than other stones.

As a result, Basalt, Urfa and Pebble stones as natural stones found in Şanlıurfa have potential for heat storage and can be used as heat storage material.

REFERENCES

[1] H. Ioannis, A. Poullikkas, and V. Efthimiou. "Overview of current and future energy storage technologies for electric power applications" *Renewable and sustainable energy reviews*, 13.6-7, 2009.

[2] R.T. Oğulata, Enerji Tasarrufunda Dikkat Edilecek Hususlar. TSE, Ankara. 9(2): 429-433, 1997.

[3] H. Benli and A. Durmuş, "Havalı Güneş Kolektörleri ve Gizli Isı Depolama Yöntemi Kullanılarak Sera Isıtılması", *Mühendis ve Makine Dergisi*, *48*(569), 2002.

[4] M.N. A Hawlader, S. K., Chou, and M. Z. Ullah. "The Performance of a Solar Assisted Heat Pump Water Heating System". *Applied Thermal Engineering,* 21(10): 1049-1065, 2001.

[5] N. Ü. Kelek, "Hava Isıtıcılı Optimum Güneş Kollektörü Dizaynı". Erciyes Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Kayseri,65s, 1996.

[6] İ. T., Toğrul, and D. Pehlivan,. "Konik Yoğunlaştırmalı Bir Güneş Enerjili Hava Isıtıcının Verimine Farklı Absorber Yüzey Kullanımının Etkisi". *Isı Bilimi ve Tekniği*, 22(2): 47-53, 2002.

[7] M. Boztepe, "Enerji Depolama". http://www.solar-academy.com/menuis/Enerji-Depolama-EES-Yeni-Enerji-Kaynaklari-2006115408. 2006pdf(29.01.2019).

[8] T. V. Arjunan, H. S. Aybar, P. Sadagopan, B. Sarat Chandran, S. Neelakrishnan, and N. Nedunchezhian, "The effect of energy storage materials on the performance of a simple solar still" *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *36*(2), 2014.

[9] L. Dominique and F. H. Tezel. "A review of energy storage technologies with a focus on adsorption thermal energy storage processes for heating applications." *Renewable and Sustainable Energy Reviews* 67, 2017.

[10] P. Turgut, M. İ. Yesilnacar and H. Bulut**.** "Physico-Thermal and Mechanical Properties of Şanlıurfa Limestone, Turkey". *Bulletin of Engineering Geology and the Environment*, 67(4), 485-490. 2008.