ICAT'19

8TH INTERNATIONAL CONFERENCE ON ADVANCED TECHNOLOGIES

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Editors
Ismail SARITAS
Omer Faruk BAY

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8th International Conference, ICAT'19
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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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An Experimental Study on Thermal Energy Storage in Urfa and Basalt Stones at Constant Temperature Charging

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***Abstract*— Thermal storage applications are important solutions in terms of energy efficiency and energy sustainability. There are different thermal storage methods, especially sensible and latent thermal storage methods and these methods are used in many applications. Thermal energy storage can be done with different materials for later use when the energy is excessive or interrupted and the energy costs are low. In this study, the thermal energy storage potential of Urfa and basalt stones, which are natural stones in Şanlıurfa located in south-eastern Turkey, were investigated experimentally at constant temperature charging and discharging. The experimental setup consists of an insulated box in which the stones are placed, an electrical heater and measuring devices were used for this purpose. The inlet and outlet air temperatures, stone temperature and ambient temperature were measured with thermocouples and recorded in the datalogger. According to the measurements carried out at different temperatures and air velocities, the thermal energy storage quantities of the stones were determined and the time-dependent temperature changes were investigated. It found that charging time is shorter as air velocity and temperature increase. As a result of the study, it was determined that the thermal storage potential of basalt stone was higher than that of the Urfa stone. It has been seen that the thermal storage potentials of natural stones can be used in terms of increasing energy efficiency in heating systems. With these results, it is found that the volume, the capacity, the structure and the insulation of storage box should be selected appropriately for high thermal storage. In addition, the installation of an automation system is required in order to achieve a high performance in energy storage.**

***Keywords*— Heat storage, Constant temperature, Natural stones, Urfa Stone, Basalt.**

I. INTRODUCTION

Energy is the most important parameter behind increasing economic and social development worldwide. Although it is stated in the researches that fossil-based energy will continue for 300-400 years, it is seen that this period may be shortened further since the use of energy has increased considerably in recent years. Therefore, it is important to increase the use of renewable energy as well as the efficient use of available resources [1,2].

Energy storage systems and technologies are used in cases where the energy source is not continuous, there is excess and waste energy or when the energy usage time is postponed.

Energy storage can be summarized as giving energy to a storage system for later use. Thermal energy storage (TES) is the storage of energy by cooling, heating, melting, solidifying or evaporating a material; it can also be defined as the use of this stored energy when the process is reversed [3,4]. TES is used in different applications such as building heating, hot water, cooling, air conditioning, greenhouse heating and drying. High energy density (high storage capacity) of the material to be used in storage, suitable heat transfer between the fluid to be used and the storage material, mechanical and chemical stability of the storage material, prevention of thermal losses during storage are the basic parameters to be considered in TES system design [5].

TES methods can be classified under two headings as latent heat and sensible heat storage.

In latent heat storage, use of phase changed material (PCM) is one of the most common methods. Heat during phase change; stored as latent heat and the temperature is constant in this process. The phase change process can be stored as solid-liquid, solid-solid and liquid-gas. The amount of heat stored can be calculated from Equation 1:

$$Q = m\,\Delta h \qquad (1)$$

Q is the amount of heat stored in the material (kJ), m is the mass of the storage material (kg), and h is the phase change enthalpy, also called melting enthalpy or fusion heat (kJ / kg).

In sensible heat storage; energy is stored by changing the temperature of a storage medium or substance, such as water, air, oil, rock beds, bricks, sand, soil or stone. In this method, no phase change occurs during storage. The amount of heat stored in sensible heat storage can be expressed as shown in Equation 2:

$$Q = m\,c\,\Delta T \qquad (2)$$

Q is the amount of heat stored in the material (kJ), m is the mass of the storage material (kg), c is the specific heat of the storage material (kJ / kg K) and ΔT is the temperature change (K). Fig. 1 displays an overview of the major techniques involved for thermal energy storage.

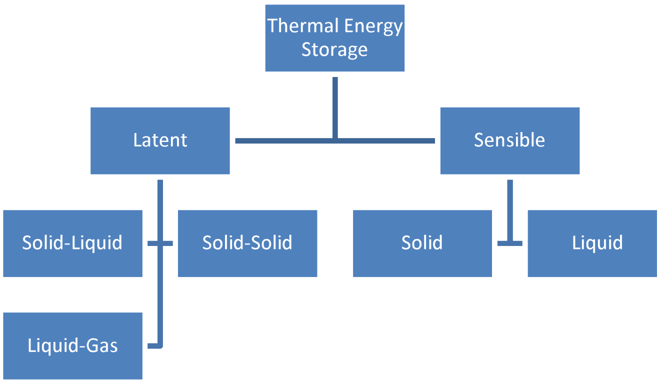

Fig.1 Different types of thermal energy storage

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
Urfa Stone	2570	1041	2.68
Basalt Stone	2800	1500	4.20

In a study examining laboratory-scale sensible heat storage prototypes made of cast steel and concrete, thermal storage performances of the prototypes in terms of charge-discharge times and energy storage-discharge rates were analysed at various operating temperatures and at different heat transfer fluid velocities. In the experimental study, it is stated that the storage performance of the system depends on the temperature range due to the thermophysical properties of cast steel and concrete materials and heat transfer fluid [6].

In another study, the effect of factors such as geometric structure of the storage tank, fluid properties, fluid inlet temperature, etc. on sensible heat storage in energy and exergy performance was compared with the results of latent heat storage system [7].

A series of studies and reviews on TES technologies are available in the literature [8-10].

II. METHOD

In this study, the thermal energy storage potential of Urfa and basalt stones, which are natural stones in Şanlıurfa located in south-eastern Turkey, were investigated at constant temperature charging and discharging. For this purpose, the experimental setup consists of an insulated box in which the stones are placed, an electrical heater and measuring devices were used. Fig. 2 shows the experimental setup with electric heater and adiabatic thermal storage volume. Experiments were carried out in Harran University Faculty of Engineering Mechanical Engineering Solar Energy laboratory. The inlet and outlet air temperatures, stone temperature and ambient temperature were measured with K type thermocouples and recorded in the datalogger. According to the measurements made at different temperatures and air velocities, the thermal energy storage quantities of the stones were determined and the time-dependent temperature changes were investigated.

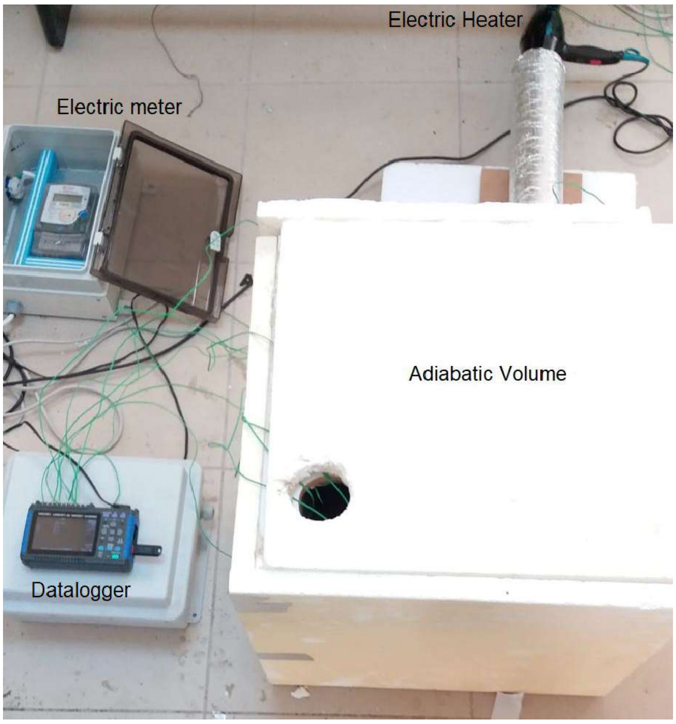

Fig.2 Experimental setup of thermal energy storage system

The adiabatic volume in which the basalt and Urfa stones are placed is shown in Fig. 3.

Fig.3 Adiabatic volume, basalt and Urfa stones.

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. 4).

Fig. 4 Basalt stones

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

Fig. 5 Urfa stones

III. RESULTS AND DISCUSSIONS

In the study, the inlet and outlet air temperature, stone temperature and ambient temperature were measured and recorded in the datalogger. When the records taken with the datalogger are examined, the thermal storage time of the stones increases with the resistance. It is seen that the charge-discharge times of the sphere Urfa stones are earlier than the other stones. However, it is understood from the graph that the charge and discharge time of the cylindrical basalt stone is later than other stones and the yield is higher. It is also seen that they can be stored together and separately in the same insulated volume (Fig. 6).

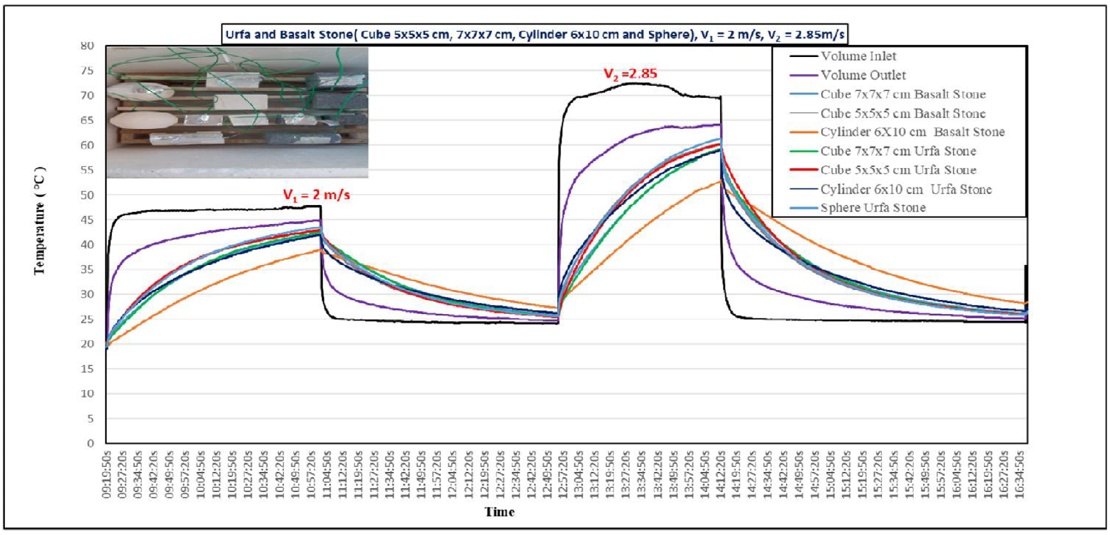

Fig. 6. Variation of Urfa and basalt stones temperatures during charge and discharge processes at high and low constant temperatures

Fig. 7 shows the Urfa and basalt stone temperature and volume input-output temperature change over time with different geometries of stones at constant temperature. In the measurements made by using electric heater, heat storage changes of the stones, temperature change of the stones with a constant time of charging according to time and air velocity are observed. Charging time seems to be early as air velocity and temperature increase. In the experiment, when the air velocity is high, it is seen that the temperature goes to high values. The cube basalt stone measuring 7x7x7 cm, which is one of the stones used in the experiment, was found to be enter the regime conditions earlier.

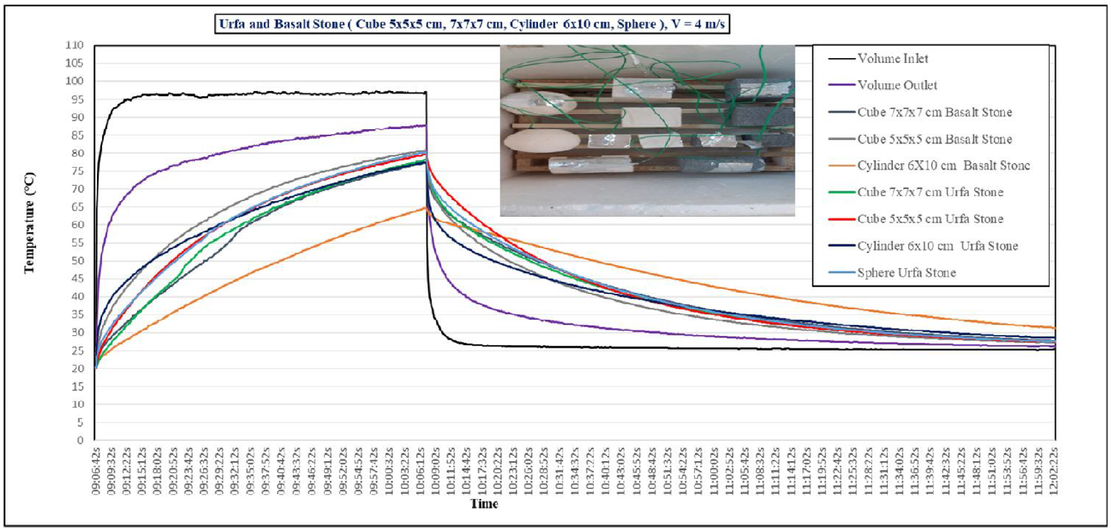

Fig. 7. Variation of Urfa and basalt stone temperature and volume input-output temperature with time at different geometries of stones.

IV. Conclusions

In this study, the thermal energy storage potential of Urfa and basalt stones, which are natural stones in Şanlıurfa located in south-eastern Turkey, were investigated at constant temperature charging and discharging. It is seen that basalt and Urfa stone have heat storage properties and can be used as heat storage material. It has been determined that the heat storage capacity of basalt stone is higher than that of Urfa stone.

It found that charging time is shorter as air velocity and temperature increase. The geometric shapes of the stones used for the experiments were found to influence the thermal storage properties of the stones. According to the geometric shapes of the stones, it was determined that the spherical stone has the best storage property. It has been seen that the thermal storage potentials of natural stones can be used in terms of increasing energy efficiency in heating systems. With these results, it is found that the volume, the capacity, the structure and the insulation of storage box should be selected appropriately for high thermal storage. In addition, the installation of an automation system is required in order to achieve a high performance in energy storage.

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