Research Article **ISSN: 2395 – 5597**

International Journal of Engineering and Robot Technology

Journal home page: www.ijerobot.com

EXPERIMENTAL INVESTIGATION ON HEAT STORAGE CO-EFFICIENT OF TWO-PHASE MATERIALS

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ABSTRACT

The heat storage coefficient deals with the thermal behaviour of a substance. It is calculated from the thermal conductivity and the volumetric heat capacity. An experimental investigation has been carried out to understand the behaviour of the heat storage coefficient of different materials at different gas pressures. The purpose of this article is to investigate the capability of multiphase systems to insulate heat at both normal and interstitial gas pressures. The study is important because of its usefulness in selecting materials mainly for the design of storage tanks, pipe lines, construction of buildings, fabrication of walls of furnaces and the design of solar storage tanks.

KEYWORDS

Heat storage co-efficient and Experimental investigation.

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INTRODUCTION

The heat storage coefficient is a thermo physical parameter which describes the thermal behaviour of a substance. It characterizes a medium from the viewpoint of its heat storage ability. In thermodynamics, the Heat Storage Coefficient (HSC) of a material is defined as the square root of the product of the thermal conductivity and volumetric heat capacity of the material. The heat storage coefficient is a measure of ability to exchange thermal energy with its surroundings. Ina gas-solid two phase system, the interstitial gas is mainly confined inside the pores and it behaves differently than unconfined gas. When the pore diameter is comparable to the mean free path at interstitial gas pressure, the collision of gas molecules at the pore surface frequently. The consideration of total probability of the inter molecular collisions for all values of molecular displacements helps to determine the effective mean free path from which heat storage coefficient can be determined. The purpose of the project is to investigate the capability of three phase loose mixtures to insulate heat at interstitial gas pressures. A. K. Shrotriya and R. Mishra[1] has been carried out a work to find the heat storage coefficient of two phase systems. A theoretical model to predict the heat storage coefficient (HSC) of two phase materials from the values of heat storage coefficient of the constituent phases and their volume fractions is presented. Two-phase materials have been assumed to contain spherical particles arranged in a regular manner in a three-dimensional cubic geometry, such that each unit cell contains a sphere inside it. The heat storage coefficient of the unit cell has been determined by applying the resistor model. Theoretical calculations of the heat storage coefficient have been carried out for suspensions and loose granular systems and comparisons has been made with other models and experimental values cited in the literature. The values predicted by the proposed model are in close agreement with experimental values of heat storage coefficient reported in the literature and more accurate than those obtained from existing models. L. S. Verma and D. R. Chaudary[2] has been carried out a work to calculate the thermal conductivity using resistor model. The effective thermal conductivity of heterogeneous materials such as soils, ceramics, fibre reinforced materials and composites are becoming increasingly important in the technological developments and in many applications. Though a large number of models exist in the literature, a general expression which can predict (ETC) of all kinds of two phase systems is developed. The paper is an effort to find a suitable expression to predict the thermal conductivity of various kinds of two phase systems. The electrical analog of various parameters have been assumed to develop the expression.

Equivalent thermal resistors formed out of the phases in form of parallel slabs are considered and the resistor model approach has been applied. The slabs are taken to be inclined to the direction of heat flow. By varying the angle of the slabs, the conductivity of different two phase materials can be predicted. The angle has been defined in terms of various structural and thermal parameters. Keshok and Pande[3] has been carried out a work to determine the heat the heat storage coefficient of three phase systems. An expression for the heat storage coefficient of loose multi-phase system was developed. Depending on the utility of the partially evacuated granular system in large scale energy storage, measurements were carried on systems with metallic and nonmetallic dispersions. The considerations of total probability of inter molecular collision for all values of molecular displacement was used in determining the expression for the heat storage coefficient.

EXPERIMENTAL SETUP

Design and fabrication of apparatus to determine the heat storage coefficient of multi-phase materials has been discussed.

A. Pressure chamber

A copper sheet of dimensions 785mm x 350mm with thickness 3 mm has been used to create a hollow cylinder of diameter 240 mm and length 350 mm by rolling process and sturdy enough to bear a pressure of 5 atmospheres.

B. RTD sensor

Resistance Temperature Detectors are the sensors that measure the temperature by correlating the resistance of the element with temperature. The operating principle is based on the fact that a materials electrical resistance changes with temperature. These elements nearly always require insulated leads attached. The measuring point and usually most of the leads require a housing or protective sleeve often made of metal alloy that is chemically inert to the process being monitored. Selecting and designing protection sheaths can require more care than actual sensor, as the sheath must withstand chemical or physical attack and provide convenient attachments points.

C. Pressure gauge

The pressure inside the container is increased by using a pump and the value is noted from the pressure gauge used and the inlet air flow is controlled by means of a valve attached to the lid. The pressure within the container is varied by using the value. The pressure valve was attached to the lid by initially making a hole to the size of the thread in valve and then welded to fix it with the lid. The attachment is made air tight with the container to avoid the leakage.

D. Embedded kit

The input power supply of 230V AC is stepped down to 5V by a step down transformer. The alternating current is then converted to the direct current by using full wave bridge rectifier. The capacitor is used in between to act as a energy storing device. The RTD sensor sends the signal to the chip for processing which then displays the value of the temperature in as display provided in the board. The relay operated based on the limitation of the temperature values. Thus the embedded kit comprises of three units namely microcontroller chip, relay and power supply board. The heating element starts heating the sample container once the supply is witched on by using the embedded kit and the relay is used to automatically turn on and off the circuit once the temperature limit is attained.

RESULTS AND DISCUSSION

The aluminium powder and cement powder were taken as samples for the experimentation. The sample container was filled with the sample. The power supply is switched on and the sample starts getting heated and rise in temperature is seen in the display panel. The relay is set up for 45^{O}C. Once the temperature attained the value, the circuit gets turned off. Now the fall in temperature with respect to time is noted.

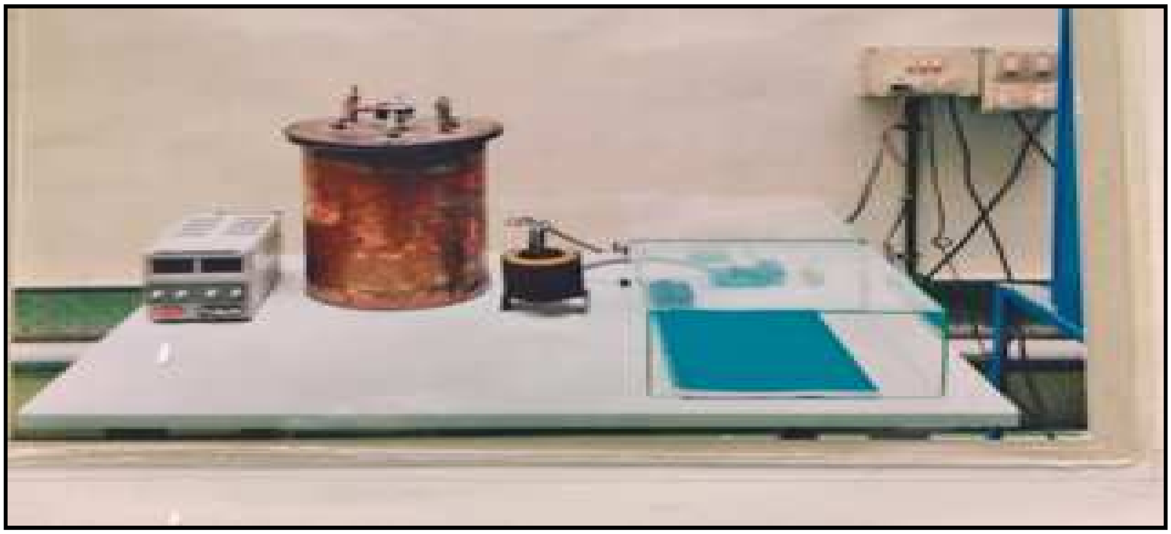

Figure No.1: Experimental setup of heat storage coefficient apparatus

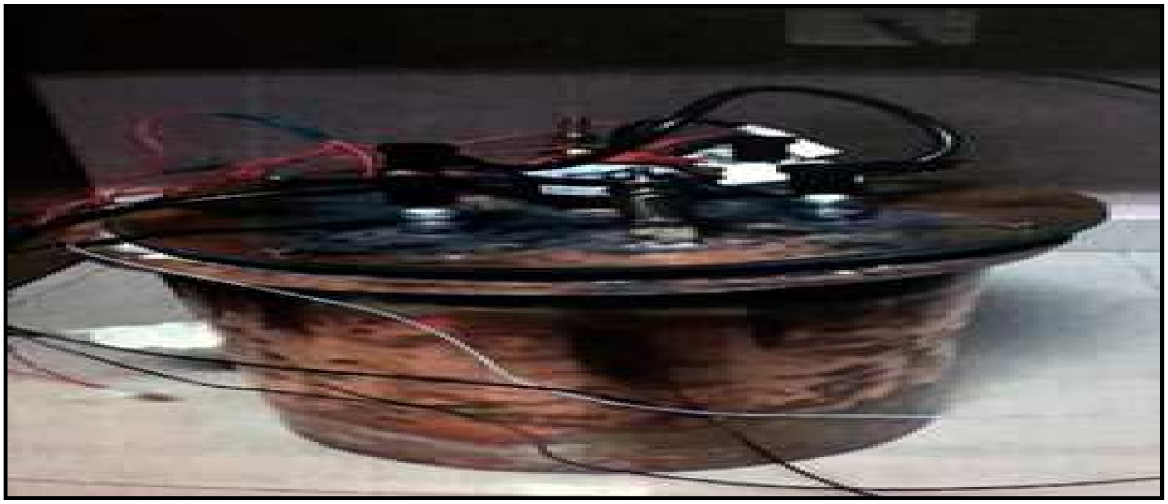

Figure No.2: Pressure chamber

The temperature for time step of 10 seconds is noted for aluminium powder.

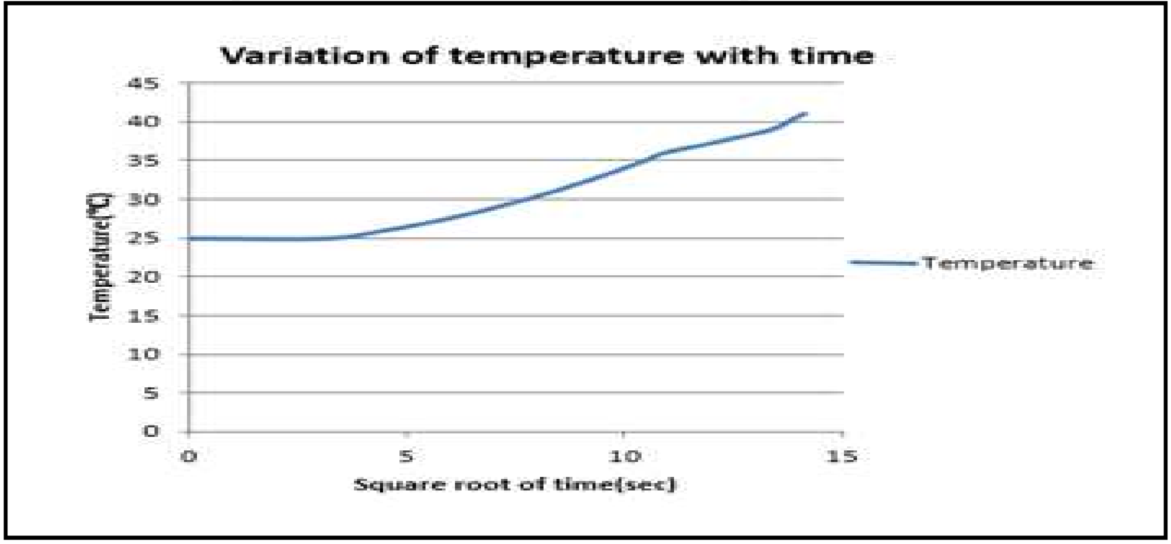

Figure No.3: Variation of temperature with time for aluminium powder

The temperature for time step of 10 seconds is noted for cement powder.

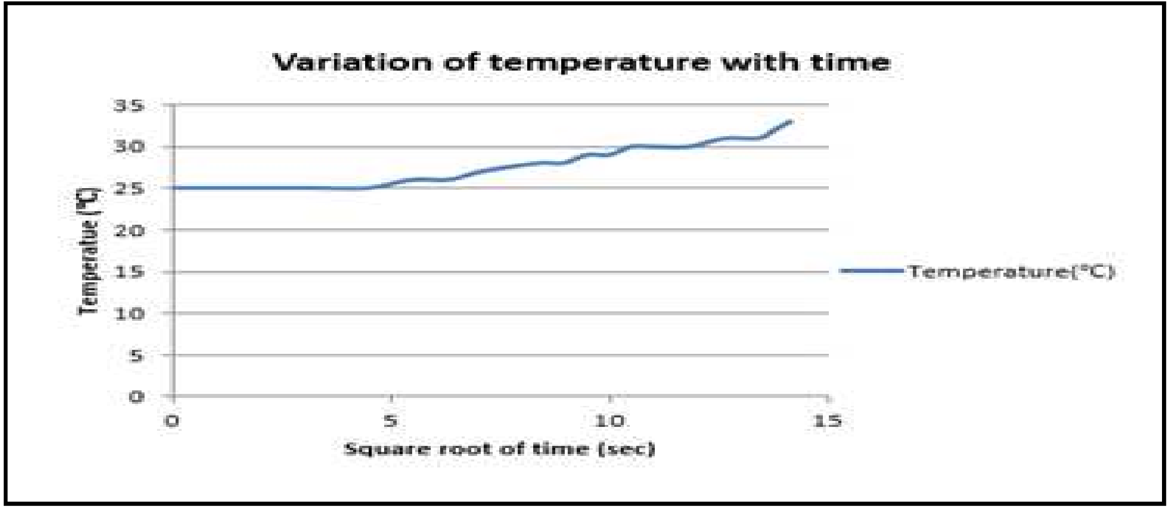

Figure No.4: Variation of temperature with time for cement powder

CONCLUSION

The apparatus for determining the heat storage coefficient is designed and fabricated. The experimentation is carried out on aluminium powder and cement powder. The heat storage coefficient value of aluminium powder and cement powder were found to be 19874.62$Wm^{-2}K^{-1}s^{1/2}$and 2963.14 $Wm^{-2}K^{-1}s^{1/2}$. The aluminium powder has high heat storage coefficient value than cement powder and hence the aluminium powder is selected at places where high temperature fluids have to be carried and stored. The cement powder is suitable for low temperature storage tanks. Thus depending upon the application the materials with suitable heat storage coefficient are considered. Hence this experimentation finds its usefulness in the selection of materials for pipelines, walls of furnaces and storage tanks.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to Department of Mechanical Engineering, PSG College of Technology, Coimbatore, India for providing necessary facilities to carry out this research work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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Please cite this article in press as: Senthil Kumar A P *et al.* Experimental investigation on heat storage co-efficient of two-phase materials, *International Journal of Engineering and Robot Technology,* 5(1), 2018, 1-5.