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Performance Analysis of Advance PCM with Activated carbon powder by the use of Evacuated Tube Solar Collector

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ABSTRACT

This paper experimentally investigates effects of doping active carbon powder and titanium dioxide in paraffin wax. Paraffin wax (PCM) is most promising method of energy storage. The work is concern about performance enhancement methods of PCM as latent heat storage system. Performance can be improved by doping high thermal conducting material and high pores material to ensure better heat flow and availability of more surface area respectively. Thermal charging and discharging, Decrement in relative humidity of ambient air are parameters considered for study. Three samples are prepared by mixing paraffin wax with active carbon having three different mass concentrations of 20%, 26% and 34%. Titanium Dioxide is added to every sample by a fixed mass concentration of 1%. Experimental data, presented in this paper, has helped to find conclusive results.

Keywords – Activated Carbon Powder, Evacuated Tube Solar Collector, Paraffin wax, Titanium Dioxide

1. INTRODUCTION

The gap between supply of energy and demand of energy is continuously growing. This gap is leading serious consideration towards renewable energy technology. With the use of renewable energies, demands of population can be fulfilled without disturbing the balance of nature. All around the world many efforts are being carried out to use the renewable sources as much as possible. Numbers of inventions are done which is leading to reduce global warming and greenhouse effect. Further improvements are made in renewable energy technology for better performance. Energy is one of the main factors to be required for the development of country. Penetration of renewable energy sector in Indian society is low so the scope of development is very high. Increment in constructive energy consumption signifies the development of various sectors of country. Many of renewable sources in the environment are available such as wind, solar, hydro, biomass etc. In all of these renewable energy sources, solar energy is easily available and rich in the environment. Electricity based on renewable sources is the future of energy sector [1]. K. Chopra et al. [2] this work had been carried out experimentally to investigate the thermal performance of PCM integrated with evacuated tube solar collector system. This work was conducted in two cases such as (1) with PCM & (2) without PCM with constant surrounding condition. SA-67 is used as a phase change material. In this experimental work it had also been shown that SA-67 PCM exhibit better thermal and chemical stability as it incurred very less decrement in melting point and heat storing capacity. Mohamed A. Essa et al. [3], this work was an experimental investigation. In this study, it had been showed by researchers that phase change process affected the performance of Evacuated Tube Collector (ETC). Two finned U-tube direct flow collector were used and this experiment propounded that low flow rate is more effective as compare to high flow rates. Paraffin wax was used as phase change material in this experiment. A.E. Kabeel et al. [4], had presented their work an aim of performance improvement of evacuated U tube solar collector. This solar water collector was integrated with integrated advance energy storage material and cylindrical shaped parabolic concentrators which improved concentration of incident solar radiation. Energy storage material blended with nanoparticles of graphite in different mass concentration to evaluate the effect on thermal performance of modified tube. The rate of feed water also varied along with mass concentration and compared with the situation when no storage material was used with U tube. Performance improvement varied between 63.5% and 71.1%.

2. EXPERIMENTAL SETUP

This project work is carried out for performance assessment of wax as a phase change material with activated carbon particle of different mass concentration

along with fixed mass concentration of Titanium oxide as blending material.

2.1 Methodology

This experiment has been performed to check the improvement in performance efficiency of wax blend with carbon particles of micro size. Advance phase change material is prepared by mixing wax with active carbon particle having mass concentration of 20%, 26% and 34%. These three mass concentrations termed as sample 1, sample 2 and sample 3 respectively. TiO2 has also been mixed in every sample with a fixed mass concentration of 1%. Each sample is heated partially to ensure proper mixing of its constituents. Charging of all the samples prepared is done with steam coming out from ETSC for 120 minutes. Each sample is kept in PCM box which consists of 6 pipes to hold blended PCM. Each pipe covered with fine net of aluminum contains holes to pass steam through it. Discharging of every sample has been done by connecting a fan at the top of PCM box. Data are measured and compared with normal paraffin wax for investigation of performance improvement.

2.2 Figures

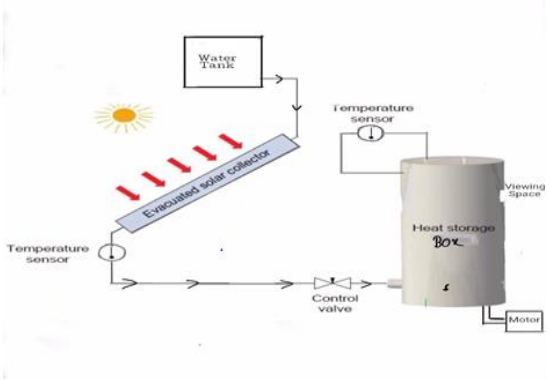

Figure 1: Schematic Diagram of Experiment setup

Figure 2: Actual Experimental setup

Figure 3: Activated carbon

Figure 4: Titanium Dioxide

3. RESULTS AND DISCUSSION

3.1 Graphs have been plotted on the basis of data observed for the sample 1

3.1.1 Figures:

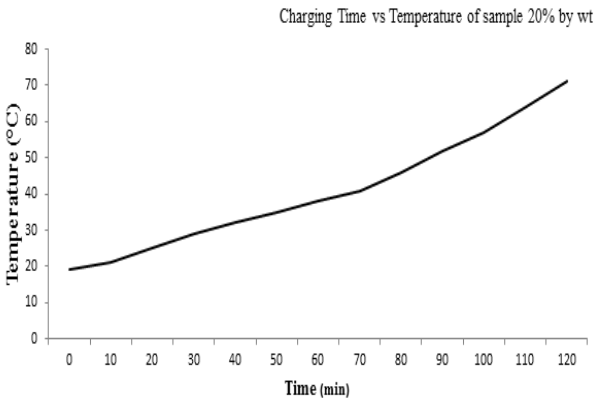

Figure 5: Charging Time vs Temperature

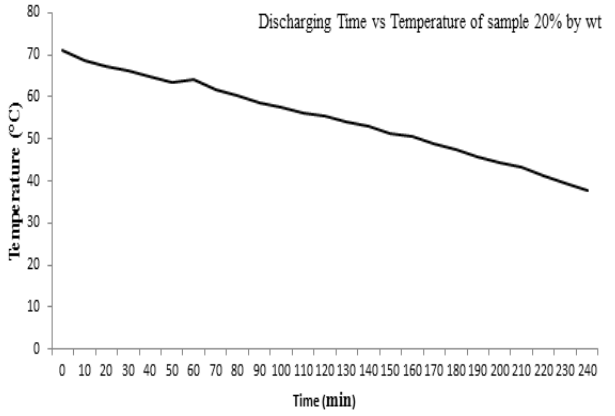

Figure 6: Discharging Time vs Temperature

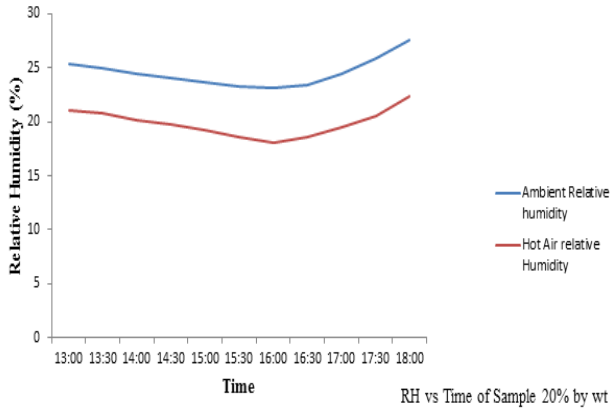

Figure 7: Relative Humidity vs Time

3.2 Graphs have been plotted on the basis of data observed for the sample 2

3.2.1 Figures:

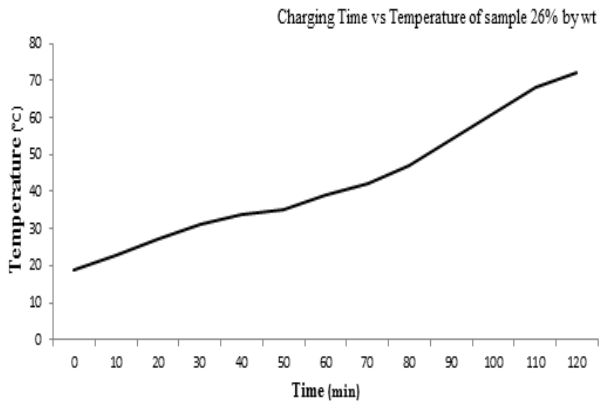

Figure 8: Charging Time vs Temperature

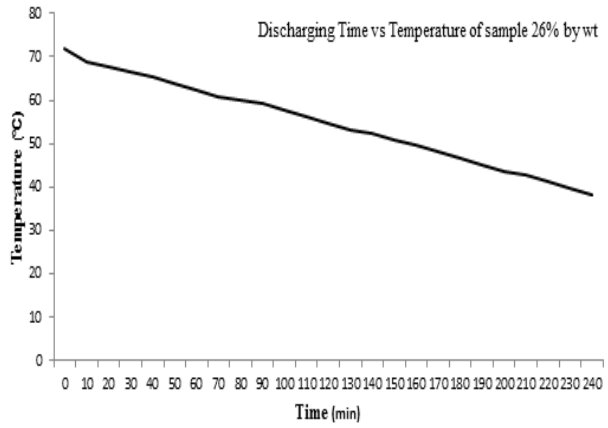

Figure 9: Discharging Time vs Temperature

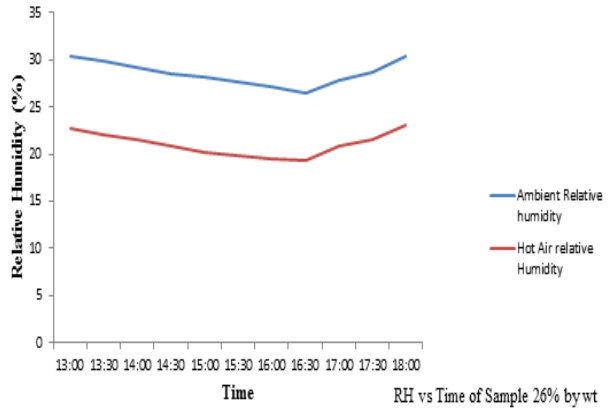

Figure 10: Relative Humidity vs Time

3.3 Graphs have been plotted on the basis of data observed for the sample 3

3.3.1 Figures:

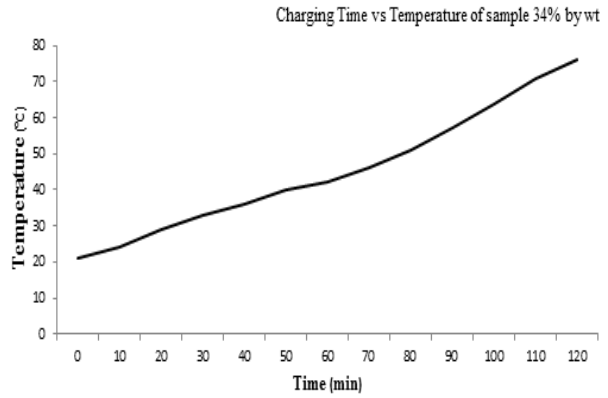

Figure 11: Charging Time vs Temperature

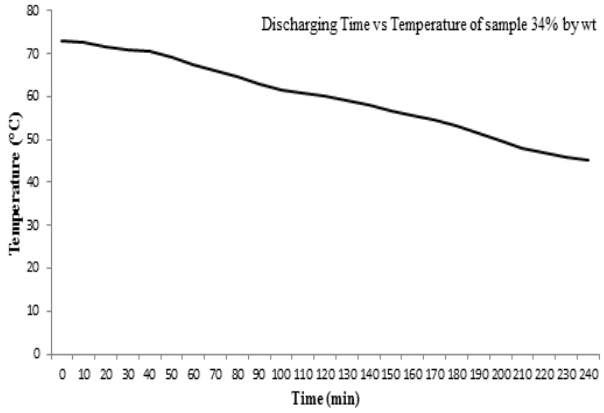

Figure 12: Discharging Time vs Temperature

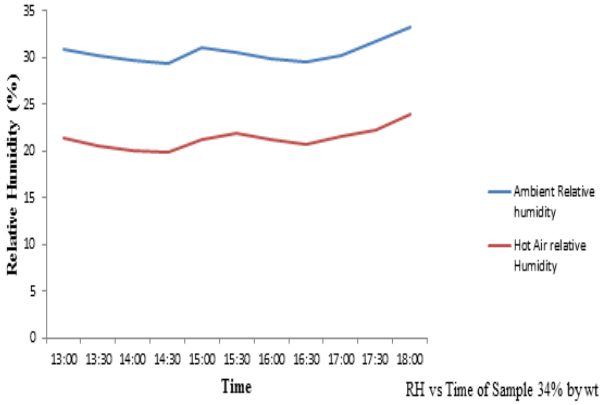

Figure 13: Relative Humidity vs Time

3.4 Discussion

Maximum temperatures achieved are 71°C, 72°C, 76°C for sample1, sample2, sample3 respectively. Discharging lasted 240 minutes for each sample. At the end of discharging of each sample, highest temperature of 45.1°C is obtained for sample3. 37.8°C temperature obtained for sample1 and 39.1°C temperature obtained for sample2. It can be concluded that sample 3 has shown superior thermal performance followed by sample2 and sample1. Decrement found in relative humidity of air coming out from PCM box during discharging process. Decrement observed for sample 1 is 19.11%, for sample 2 it is 26.57% and for sample 3 it turn out to be 30.20%. Performance of sample 3 found to be as most optimum.

4. CONCLUSION

This experiment is performed with an aim to investigate the performance of newly prepared advance PCM. Conclusive results were found as all the three tested samples have given data for comparative analysis. Sample 3 turn out to be most promising. It achieved highest temperature while charging which results more energy to be stored. Decrement in relative humidity of air caused by sample 3 is maximum which ensures prolong duration of energy delivery i.e. energy availability duration will be more.

NOMENCLATURE

ETSC: Evacuated Tube Solar Collector

PCM: Phase Change Material

TiO2: Titanium Dioxide

Sample 1: PCM blended with 20% of mass concentration of active carbon and 1% TiO_2

Sample 2: PCM blended with 26% of mass concentration of active carbon and 1% TiO_2

Sample 3: PCM blended with 34% of mass concentration of active carbon and 1% TiO_2

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