IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 5, May 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Thermal Analyses on Solar Collectors with Nano Carbon Coated Absorbers

P.H.Sudharlin Paul*[1], R.V.Jeba Rajasekhar [2]

[1]Department of Physics, St.Alphonsa College of Arts & Science, Karinkal, Kanyakumari District
[2]Department of Physics, Government Arts College, Melur

.

Abstract

Novel drying systems with enhanced thermal performances are necessitated so as to match the demand and supply of hot air. The thermal analyses on these novel drying systems are also necessitated so as to utilize these solar thermal systems in the application sectors. In the present investigation, a novel solar drying system with nano carbon coated absorbers that had been designed and fabricated was tested experimentally. It was found that the maximum temperature elevation of the working fluid was 43.5°C. It was also found that the thermal efficiency of the solar drying system was 39.3% in drying the vulcanized rubber. As the thermal analyses on the solar air heater and solar drying system showed that they had satisfactory thermal enhancements and efficiencies, it could be concluded that the solar drying systems with nano carbon coated absorbers would be effectively used in application sectors.

Introduction

A solar collector, which is the central component of any solar thermal gadget, is a device designed to absorb incident solar radiation and to transfer the energy by means of conduction to a fluid passing in contact with it. The fundamental component of the flat plate collector is absorber plate and nano-particle dispersion on the black coatings that is deposited on the absorber plate is mandatory for increasing the thermal performance of this type of solar collector. In the present investigation, a solar drying system (with nano-carbon coated absorber plate that is integrated in solar collector) that had been designed and fabricated was selected as the test sample. The objectives of the present research included measurements of dimensions of solar collector, estimation of temperature enhancements of working fluid and estimation of thermal performance of the solar collector and solar drying system. All these objectives were materialized by adopting standard methodology.

Materials and methods

Test sample

A solar drying system with a two pass solar collector that consisted of the transparent glass cover, nano carbon coated absorber plate and rock wool insulation was the test sample of the present investigation.

Design and development of solar collector and dryer

Toughened glass with transmittance of 82% was used as glass cover and the aluminium sheets (after scraping) sprayed with nano carbon coating were used as absorbers. These absorbers were backed with rock wool as insulation material so as to minimize the heat losses. Aluminium baffles were used over and below the absorbers so as to increase the length of fluid flow in the collector. The hot working fluid from the collector was collected with the help of blowers. This blower could deliver the hot fluid to the drier where the samples would be kept in stainless steel trays for dehydration.

Evaluation of thermal performance of solar collector and dryer

One of the major thermal tests on solar collectors is performance test, which is carried out to evaluate the extent of the capability of solar collectors to provide useful heat under given climatic and operation conditions. In fact, the thermal performance tests are performed to obtain values of performance as a function of solar irradiance, ambient air temperature and inlet fluid temperature.

If the thermal performance of a solar collector is defined as a ratio of the actual useful energy collected to that of the solar energy intercepted by the gross area of solar collector, then the performance of non – concentrating collector may be defined as

$$\eta = F_R (\tau\alpha)_e - F_R [Ti - Ta / G] \qquad (1)$$

The equation (1) indicates that the thermal performance of a flat plate solar collector is a linear function of (Ti - Ta)/G assuming that U_L is constant. So, graphical representation of data can be made in terms of (Ti – Ta/G) versus η and the overall performance can be found by noting the value of y intercept. The equation (1) can be written in terms of an instantaneous performance as

$$\eta_i = Q / A_g G = F_R (\tau\alpha)_e - F_R (T_i - T_a)/ G \qquad (2)$$

$$\eta = m C_p (T_0 - T_i)/A_g G \qquad (3)$$

Where m is mass flow rate, C_p is specific heat capacity, T_0 is outlet air temperature, T_i is inlet air temperature, A_g is area of collector and G is incident solar radiation. While the instantaneous thermal performance of the solar collector can be calculated by using the equation 3, the thermal performance of the solar drying system can be calculated by using the major factors such as inlet temperature of air, outlet temperature of air, moisture content evaporated in specific time, latent heat of vaporization and mass flow rate of air and other related parameters.

Results and Discussion

All the measurements on components, tests on components and tests on collector were carried out mainly for finding out the durability, integrity and thermal characteristics of solar collector and solar drying system of current concern. All the measurements pertaining to the thermal performances were taken and the thermal performances of the collectors were calculated.

Table 1 Temperature elevation of working fluid

Sl. No.	Time	Solar radiation (watt/m^2)	Inlet temperature (°C)	Outlet temperature (°C)	Temperature elevation (°C)
1	09:00 a.m.	540.2	31.6	38.7	07.1
2	10:00	650.3	35.5	53.1	17.6
3	11:00	777.0	37.3	70.7	32.8
4	12:00	890.5	39.1	82.6	43.5
5	13:00 p.m.	913.8	39.5	78.1	38.6
6	14:00	799.9	38.1	75.6	37.5
7	15:00	576.2	36.2	56.4	20.2
8	16.00	505.0	34.1	47.8	13.7
9	17:00	460.4	29.0	39.8	10.8
Drying duration of vulcanized rubber					8 hours
Thermal performance of drying system					39.3%

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 5, May 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

SEM IMAGES OF CARBON PARTICLE

Figure.1

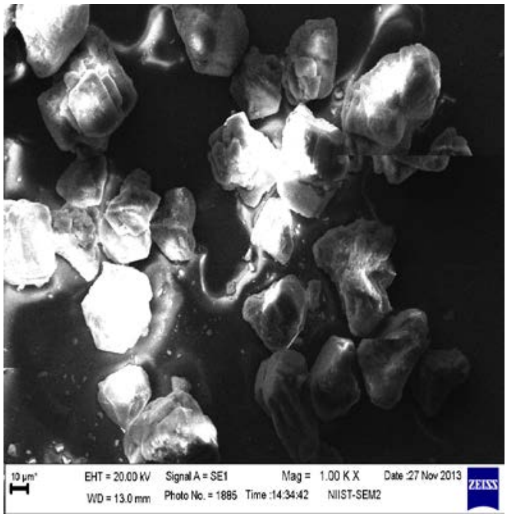
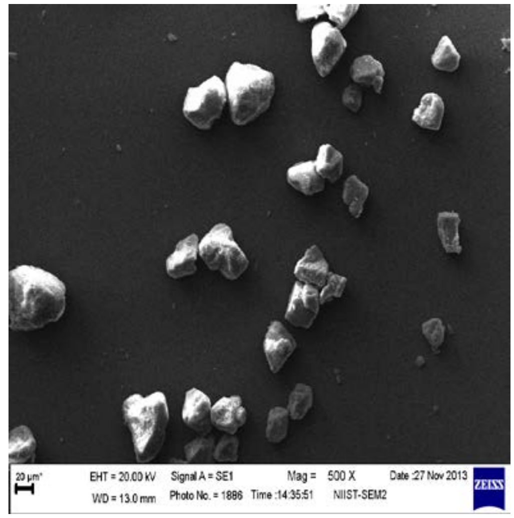


Figure.2.



TEM IMAGES OF CARBON PARTICLE

Figure.3

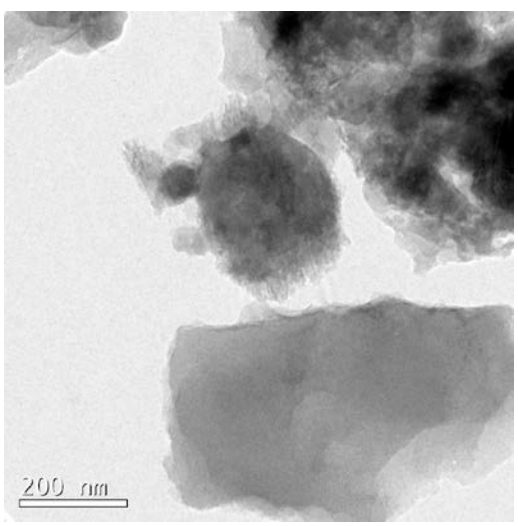
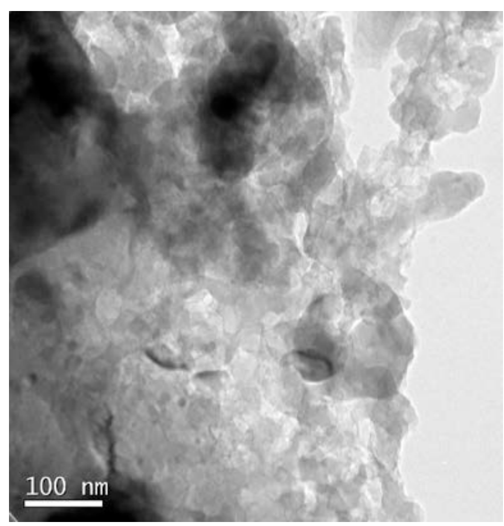


Figure.4



In the present investigation, by using the solar collector, the hot working fluid was generated. The temperature elevation of the working fluid was found to vary from 7.1 to 43.5 °C.

The generated hot working fluid was passed through the drying chamber. The vulcanized rubber sheets that were kept in the drying chamber were dried by using the hot working fluid. It was found that the drying duration of vulcanized rubber was eight hours. It was also found that the drying efficiency of the drying system was 39.3%.

While comparing with conventional drying system, it was found that the nano carbon coated absorber integrated solar heating system had relatively higher thermal performance. So, on the whole, the enhanced thermal performance of the present novel solar drying system could be correlated with the enhanced levels of incident solar radiation, usage of absorber plates with nano-carbon coating and usage of novel drying chamber.

Conclusion

As the thermal analyses on the solar air heater and solar drying system showed that they had satisfactory thermal enhancements and efficiencies, it could be concluded that the solar drying systems with nano carbon coated absorbers would be effectively used in application sectors.

References

1) Duffie, J.A., Beckman, W.A., 1980, Solar thermal engineering processes, A Wiley Interscience publication, New York, U.S.A.
2) Furbo, S., Jivan shah, L.,2003, Thermal advantages for solar heating systems with a glass cover with anti reflection surfaces, Solar Energy 2003 : 74:513-523.
3) IS 12933 (Part 1, 2 & 5: 1992 together with amendment No.1 of amendment 2000), Bureau of Indian Standards, India.
4) IS 12933 (Part 1, 2, 3 & 5: 2003 together with amendment No.1 of June 2005), Bureau of Indian Standards, India.
5) Kalogirou, S.A., 2004, Solar Thermal Collectors and Applications, *Progress in Energy and Combustion Science*. New York : Elsevier Science Publishing Company, 30 : 231 - 295.
6) Jeba Rajasekhar, R.V., 1996, Comparison of thermal performance of two types of solar air heaters in a fruit dehydration unit. M.Phil., Dissertation. School of Energy Sciences. Madurai Kamaraj University. Madurai. India.
7) Mohanraj,M., Chandrasekar, P., 2009, Performance of a solar drier with and without heat storage material for copra drying, International Journal of Energy Issues, 32 (2) : 112-121.