ISSN:2348-2079

Volume-5 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

A Critical Review on Solar Drying Methods

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Abstract - The process of drying is an important process in agricultural products. By applying this method, we can increase the self-life of the products by removing the moisture content from it. By using conventional drying methods, the products may be contaminated due to direct or open drying. In order to overcome this defect, the drying is done in closed medium by using solar dryer. In this paper, we shall see several methods of solar drying based on the specific application. Also some idea can be extracted for future study.

Keywords: dryer, solar energy, humidity air, temperature, greenhouse dryer, thermal energy storage.

I. INTRODUCTION

In current scenario, the world is moving towards the environmental friendly devices. One among them is the use of solar energy for drying application in closed medium. The advantages of using solar dryer are energy efficient, less area, less time consuming. The usage of fuel and power is reduced in this method. The main purpose of this device is to dry products especially the food products. In order to preserve foods for longer life, most of the industries use the method of drying. Thus, the foods, vegetables and fruits are dried by using solar dryer. In recent times, the fuel prices are increasing frequently and also depleting. Solar energy can be used as an alternate source as the fuel. Countries like India, solar energy assisted drying system works well due to its location in subtropical region.This paper contains the experimental results for several papers on solar drying methods.

II. LITERATURE SURVEY

In this heading, we going to see the literature survey on the types of dryer, PCM usage and its application, types of collectors, types of PCM used. Also the future scopes of the papers are studied. The following papers are:

Yefri Chan et al [1] designed a recirculation type ICDC [integrated solar collector for drying chamber]. An alternative method has been suggested in order to come up the disadvantage in the conventional process. It also uses pneumatic conveying system where the granular materials are transported to drying system. This type of solar dryer is capable of reducing the initial moisture content from 28.4% wb to final moisture content of 14.3% wb within 5 hrs.

Amina Benhamou et al [2] conducted study to determine thedrying curve and the change rate of drying by solar energy on two plant materials, olive pomance, and colocynth, depending on solar radiation. On investigation of drying curves for the above application, it is found that the solar radiation increases from the morning till at the time around 14:00hrs, then decreases slowly due to passing clouds.

Wisut Chramsa-arda et al [3] done their research work in the desiccant bed solar dryer by evaluating their performance. Desiccant bed is used to reduce the humidity of drying air by using silica gel beds (SGB).The parameters that effects to adsorption rate are air, temperature and humidity ratio of humid air. As the conclusion, the adsorption rate of silica gel is directly proportional with humidity ratio and inversely proportional with the air temperature. By using silica gel beds in condition of 0.08%kg/s mass flow rate and 60^{o}C as the drying temperature, the chili can be dried within 19 hours.

Elsamila Aritesty and Dyah Wulandani [4] evaluated the performance of the Rack type-

greenhouse effect solar dryer for wild ginger drying. At temperature standard deviation of 2.32^{o}C, the uniform distribution is achieved. Degradation of dried wild ginger quality was indicated by pale color, hardness and shrinkage occurred as the consequence of drying.

David Gudiño-Ayalaet al [5] invented the pineapple drying process using a new solar hybrid dryer. In hybrid mode, the pineapple can be dried 2hrs earlier than the solar mode which is 31.2% longer but the efficiency in solar mode is 23.4% where as in hybrid mode is 13.4%.

Romero. V.M. et al [6] performed the simulation and validation of vanilla drying process in the indirect solar drying prototype using CFD fluent program. On comparing the results of simulated value and experimented value, there is a good similarity at solar collector but there is a difference at inside the cabinet. The weight of vanilla is reduced up to 62% as the result of drying.

A.K.Srivastava et al [7] evaluated the solar dryer/air heater performance. They also investigated the use of the lauric acid as the phase changing material to store the excess solar energy and release it when energy availability is inadequate for the drying process. As the result, it is clear that the efficiency of collector and dryer varies with the intensity. The future scope of this paper is the usage of 'phase change material' as the latent heat storage can be considered and evaluated.

Adolfo G. Finck-Pastrana [8] published the paper on cactus drying process using indirect solar drying method. The indirect solar drying is the best fit for cactus to protect it from contaminates from air. Fermentation and washing process is to be done for the correct drying of cactus. The drying rate decreases from the beginning. The average speed of drying cactus is 0.132g/cm^{2}hr.

J. Kaewkiewet al [9] carried out the Experimental investigation of the performance of a large-scale greenhouse type solar dryer for drying chili in Thailand. This method of drying results with greater efficiency than the normal solar dryers and also the color of the dried products are also good. The payback period is about 2 years.

Borah et al [10] carried out the drying process of sliced turmeric rhizomes in a solar conduction dryer. The temperature was found to be varied within 39^{o}C-51^{o}C. The efficiency is 55.6% for sliced turmeric and 55.36% for whole turmeric. The moisture content could be reduced from 78.65% wb to 5.5% wb.

Prashant Singh Chauhan and Anil Kumar [11] investigated the Performance analysis of greenhouse dryer by using insulated North-wall under natural convection mode. The conclusion of the experiment on NWIGHD (North wall insulated greenhouse dryer) has been done in two different cases where case I is solar collector is placed inside the dryer and case II is NWIGHD without solar collector. As the result NWIGHD using solar collector is found to be most effective in drying when compared to available greenhouse dryer. The heat utilization factor 0.616 for case I is obtained on 2nd day, whereas in case II 0.769 is obtained on 3rd day of the experiment.

Om Prakash Anil Kumar and Vinod Laguri [12] carried out the Performance of modified greenhouse dryer with thermal energy storage. The main purpose of this attempt is to calculate the annual performance of environomical analysis, energy analysis and exergy analysis of modified greenhouse dryer. This experimental study is carried out in three different floor conditions namely Barren Concrete floor, Ground Concrete floor covered with black PVC sheet and concrete floor coloured by heat resistant black paint. It is found that for higher moisture content in the crop, the modified greenhouse dryer under active mode is better in drying than in passive mode.

D.J. Malan et al [13] conducted experiment on solar dryers with phase change material and also with heat pipes and fins in order to increase the heat transfer. Here the PCM material used is paraffin.

III. CONCLUSION

On studying the above literature papers, the following conclusions are made:

1. The silica gel beds can be used in in dryer for reducing the moisture content in the product.
2. Greenhouse dryer, helps in eradicating the characters like pale color, hardness and shrinkage of the dried products.
3. On comparing the solar mode and hybrid mode, solar mode gives twice the efficiency of hybrid mode.

4. Average drying speed for cactus is 0.132g/cm^{2}hr.
5. By using the conduction dryer, we can reduce the moisture content from 78.65%wb to 5.5%wb.
6. PVC flooring is used to improve the drying efficiency.
7. Fins can be used to increase the heat transfer between drying chamber and PCM storage, up to 5% efficiency is increased.

IV. FUTURE SCOPES

On reading the above papers, the research can be carried out on the following areas:

1. Lauric acid can be used as Phase Change Material.
2. The effect of drying rate can be increased by reducing the relative humidity.

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