STUDY AND PERFORMANCE ANALYSIS OF SOLAR DRYER FOR FOOD PRODUCTS

A. Abdul kani[1], A.Fakrudeen[2], S. Magesh kumar[3], B. Vineeth[4]

[1,2,3,4]**UG Scholar, Mechanical Department, Dhanalakshmi Srinivasan College of Engineering, Perambalur.**

ABSTRACT: Solar energy is a renewable energy, which is available in abundant, its uses in recent years reached as a remarkable edge. Spoiled food is a common problem that affects a wide variety of people. The simplest form of preventing spoilage is to remove moisture from vegetables and fruits to extend their storage lives. The quality of the products can be spoiled when exposed in direct sun light. The drying rate is very slow in direct type solar dryers. These disadvantages are overcome by indirect type solar dryers Also can be drying during the period of low sunshine. Bitter gourd is chosen as the dried product because of its sudden deterioration property. Their performance can be studied through parameters such as air velocity, temperature, collector efficiency and weight loss. The effect of temperature to moisture contents with respect to time and rate of drying are studied. Drying result obtained was compared with the result of the naturally direct sun-dried product.

Keywords: Solar Dryer, Bitter Gourd Drying, Drying Efficiency, Drying Rate.

I. INTRODUCTION

Drying is one of the methods using solar energy where the products are directly exposed to the sun. Drying means preservation of food, fruits and vegetables for long time with good quality. It is a process of moisture removal due to simultaneous heat and mass transfer. Agricultural products, especially fruits and vegetables require hot air in the temperature range of 45–60˚C for safe drying It is a simple process of removing the moisture contents from a natural or industrial product in order to reach the standard specification. However, direct method has many disadvantages such as spoilt products due to rain, wind, dust, insect infestation and fungi. Because of that, the solar dryer technology will become an alternative method which can process the products in clean, safe, hygienic and produce better quality and more nutritious foods. Drying under hostile climate conditions usually leads to severe losses in the quantity and quality of the product[10]. In general, this solar dryer has saved energy, labor intensive, time, less area for spreading the product to dry, makes the process more efficient and protects the environment. This method is economical on a large scale drying because of cheaper operating costs compared to the drying machine.

In developing countries, majority of population is engaged in farming activities. Faced with the challenges of inadequate supply of electricity, on one hand, and the need to make farm produce competitive in the international market, on the other hand, the closest solution option is the use of solar dryer[12]. Almost 80% of the total food products are cultivated by small farmers. These farmers use conventional means of drying (open sun drying) for their produce. Open sun drying is still the most common and the oldest method to preserve agricultural produce. But, this type of drying has many drawbacks like contamination problems, uneven type of drying, and uncontrolled moisture content in end products, causing degradation in the quality of the products. Solar dryers have thus been developed to overcome these problems of open sun drying. Indirect type solar dryers are classified into natural convection (passive) type and forced convection (active) type depending upon the method used to pass the air over the products. In natural convection indirect type solar dryers, the products are stored in the cabin or hot box units. Solar collector is used to absorb the incident solar radiation and heat the air which passes over the stored products. As the air is heated, its density gets reduced and it flows into the drying section naturally. Since, in this case, the flow of air is by density difference only, these are called natural convection solar dryers. In forced convection solar dryers, the heated air is forced into the drying cabinet by means of an external device (e.g. blower, fan, etc.).When any agricultural product is drying under controlled condition at specific humidity as well as temperature it gives rapid superior quality of dry product. Drying involves the application of heat to vaporize moisture and some means of removing water vapor after its separation from the food products. The most important advantage of the solar dryers is that they work on renewable energy and are pollution free. Also, solar dryers can be easily constructed from local materials. It is successfully proved how solar dryer technology is key element to climatic and environmental protection as well as sustainable development.

a) PROJECT OBJECTIVES

There are two main objectives to achieve in this research which are:
i. To study a characteristics and performance of the solar dryer system.
ii. To develop a solar dryer system for food drying.

II. MATERIALS AND METHODS

a) DESCRIPTION OF SOLAR DRYER:

The solar dryer was designed and constructed to dry the food products in them. Solar dryer uses solar energy to dry food substances. The efficiency of food products can be improved by drying in the solar dryer. The moisture removal rate is faster compared to direct sun drying. Oil is used as a working fluid which circulates throughout the system. The experimental setup of solar dryer consists of several parts such as solar panel, flat plate collector, riser tubes, drying chamber.

b) AIR HEATER:

The air heater is mainly used in order to increase the heat content before sending to the chamber. The air heater is placed near the flat plate collector so the solar collector gathers heat from them. Air is circulated through collector while the fan moves the air through ducts. The atmospheric air is heated at some range and send into the collector. Air velocity will be varied from 1.5 to 3 m/s. It is used as an additional heat supplier. The basic components are solar panel, air blowers, insulated hot air ducts. The solar air heater performance mainly depends upon the heat transfer rate from the absorber plate to the air[11]

c) DRYING CHAMBER:

The drying chamber consists of five trays each is of same weight and size. It receives the hot air from the flat plate collector. The air heater is used in order to increase the efficiency of solar drying unit. The tray was made up of an aluminum material. The hot air is passed from the solar panel and transfers to the flat plate collector. From this the heated air is again heated by air heater. Therefore this drying chamber receives this hot air and is circulated inside the chamber. The drying air is passed across the food products. In order to follow a uniform circulation through the dryer a fan was used to suck the atmospheric air to the collector. The air from the solar collector enters the chamber and flows over the drying tray before exhausting to the outlet. The heat energy absorbed by the air heater is circulated in the drying chamber from the bottom. The drying chamber consists of a chimney for passage of exhaust gas. The air passage of the solar air heater increases the air fill factor. The hot is passed through the ducts to enter the drying chamber. The drying air was heated multiple times before sending into the drying chamber.

III. EXPERIMENTAL PROCEDURE

The material used is Bitter gourd. It was purchased freshly without any damages. The whole apparatus will be running empty in order to stabilize it. This continues for 1 hour to maintain constant air temperature and air velocity, after that the experiment is started by loading the materials. The bitter gourd was placed in the trays inside the drying chamber with a weight of 9kg. To compare the performance of the dryer with sun drying some samples (9kg) of bitter gourd were placed in open sun. Drying was started at 9:00 and discontinued at 16:30. This was continued till the moisture content was removed. The convection mode of heat transfer is followed and the weight losses of bitter gourd were measured every three hours. The following fig1 shows the block diagram for our experimental setup.

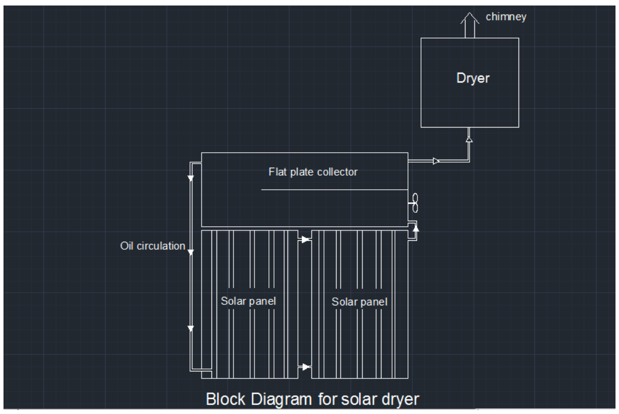

Fig1: Block Diagram Of Solar Dryer

The position of the collector is tilted to an angle of 25° with respect to the horizontal direction in order to maximize the solar radiation.

The weight loss of both samples is measured respectively. Also the air velocity is measured using anemometer (m/s) and solar radiation is measured using solar intensifier (W/m^2). The inlet air and outlet air temperature, collector temperature is noted down using thermocouples at an interval of one hour.

The therminol oil is used as a working fluid which is passed through the riser tubes and also through collectors. In addition to increase the heat fan is used as a blower.

Then the heat travels from collector to the drying chamber through ducts. The remaining air is passed through the exhaust. After the completion of drying the dried bitter gourd samples were collected, cooled in a shade and then sealed it in the plastic bags.

IV. RESULT AND DISCUSION

a) COLLECTOR PERFORMANCE

Heat Collection Only With Fluid Flow

The inlet and outlet passage of solar air collector is closed to determine the stagnation temperature of solar air heater with zero useful heat gain. In this project we took therminol oil as working fluid.

Stagnation temperature of solar air heater and ambient temperature were recorded the solar intensifier was placed adjacent to the glazing cover of solar panel facing due east. Solar irradiation on the aperture of the solar air heater ambient temperature and stagnation temperature in the solar air heaters were recorded every one hour.

The Maximum stagnation temperature is recorded for Solar air heater as 41^0 C. The corresponding solar radiation and ambient temperature for solar air heater are 1080 W/m^2 and 32^0C respectively.

Fig2 shows the expected variation of the drying rate for the period of experimentation (i.e., hours)

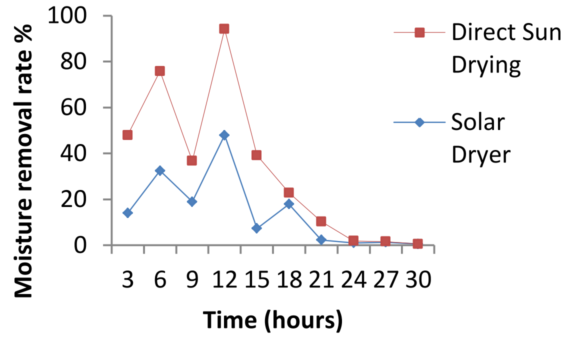

Fig2: Comparison Between Time And Moisture Removal Rate

b) DRYER PERFORMANCE

Fully loaded experiment was performed to check the capacity of the dryer. A single layer of bitter gourd with initial moisture content 82% was used in this study it was found that the capacity of dryer was 9kg of this product the system was worked as a solar dryer with additional heating unit to heat of the fluid inside the Raiser tube during the time of low sun shine and it can raising drying air temperature from 25^0C to 35^0C above the ambient air and the drying time was above 8 hour.

The expected variation of moisture content (wet basis) with drying time is illustrated in Fig3.

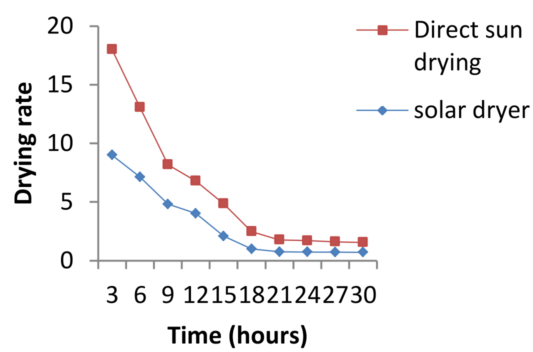

Fig3: Variation Comparison Of Drying Rate Against Drying Time

Temperature inside dryer was higher than the ambient temperature and corresponding relative humidity in the dryer was lower than the ambient relative humidity. The reason for sudden increase in drying rate in a solar dryer is due to increase in collector outlet temperature. During low sunshine hours, dryer utilizes the heat energy stored in the riser tubes which is fitted in the bottom of absorber plate. The drying system efficiency using solar dryer and direct sun light methods were calculated. Use of solar dryer with the integration of copper tubes will improves the efficiency of the dryer and reduces the dependency of conventional energy sources, which reduces indirect global warming.

c) DIRECT SUN DRYING

The direct sun drying was tested for drying of bitter gourd. The capacity of the dryer was to dry about 9 kg of drying products in 25 hour in sunny day from an initial moisture content of 82% to the final moisture content of 18%.The drying system efficiency of the dryer when using in direct sun drying was found as 31.19%..

d) SOLAR DRYER

The system was worked as a solar dryer with additional heating unit to heat up the water inside the riser tubes, during the time of low sunshine and it can rise the drying air temperature from 25 to 35 °C above the ambient air. The maximum incident of radiation for a corresponding drying chamber temperature of 66.1°C and an ambient temperature of 34.9°C, values obtained at 1.30 p.m.

For a drying time about 25 h, the moisture content of the bitter gourd using the solar dryer was 0.716kg and for the dried bitter gourd by the direct sun drying was 0.840kg. Heat removal factor of the collector keeps on increasing every day and reaches maximum of 1.36 at noon and decreases afterwards. It is observed that the collector efficiency factor is increasing with the mass flow rate is increased.

It is clear from the above results use of solar dryer with the integration of heat storage materials (riser tubes) will improves the efficiency of the drier and controls the air temperature through the drying process during bad weather condition and reduces the dependency of direct sun, which reduces indirect global warming. The color, aroma and texture of the solar dried products were better than the sun drying products.

e) SUGGESTION FOR FUTURE WORK

1. Usage of various fluids and refrigerants as working fluid can be analyzed.
2. It is to analyze the performance of the system with fins attachment of riser tubes in the solar air heater.

V. CONCLUSION

This chapter discusses about concluding remarks from the experimental and simulation studies is described as below. The following conclusions have been drawn based on the results obtained from the experimental studies in solar dryer. Solar dryer has been designed by additional heat gained by the air from the riser tubes. The experiment will be conducted in the solar dryer and direct sun, by varying the different parameters. This experiment consists of measuring the mass, moisture content and watching the drying performance of the product to be dried. A single layer of drying product with initial moisture content is expected to be 75–85% in this study. Moisture removal rate depends based on collector area and the method of drying system.

All these data will be analyzed for an improved performance in the behavior of the dryer and the methods used according to the products. The overall weight loss in solar dryer and open sun is calculated. The improvement in thermal performance of solar dryer is compared with that of direct sun drying, as direct sun drying has been taken as the base case for solar dryer. It is studied as solar dryer is more efficient than open sun drying.

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REFERENCE

1. Bala, B . K. and Woods, J . L. 1994. Simulation of the indirect natural convection solar drying of rough rice. Solar energy 53(3): 259-266
2. Bennamoun, L. and Belhamri, A. 2003. Design and simulation of a solar dryer for agricultural products. Journal of food eng 59:259-66.
3. Ekechukwu, O.V. 1999. Review of solar energydrying systems- An overview drying principles and theory. *Energy conversion and management* 40 (6): 593-613
4. Ekechukwu, O.V. Norton, B. 1999. Review of solar energydrying systems II: an overview of solar drying technology. *Energy conversion and management* 40 (6): 615-655
5. Esper, A. and muhlbauer, W. 1998. Solar dring an effective means of food preservation. *Renew Energy* 15: 95-100
6. Fudholi, A., Sopioan, K., Rulslan, M.H., Alghoul, M.A. and sulaiman, M.Y. 2010. Review of solar dryers for agricultural and marine products
7. Ong, K.S. 1999. Solar dryers in asia-pacific region. *Renewable Energy 16: 779-784*
8. *Sharma, V.K., Colangelo, A. and Spagna, G. 1994*. Experimental investigation of different solar dryers suitable for fruits and vegetable drying. Department Enerzia, Divisione Ingegneria sperimentale, Italy. *Drying 94: 879-886*
9. R. vengatesh., w.christraj., Design and performance evaluation of multi functional passive solar dryer for paddy
10. Shrenik G. Yelttiwar, Pooja N.Wajire, & Dr. S. R. Kalbande, Investigation on domestic solar cabinet dryer assisted with reflectors, Volume No: 1(2014).
11. Harish Kumar Patel; Saurabh Singh; Alfa Tigga ; Krishna Kumar Darpan, Thermal Performance of Solar Air Heater by with artificial roughness-A Review.
12. A. O. Adelaja and B. I. Babatope, Analysis and Testing of a Natural Convection Solar Dryer for the Tropics.