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Design and Fabrication of Solar dryer with Spiral Water Heater

[1]Manimaran M, [2]Swaminathan M, [3]Anburaj P, [4]Muthukumar R, [5]Ilayasuriyan R

[1]Student, University VOC College of Engineering, Thoothukudi-628008, Tamilnadu, India
[2]Student, University VOC College of Engineering, Thoothukudi-628008, Tamilnadu, India
[3]Teaching Fellow, University VOC College of Engineering, Thoothukudi-628008, Tamilnadu, India
[4]Student, University VOC College of Engineering, Thoothukudi-628008, Tamilnadu, India
[5]Student, University VOC College of Engineering, Thoothukudi-628008, Tamilnadu, India

***Abstract*--- The solar drying system utilizes solar energy to heat up air and to dry any food substance loaded, which is beneficial in reducing wastage of agricultural product and helps in preservation of agricultural product. This project presents the design, construction and performance of a mixed-mode solar dryer for food preservation. In the dryer, the solar from the sunlight which is incident on the glass plate on the wooden box. Thus the radiation will increased the temperature inside the dryer. Due to this food materials will be dried and the remaining excess of heat will be used to heat the water which will flow through the spiral copper tube inside the dryer. The result obtained during the test period shows that the temperature inside the dryer will be higher than the ambient temperature during most of the day-light hours. The dryer exhibit sufficient ability to dry food items reasonably rapid to a safe moisture level and it ensures a better quality of the dried product.**

Keywords: **Dryer, Water heater, Copper coil, Multimeter**

I. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several years. Drying is the oldest preservation techniques of agricultural products and it is an energy intensive process. High prices and shortages of fossil fuels have increased the emphasis on using alternative renewable energy resources. Drying of agricultural products using renewable energy such as solar energy is environment friendly and has less environmental impact. Different types of solar dryers have been designed, developed and tested in the different regions of the tropics and subtropics. The major two categories of the dryers are natural convection solar dryers and forced convection solar dryers. In natural convection solar dryer the air flow is established by buoyancy includes air flow while in the forced convection solar dryers the air flow is provided by using fan operated either by electricity/solar module or fossil fuels. Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in agricultural application. It is preferred to other alternative sources of energy such as wind and shale, because it is abundant, inexhaustible, and non-polluting. Solar air heaters are simple devices to heat air by utilizing solar energy and it is employed in many applications requiring low to moderate temperature below 80ºC, such as crop drying and space heating. Solar water heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations are available at varying cost to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial applications.

Objectives:

- To obtain a better quality of products.
- To reduces losses and better price to the product.
- To prevent fuel dependence and reduces the environmental impact.
- To reuse the hot exhaust air to heat water by using spiral water heater.
- To reduce moisture in the food materials which has been dried in the dryer,
- To study a characteristics and performance of the solar dryer system.
- To develop a solar dryer system for food drying

Literature Review:

Dryers have been developed and used to dry agricultural products in order to improve shelf life. Most projects of these natures have not been adopted by the small farmers, either because the final design and data collection procedures are frequently inappropriate or the cost has remained inaccessible and the subsequent transfer of technology from researcher to the end user has been anything but effective [8]. Drying may be an interesting method in order to prevent fresh fruit deterioration. There is spoilage of fruits and other fresh foods that could be preserved using drying techniques in India and other developing countries. Seasonal fruits like mangoes are not presently dried for export, or for local consumption during period of scarcity.

Open sun drying (OSD) is the most common method of crop drying in developing countries. Despite several disadvantages, it is widely practiced because it is a simple way of drying. Crop temperature, temperature around the crop, solar air temperature, and rate of moisture evaporation are the important parameters in OSD. The thermal behavior of OSD of green chilies, green pea, white gram (kabuli Chana), onions, potatoes, and cauliflower was studied. The heat transfer analysis which is mainly dependent on the rate of moisture transfer has also been extended during drying process [7]. A mathematical model has been developed to predict the crop temperature, rate of moisture removal, and solar air temperature for a steady state condition. The rate of moisture transfer for potato slices and cauliflower was significantly higher than that in other crops.

Solar drying is an integral part of rural life for various products, especially vegetable, fruits & spices which are produced in rural areas and have no scientific means of preserving such raw products. This paper is an attempt to review the solar drying process & solar dryers used for chili drying worldwide which includes types of solar dryer, drying process & techno economic feasibility of drying process [2]. Open sun drying is very much common between farmers compared to solar drying by solar dryer due to various reasons especially economic viability. Research is going on for improvement in process, types of dryer used for improving efficiency and cost of drying.

The solar drying system utilizes solar energy to heat up air and to dry any food substance. The most of the researches have found for solar drying process i.e. on the flat plate, direct solar dryer system, Solar cabinet dryer, Glass roof solar dryer, Indirect natural convection solar dryer with chimney [1]. This paper presents the design and construction of a solar food dryer. This system runs by force convection, free convection method for drying multiple fruits. The time, intensity, temperature and the moisture contain in the fruits were

calculated for grapes. In this type of solar air heater glass tube and flat glass plate was used for absorption of reflected solar radiation.

Heating water for domestic purpose is a simple and effective way of utilizing solar energy. Initial cost of solar water heating system is high. But we get zero green energy cost [6]. This paper discuss improving the performance of a flat plate solar energy collector by changing the design parameters of the number of riser tubes and the arrangement of riser tubes in zig-zag pattern from the existing flat plat collector system. Experiments were conducted using copper tube in header and riser with different dimensions.

A solar water heating system for domestic use has been designed and constructed using locally available materials. Solar energy is received by a flat-plate collector consisting of a thin absorber plate, integrated with underneath grids of fluid carrying tubes, and placed in an insulated casing with a transparent glass cover having a cold and a hot water tank integrated in the system [5]. The radiation emitted by the absorber plate cannot escape through the glass, thus increasing its temperature. The water gets heated and flows into a storage tank through thermosyphon principle. This solar water heating system finds useful application and acts as a renewable energy resource in regions where there is abundant and consistent sunlight.

An indirect forced convection solar drier integrated with different sensible heat storage maternal has been developed and tested its performance for drying chili under the metrological conditions of Pollachi, India [4]. The system consists of a flat plate solar air heater with heat storage unit, a drying chamber and a centrifugal blower. Drying experiments have been performed at an air flow rate of 0.25 kg/s.

The sun which is source of all energy the solar energy which is available from sun can be used for many application water heating, air heating and power generation like solar water heater are the system those collect solar energy and transfer the heat to passing water [3]. The present work includes to carry out comparative study for thermal performance of the straight tube solar water heater with the proposed spiral tube solar heater.

II. SPECIFICATION OF PROBLEM

Food scientists have found that by reducing the moisture content of food to between 10 and 20%, bacteria, yeast, mold and enzymes are prevented from spoiling it. The flavour and most of the nutritional value is preserved and concentrated. Wherever possible, it is traditional to harvest most grain crops during a dry period or season and simple drying methods such as sun drying are adequate. However, maturity of the crop does not always coincide with a suitably dry period. Furthermore, the introduction of high-yielding varieties, irrigation, and improved farming practices have led to the need for alternative drying practices to cope with the increased production and grain harvested during the wet season as a result of multi-cropping.

Drying and preservation of agricultural products have been one of the oldest uses of solar energy. The traditional method, still widely used throughout the world, is open sun drying where diverse crops, such as fruits, vegetables, cereals, grains, tobacco, etc. are spread on the ground and turned regularly until sufficiently dried so that they can be stored safely. However, there exist many problems associated with open sun drying. It has been seen that open sun drying has the following disadvantages. It requires both large amount of space and

long drying time. The crop is damaged because of the hostile 19 weather conditions; contamination of crops from the foreign materials, degradation by overheating, and the crop is subject to insect infestation, the crop is susceptible to reabsorption of moisture if it is left on the ground during periods of no sun, and there is no control on the drying process. This could lead to slow drying rate, contamination and poor quality of dried products, and loss in production. Although the spreading of the crop on the ground or on a platform and drying it.

III. PROCESS INVOLVED

The principles of the solar dryer is mainly depends upon the method of solar energy collection and its conversion to useful thermal energy for drying. Conservation of energy in which one form of energy is converted into another form of energy Black body which absorbs the heat of the incident sunlight and makes the temperature of the chamber more than the surrounding temperature.

Working:

Our project "solar dryer with spiral water heater" is based on the fact that when the sunlight falls on the glass plate which is placed on the top of the wooden box. Normally the inside temperature is higher than the atmospheric temperature due to the radiation will flow from the glass plate. Thus the radiation will fall on the food materials which is placed on the trays. Then the food material will be dried and reduces the moisture due to the heat. Excess of heat will be present inside the dryer and thus the heat will be used to heat the water by using spiral copper tube. Wooden chamber absorbs the sunlight and generates the heaty and after sometime inner temperature becomes much larger than the outer temperature. Covering glass restrict the flow of heat outside. (BLACK BODY)

Fig.1 working process of the solar dryer with spiral water heater

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IV. CALCULATION

Specification of the dryer:

- Dimensions of glass plate :100x60x0.4cm
- Dimensions of copper tube : ϕ0.6x600cm
- Dimensions of wooden box : 100x60x25cm
- Dimensions of the tray : 100x58x2cm

The removal of moisture content in drying crops is calculated by

$$M_{wb} = \frac{(M_i - M_d)}{M_i} * 100$$

Where,

Mwb -Moisture on wet basis,

Mi -Initial mass of the sample

Md -Final mass of the sample

V. RESULT AND DISCUSSION

TABLE 1 RECEIVED DATA FROM DRYING CROP CHILIES (DAY 1) LATITUDE $8^0 78^0$

TIME	AMBIENT TEMP (°C)	GLASS TEMP (°C)	TRAY TEMP (°C)	BASE TEMP (°C)	WATER IN TEMP (°C)	WATER OUT TEMP(°C)
08:00AM	28	32	37	30	26	29
09:00AM	28	37	41	35	26	31
10:00AM	31	44	48	41	28	33
11:00AM	32	46	57	48	31	37
12:00PM	33	49	60	50	31	41
13:00PM	34	55	68	57	31	50
14:00PM	34	53	65	53	31	48
15:00PM	33	48	58	50	31	40
16:00PM	31	40	50	38	30	35
17:00PM	29	36	41	35	28	30
18:00PM	27	31	36	30	26	28

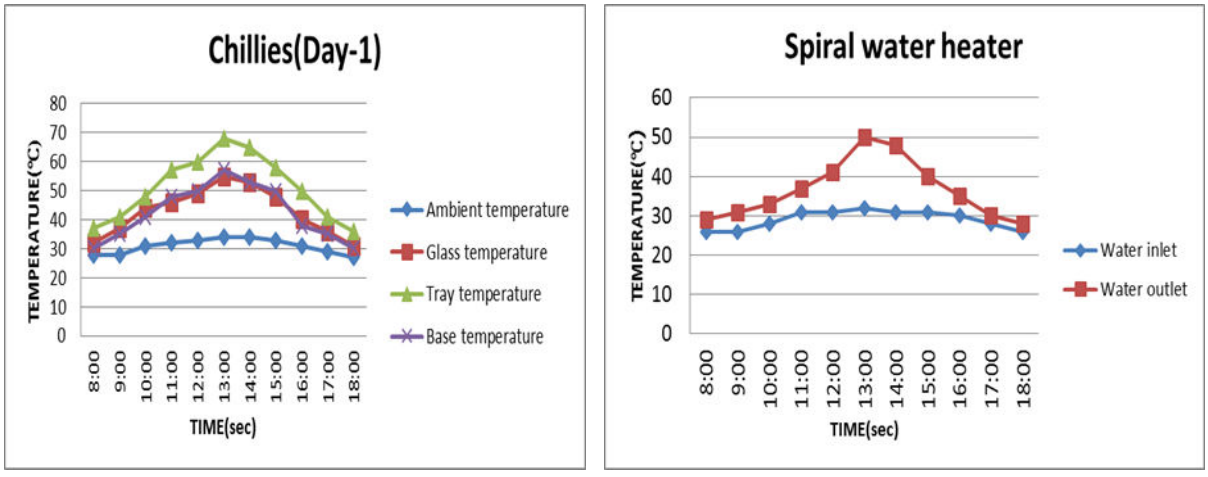

Fig 2. Temperature vs Time

Table 1.shows the variation of temperature in the glass roof, trays, and water in and out of the solar dryer is using solar radiation. We took those values from 8:00 AM to 6:00 PM. The solar dryer tray received maximum temperature 68ºC and minimum temperature 36ºC using solar radiation.

TABLE 2 RECEIVED DATA FROM DRYING CROP CHILIES (DAY 1) LATITUDE $8^0 78^0$

TIME	AMBIENT TEMP (°C)	GLASS TEMP (°C)	TRAY TEMP (°C)	BASE TEMP (°C)	WATER IN TEMP(°C)	WATER OUT TEMP(°C)
08:00AM	28	32	35	30	26	29
09:00AM	28	37	41	35	26	31
10:00AM	31	43	48	41	28	33
11:00AM	32	46	57	47	31	38
12:00PM	33	49	60	49	31	43
13:00PM	34	54	70	57	31	50
14:00PM	34	52	66	53	31	48
15:00PM	33	48	58	50	31	40
16:00PM	31	40	50	38	30	34
17:00PM	29	36	40	35	29	30
18:00PM	27	32	34	30	26	28

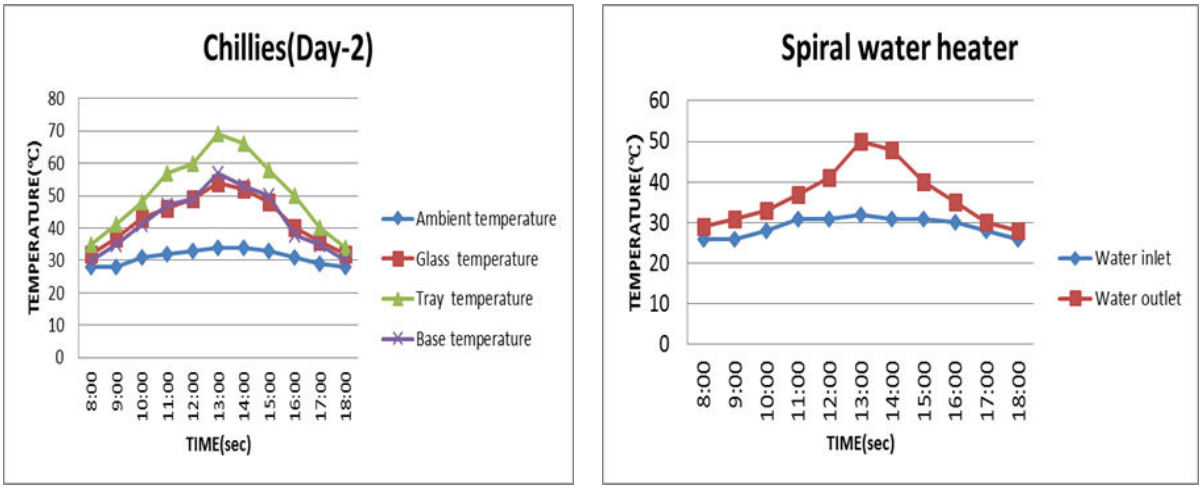

Fig 3. Temperature vs Time

Table 2.shows the variation of temperature in the glass roof, trays, and water in and out of the solar dryer is using solar radiation. We took those values from 8:00 AM to 6:00 PM. The solar dryer tray received maximum temperature 70ºC and minimum temperature 34ºC using solar radiation.

Fig 4. Open drying vs Controlled drying

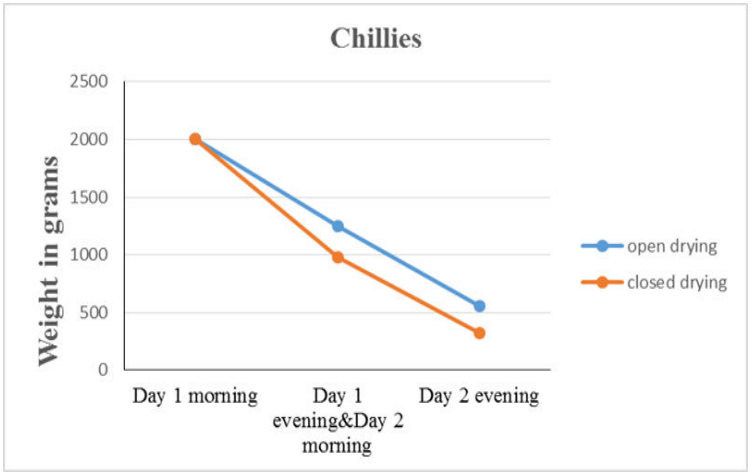

Fig 5. Open drying vs Controlled drying graph

At first day 2000 grams of chillies was placed to dry in open drying system and solar (closed) drying system. The weights of chillies were found at evening in open drying 1250 grams and in closed drying it was 980 grams. Then this item is placed drying for next day morning and by the end of the evening it was found to be that as in open drying 560 grams and closed drying as 325 grams.

VI. Conclusion

A solar dryer is designed and constructed based on preliminary investigations of drying under controlled conditions. The constructed dryer is to be used to dry vegetables under controlled and protected conditions. The designed dryer with a collector area of 100x60cm is expected to dry 2kg fresh vegetables (chillies) from 89.6% to 13% wet basis in two days under ambient conditions during harvesting period from February to March. A prototype of the dryer with 0.60m2 solar collector area was constructed to be used in experimental drying tests. Along with this the water heating system is also employed to the

dryer to recover the waste heat getting from the dryer. Hence the practical usage of dryer is greatly increased by employing the water heating system along with dryer.

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