Design, Manufacturing and Testing of a Solar Dryer

[1]Mr. Abhijeet Mohite, [2]Ms. Harshali Makade, [3]Mr. Girish Bait, [4]Mr. Gourav Patil

[1,2,3,4]UG Student, Mechanical Engineering Department, Rajendra Mane College of Engineering & Technology, Ambav (Devrukh) , Dist-Ratnagiri, Maharashtra, India.

Abstract: Variety of Fruits and vegetables are available in the market. To enhance life cycle of fruits and vegetables; drying is the most preferable method. There are different techniques like microwave vacuum drying, open sunlight drying, household ovens, etc. Drying/dehydration are a simple, low cost way to preserve food as compared with other techniques. Open sun drying is the most common method practiced by people to dry food for past several years. But this process causes problem to the quantity of food item in terms of its taste and color. Also, these items are easily contaminated by dust, fungus, insects, rodents and other animals. Different types of solar dryers have been designed, developed and tested in different region of tropics and subtropics. This paper represents the design, manufacturing and testing of a portable natural convection type of solar dryer. This solar dryer can be used for drying of vegetables and fruits. Due to its portability, the solar dryer is convenient to use at any place.

Keywords —Solar Energy, Solar Dryer, Natural Convection, Portable, Fruits, Vegetables

I. INTRODUCTION

Drying/dehydration are a simple, low cost way to preserve food as compared with other techniques. Drying removes water and thus prevents fermentation or growth of molds. It also slows the chemical changes that take place naturally in food, as when a fruit ripens. Open sun drying is the most common method practiced by people to dry food for past several years. But this process causes problem to the quantity of food item in terms of its taste, color also these items are easily contaminated by dust, fungus, insects, rodents and other animals.

To overcome these drawbacks, different types of solar dryers have been designed, developed and tested in different region of tropics and subtropics. The major two categories of dryers are natural convection solar dryers and forced convection solar dryers. In natural convection solar dryer, air flow is established by buoyancy induced airflow, while in forced convection solar dryers, air flow is provided by using fan operated either by electricity or solar module. The primary objective of the study is to develop a portable solar dryer of natural convection type in which food items can be heated by hot air through radiation collected from roof and walls of cabinets and from solar collector. In the dryer, the hot air from solar collector is allowed to pass through a food bed and at the same time, drying cabinet directly absorbs solar energy through roof and walls. The results obtained during test period revealed that temperature inside dryer and solar collector were considerably higher than the atmospheric temperature during most hours of day light.

II. LITERATURE REVIEW

There are various types of solar dryers such as active solar cabinet dryer, cabinet dryers with back-up heating, greenhouse dryer, solar drying system using the V-groove solar collector, double pass solar collector with fins, Indirect active hybrid solar–electrical dryer system, Solar drying system with chemical heat pump, Solar dryer with dehumidification system for different agricultural products for best processing and good quality food. [1]

For conservation of cocoa beans, mainly Drying process is used. Controlling its drying parameters is extremely essential. The parameters like shrinkage, density, porosity, and heat and mass transfer coefficients of cocoa beans during indirect solar drying were investigated. The results showed that shrinkage and porosity increased with decrease in reduced moisture content. The real density varied during drying process. Its density at the beginning of experiment was 825.10 kg/m3 which was reduced to 696.25 kg/m3 at the after the drying process. The final porosity of cocoa beans was approximately 25% and most of the evaporated water contents during the process of drying were replaced by gas. [2]

An updraft solar dryer of indirect natural convection type was designed and fabricated. The objectives were to; analyze air properties, suit for mid-latitude applications, determine efficiency, and evaluate the quality of dried product. For fabrication of dryer, locally available and low-cost materials were used. For the regions located in mid-latitude, the zenith angle depends on latitude, solar declination angle, time of the year and of the day. To suit these conditions, the design of solar dryer was based on these changing parameters. It was found that the apples of 886.64 grams having 86% moisture content can be dried to 8.12% moisture content during 9.5 hours with average irradiance of 534.45Watt/Sq. m. [3]

The hybrid solar dryer of collector-greenhouse type is more advantageous in the development direction of low temperature drying category. The core technology of the solar dryer is collector tube which is the key component of the dryer. [4]

A solar dryer was designed and constructed for drying fish. It was designed to use it during sunset when solar rays with small angle of incidence are spread over a large surface with less energy per unit area. The testing of this fish dryer was carried out and it was found to be effective. It was observed that the temperature of the fish within the system was increased to about 82°C. [5]

Worldwide, many researchers have been attracted to the research in Solar energy. The solar energy is abundantly available in direct as well as indirect form. Hence the researchers have focused on development of efficient and inexpensive equipment for the drying of agricultural and marine products using solar power. It has enhanced the quality of the products as well as the quality of life. [6]

Solar energy is used to heat up air and to dry any food substance loaded. It reduces the wastage of agricultural products and helps in its preservation. [7]

III. Design of Solar Dryer

Material Selection:

1. Wood – The casing of the dryer is made up of Wood as it is easily available, light in weight, and cheaper in cost as compared to other materials.

2. Glass – The upper covering of the air heater chamber is made up of glass as it easily permits the sunrays to enter inside and heat the sheet. It also resists the heat to go out.

3. Galvanized iron sheet and Aluminum sheet of 0.9 mm thickness each have been used to increase the temperature of air passing through the air chamber. Tar was used to paint the air chamber black for enhanced absorption of solar radiations.

4. Stainless steel wire mesh is used for constructing the trays for placing the product in the drying chamber.

5. Caster Wheels are used for easy movement of dryer from one place to another place.

Design Considerations:

1. Temperature - 35°C and 65°C are considered as the minimum temperature and the maximum temperature for drying food. Hence, for drying vegetables, fruits and other agricultural products, 50°C and above is considered as average temperature.

2. Air gap - It is suggested that a gap of 10 cm should be created as air vent (inlet) and air passage for hot climate passive solar dryers.

3. Glass and flat plate solar collector – According to the literature published, 4 to 5 mm thickness is essential for the glass covering. This solar dryer uses a 4 mm thick and transparent glass. Referring the literature, 0.9 mm thick sheets of aluminum and galvanized iron were used.

4. Cabinet Dimensions – It is suggested that in any solar dryer design, a constant exchange of air and a roomy drying chamber must be considered. Hence the drying chamber of the solar dryer was made as spacious as possible with average dimension of 60cm × 60cm × 35cm with air passage (air vent) out of the cabinet of (20 × 5) cm^2.

5. Dryer Trays – For the trays, Stainless steel wire mesh was used to improve air circulation within the drying chamber. Three trays were made with dimension of each tray as 24cm × 24cm.

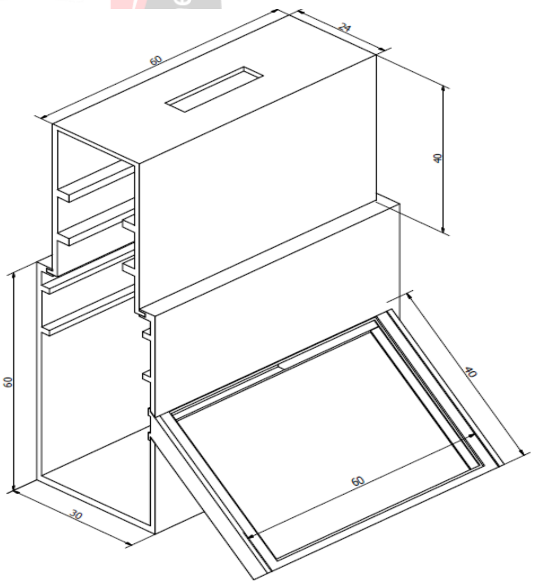
6. Efficiency – The efficiency of solar dryer is defined as the ratio of the mass of product after drying to the mass of product before drying.

7. Latitude of collector location- The latitude of Konkan region where the dryer is designed is latitude 17N. Hence the angle of Solar collector is 32°.

8. Average air speed Va = 0.200 m/s.

The constructional details of the solar dryer are as represented in the Fig. 1

Constructional Details:



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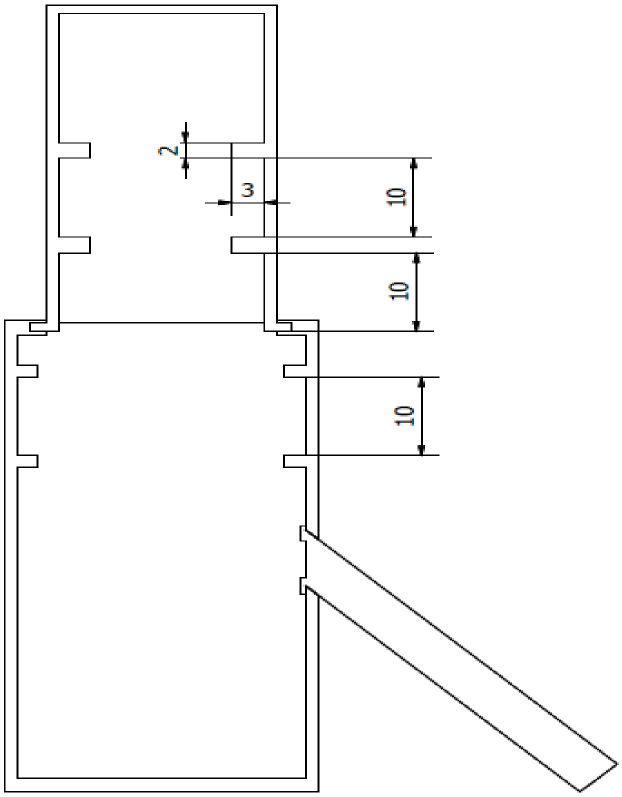

Fig. 1 Constructional details of the solar dryer (All dimensions are in cm)

IV. TESTING OF SOLAR DRYER

The solar dryer has been tested by considering Onion as the sample for drying. Two materials viz. Aluminum sheet and Galvanized Iron sheet were used for flat plate collector. The various parameters measured using a hygrometer were Wet Bulb Temperature (WBT °C), Dry Bulb Temperature (DBT °C), Enthalpy (KJ/Kg of dry Air) and Mass (Kg/Kg of dry air). The measurement was taken at inlet, outlet and at individual trays at different timings during the summer season.

Following Table 1 shows the results obtained after the testing of solar dryer.

Table 1. Testing of Solar Dryer

Parameter	Galvanized Iron Sheet	Aluminum Sheet
Initial Weight (gms) of Onions	1450	1450
Final weight (gms) of Onions	242	170
Effective Time Required for Drying (hrs.)	24	12

V. CONCLUSIONS

Following conclusions are derived from successful testing of solar dryer by using both flat plate collector materials; i.e. G.I. sheet and Aluminum sheet.

1. Final weight of onion and time required for drying process by using aluminum sheet is much lesser than G. I. sheet.

2. Telescopic arrangement of cabinets and use of caster wheels makes portability of solar dryer easy.

3. Provision of hygrometer device enables real time monitoring of temperature and other properties at specified location.

VI. FUTURE SCOPE

As we know solar dryer's moisture removal rate is more dependent on collector area, one can improve the effectiveness by increasing solar collector area.

Also, solar dryer can be made useful in night time too by using PCM (phase changing material) which stores the thermal energy in day time and by changing its phase in night time one can utilize the stored energy.

Provision of parabolic trough solar collector instead of black coated aluminum/ G.I. absorber plate to increase heating of air.

APPENDIX

The physical set up is represented in following Fig. 2 and Fig. 3

Fig. 2 Front View of the Solar Dryer

Fig. 3 Side View showing the flat plate collector

REFERENCES

[1] Anupam Tiwari, "A Review on Solar Drying of Agricultural Produce", by *Journal of Food Processing and Technology*, 2016

[2] Blaise Kamenan Koua, Paul Magloire Ekoun Koffi, Prosper Gbaha, "Evolution of shrinkage, real density, porosity, heat and mass transfer coefficients during indirect solar drying of cocoa beans", *Journal of saudi Society of Agricultural Science*, 2017

[3] Maundu Nicholas Musembi , Kosgei Sam Kiptoo, Nakajo Yuichi , "Design and Analysis of Solar Dryer for Mid-Latitude Region", *3rd International Conference on Power and Energy Systems Engineering*, CPESE 2016, 8-12 September 2016, Kitakyushu, Japan.

[4] Mingle Liu, Shuangyan Wang, Kerong Li, "Study of the Solar Energy Drying Device and Its Application in Traditional Chinese Medicine in Drying", *International Journal of Clinical Medicine*, 2015, 6, 271-280.

[5] Mujau Numbing1, Gaius Maikasuwa, "Construction of domestic solar fish dryer", *IOSR Journal of Applied Physics (IOSR-JAP)* e-ISSN: 2278-4861.

[6] UmeshToshniwal, S.R Karale, "A review paper on Solar Dryer", *International Journal of Engineering Research and Applications (IJERA)* ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 2, March -April 2013, pp.896-902

[7] Sunday Sobowale, "Design Construction and Evaluation of Solar Dryer" *Journal of Engineering and Applied Science*, 2012.

