DESIGN AND ANALYSIS OF SOLAR DRYER

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Abstract

The ongoing search for alternate energy sources was spurred by the unpredictable rise and periodic scarcity of fossil fuel. One of the clean and renewable energy sources that has drawn a sizable group of academics from all around the world is solar. This is largely due to its abundance in both direct and indirect form. So, the creation of effective and affordable equipment for the solar-powered drying of agricultural and marine products evolved, enhancing both the quality of the products and the quality of life. Using solar dryers to dry agricultural products can drastically minimise or eliminate product waste, prevent food illness, and occasionally increase farmer production for higher profits. A solar crop drying system mixes fuel burning with solar energy to reduce the need for fossil fuels while still allowing it to function. This study offers a review of the solar dryer. The many solar dryer designs that have been documented in the literature so far are presented

Introduction

The most typical way for processing and preserving agricultural products is still open air and unrestricted sun drying. However, uncontrolled drying is plagued by the serious problems of wind-borne dust and insect infestation, and the product may be so seriously damaged that it sometimes loses all market value. The resulting loss of and damage to the food quality may have negative economic effects on both the domestic and global markets. To extend the shelf life of agricultural products, dryers have been created and employed (Esper and Muhlbauer, 1996). The majority of these either combine solar energy with another type of energy or employ a costly energy source, like electricity (El- Shiatry et al., 1991). (Sesay and Stenning, 1996). The majority of these projects haven't been adopted by small farmers, either because the final designs and data collection techniques are frequently ineffective or because the cost has remained out of reach. Additionally, the subsequent transfer of technology from researchers to end users hasn't exactly been successful (Berinyuy,2004). The objective of this study is to present some of the basic types of solar dryer with a view of providing a better clue on their effectiveness in the drying of agricultural products.

Advantages of Solar Drying System

1) Better Quality of Products are obtained
2) It Reduces Losses and Better market price to the products.
3) Products are protected against flies, rain and dust; product can be left in the dryer overnight during rain, since dryers are waterproof.
4) Prevent fuel dependence and Reduces the environmental impact
5) It is more efficient and cheap.

Disadvantages of Solar Drying System

1) Quality of products are not obtained in somecases.
2) Adequate solar radiation is required.
3) It is more expensive
   Require more time for drying.

Classification of Solar Dryer

Solar dryers are available in a range of size and design and are used for drying of various agricultural products. Various types of Dryers are available in the market as per requirement of farmers. Primarily all the drying systems are classified on the basis of their operating temperature ranges that is High

Temperature solar dryer and Low Temperature Solar dryer. Following criteria's are required for the classification of solar dryer:-

1) Air movement mode
2) Insulation exposure
3) Air flow direction
4) Dryer arrangement
5) Solar contribution
6) Type of fruit to be dried

1) Direct Solar Dryer

It is a type of dryer in which solar radiation is directly absorbed by the product to be dried.it is also called as natural convection cabinet dryer since the solar radiation is directly fall on the product ,the quality of product is reduced. This dryer comprises of a drying chamber that is covered by a transparent cover made of glass or plastic. The drying chamber is usually a shallow, insulated box with air-holes in it to allow air to enter and exit the box .Fig. shows a schematic of a simple direct dryer (Murthy, 2009).

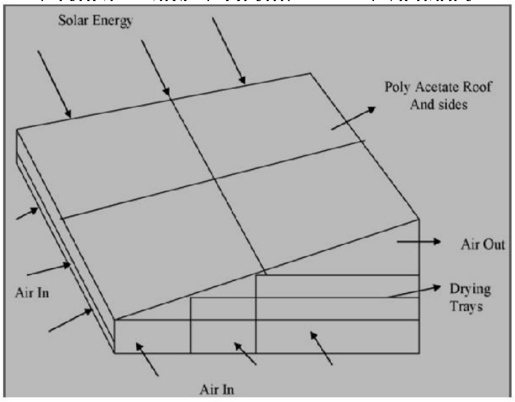

Fig.1 Direct solar drying (Natural convection type cabinet drier)

Physical features of the dryer	Thermal performance	Quality of dried products	Economics and other parameters
types size	Drying ... moisture content reaches 10%,	Sensory ... comparison	Cost of drying and payback periods, floor space requirement,
Drying capacity/loading density (kg/unit aperture area),	first day drying efficiency	rehydration capacity	skills and operator requirements
tray area and numbers of layers	drying air temperature and relative humidity	consistency in presentation	safety and reliability.
loading/unloading convenience and time,	maximum drying temperature at no- load and with load	uniformity of drying	
handling and cleaning		duration of drying air temperature 10^0c above ambient	
maintenance convenience and ease of construction		flow rate	

1) Indirect Solar Dryer

The solar radiation gained by the system is utilized to heat the air which flows through the product to be dried in this dryer. In this of dryer quality of product improved though drying rate increased. Heated air is blown through the drying chamber . At the top of drying chamber vents are provide through which moisture is removed. In indirect type of solar drying systems a better control over drying is achieved. Fig. describes another principle of indirect solar drying which is generally known asconventional dryer.

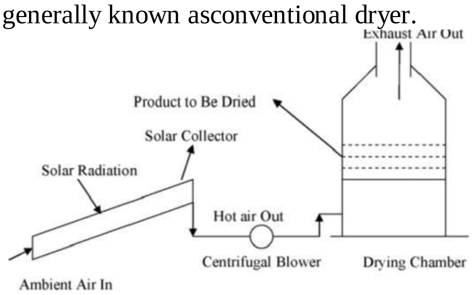

Fig.2 İndirect solar drier (Forced convection solar drier)

2) Forced Convection and Natural ConvectionSolar Dryer

Forced convection- In this type of dryer air is forced through a solar collector and the product bed by a fan or a blower, normally referred to as active dryer.

Natural convection – In this dryer natural movement of air takes place thus called as passive dryers.The heated air flow is induced by thermal gradient.

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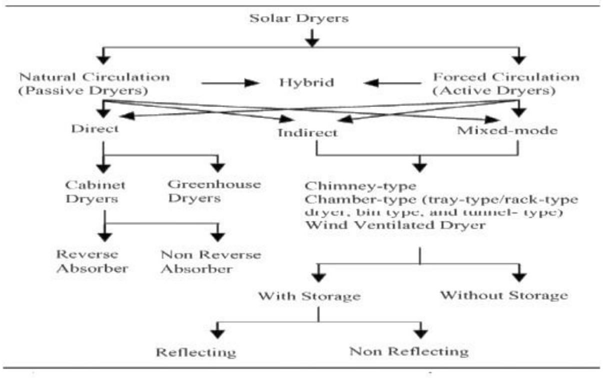


Fig.3 Classes of solar dryers and their drying modes (adopted from [11])

Solar Dryer Evaluation Methods:

A review of evaluation methods and the parameters generally considered for evaluation of solar dryers was presented by [12],[13]; Table gives the summary of the parameters.

Literature Review

[1] Diemuodeke E. OGHENERUONA*, Momoh O.L. YUSUF:- Designed and fabricated direct natural convection solar dryer to dry tapioca in rural areas. A minimum of 7.56 m2 solar collector area is required to dry a batch of 100 kg *tapioca* in 20 hours (two days drying period). The initial and final moisture content considered were 79 % and 10 % wet basis, respectively. The average ambient conditions are 32ºC air temperatures and 74 % relative humidity with daily global solar radiation incident on horizontal surface of 13 MJ/m2/day. The weather conditions considered are of Warri (lat. 5°30’, long. 5°41’), Nigeria.A prototype of dryer was fabricated with minimum collector area of 1.08 m^2.

[2] M. MOHANRAJ, P. CHANDRASEKAR:-The performance of an indirect forced convection solar drier integrated with heat storage material was designed, fabricated and investigated for chili drying. The drier with heat storage material enables to maintain consistent air temperature inside the drier. The inclusion of heat storage material also increases the drying time by about 4 h per day. The chili was dried from initial moisture content 72.8% to the final moisture content about 9.2% and 9.7% (wet basis) in the bottom and top trays respectively. They concluded that, forced convection solar drier is more suitable for producing high quality dried chilli for small holders. Thermal efficiency of the solar drier was estimated to be about 21% with specific moisture extraction rate of about 0.87 kg/kW h.

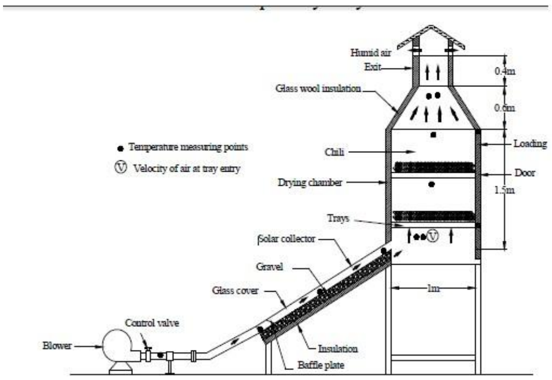


Fig.4 Schematic View of Experimental Setup

[3] Bukola O. Bolaji and Ayoola P. Olalusi: Built a simple and inexpensive mixed mode solar dry locally source materials. The temperature rise inside the drying cabinet was up to 24^o C (74%) for a hours immediately after 12.00h(noon). The drying rate, collector efficiency and percentage of moist removed (dry basis) for drying yam chips were 0.62 kgh-1, 57.5 and 85.4% respectively. The dryer sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneouslyit superior quality of the dried product.

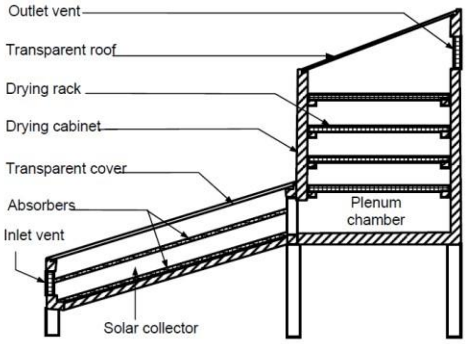


Fig.5 Sectional view of mixed mode dryer

[4] Bukola O. Bolaji.et.al:-

Designed, constructed and tested the solar wind- ventilated cabinet dryer in Nigeria on latitude 7.5o N.Comparatively, drying with the solar cabinet dryer showed better results than open air-drying.
During the period of test, the average air velocity through the solar dryer was 1.62 m/s and the average daylight efficiency of the system was 46.7%. The maximum drying air temperatures was found to be 64oC inside the dryer. The average drying air temperature in the drying cabinet was higher than the ambient temperature in the range of 5oC in the early hours of the day to 31oC at mid- day.80% and 55% weight losses were obtained in the drying of pepper and yam chips, respectively, in the dryer .

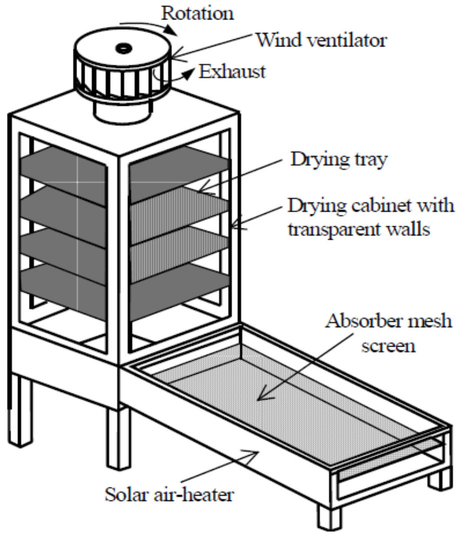


Fig.6 Solar cabinet dryer

[5] Ahmed AbedGatea

Designed and developed solar drying system for maize with V-groove collector of 2.04 m² area, drying chamber and blower. The thermal energy and heat losses from solar collector were calculated for each three tilt angles (30º,45º, 60º). The results obtained during the test period denoted that the maximum gained energy occurred at 11 o'clock hourand then gradually declined since the maximum

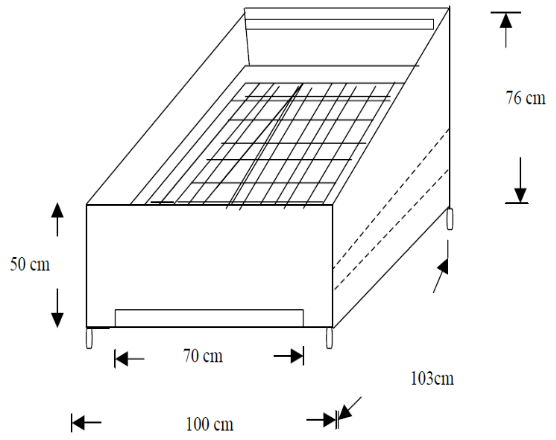


Fig 9 Isometric view of the constructed solar dryer

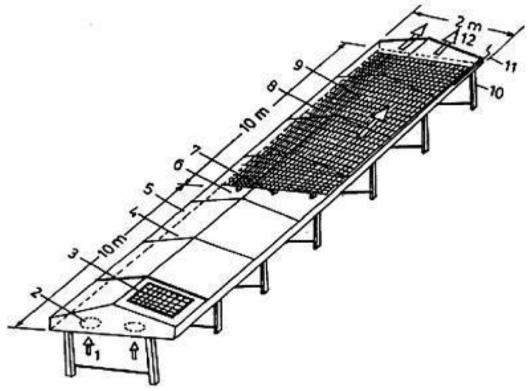


Fig 11.Solar tunnel dryer

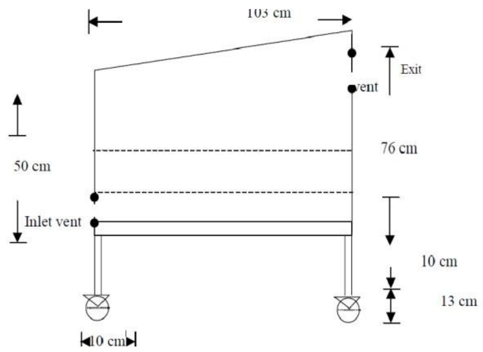


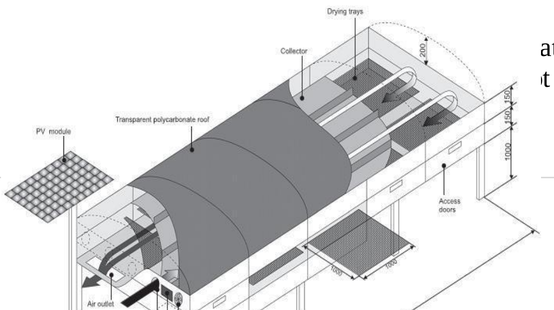
Fig 10 Side view of the constructed dryer[8]M.A. Hossaina and B.K. Bala

Designed and developed A Mixed mode type forced convection solar tunnel drier to dry hot red and green chillies under the tropical weather conditions of Bangladesh as shown in figure .The dryer consists of (1.air inlet 2.fan;3.solar module;4.solar collector;5.side metal frame;6.outlet of the Collector7.wooden support; 8.plastic net; 9.roof structure for supporting the plastic cover; 10.base structure forsupporting The dryer;11.rolling bar; 12,outlet of the drying tunnel.)Moisture content of red chilli was reduced from 2.85to 0.05 kg/kg(db) in 20 h in solar tunnel drier and it took 32 h to reduce the moisture content to 0.09 and 0.40 kg/kg (db) in improved and conventional sun drying methods, respectively.

[9] J. Banout et.al

Doubled Pass Solar Dryer (DPSD) was designed for drying red chilli in central Vietnam and DPSD is compared with cabinet dryer (CD) and traditional open sun drying. They found that average drying temperatures were 60ºC, 52ºC and 35.8ºC and corresponding relative humidity 34%, 45% and 62% for DPSD, CD and open air sun drying, respectively. The overall drying efficiency of DPSD is 20% which is typical for forced convection solar dryer. The moisture content of fresh red chilli was almost similar during all drying tests where as the initial values were 9.18kg/kg,9.17kg/kg and 9.30kg/kg (db) for DPSD, CD and open-air sun drying, respectively. Where the final moisture content in case of DPSD 0.05kg/kg was reached after 23 h, 0.09kg/kg after 29h for CD and 0.18kg/kg after 36 h in case of open sun drying (excluding nights).The performances of a new designed DPSD have been compared with those of a typical CD and a traditional open-air sun drying for drying of red chilli. The DPSD resulted in the shortest drying time to meet desired moisture content of chilli (10% w.b.), which corresponds to the highest drying rate comparing to other methods. Although the construction cost of DPSD was higher than CD the overall drying efficiency was more than two times higher in case of DPSD compared to CD. Hence, Double pass solar drier was found to be technically and economically suitable for drying of red chillies under the specific conditions in central Vietnam.

Conclusion



Ther at solar drying methods are preferable to those using the sun. ıt very useful when it is overcast outside. They may function too well when the weather is good. Although solar dryers need a one-time investment, the improved appearance, taste, and nutrition of the crops they generate increase their marketability and food value. Also, they are more effective, faster, and safe than conventional sun drying methods.

igure 11Description of double pass solar dryer

[10] Ahmed AbedGatea

A cylindrical section solar drying system was designed and analysis of performance takes place. The system consists of a solar collector flat plate with length of 1.10 m and width of 1.10 m drying chamber cylindrical section and a fan was built and designed for the purpose of drying 70 kg of bean crop. The performance of the solar air collector using three air flow rates has been tested. The highest temperature (71.4°C) of the outlet solar collector has been obtained at 11 am. At radiation intensity 750 W/m² for air flowrate of 0.0401 kg/s was obtained and minimum temperature (40.0°C) was obtained when air flow ratewas 0.0675 kg/s at radiation intensity 460 W/m² was obtained. The maximum value of average thermalefficiency 25.64% of the solar air collector obtained at air flow rate of 0.0675 kg/s, and minimum average thermal efficiency is 18.63% at air flow rate of 0.0405 kg/s. The initial moisture content of beans was 70% and final 14% when the air flow rate was 0.0405 kg/s 18% d.b at air flow rate of 0.0540 kg/s and 20% d.b at air flow rate of 0.0765 kg/s

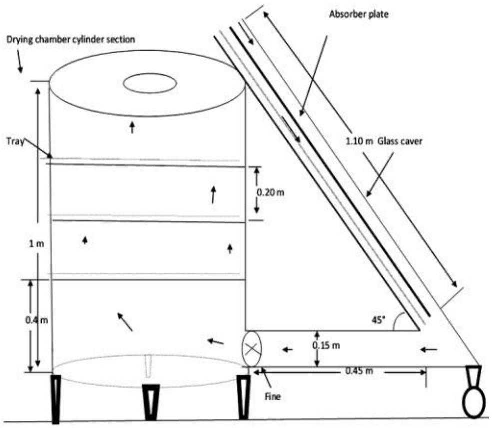


Figure 12Sectional view of the solar drying system,acylindrical section

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