A review paper on Solar Dryer

1*UmeshToshniwal and 2 S.R Karale
1* Student,4thSemester,M-Tech,Heat Power Engineering,2 Professor
Mechanical Engineering Department, G.H Raisoni College of Engineering,
Nagpur-440016,INDIA

Abstract

The unpredictable rise and frequent scarcity of fossil fuel accelerated the continuous search for an alternative power source. Solar is one of the renewable and sustainable sources of power that attracted a large community of researchers from all over the world. This is largely due to its abundant in both direct and indirect form. As such the development of efficient and inexpensive equipment for the drying of agricultural and marine products using solar power evolved thereby improving the quality of the products as well as improving the quality of life. The use of solar dryers in the drying of agricultural products can significantly reduce or eliminate product wastage, food poisoning and at the sometime enhance productivity of the farmers towards better revenue derived. A solar crop drying system does not solely depend on solar energy to function; it combines fuel burning with the energy of the sun, thus reducing fossil fuel consumption. In this paper a review of the solar dryer is presented. The various design of the solar dryer is reported in the literature thus far is presented..

Introduction

Open air and uncontrolled sun drying is still the most common method used to preserve and process Agricultural product.But uncontrolled drying suffers from serious problem of wind born dust, infestation by insect, product may be seriously degraded to the extent that sometimes become market valueless and resultant loss of and have to the food quality may have adverse economic effects on domestic and international market. Dryers have been developed and used to dry agricultural products in order to improve shelf life (Esper and Muhlbauer, 1996). Most of these either use an expensive source of energy such as electricity (El-Shiatry*et al.*, 1991) or a combination of solar energy and some other form of energy (Sesay and Stenning, 1996). Most projects of these nature 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 (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 some cases.
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

Physical features of the dryer	Thermal performance	Quality of dried products	Economics and other parameters
types, size and shape	Drying time/drying rate up to 10% product moisture content, (varies with product)	Sensory quality (color, flavor, taste, and aroma),	Cost of drying and payback periods,
collector area and solar aperture,	dryer/drying efficiency until product moisture content reaches 10%,	nutritional attributes- quantified for easy comparison	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 10^0 c above ambient	
maintenance convenience and ease of construction		flow rate	

box .Fig. shows a schematic of a simple direct dryer (Murthy, 2009).

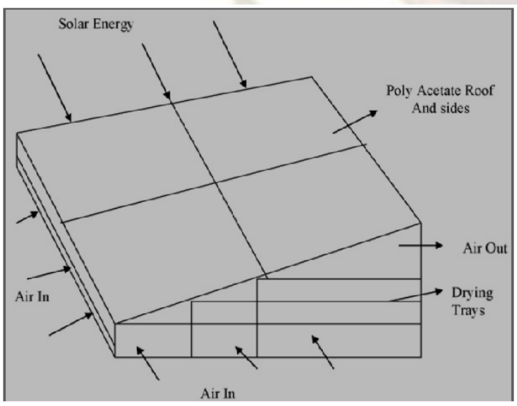


Fig.1 Direct solar drying (Natural convection type cabinet drier)

2) 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.

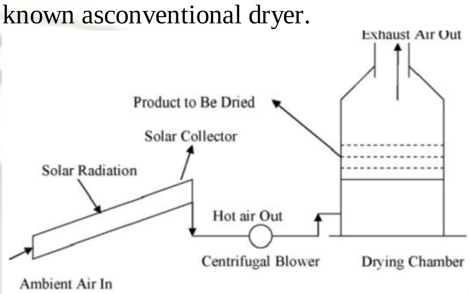


Fig.2 İndirect solar drier (Forced convection solar drier)

3) Forced Convection and Natural Convection Solar 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.

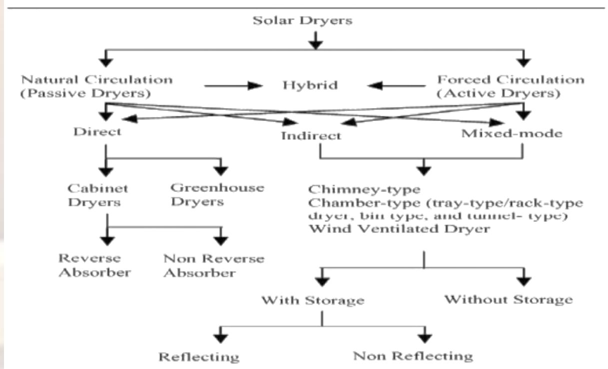


Fig.3 Classes of solar dryers and their drying modes (adopted from [11])

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.

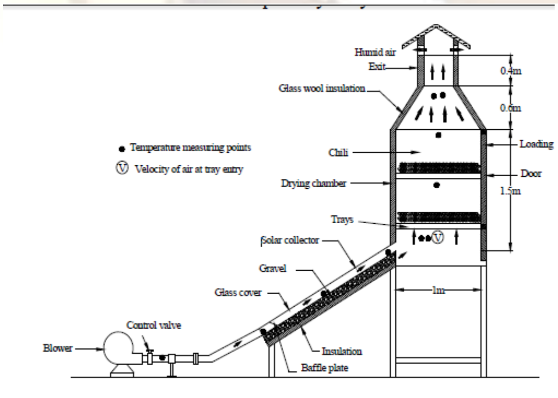


Fig.4 Schematic View of Experimental Setup

[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 simultaneously it superior quality of the dried product.

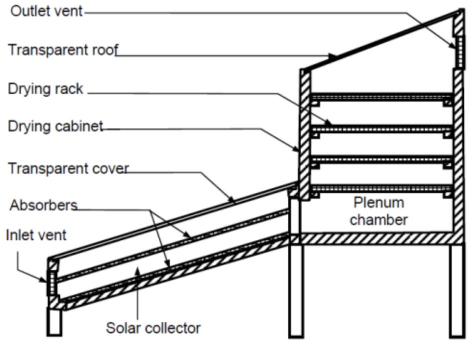


Fig.5 Sectional view of mixed mode dryer

[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 .

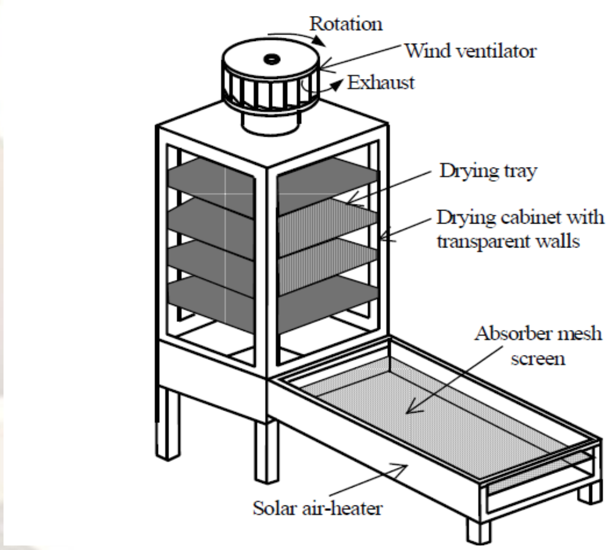


Fig.6 Solar cabinet dryer

[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 hour and then gradually declined since the maximum

solar radiation occurred at this time. Other many important results found are The theoretical thermal energy, the experimentally actual heats gain increase by increasing radiation intensity, the maximum values occurred at the 11 am and then gradually declined. The energy gained obtained at the angle tilt 45º is higher than the corresponding values obtained at 60º, 30º tilt.

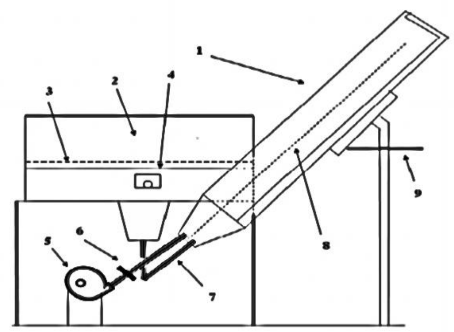
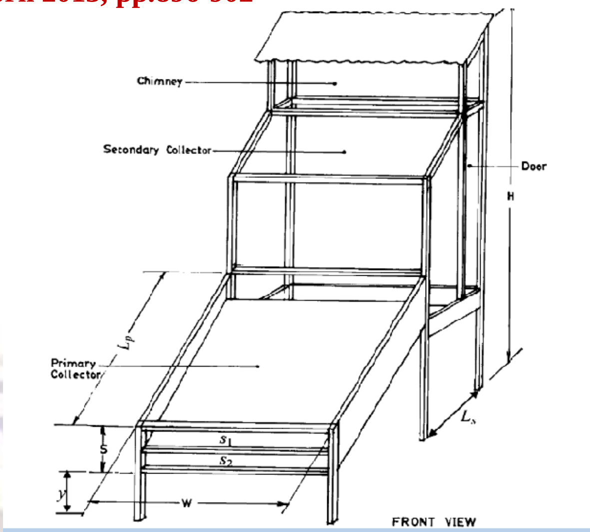


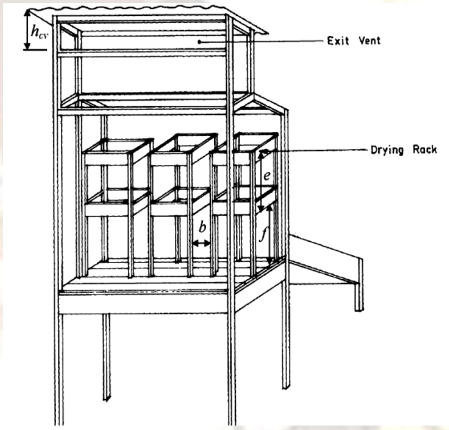
Figure 2. Section of the solar drying system: 1. Solar collector. 2. Drying chamber. 3. Drying tray. 4. Thermostat temperature. 5. Air blower. 6. Air valve. 7. Connecting pipes. 8. Absorption plates of two air passes. 9. Slide rule.

Fig 7 Section of solar dryer

[6] F.K. Forson.et.al

Designed A mixed-mode natural convection solar crop dryer (MNCSCD) for dryingcassava and other crops. A batch of cassava 160 kg by mass, having an initial moisture content of 67% wet basis from which 100 kg of water is required to be removed to have it dried to a desired moisture content of 17% wet basis, is used as the drying load in designing the dryer. A drying time of 30–36 h is assumed for the anticipated test location (Kumasi; 6.71N,1.61W) with an expected average solar irradiance of 400W/m2 and ambient conditions of 25 1C and 77.8% relative humidity.They concluded that A minimum of 42.4m^2 of solar collection area, according to the design, is required for an expected drying efficiency of 12.5%. Under average ambient conditions of 28.2 1C and 72.1% relative humidity with solar irradiance of 340.4W/m^2, a drying time of 35.5 h was realised and the drying efficiency was evaluated as 12.3% when tested under full designed load signifying that the design procedure proposed is sufficiently.





Back view

Fig 8 Schematic views of the MNCSCD

[7] EL- Amin Omda Mohamed Akoy.et.al

A natural convection solar dryer(Cabinet Type) was designed and constructed to dry mango slices. They concluded that the designed dryer with a collector area of 16.8m2 is expected to dry 195.2kg fresh mango (100kg of sliced mango) from 81.4% to 10% wet basis in two days under ambient conditions during harvesting period from April to June. A prototype of the dryer is designed and constructed that has a maximum collector area of 1.03m^2.

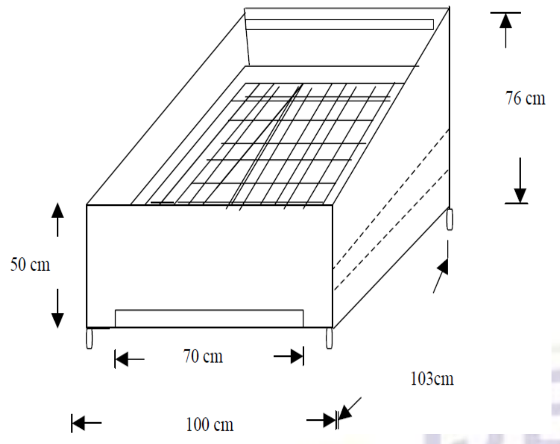


Fig 9 Isometric view of the constructed solar dryer

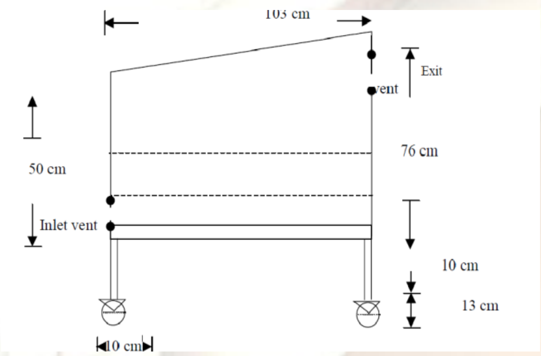


Fig 10 Side view of the constructed dryer

[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.

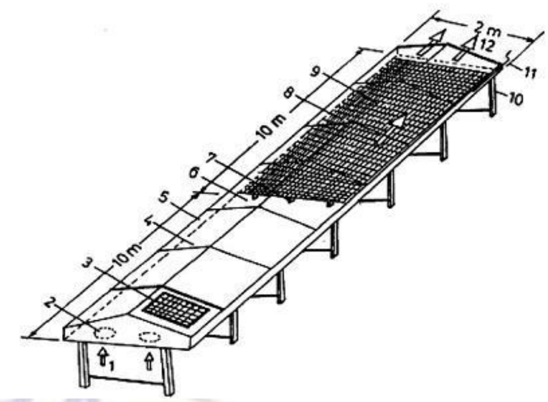


Fig 11.Solar tunnel dryer

[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.

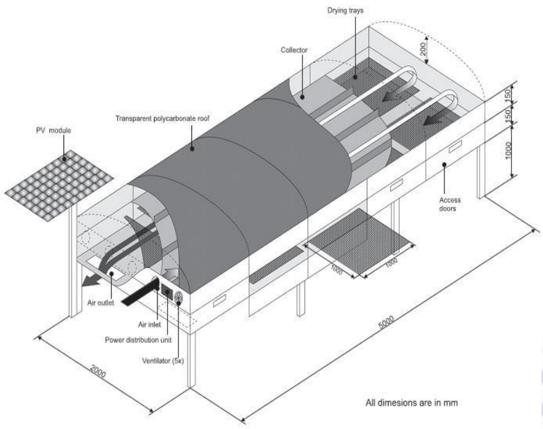


Figure 11Description of double pass solar dryer

[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

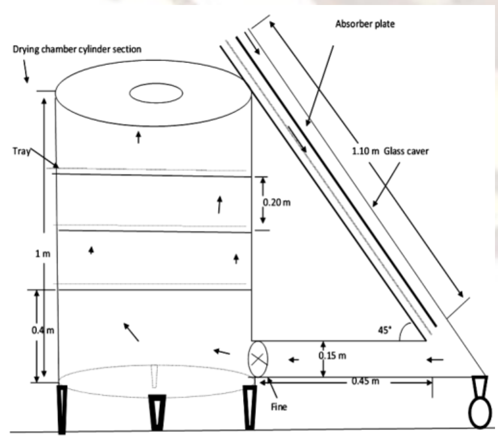


Figure 12Sectional view of the solar drying system,a cylindrical section

Conclusion

In this paper, a review of the research paper is state that, the solar dryer is beneficial than the sun drying techniques . Solar dryers do have shortcomings. They are of little use during cloudy weather. During fair weather they can work too well. Although solar dryers involve an initial expense, they produce better looking, better tasting, and more nutritious foods, enhancing both their food value -and their marketability. They also are faster, safer, and more efficient than traditional sun drying techniques.

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