A review on Solar Tunnel Dryer

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Abstract- *Due to current trends towards higher cost of fossil fuel and uncertainty regarding future cost and availability, use of solar energy in food processing will probably increases and become more economically feasible in near future. Solar dryer have a some advantage over sun drying when correctly designed. They give faster drying rate by heating the air to 10oc to 300c above the ambient temperature which causes air to move faster through dryer, faster the drying reduces the risk of spoilage, improve quality of product. Solar dryer also protect food from dust, insect, birds and animals. They can be constructed from locally available material at a relatively low capital cost and there is no fuel cost. In this paper a review of all type of solar dryer is presented.*

Keywords- Solar tunneldryer, natural convection dryer,forced convection dryer.

I. INTRODUCTION

Drying is the oldest preservative technique for agricultural products. In developing countries traditional sun drying is commonly used for drying agricultural product. Although it is most inexpensive method. The open drying product suffers from quality, contamination by insects and birds and airbone dusts as well as unexpected rain fall these contaminants can have a serious effect on economy of developing countries.so to reduce this problem solar dryer is one of the best method for drying the agricultural as well as medical products.Solar drying is a process of using solar energy to heat air and product so to achieve dehydration of product and about 450c to 600c of hot air required for safe drying.

II. CLASSIFICATION OF SOLAR TUNNEL DRYER

1) Direct solar dryer-In this type of dryer the direct solar radiation are used for drying the foods. The hot air supply is provided through solar collector which are employed in drying unit in which product is dried by solar energy through transparent sheet covering with chamber.One of the disadvantage is poor quality of product proceed which may causes black surface on product due to direct solar radiation onproduct also the drying time required is more. Example: cabinet type[4].

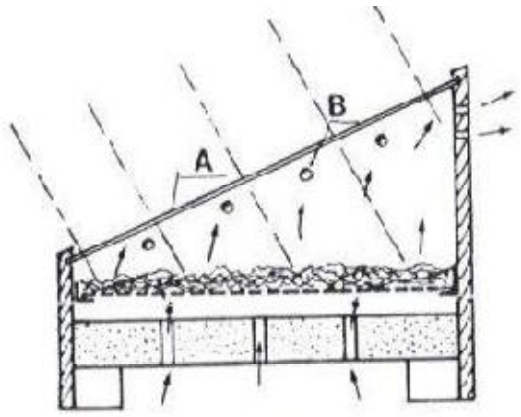


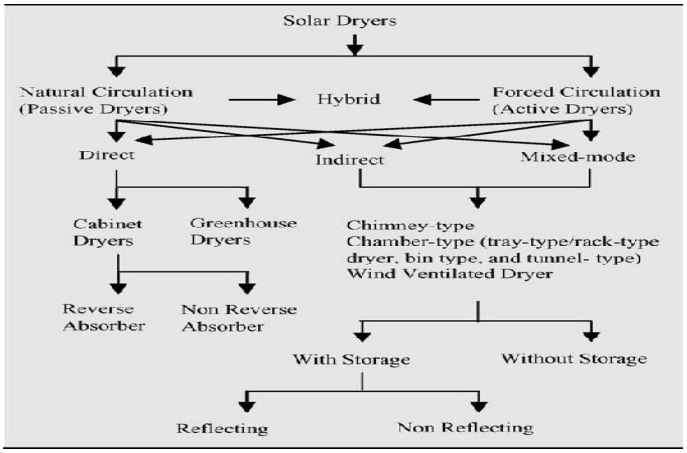
Figure 1
Direct absorption dryer. A: Glass cover B: Ventilation holes. Arrows indicate ai flow.

Figure 1 Direct solar dryer

2) Indirect solar dryer- In this type of dryer the solar radiation gained by system is utilized to heat the air which flows through the product to be dried. The air is normally heated by convection thermal energy from absorbed solar radiation from separate solar collector. in this type of dryer the side of drying chamber are insulated in order to prevent solar radiation and at same time decrease the heat loss through sides. The quality of product is improved but there is increase rate of drying.[4]

3) Mixed and hybrid solar dryer -The mixed type is a combined heat and indirect drying where the hot air from exterior solar heater is combined with direct solar heating of product through transparent roof of the drying cabinet while in hybrid system a combined solar heat with another source of heat such as a fossil fuel or biomass is employed in order to have double heating effect.[4]

4) Forced convection and natural convection dryer- In the forced convection dryer air is forced through solar collector and product by a fan or blower normally referred to as a active dryer.In natural convection dryer design the heated air flow is induced by thermal gradients and it is also called as passive dryer.[4]



1) Tawan Usab (2008) presented that the experimental performance of a solar tunnel dryer for drying silkwarm pupae. This dryer consist of transparent glass covered with flat plate collector and the dryer has 6.2m long 1.8m wide. This drying unit had a capacity of 30 kg of silkworm pupae. Moisture rate was reduced from 3.70 kg to 0.20kg in 570min at flow rate of 0.30 kgs^{-1} and for open sun drying it required 945min that is 40% time required is less than open sun drying. The maximum drying efficiency is 30.14% and overall efficiency is 19.68% at 0.30 kgs^{-1} flow rate also the drying time was not only dependent on drying flow rate but also depend upon drying air temperature.

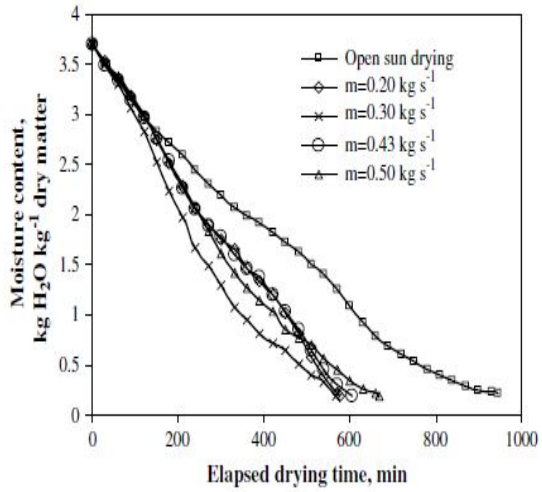


Figure 2 Variation of moisture content with time

2) Garg and kumar (2000) presented the modelling and thermal performance of a semi cylindrical solar tunnel dryer in a natural circulation mode. They concluded that solar tunnel dryer system can be used in natural as well as forced convection mode. In natural convection system volume flow rate rises in inlet air temperature around peak sunshine hours are sufficient for crop drying. The author also presented that as tilt angle increases from 5 ^{o} to 45^{o} there is fall in temperature and increase in mass flow rate. This can be understood as higher value of solar tunnel dryer tilt create more buoyancy force effect in direction of air flow. So there is increase in volume flow rate so that only a small tilt (15^{o}) may generate a volume rate of 1000m^3/hr during peak sunshine hours also temperature about 24^{o} to 30^{o}c for month of December and may required. Therefore the value of collector tilt is very important to crate natural circulation mode.

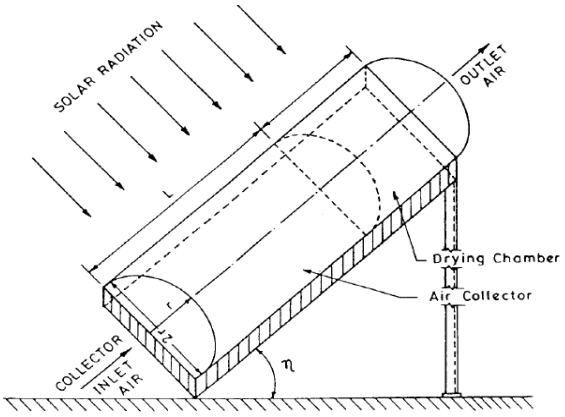


Figure 3 schematic diagram for semi cylindrical solar tunnel dryer

3) Serm Janjai(2011) presented the paper on large scale solar green house dryer with a loading capacity of 1000 kg of fruits and vegetable. The dryer area has 7.5×20m^2 nine DC fan powered by three 50 W solar cell module 1000 kg of banana with 68% moisture content was dried within 5 days compared to 7 days required for natural sun drying with same whether condition. Also 300kg chilli with initial moisture content 75% was dried within 3 days while natural sun dried required 5 days. 200kg of coffee with initial moisture 52% was dried with 2 days compared to 4 days and payback period was obtained to be 2.5 years.

4) Babagana Gutti(2012) presented that the solar dryer is an effective tool for preservation of foods . author also concluded that solar drying processing helps in preservation of food and good quality of food product and provide opportunity for farmer to add local, regional and international market also solar dryer has no any environmental impact since it is renewable source.

5) Ratthasak Prommas (2010) presented the paper on energy and exergy analysis in convective drying process of multilayerd porous packed bed. The author concluded that the drying rate in the F-C bed is slightly higher than of C-F bed. This is because higher capillary pressure for F-C

bed results in to maintain a wetted drying surface for a longer period of time.

6) M.M.I Choudhary (2011) presented that energy and exergy analysis of solar drying of jackfruit leather in a solar tunnel dryer. The dryer was 20m long , 1.8m wide and 380mm high as a 15^{o} of tilt of rod slope and glass wool used at bottom both to reduce heat loss from bottom both collector and drying area were covered with 0.2 mm thick transparent UV polyethylene sheet. The author concluded that the initial moisture content in jackfruit leather was 76% and it reduce to 11.88% moisture in solar tunnel dryer within 2 days while moisture content reach to 13.8% by open sun drying. Also exergy input and exergy loss for the dryer increase solar radiation. The energy efficiency of collector varied between 27.45% and 42.50% while that of dryer varied between 32.34 and 65.30% and mean value of exergy efficiency of dryer was 41.42%.

7) Lyes Bennamoun(2008) presented the paper on global behavior of deep drying as a porous media at the macroscopic scale of shrinkage effect. Shrinkage make changes of many parameter of the dried product such as its diameter, specific heat, conduction also air velocity.Also they concluded that drying process is non homogeneous manner a front of evaporation is then observed. The whole of received energy is used for the evaporation of product water at beginning of process.

8) M.A.Hossain(2004) have investigated optimization of solar tunnel dryer of chilli in Bangladesh. Two optimum design 1 for both collector and drying unit are 14m long and 1.9m wide for design 2 both collector and drying unit are 10m long and 1.8m wide. The capacity of optimum mode dryer is higher than basic mode dryer and achieve a cost saving 15.9% pay back period of basic mode dryer is 4 year and optimum mode dryer at 3 years.

9) Mohammad Zarein(2013) presented a paper on investigation of microwave dryer effect on energy efficiency during drying of apple slice . the experiment was carried out on thin layer (5mm) microwave drying of apple at 2450MHZ and the experiment carried out at 200,400,600w. the drying time of apple slices and effective diifusivity increase as the microwave output power increase the value of effective diffusivity for microwave drying of apple from 3.93×10^{-7} to $2.27\times10^{-6}m^{2/}s$. they concluded that 600w is optimum microwave power level in microwave drying of apple with respect to drying time energy efficiency.

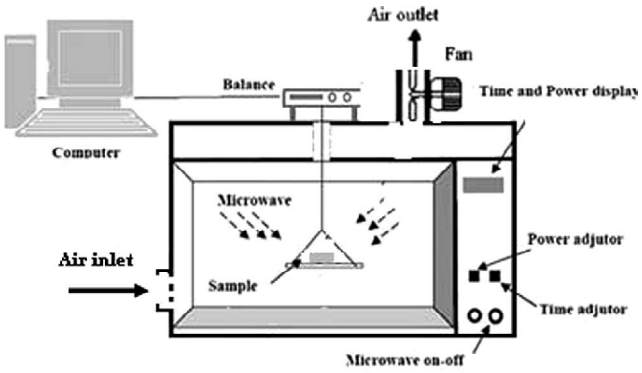


Figure 4 A schematic diagram of microwave–convective oven dryer

10) Jiang Wu (2012) researched on characteristics of a noval solar drying system and its application. A noval device designed to connect with solar energy collector and it can be connected to domestic solar water to effectively use excess energy of solar water heater. The device consist of insulation sheet ,good heat transfer system, ventilation system .drainage system, temperature, humidity control system. This device installed with ultraviolet disinfection light and hollowed aromatherapy box so it can sterilize cloth and fresh air during clothes so as to achieve better results than cloth are dried outside of window. Author concluded that by using this technology it required 3 hours to dry the cloth and while drying cloth it can reach more than 60^{o}c room temperature.

11) Samira chouchia (2013) presented the paper on solar drying of sliced potatoes. This experiment consist of 75W of solar panel and hot air production system is composed of solar collector with simple circulation and ordinary glass with area of $2.5m^{2}$ inclined at 31^{o}. the drying room is parallelipedic form of 1.6m high,0.7m long and 0.6m large. The exterior wall made of galvanized iron sheet with an interior isolation made as polyster inside the drying room. Electric resistance are placed and powered to 1500w and fan is used for air circulation.

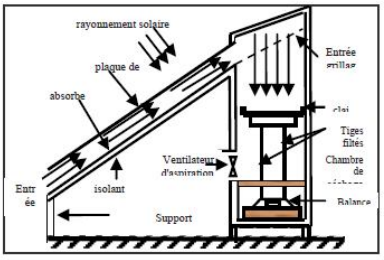


Figure 5 Schematic description of the drying system

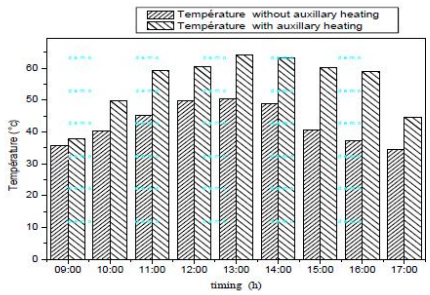


Figure 6 comparision between the temperature of the drying air for a solar tunnel dryer with and without auxillary heating

Graph shows that it is very important to use solar drying with auxiliary heating in composition with one without it. These results show that air temperature in drying without using auxillary heating has not reached the highest level in drying the product. However the use of auxillary heating in drying enable to reach the desired product with 20°c gained. Also author concluded that time required for drying to have final water content X_f=0.13 kg with single solar panel required was 3H. in case of two panel this time was found 2H45min.

12) Varun sunil(2012) presented paper on construction and performance analysis of an indirect solar dryer integrated with solar air heater . Solar collector has a dimension of 1300mm×600mm×120mm made from 12mm thick plywood. Absorber plate used in soalr collector is G.I sheet painted with black paint and placed below 30mm cover plate of glass thickness 4mm.this solar dryer capable of producing an average temperature of 45°c which is suitable for dehydration of food product. The overall efficiency of drying chamber was found to be 17% and efficiency of collector was 30%. In natural convection dryer moisture of tomato was reduced from 1800gm to 180gm in two days drying time and in forced convection the mass was reduced from1800gm to 140gm in same period. The mass flow rate of 0.00653kg/s and 0.019kg/s were found in natural and forced convection.

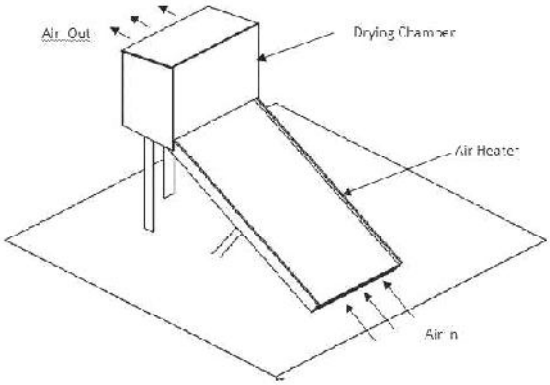


Figure 7 Schematic diagram of experimental setup

13) N.Rajeshwari(2012) presented the paper on construction of box type solar dryer with low cost material.This is a box type solar dryer with length 30 cm , width 15cm and height 45cm. the system consist of absorber plate ,single glass cover, back door and thermo Cole used at insulator. The material gets dried with system efficiency of 15% to 18% the drying time compared to open air drying was reducing by about 20% and produce drying material on tray are better quality . the minimum of 0.045m^2 solar collection area to design is required for an expected drying efficiency of 69.6% under average ambient condition of 30°c and 76.1% reducing humidity with average solar radiation of 650 W/m^2 and also drying efficiency was evaluated as 69.6%.

14) serm janjai(2012) presented paper on greenhouse type solar dryer for small scale drier food industries. The dryer consist of parabolic roof structure covered with polycarbonate sheets on concrete floor . the system is 8.0m in width and 20m in length as wall as 3.5m in height with loading capacity 1000kg of fruits. To ensure continuous drying operation a 100kw LPG gas burner was used to supply hot air to dryer during cloudy season. Nine 15 W DC fans powered by 50W pv module used to ventilate drier results obtained from experiment showed that drying air temperature varies from 35°c to 65°cand drying time 2 to 3 days required than natural sun drying and good quality dried product obtained.

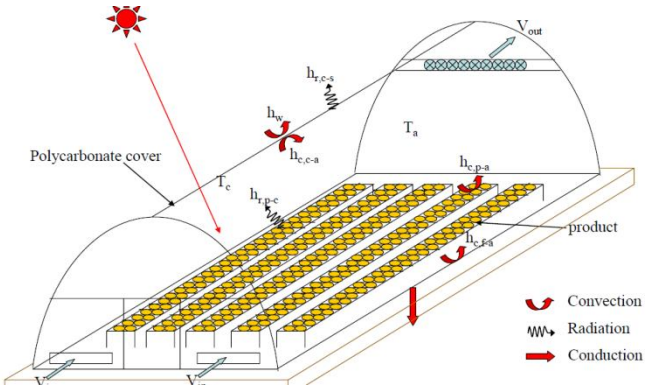


Figure 8 Solar tunnel dryer with polycarbonate sheet

15) A.S.M. MOHSIN (2011) presented the paper on pro-spect future of solar dryer. They analyzed that use of solar dryer leads to considerable reduction of drying time in comparison to sun drying the quality of product dried in solar drier as compared to sun drier are simple in construction and can be constructed using locally available material by the local craftsman . the solar drier can be operated by a photovoltaic module independent on electric grid.

16) M.S.Dulawat(2012) presented the innovation of solar tunnel dryer . it is walk in type semi cylindrical poly house framed structure with UV stabilized polythene sheet. The moisture content in chilli reduce from 83.4% to 9% and Aonla pulp from moisture content of 81% to 9.5% and 20^{o}c to 30^{o}cof higher temperature was obtained in solar tunnel dryer over the ambient temperature and net saving in drying time of 405 to 50% for solar tunnel dryer over open sun.

17) J. Kaewkiew(2011) presented paper on large scale green house type solar dryer for drying chilli in Thailand. The dryer has a parabolic shaped and it covered with polycarbonate sheet the base area is 8×20 m^2 nine DC fans operated with 50W solar cell. It was found that 500kg of chilli with initial moisture content 74% were dry within 3 days as open sun drying required 5 days.

18) S. Arun(2014) presented a paper on Experimental Studies on Drying Characteristics of Coconuts in a Solar Tunnel Greenhouse Dryer. Three experimental are carried out with 5000 coconuts were carried out in the dryer during the month of March 2014. The drying time and the product quality were the main deciding performance parameters of the dryer which are studied in comparison with the traditional drying method (open sun drying). It was found that the coconuts which has an initial moisture content of 53.84% were dried to final moisture content of 7.4% in the solar tunnel greenhouse dryer for a time period of 56 hours whereas the open sun drying method took 147 hours for the same.

III.CONCLUSION

In this paper a review of the research paper related to solar dryer studied and after that we conclude that solar dryer is beneficial than open sun drying technique but solar dryer have some limitation that is they can not work effectively during cloudy weather condition. Although solar dryer required more initial cost but the quality of dried dried product in terms of colour, texture and time required for drying was favourable in natural as well as forced convection dryer as compared to open sun drying.

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