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Effect Of Design And Environmental Parameter On Efficiency Of Solar Air Heater: A Review

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Abstract: The sun based drying structure Uses the sun situated heat energy to heat up air and to dry food substance stacked, which is significant in diminishing wastage of provincial thing and helps in safeguarding of plant thing and food thing. The requirements of the typical sun drying for instance receptiveness to facilitate sunshine, hazard to vermin and rodents nonappearance of fitting noticing, and the elevated expense of the mechanical dryer, a sun based is thusly advanced to provide food for this cutoff. This assignment presents the arrangement, advancement and execution of a mixed mode sun based dryer for food protection. In the dryer, the warmed air from an alternate sun fueled finder is gone through a grain bed, and at the same time, the drying authority holds sun arranged energy directly through the clear dividers and housetop. The results obtained during the preliminary uncovered that the temperatures inside the dryer and sun fueled finder were much higher than the incorporating temperature during most hours of the daylight.

Index Terms - solar dryer, solar collector, rough surface, double mode, transparent glass cover.

INTRODUCTION

The sun based drying framework Uses the sun oriented heat energy to warm up air and to dry food substance stacked, which is valuable in decreasing wastage of rural item and helps in protecting of horticultural item and food item. The constraints of the normal sun drying for example openness to coordinate daylight, risk to vermin and rodents absence of appropriate observing, and the heightened cost of the mechanical dryer, a sun based is subsequently evolved to cater for this limit. This task presents the plan, development and execution of a blended mode sun based dryer for food conservation. In the dryer, the warmed air from a different sun powered gatherer is gone through a grain bed, and simultaneously, the drying bureau retains sun oriented energy straightforwardly through the straightforward dividers and rooftop.

Problem Definition

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 flavor and most of the nutritional value is preserved and concentrated [16]. 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.

Objectives

The objective of present study is to study a double mode solar air dryer in which the grains are dried simultaneously by direct radiation through the transparent walls and roof of the cabinet and by the heated air from the solar collector. The issues of low and medium scale processor could be reduced, assuming the sun based dryer is planned and developed with the thought of defeating the constraints of immediate and aberrant kind of sun oriented dryer. So subsequently, this work will be founded on the significance of a blended mode sun powered dryer which is solid and financially, plan and build a blended mode sunlight based dryer utilizing locally accessible materials and to assess the exhibition of this sun oriented dryer. This venture presents the plan, development and execution of a blended mode sun powered dryer for food conservation. In the dryer, the warmed air from a different sunlight based gatherer is gone through a grain bed, and simultaneously, the drying bureau retains sun powered energy straightforwardly through the straightforward dividers and rooftop. The outcomes got during the trial uncovered that the

temperatures inside the dryer and sunlight based authority were a lot higher than the encompassing temperature during most hours of the sunshine. The temperature climb inside the evaporating bureau was to 70% for around three hours following 12.00h (early afternoon). The dryer displayed adequate capacity to dry food things sensibly quickly to a protected dampness level and at the same time it guarantees a predominant nature of the dried item.

Problem Constraints

Drying processes play an important role in the preservation of agricultural products. They are defined as a process of moisture removal due to simultaneous heat and mass transfer. The aim of this project is to present the developments and potentials of solar drying technologies for drying grains, fruits, vegetables, spices, medicinal plants. The traditional method of drying, known as _sun drying', involves simply laying the product in the sun on mats, roofs or drying floors. Major disadvantage of this method is contamination of the products by dust, birds and insects – Some percentage will usually be lost or damaged, it is labour intensive, nutrients loss, such as vitamin A and the method totally depends on good weather conditions.

Because the energy requirements - sun and wind - are readily available in the ambient environment, little capital is required. This type of drying is frequently the only commercially used and viable methods in which to dry agricultural products in developing countries. The safer alternative to open sun drying is solar dryer. This is a more efficient method of drying that produces better quality products, but it also requires initial investments. If drying conditions such as weather and food supply are good, natural circulation solar energy, solar dryers appear to be increasingly attractive as commercial proposition.

Literature Review

Dronachari M.1* and Shriramuluet. et al4 Due to exponential rise in the price of fuel and depletion of fossil fuel, there is a need to look for other alternatives like nonconventional energy resources viz. solar energy. India is blessed with good sunshine hours. A review paper is made to use solar energy for drying of agricultural food products with different dryers available, such as direct type, indirect type, mixed mode and hybrid solar dryers, also reviews about different heat storage material used in solar dryers after sunshine hours. In India most of rural areas follows the open sun drying method for drying of agricultural material like grains, fruits and vegetables, but it has some disadvantages like time consuming, labour demanded and environmental contamination.[4]

Megha S. Sontakke1, Prof. Sanjay P. et al5 Solar drying is one of the application of solar energy. Drying means moisture removal from the product. Drying is helpful in preserving food product for long time; it prevent product from contamination. Direct solar drying, indirect solar drying, and mixed mode solar drying these are different solar drying methods. Primarily open to the sun or direct sun drying technique is used. However, it has some disadvantages. These disadvantages can be eliminated by indirect type of dryer which is used for drying products as application of solar energy. In this paper, we studied the different technique of drying and various modes of solar drying [5].

EL- Amin Omda Mohamed Akoy et al5, developed a natural convection solar dryer (Cabinet Type) to dry mango slices . The designed dryer had a collector area of 16.8m2 . They dried 195.2 kg of fresh mangoes from 81.4% to 10% wet basis. They dried mangoes in two days under ambient conditions during harvesting period of April to June.

Sharma, A., Chen, C. R., Vu Lan, N. et. Al Solar drying is often differentiated from ―sun drying by the use of equipment to collect the sun's radiation in order to harness the radiative energy for drying applications. Sun drying is a common farming and agricultural process in many countries, particularly where the outdoor temperature reaches 30OC or higher. In many parts of South East Asia, spice s and herbs are routinely dried. However, weather conditions often preclude the use of sun drying because of spoilage due to rehydration during unexpected rainy days. Furthermore, any direct exposure to the sun during high temperature days might cause case hardening, where a hard shell develops on the outside of the agricultural products, trapping moisture inside. Therefore, the employment of solar dryer taps on the freely available sun energy while ensuring good product quality via judicious control of the radioactive heat. Solar energy has been used throughout the world to dry products. Such is the diversity of solar dryers that commonly solar-dried products include grains, fruits, meat, vegetables and fish. A typical solar dryer improves upon the traditional open-air sun system in five important ways [21].

DESIGN APPROACH AND METHODOLOGY

Solar drying refers to a technique that utilizes incident solar radiation to convert it into thermal energy required for drying purposes. Most solar dryers use solar air heaters and the heated air is then passed through the drying chamber (containing material) to be dried. The air transfers its energy to the material causing evaporation of moisture of the material.

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.

A. High Temperature Solar Dryer
B. Low Temperature Dryer

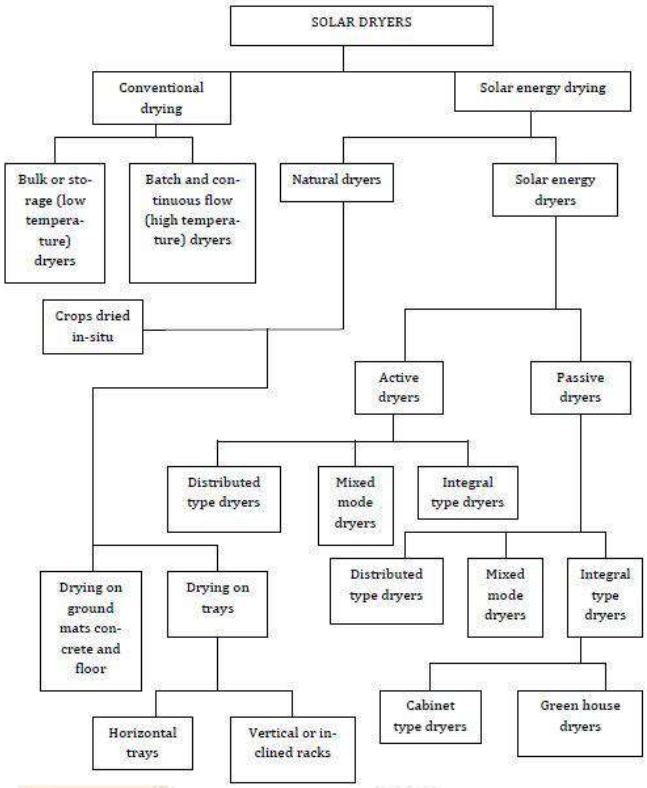

Fig. Classification of dryer and drying mode [6].

Design Methodology

Types of solar driers

Solar-energy drying systems are classified primarily according to their heating modes and the manner in which the solar heat is utilized. In broad terms; they can be classified into two major groups, namely [5]:

- Active solar-energy drying systems
- Passive solar-energy drying systems

Another Three distinct sub-classes of either the active or passive solar drying systems can be classified which vary mainly in the design arrangement of system components and the mode of utilization of the solar heat, namely [7]:

I. Direct solar dryers
II. Indirect solar dryers
III. Mixed-mode dryers
IV. Hybrid solar dryers

I . Direct (integral) type solar dryers

In this class of dryer, the solar radiation is absorbed directly by the product intended to be dried. The hot air supply is provided through solar collectors which are employed in the drying unit in which the product is directly irradiated by solar energy through transparent sheet covering the east and west sides of the chamber. One of the disadvantages of this system is poor quality of product processed which may causes black surface on the product due to the direct solar radiation on the product. On the other hand the drying time is very fast and this class of dryers came with a simple design which can be assembled by farmers themselves using locally available materials.[7]

The direct type solar dryer again classified into following catagories.

(i) open sun, (ii) direct and (iii) indirect in the presence of solar energy.

(i) Open Sun Dryer OSD

As shown in fig. 2.5 the working principle of open sun drying by using solar energy. The short wave length solar energy falls on the uneven product surface. A part of this energy is reflected back and the remaining part is absorbed by the surface. The absorbed radiation is converted into thermal energy and the temperature of product statrs increasing. This results in long wavelength radiation loss from the surface of product to ambient air through moist air.

In addition to long wave length radiation loss there is convective heat loss too due to the blowing wind through moist air over the material surface. Evaporation of moisture takes place in the form of evaporative losses and so the material is dried. Further apart of absorbed thermal energy is conducted into the interior of the product. This causes a rise in temperature and formation of water vapor inside the material and then diffuses towards the surface of the and finally losses thermal energy in the end then diffuses towards the surface of the and finally losses the thermal energy in the form of evaporation In the initial stages, the moisture removal is rapid since the excess moisture on the surface of the product presents a wet surface to the drying air. Subsequently, drying depends upon the rate at which the moisture within the product moves to the surface by a diffusion process depending upon the type of the product [11].

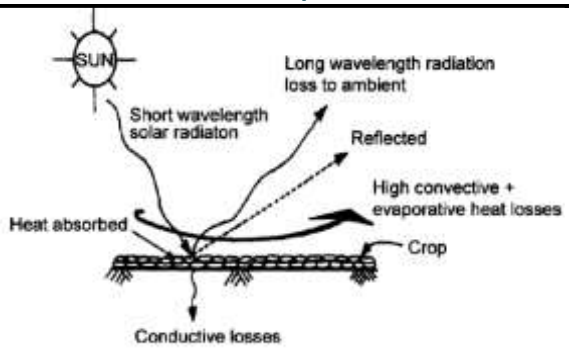

Fig. working principle of open sun drying

(ii) Direct type solar drying (DSD)

Direct solar drying is also called natural convection cabinet dryer. Direct solar dryers use only the natural movement of heated air. A part of incidence solar radiation on the glass cover is reflected back to atmosphere and remaining is transmitted inside cabin dryer. Further, a part of transmitted radiation is reflected back from the surface of the product. The remaining part is absorbed by the surface of the material. Due to the absorption of solar radiation, product temperature increase and the material starts emitting long wave length radiation which is not allowed to escape to atmosphere due to presence of glass cover unlike open sun drying. The glass cover server one more purpose of reducing direct convective losses to the ambient which further become beneficial for rise in product and chamber temperature respectively [12].

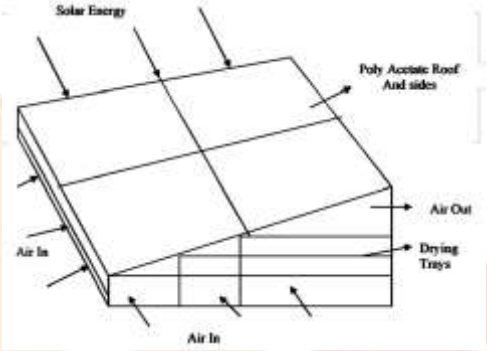

Fig. Direct solar drying (Natural convection type cabinet drier)

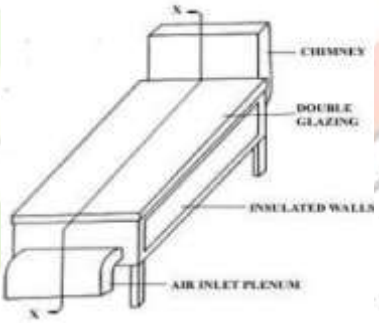

Fig. Direct solar drying [7]

3.2. 2 Indirect type solar drying (ISD)

In this type of dryer, the solar radiation acquired by the system is used to heat the air circulating around the product to be dried. The air is typically heated by the thermal energy converted from solar radiation absorbed with separate collector. In this operating mode, the sides of the drying chamber are insulated to prevent the loss of solar radiation through the sides. Product quality is improved by an increase of the drying speed. Indirect dryers are generally predestined for the manufacture by small industries in most cases.

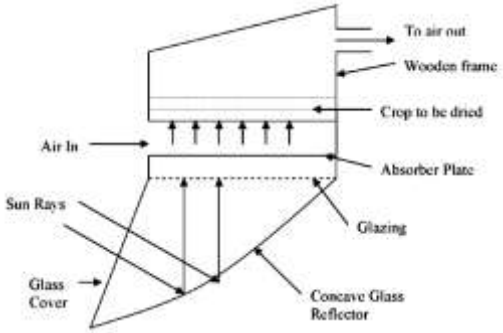

Fig. Reverse absorber cabinet drier [7]

The fig elaborates another principle of indirect solar drying which is generally known as conventional dryer. In this case, a separate unit termed as solar air heater is used for solar energy collection for heating of entering air into this unit. The air heater is connected to a separate drying chamber where the product is kept. The heated air is allowed to flow through wet material. Here, the heat from moisture evaporation is provided by convective heat transfer between the hot air and the wet material. The drying is

basically by the difference in moisture concentration between the drying air and the air in the vicinity of product surface. A better control over drying is achieved in indirect type of solar drying systems and the product obtained is good quality.

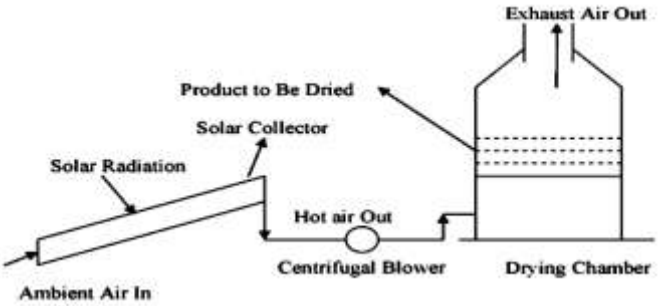

Fig. Indirect solar drier (Forced convection solar drier)

There are different types of Indirect solar drier shown below which are designed and fabricated by keeping in mind to increase the efficiency with minimum expenditure. The best potential and popular ones are natural convection cabinet type, forced convection indirect type and green house type.

Fig. 3.11 Indirect solar drying [7]

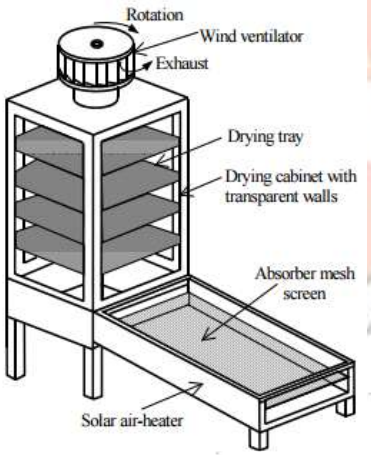

Fig. 3.12 Indirect solar drying [7]

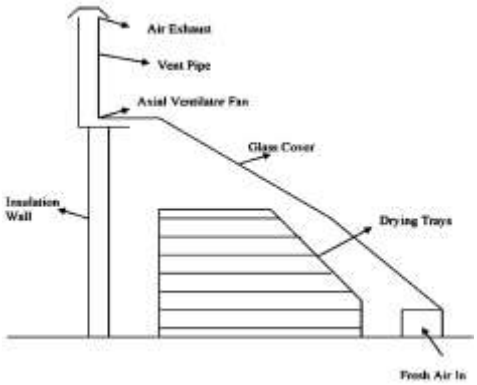

Fig. 3.13 **Green house type solar drier[3]**

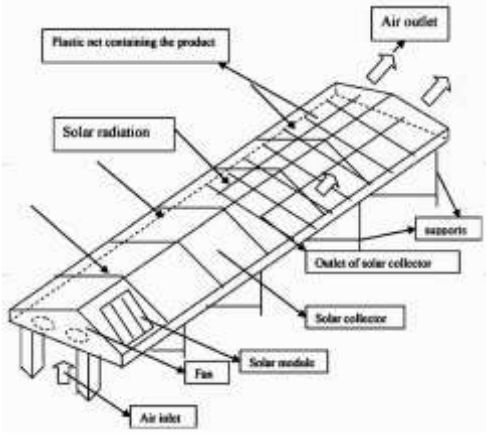

Fig. **solar tunnel drier[3]**

Apart from the obvious advantages of passive solar-energy dryers over the active types (for applications in rural farm locations in developing countries), the advantages of the natural circulation solar-energy "ventilated green house dryer" over other passive solar-energy dryer designs include its low cost and its simplicity in both on-the-site construction and operation. Its major drawback is its susceptibility to damage under very high wind speeds

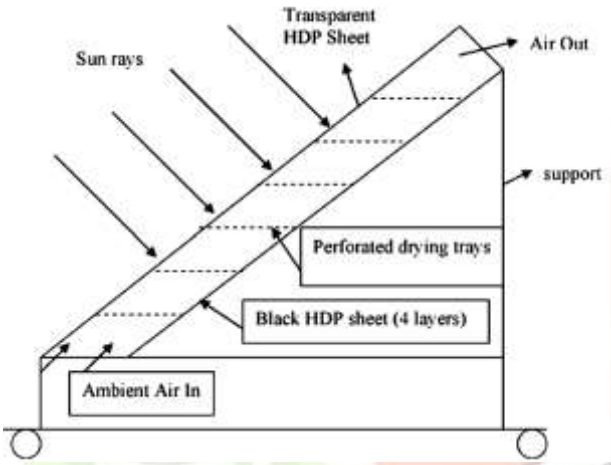

Fig. Multiple-shelf portable solar drier

A staircase type dryer [13] is developed which is in the shape of a metal staircase with its base and sides covered with double walled galvanized metal sheets with a cavity filled with no degradable thermal insulation (see Fig.3.15).

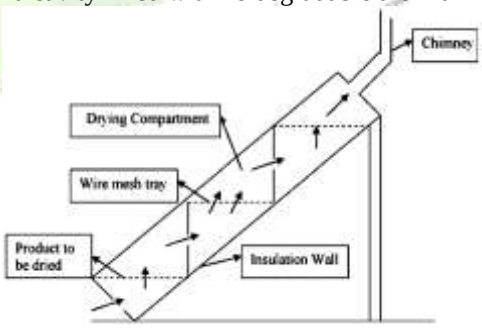

Fig. Staircase solar drier[13]

Since the products need to be spread in a single layer for efficient drying, total trays are available in the dryer for spreading the product is important. In an attempt to acquire the area, the roof top of a farm house has been used as a collector. In extension to this type of drier [10], a dual purpose of illuminating the room by providing a low temperature roof integrated solar flat plate air heater is introduced.[14]

Some have been improved further by using other methods such as increased convection, etc., which are briefly discussed below.

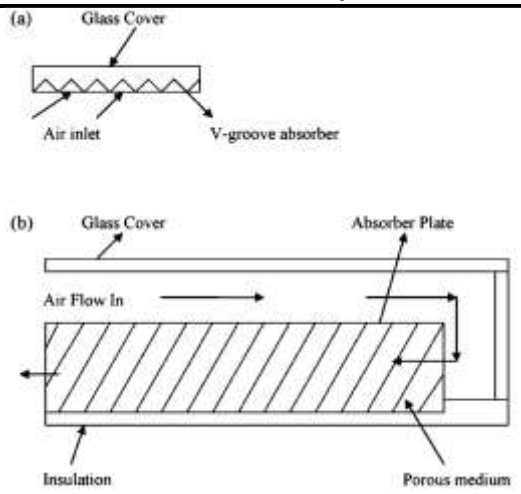

Fig. Solar assisted drying systems

In order to make the driers cost effective and comparable to open sun drying, natural convection type green house driers [11] are developed and tested. There are two types of driers (see Figs. 2.18 and 2.19). The driers are tested without load–without chimney, with load–without chimney and with load–with chimney. When the driers are loaded (pepper in the present case), the efficiency reduces. It is found that the green house driers are increase the air temperature by 5–9 oC and the chimney provides better natural circulation of air.

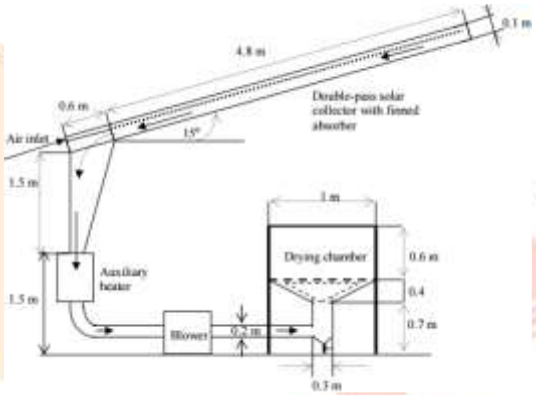

Fig. Solar assisted drying systems

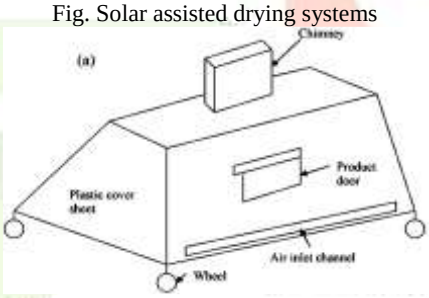

Fig. A simple presentation of first model

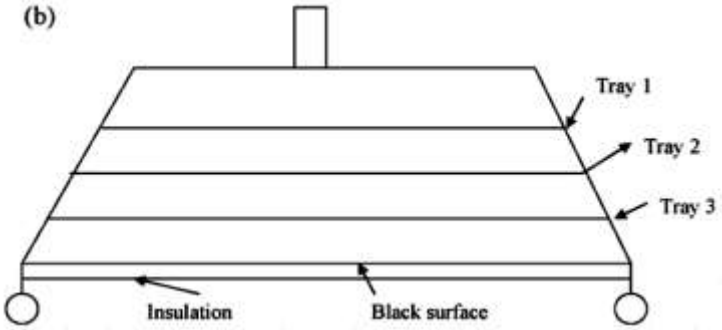

Fig. Side view of first model

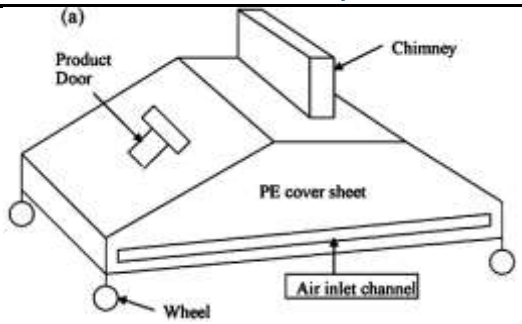

Fig. simple representation of second model

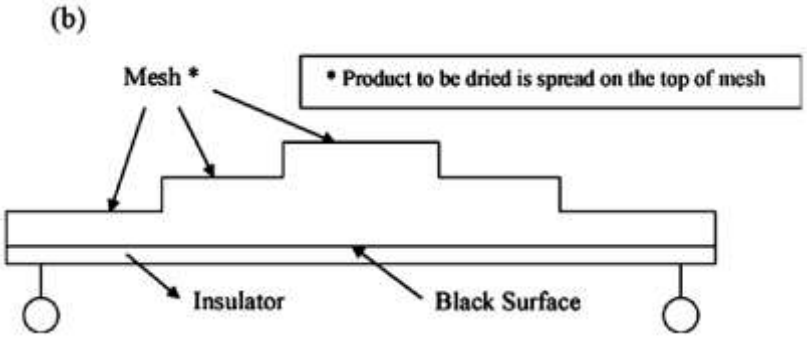

Fig. Side view of internal representation of second model

Totally different methods of drying have been developed which continue to dry the products even in the night times thereby reducing the drying time drastically. The desiccant materials [15] are used which absorb the moisture from the products to be dried. Yet another type is the one with thermal storage (sensible) to take care of intermittent incoming solar radiation. The length and width of the air heater, the gap between the absorber plate and glass cover and thickness of the storage material are optimized in this type of drier [16]. The thermal efficiency of the air heater is found to be sufficient for drying of various materials.

APPLICATIONS OF SOLAR DRIERS

The drying process has been experimentally studied and analyzed to simulate and design a drier. As drying is a process of removing moisture to a safe level, the equilibrium moisture content is defined as the moisture content in equilibrium with the relative humidity of the environment. The equilibrium moisture content is divided into, static and dynamic. While the static is used for food storage process, dynamic is used for drying process. The drying process is experimentally obtained and presented as moisture content on x-axis and rate of drying on y-axis. A deep bed of food grains is assumed to be composed of thin layers normal to the hot air flow direction. The equations for thin layer were written initially, using empirical, theoretical and semi theoretical equations. The conditions of the grain and air change with position and time during drying of a deep bed of grains. Logarithmic and partial differential equation models to simulate the deep bed dry modeling are dealt in detail.[16]

In a different direction, the first and second laws of thermodynamics [25] have been used to develop the design methods for a particular application. Semi-empirical formulae are developed to calculate the rise in air temperature as it passes through the heater.NTU (number of transfer units) has been defined analogous to the heat exchangers, as a part of design. Using entropy balance the maximum temperature reached by solar collector is written and then Entropy Generation Number is developed to find the entropy generated during thermal conversion of solar energy. Finally, the drying temperature is established as a function of the maximum limit of temperature the material might support.

The drying process in the three zones of the bed is theoretically analyzed. The solar collector is equipped with a flat plate absorber and offset plate fins absorber plate. Under constant incident fluxes, at the same mass flow rate of air, the drying rate and time has been studied to find that offset plate fins collector is better. The known facts that, the inlet temperature of the air is variable (because of variable incoming solar radiation) and the products shrink as drying process continues are taken into consideration for modeling [18].

DESIGN SPECIFICATIONS AND ASSUMPTIONS

Solar drying may be classified into direct and indirect solar dryer. In direct solar dryers the air heater contains the grains and solar energy which passes through a transparent cover and is absorbed by the grains. Essentially, the heat required for drying is provided by radiation to the upper layers and subsequent conduction into the grain bed. However, in indirect dryers, solar energy is collected in a separate solar collector (air heater) and the heated air then passes through the grain bed, while in the mixed-mode type of dryer, the heated air from a separate solar collector is passed through a grain bed, and at the same time, the drying cabinet absorbs solar energy directly through the transparent walls or the roof. The objective of this study is to design a mixed-mode solar dryer in which the grains are dried simultaneously by both direct radiation through the transparent walls and roof of the cabinet and by the heated air from the solar collector.

DESIGN PROCEDURE

In many parts of the world there is a growing awareness that renewable energy have an important role to play in extending technology to the farmer in developing countries to increase their productivity [19]. Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in agriculture application. It is preferred to other alternative sources of energy such as wind and shale, because it is abundant, inexhaustible, and non-polluting [20]. Mix mode solar dryer is the combination of direct and indirect type of solar dryer. Product is dry by directly exposure to the sun light and also by hot air supplier on it. Air is heated in a collector and then this hot air is supplied to the drying chamber and drying chamber top is made up of glass cover. Which can directly absorbs solar radiation. In this way drying rate is higher as compared to direct solar drying. The governing equations were derived with respect of the drying air temperature, humidity ratio, product temperature and its moisture content [21]. It was found that inside temperature of drying chamber was up to 74% after 12 pm for about 3 hours. Drying rate obtained is 0.62kg/h and system efficiency obtained is 57.5% [23]. Tripathy and Kumar gives information of dryer in which flat plate collector placed in series. They used this dryer for drying potato slices of diameter 0.05m and thickness 0.01m [22].

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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