Design and Fabrication of Multi-Utility solar Dryer

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ABSTRACT

This work presents the design, construction and performance of a mixed-mode solar dryer for food preservation. In the 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 and roof. The results obtained during the test period revealed that the temperatures inside the dryer and solar collector were much higher than the ambient temperature during most hours of the day-light. The temperature rise inside the drying cabinet was up to 74% for about three hours immediately after 12.00h (noon). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

Key words: solar collector, dryer, transparent cover.

1. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several thousand years. 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. Drying is the oldest preservation technique of agricultural products and it is an energy intensive process. High prices and shortages of fossil fuels have increased the emphasis on using alternative renewable energy resources. Different types of solar dryers have been designed, developed and tested in the different regions of the tropics and subtropics. The major two categories of the dryers are natural convection solar dryers and forced convection solar dryers. In the natural convection solar dryers the airflow is established by buoyancy induced airflow while in forced convection solar dryers the airflow is provided by using fan operated either by electricity/solar module or fossil fuel. Now the solar dryer designed and developed for and used in tropics and subtropics are discussed under two headings.

2. PROBLEM STATEMENT OBJECTIVES

The objective of this work is to develop a mixed-mode solar dryer in which the Bitter Gourd 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, if the solar dryer is designed and constructed with the consideration of overcoming the limitations of direct and indirect type of solar dryer.

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.

3. DESIGN PROCEDURES

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. 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 Solar air heaters are simple devices to heat air by utilizing solar energy and employed in many applications requiring low to moderate temperature below 80°C , such as crop drying and space heating. Drying processes play an important role in the preservation of agricultural products In order to improve traditional drying, solar dryers which have the potential of substantially reducing the above-mentioned disadvantages of open air drying. Solar dryers of the forced convection type can be effectively used. They however need electricity, which unfortunately is non-existent in many rural areas. Even when electricity exists, the potential users of the dryers are unable to pay for it due to their very low income. Forced convection dryers are for this reason not going to be readily applicable on a wide scale in many developing countries. Natural convection dryers circulate the drying air without the aid of a fan.

4. EXPERIMENTAL SET-UP

The mixed-mode solar dryer with box-type absorber collector was constructed using the materials that are easily obtainable from the local market. Shows a section of the solar dryer. The dryer has four main features namely: the box-type absorber solar air collector, the drying chamber, the drying rack and two fans electric

4.1 Collector (solar air heater)

The heat absorber (inner box) of the solar air heater was constructed using 1 mm thick galvanized plate, painted black, the surface facing sunlight was painted with black paint containing (5%) black chromium powder to increase its absorbing capability. The solar collector was insulated with rock wool of about 5 cm thickness and thermal conductivity of $0.04 \text{ Wm}^{-1} \text{ K}^{-1}$ on all sides. The solar collector assembly consists of air flow channel enclosed by transparent cover (glazing). The glazing is a single layer of 4mm thick transparent glass sheet. It has a surface area of $0.82 \text{ by } 1.20 \text{ m}$ and of transmittance above 0.86

Fig4.1.1 mixed-mode solar dryer

5. DRYING CABINET AND DRYING RACKS

The designing of the drying chamber depends on many factors such as the product to be dried, the required temperature and velocity of the air to dry food material, the quantity of the dried product and the relative humidity of the air passing over the food material. The drying chamber houses four drying racks, between a tray and another tray is 10 cm as shown in Figure 1. Four trays of dimension (0.75 x 0.30 x 0.08 m) were fabricated and stacked uniformly/evenly at distances (0.02 m) apart, for placing of material to be dried. The tray was made from an aluminum wire mesh (0.003 x 0.003 m in size) attached to it. Metal handles (0.076 m) were attached on each tray for ease of handling and sliding the trays inside the chamber through the produce to be dried. The drying chamber was also lined with foam insulation material 5 cm thick to prevent loss of heat

6. DRYING MECHANISM

In the process of drying, heat is necessary to evaporate moisture from the material and a flow of air helps in carrying away the evaporated moisture. There are two basic mechanisms involved in the drying process: migration of moisture from the interior of an individual material to the surface. And The evaporation of moisture from the surface to the surrounding air [. The drying of a product is a complex heat and mass transfer process which depends on external variables such as temperature, humidity and velocity of the air stream and internal variables which depend on parameters like surface characteristics (rough or smooth surface), chemical composition (sugars, starches, etc.), physical structure (porosity, density, etc.), and size and shape of product.

7. RESULTS AND DISCUSSION

This project presents the design, construction and performance of a mixed-mode solar dryer for food preservation. In the 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 and roof. The results obtained during the test period revealed that the temperatures inside the dryer and solar collector were much higher than the ambient temperature during most hours of the day-light. The temperature rise inside the drying cabinet was up to 74% for about three hours immediately after 12.00h (noon). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

Variation of the temperatures in the solar collector and the drying cabinet compared to the ambient temperature

Variation of temperature and time

variation of relative humidity and time

Above fig shows a typical day results of the hourly variation of the temperatures in the solar collector and the drying cabinet compared to the ambient temperature. The dryer is hottest about mid-day when the sun is usually overhead. The temperatures inside the dryer and the solar collector were much higher than the ambient temperature during most hours of the daylight. The temperature rise inside drying cabinet was up to 24°C (74%) for about three hours immediately after 12.00h (noon). This indicates prospect for better performance than open-air sun drying.

8. CONCLUSION

From the test carried out, the following conclusions were made. The solar dryer can raise the ambient air temperature to a considerable high value for increasing the drying rate of agricultural crops. The product inside the dryer requires less attentions, like attack of the product by rain or pest (both human and animals), compared with those in the open sun drying. Although the dryer was used to dry Potato, it can be used to dry other crops like yams, cassava, maize and plantain etc. There is ease in monitoring when compared to the natural sun drying technique. The capital cost involved in the construction of a solar dryer is much lower to that of a mechanical dryer. Also from the test carried out, the simple and inexpensive mixed-mode solar dryer was designed and constructed using locally sourced materials. The hourly variation of the temperatures inside the cabinet and air-heater are much higher than the ambient temperature during the most hours of the day-light. The temperature rise inside the drying cabinet was up to 24°C (74%) for about three hours immediately after 12.00h (noon). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

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