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Development of Hybrid Solar Dryer System

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ABSTRACT -

A review of the solar-powered dryer is given in this lecture. Out of the over 6 billion people on the planet, 20–25 percent do not have access to enough food. According to estimates, more than 25–30% of food grains and 30–50% of fruits, vegetables, and other produce are wasted before it reaches customers worldwide. Fruit, grains, and vegetables can be preserved using a variety of techniques, but the finest ones are derived from renewable resources, which allow us to preserve food while retaining its inherent flavour. Agricultural items are dried in an enclosed machine called a solar dryer. Additionally, food must be protected against rot, birds, insects, and sudden downpours. Throughout history, people have employed solar dryers, sometimes referred to as dehydrators, to remove moisture from grains, vegetables, and fruits. Any size and capacity solar dryer may be manufactured locally, and if cash crops are dried, solar dryers are cost-effective. The different solar dryer designs that have been documented in the literature up to this point are shown.

Keywords: Solar energy, Air dryer, Battery, Temperature sensor etc.

INTRODUCTION

Although drying in the sun is easy and inexpensive, it has some disadvantages, including no control over the rate of drying, over-drying of the crop, UV discolouration, insect and fungal attack, unfavourable weather, etc. Open sun drying generally does not meet international quality standards and hence cannot be sold both domestically and internationally. The following drawbacks of the alternative direct drying method:

a) Small capacity;
b) Food discoloration within the drier;
c) Moisture collection inside glass covers; and
d) Inadequate rise in food temperature.

By converting solar energy into electrical energy, problems caused by direct sun exposure are avoided in indirect drying systems. It will also be used to run the heating and air exposure units, the closed chamber, and the very low issue of product discolouration and cracking in indirect dryers.

High temperature, humid free air is fed into the drying chamber by a separate air exposure unit with a heating function. Thus, in an indirect drying method, moisture evaporation happens more quickly. By insulating the drying chamber, heat losses in an indirect type solar dryer can be reduced.

Citrus fruits are agricultural goods valued for their high vitamin content, high moisture content, and low fat content. Since they are seasonal crops, the best time to find them is during the growing season. Despite the growth, the expanding population's need for citrus fruits has not been satisfied.

This is due to wastes from biochemical and biological reactions occurring in the fresh product, as well as adverse storage, handling, and transportation circumstances, as well as inadequate post-harvest infrastructure and subpar market outlets. In more tropical and subtropical nations, sun drying is still a popular method for preserving agricultural items like grains and vegetables.

For all those women who work on such products, this project proposes the design and building of a solar dryer for drying such food. The solar panel and the high-speed air that is permitted entry through the air intake inside the insulated box make up the dryer. It is used for drying (removing the moisture content form the food substances or the vegetable or fruit product which is loaded in it) in the solar collection chamber and channelled via the drying chamber. This design uses a portable solar-powered device to quickly and easily remove moisture from fruits and vegetables.

PROBLEM IDENTIFICATION

One of the oldest solar energy techniques is drying, which involves exposing the products to the sun directly to dry them out, like fruits, vegetables, fish, and meat. There are numerous drawbacks to this practice, including items that get spoiled by wind, rain, dust, insects, animals, and fungi. The rate of drying, particularly in open sun drying, when the items are directly exposed to solar radiation, may cause the product's surface to harden before the moisture within has a chance to escape, which will lower the product's quality due to over-drying. In addition to requiring a lot of labour and handling a lot of food, especially fruits and vegetables, during bad weather, open sun drying can be expensive, crop damage and a loss in quality. The portable dryer powered by sustainable solar energy was created for this project in order to address this issue, improve product quality, and adhere to ergonomic standards.

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OBJECTIVE

The aim of this project is to use solar energy and a battery unit to design, develop, and assess the performance of a prototype indirect solar dryer for fruits and vegetables in both passive and active modes.

The layout of a working solar dryer system would mitigate every drawback. Both modes' designs were used, and their performance was tested using various parameters like temperature, air velocity, collector efficiency, and weight loss.

Research demonstrated that, when compared to traditional drying methods, the usage of this kind of solar dryer resulted in a considerable reduction in drying time as well as improved product quality. This study examines the relationship between temperature, moisture content, drying time, and drying rate.

There are two main objectives to achieve in this research which are:

i. To research the features and functionality of the solar dryer equipment.

ii. To create a solar-powered drying system for vegetables and fruits.

LITERATURE REVIEW

- There is a growing recognition around the globe that renewable energy may play a significant role in providing developing country farmers with access to technology that will boost their output (Waewsak, et al., 2006).

- One technology that is quickly gaining traction in farm applications as an energy-saving solution is solar thermal technology. It is favoured over other renewable energy sources like shale and wind since it is plentiful, endless, and non-polluting (Akinola 1999; Akinola and Fapetu 2006; Akinola et al., 2006).

- Simple solar-powered air heaters are used for a variety of tasks needing low to moderate temperatures below 80 degrees Celsius, including crop drying and space heating (Kurtbas and Turgut, 2006).

- Drying procedures, which are characterised as a process of eliminating moisture owing to simultaneous mass and heat transfer, are crucial to the conservation of agricultural products (Ertekin and Yaldiz, 2004).

- (Bassey, 1989; Togrul and Pehlivan, 2004) Since traditional drying is the simplest and least expensive method of food preservation, it is most commonly employed in developing nations. Traditional drying is often done outdoors on the ground. Open air drying has a number of drawbacks, including: exposing the food to dust and rain; allowing drying to occur uncontrollably; exposing some items to direct sunlight, which is not ideal for them; insect infestation; and animal attacks; etc (Madhlopa, et al., 2002).

- Over the past 20 years, solar dryers—which have the potential to significantly lessen the aforementioned drawbacks of open air drying—have drawn a lot of interest as a means to enhance conventional drying (Bassey, 1989).

- Soponronnarit (1995) examined the 15 years of solar drying research and development carried out in Thailand (from 1980s). He discovered that solar drying some crops—like fruit, various crops, and paddy—is economically and technically possible. Farmers, however, have not embraced the technique in large numbers. The majority of solar air heaters created in Thailand have involved roof alteration. When compared to electricity, solar air heaters with or without glass covering were said to be technically and financially practical, but they haven't been able to rival fuel oil.

- Bahnasawy and Shenana (2004) created a mathematical model to simulate drying some soured dairy products in the sun (kishk). Sunlight radiation, heat conduction, heat received or lost from the dryer bin wall, and the latent heat from moisture evaporation were the major ingredients in the equations that described the drying system. For a large range of humidity ratio values, the model could forecast the drying temperatures. Additionally, it can forecast the product's moisture loss throughout a broad range of temperatures, air velocities, and relative humidity levels.

- Enein (2000) presented a parametric analysis of a solar air heater for solar drying applications both without and with thermal storage. An optimisation procedure was run both with and without thermal storage for a flat-plate solar air heater. Three different types of materials—water, stones, and sand—were used for heat storage.

- Pangavhen, et al. (2002) suggested the design, development, and testing of a novel convection solar dryer. The solar dryer can produce an average temperature of between 50 and 55°C, which is ideal for dehydrating most fruits and vegetables, including grapes.

EXPERIMENTAL BLOCK DIAGRAM

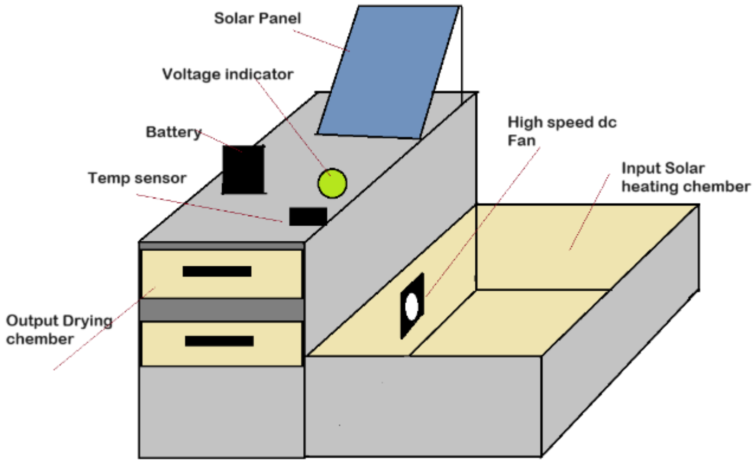

Fig. 1. System Diagram of system

WORKING PRINCIPLE

- The two main compartments or chambers of the designed and built solar dryer are the drying chamber, which is made to hold single layers of drying trays on which produce (fruits and vegetables) is placed for drying, and the solar power generation unit along with air dryer heating compartment unit, also known as the air heater.
- Solar energy is converted into electrical energy by a solar panel. This energy is sent to the battery unit via the charge controller, which is used to indicate when the battery is charging.
- This machine uses the stored energy to power every function. We attached the control board to activate various functions. Features such as a solar panel, battery, glass, container, high-speed exhaust fan, etc. able can be managed via this control panel.
- The slider is lowered to cover any product when it is placed on the tray. And reposition it. All of the functions inside the insulated box are turned on after that.
- •There is a tiny glass pane that allows you to view every activity inside. With the aid of an exhaust fan, the moisture contained in fruits and vegetables is quickly absorbed. In this manner, solar-powered portable fruit and vegetable drying systems operate effectively with the use of renewable energy sources. And in a short amount of time, fruits and vegetables are in a dried state.

APPLICATION

1. Agricultural industry: To dry crops, fruits, vegetables, grains, and herbs, solar air dryers are widely utilised in the agricultural industry.
2. Food Processing Industry: Workers work in the food processing industry to dry different food items, including as grains, herbs, and spices.
3. Timber business: To dry wood and wood products, solar air dryers are used in the timber business.
4. Textile business: Fabrics, yarns, and clothing are dried using them in this business.
5. Pharmaceutical business: To dry therapeutic plants and herbs, the pharmaceutical business uses solar air dryers.
6. Industrial Applications: They are also used to dry chemicals, minerals, and other materials in a variety of industrial operations.

SCOPE

1. Energy Efficiency: By harnessing solar energy, which is plentiful and renewable, solar air dryers provide a sustainable and energy-efficient option for drying applications.
2. Cost-Effectiveness: By harnessing free solar energy, they lessen dependency on traditional energy sources and help save operational costs related to drying operations.
3. Environmental Sustainability: By lowering greenhouse gas emissions and reliance on fossil fuels, solar air dryers help to maintain an environmentally sustainable future.
4. Scalability: Depending on the drying needs of various applications and sectors, these systems can be adjusted up or down.
5. Versatility: Because solar air dryers are adaptable to a variety of climates and geographical conditions, they may be used in a wide range of global locations.
6. Innovation: The field of solar air drying technology is still undergoing study and development, to expand the scope of applications and improve the efficiency and effectiveness of these systems.

ADVANTAGES

1. Renewable Energy Source: Solar air dryers utilize solar energy, which is a clean and renewable energy source, reducing reliance on fossil fuels.
2. Low Operating Costs: They have low operating costs as they harness free solar energy for drying, resulting in cost savings over time.
3. Reduced Environmental Impact: Solar air dryers help in reducing carbon emissions and environmental pollution associated with conventional drying methods.
4. Improved Product Quality: Drying with solar air dryers can help maintain the quality, nutritional value, and flavor of dried products compared to other drying methods.
5. Minimal Maintenance: These systems require minimal maintenance and have long lifespans, making them cost-effective and reliable solutions for drying applications.
6. Independence from Grid Power: Solar air dryers offer independence from grid power, making them suitable for remote and off-grid locations where electricity supply may be unreliable or unavailable.

CONCLUSION

In order to speed up the drying process of agricultural crops, the solar dryer has the ability to significantly increase the outside air temperature. When opposed to products drying in the open, products within the dryer require less attention from the sun, rain, and pests (both human and animal). The dryer can be used to dry other food goods in addition to the variety of food stuffs it was used to dry. Compared to the method of natural sun drying, monitoring is simpler. When compared to a mechanical dryer, the capital cost of building a solar dryer is far less. Additionally, based on the test, a straightforward and affordable solar dryer was created utilising resources that could be found locally.

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