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Design Fabrication and Performance Evaluation of Copper Plate

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Abstract: *Utilizing the most abundant and free of cost energy of the sun to heat up the air and to use that heated air to dry foods is the main goal of this thesis. In order to do this an indirect type forced convection solar dryer is fabricated with components like screen absorber solar collector, drying chamber, fan, etc. The performance of the designed solar dryer is evaluated by carrying drying experiments with potatoes. The temperature inside the drying chamber ranges from 490C to 580C while the ambient temperature ranges from 330C to 350C.*

Keywords: Copper Plate, Solar Plate, Exhaust Fan, Aluminium Sheet

I. INTRODUCTION

Sun drying is recognized as one of the most common, economical, and environmentally friendly methods for preserving agricultural products. It is widely practiced by farmers, especially in rural and developing regions, due to its simplicity and zero operational cost. In this method, crops such as fruits, vegetables, grains, and spices are spread out in open areas under direct sunlight to reduce their moisture content. However, despite its widespread use, open sun drying presents several significant limitations. These include vulnerability to unpredictable weather conditions such as rain, strong winds, high humidity, and airborne dust. Additionally, products left in the open are often exposed to contamination from insects, rodents, birds, and other animals, as well as microbial degradation, all of which compromise the safety, hygiene, and overall quality of the dried products.

Due to these shortcomings, products dried by traditional sun drying methods often fail to meet international quality and hygiene standards, limiting their market value and export potential. Moreover, small-scale farmers face technological and infrastructural challenges, such as lack of access to reliable electricity and modern drying equipment, making it difficult for them to adopt more advanced food preservation methods. In this context, solar drying technology presents a promising alternative that addresses many of the challenges associated with open sun drying.

II. LITERATURE REVIEW

Drying is a critical post-harvest process for preserving agricultural products by removing moisture content. Based on the method of heat transfer, dryers are categorized into direct and indirect types. Direct dryers apply heat directly to the product, while indirect dryers use pre-heated air, offering better control and product quality. Several drying methods are commonly used, including convection air drying, vacuum drying, drum drying, spray drying, freeze drying, and fluidized bed drying. Research has shown advancements in these technologies, such as the use of far-infrared radiation to enhance freeze-drying efficiency, hot air oven optimization for even drying of potatoes, and vacuum microwave drying for better texture and flavour in fruits. Other studies highlighted the benefits of osmotic dehydration as a pretreatment method and addressed the challenges of uneven airflow in tray dryers.

Open sun drying, while still widely practiced in rural areas due to its low cost, is highly dependent on weather conditions and exposes food to contamination from dust, pests, and animals. To mitigate these issues, solar drying technologies have been developed and classified into passive and active systems. Passive solar dryers rely on natural airflow and include direct, indirect, and mixed-mode types. Active solar dryers use mechanical fans to circulate air, enabling faster and more controlled drying, and are also available in direct, indirect, and mixed-mode configurations. Research in solar drying has led to innovations such as an evacuated tube collector dryer that significantly reduces

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drying time, low-cost indirect dryers suitable for i farmers, and solar tunnel dryers for fish that improve drying hygiene and reduce spoilage. Other studies have focused on combining solar and mechanical systems, solar vacuum dryers for fruits, and the design of efficient mixed-mode dryers for crops like cassava. These technologies show strong potential for enhancing food preservation in regions with limited electricity access.

III. PROBLEM STATEMENT

Many rural areas lack reliable electricity, which severely impacts food preservation and leads to significant post-harvest losses. Agriculture, being a major livelihood for a large portion of the population, often results in surplus crops that spoil due to inadequate storage facilities. Traditional preservation methods like refrigeration are costly and dependent on electricity, while inefficient transportation systems further contribute to spoilage. Solar dryers offer a low-cost, environmentally friendly solution that does not rely on the power grid. By removing moisture, they prevent microbial growth, extend shelf life, reduce product weight for easier transport, and enhance the handling, taste, and usability of dried foods.

IV. OBJECTIVE

The main objectives of the study are as follows:

- To design an indirect solar dryer with forced circulation of air that can dry and preserve foods within the least period of time.
- To construct the solar dryer.
- To determine the performance of the solar dryer and compare it with the traditional sun drying method.
- To design a solar dryer which solar collector can be separated from the system and can be used as a solar air heater to heat up the air in winter season
- To design a solar dryer for the unprivileged village farmers and also for the food industries which will be very economical and efficient.

V. DESCRIPTION

This project presents the design, fabrication, and testing of an indirect-type solar dryer integrated with a copper plate to enhance thermal absorption and improve the drying efficiency for vegetables, particularly potatoes. The aim is to harness the abundant and renewable energy of the sun in a cost-effective, environmentally friendly way, particularly suitable for rural farmers who lack access to modern preservation facilities. The system is built around a forced convection drying mechanism, comprising key components such as a copper plate-based solar collector, drying chamber, exhaust fan, and aluminium housing. Copper is selected for the collector due to its high thermal conductivity, allowing for efficient heat transfer to the air, which is then circulated through the drying chamber .During experiments, the dryer maintained an internal temperature between 49°C and 58°C, significantly higher than the ambient temperature of 33°C to 35°C, ensuring effective moisture removal from the sliced potatoes. This setup protects the food from dust, insects, and environmental contaminants commonly associated with traditional sun drying, while also accelerating the drying process. The device is designed with versatility in mind, allowing the solar collector to function independently as a solar air heater during colder months. This makes the system useful not only for vegetable drying but also for household or small-scale industrial heating applications.

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VI. DIAGRAM

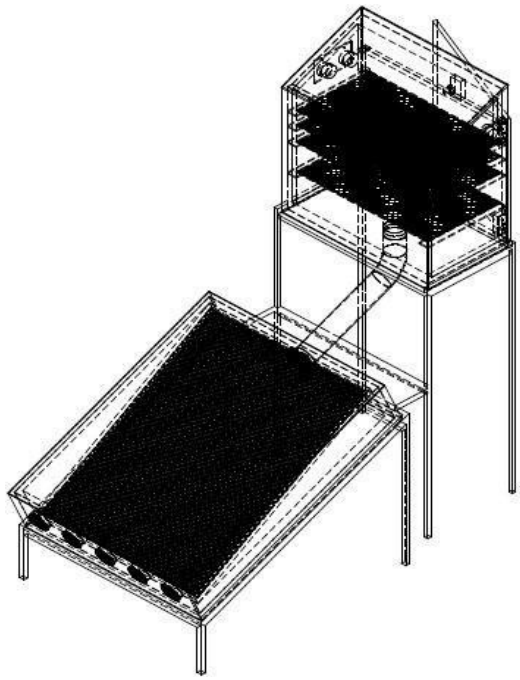

Figure 1- Indirect type active solar dryer

Figure 2- 3D Diagram

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VII. CONCLUSION

Designing an efficient solar dryer involves considering various factors to ensure optimal performance while keeping the system cost-effective. One of the most important design considerations is the material selection for the solar collector. For this system, a copper plate was chosen due to its high thermal conductivity, which allows for rapid heat absorption and effective thermal transfer to the air. The drying chamber, fan, and ductwork were made from aluminium and insulated materials to minimize heat loss. The solar collector was designed to absorb maximum solar radiation, with black paint applied to the copper surface to increase absorptivity. The system utilizes forced convection, where a solar-powered exhaust fan circulates the heated air through the drying chamber, ensuring uniform temperature distribution and accelerating the drying process.

In terms of design calculations, several factors were taken into account to ensure the system's efficiency. The solar collector efficiency was calculated to be 60.01%, based on the ratio of useful heat gained to the total solar radiation incident on the collector. The drying rate of the system was measured at 0.1161 kg/hr, which indicates the rate at which moisture was removed from the product. Furthermore, the system achieved an 80.35% moisture content reduction, showcasing its effectiveness in drying agricultural products. The overall dryer efficiency was determined to be 23.08%, indicating the proportion of solar energy effectively utilized in the drying process.

To evaluate the performance of the solar dryer, a comparison was made with traditional open sun drying. The experimental data revealed that the solar dryer performed significantly better in terms of drying time, moisture reduction, and hygiene. The drying time was considerably shorter, and the final moisture content of the product was lower compared to open sun drying. Moreover, the enclosed drying chamber protected the produce from contaminants like dust, insects, and animals, which is a common issue with open sun drying. These results demonstrate that the solar dryer offers a more efficient and hygienic alternative to traditional sun drying.

Although the system was tested using potatoes, it can be used to dry a variety of other agricultural products such as bananas, grapes, mangoes, apples, and many more. This versatility, combined with its high thermal efficiency and reduced drying time, makes the solar dryer an ideal solution for small-scale farmers, food processors, and rural communities looking for an affordable, sustainable method for preserving agricultural produce.

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