Design and Fabrication of a Solar Passive Dryer

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Abstract - Solar drying is one of the most efficient and eco-friendly techniques for preserving agricultural products. Traditional open sun drying methods lead to contamination, uneven drying, and significant post-harvest losses. This research focuses on the design and development of a solar passive dryer, which utilizes solar energy and natural air circulation for efficient drying.The developed system improves drying efficiency, maintains product quality, and reduces drying time. Experimental testing was conducted on agricultural products such as potato chips, onion slices, and chili. The system demonstrated improved temperature control and hygienic drying conditions. The results show that the solar passive dryer is a low-cost, energy-efficient, and sustainable solution suitable for rural and small-scale farming applications.

Keywords: Solar dryer, passive drying, renewable energy, agricultural drying, heat transfer

1. INTRODUCTION

Agriculture plays a vital role in the Indian economy and contributes significantly to food security and employment. However, post-harvest losses due to improper drying techniques remain a major issue.

Traditional sun drying exposes products to:

- Dust and contamination
- Uneven heating
- Weather dependency

India receives abundant solar radiation throughout the year, making solar-based technologies highly effective. A solar passive dryer utilizes natural convection and solar heat without requiring electricity, making it ideal for rural applications. This research aims to develop a cost-effective solar dryer that improves drying efficiency while maintaining product quality.

2. LITERATURE REVIEW

Previous studies highlight the effectiveness of solar dryers: **Jaivindra Singh** et al. demonstrated that indirect solar dryers improve drying efficiency and reduce contamination.**Janak Valaki** et al. concluded that solar dryers are cost-effective alternatives to mechanical dryers.

These studies indicate that solar drying systems can significantly enhance agricultural preservation techniques.

3. PROBLEM STATEMENT

Traditional drying methods suffer from several drawbacks:

- Quality degradation due to direct exposure
- High contamination risk
- Uneven drying
- Dependence on weather conditions

Mechanical dryers, although efficient, are:

- Expensive
- Energy-intensive
- Not suitable for small farmers

Therefore, there is a need for a low-cost, eco-friendly, and efficient solar passive dryer that ensures uniform and hygienic drying.

5. OBJECTIVES

To design and fabricate a solar passive dryer.
To improve drying efficiency and reduce drying time.
To maintain hygiene and product quality.
To utilize renewable solar energy.
To provide an economical solution for farmers.

5. PROPOSED METHODOLOGY

5.1 Literature Survey

Study of existing solar drying technologies and identification of limitations.

5.2 Design and Component Selection

Selection of materials (wood, glass, mesh trays)
Design based on heat transfer and airflow principles

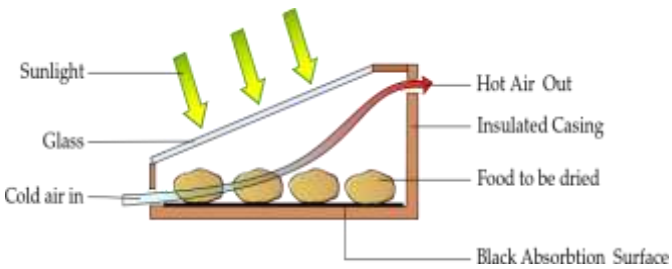

Fig -1: Solar Dryer Concept

5.3 CAD Modeling

3D modeling of the dryer using design software for visualization.

Fig -2: Solar Dryer CAD

5.4 Fabrication

Manufacturing of components and assembly of the solar dryer.

5.5 Testing and Analysis

- Temperature measurement
- Drying performance evaluation
- Product quality assessment

6. WORKING PRINCIPLE

The solar passive dryer works on the principle of:

- Solar radiation absorption
- Greenhouse effect
- Natural convection airflow

Sunlight enters through a transparent cover and heats the air inside the chamber. The hot air circulates naturally, removing moisture from the products and exiting through vents.

7. EXPERIMENTAL DATA

Temperature Observation

At 10 AM: Inside temp = 33°C
At 11 AM: Inside temp = 35°C
At 12 PM: Inside temp = 37°C
At 1 PM: Inside temp = 43°C
This shows a consistent increase in temperature, improving drying efficiency.

8. HEAT TRANSFER ANALYSIS

Area of dryer:
$A = 0.631\ m^2$

Thermal conductivity (wood):
$k = 0.13\ W/m \cdot K$

Temperature difference:
$\Delta T = 316K – 305K = 11K$

Thickness:
$L = 0.005\ m$

Heat transfer rate (Fourier Law):
$Q = (k \times A \times \Delta T) / L$

$Q = 180.46\ W$

7. CONCLUSIONS

The solar passive dryer is an effective solution for agricultural drying problems. It provides **efficient, hygienic, and cost-effective drying** using renewable solar energy.

The system reduces post-harvest losses, improves product quality, and supports sustainable farming practices. It is highly suitable for small and marginal farmers, contributing to rural development and energy conservation.

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