DESIGN AND FABRICATION OF SMART PARABOLIC TROUGH SOLAR FOOD DRYER

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Abstract:

Solar energy is renewable source of energy. Its uses do not contribute to emission of greenhouse gases and other pollutants to the environment. It is sustainable since it cannot be depleted in a time relevant to human race .it is a natural source of drying a food. So, it is always good for human health. It is also used for other applications in which heat is required in automobiles. Solar car in Japan features scope we are studying the temperature variation with respect to time. Heat energy is converted in electrical, mechanical, etc. by using concentrator. A parabolic trough concentrator is made of an aluminium sheet which is covered by a cloth on which rectangular mirror strips.

Keywords: Parabola, absorber tube, Control system, Aluminium mesh, Exhaust fan, Wooden stand

1.Introduction:

With the increasing demand for sustainable and energy-efficient food preservation methods, solar drying has emerged as an eco-friendly alternative to conventional drying techniques. Among various solar drying technologies, the parabolic trough solar food dryer stands out due to its high efficiency in capturing and utilizing solar energy [1].

This system focuses on the design and fabrication of a smart parabolic trough solar food dryer, integrating automated tracking and control systems to enhance drying performance. The parabolic trough design allows for concentrated solar radiation, which improves heat transfer and reduces drying time while maintaining food quality. The addition of smart features, such as automatic sun tracking, temperature regulation, and remote monitoring, further optimizes the drying process [2].

The proposed system aims to:

- Improve thermal efficiency by utilizing a parabolic reflector to concentrate solar energy.
- Enhance drying uniformity and speed with an optimized heat distribution mechanism.
- Incorporate smart sensors and automation to regulate temperature and airflow for better drying control.

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- Provide a cost-effective and sustainable solution for food preservation, reducing reliance on conventional fossil-fuel-based drying methods.

This study will cover the design considerations, material selection, fabrication process, and performance analysis of the smart parabolic trough solar food dryer, contributing to the advancement of renewable energy applications in food processing industries[3].

2.Objectives:

1. To explore technologies that free systems from traditional energy sources.

2. To investigate / built smart solar food dryer heating systems that can be used in any climates.

3.Theory:

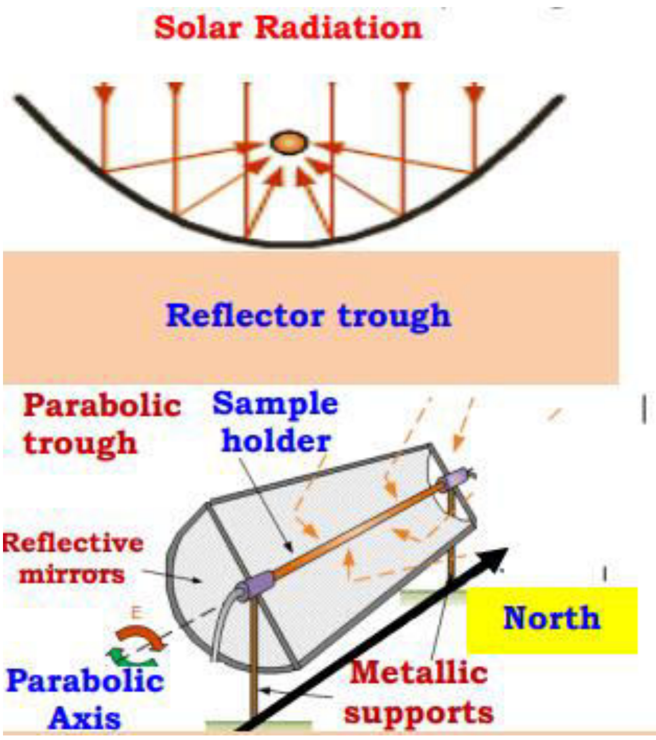


Figure 1. Theoretical setup

The system (**Figure 1 and Figure 2**) operates based on the principle of solar concentration, where a parabolic trough reflector collects and focuses solar radiation onto an absorber tube or a heat exchanger [4]. The concentrated heat is transferred to the drying chamber, where food products are placed for dehydration.

The drying process [5] involves:

- **Heat absorption**: The parabolic trough reflects and concentrates solar radiation onto the receiver.

- **Heat transfer**: The receiver (absorber tube) heats up, transferring energy to the air inside the system.
- **Hot air circulation**: A blower or natural convection moves the heated air through the drying chamber.
- **Moisture removal**: The hot air removes moisture from the food, which is then expelled from the system.

3.1 Components of the System

a. **Parabolic Trough Reflector (Concentrator)**

- Made from reflective materials such as aluminum or silver-coated mirrors.
- Designed to focus sunlight on a linear receiver.

b. **Receiver/Absorber Tube**

- Usually made of metal with a black coating to maximize heat absorption.
- Can be enclosed in a glass tube to reduce heat loss.

c. **Drying Chamber**

- A well-insulated compartment where food items are placed for drying.
- Designed to allow efficient airflow and uniform heat distribution.

d. **Air Circulation System**

- Includes fans or natural convection to ensure hot air flows through the chamber.
- Helps in removing moisture-laden air from the chamber.

3.2 Considerations

- **Material Selection**: Reflectors should have high reflectivity, and the absorber tube should have high thermal conductivity.
- **Parabolic Shape Efficiency**: The focal point should be precisely aligned to maximize solar concentration.
- **Airflow Optimization**: Ensuring sufficient and controlled airflow enhances drying efficiency.
- **Insulation**: Reduces heat loss and improves energy efficiency.

3.3 Drying Performance Analysis

- **Drying rate (kg/h)**: Measures how quickly moisture is removed from food.
- **Efficiency (%)**: Evaluates how effectively solar energy is converted into drying heat.
- **Moisture Content Reduction**: Determines the effectiveness of the drying process.

This theoretical framework [6,7]serves as the basis for designing and fabricating a smart parabolic trough solar food dryer, ensuring optimal performance for food dehydration while maximizing energy efficiency.

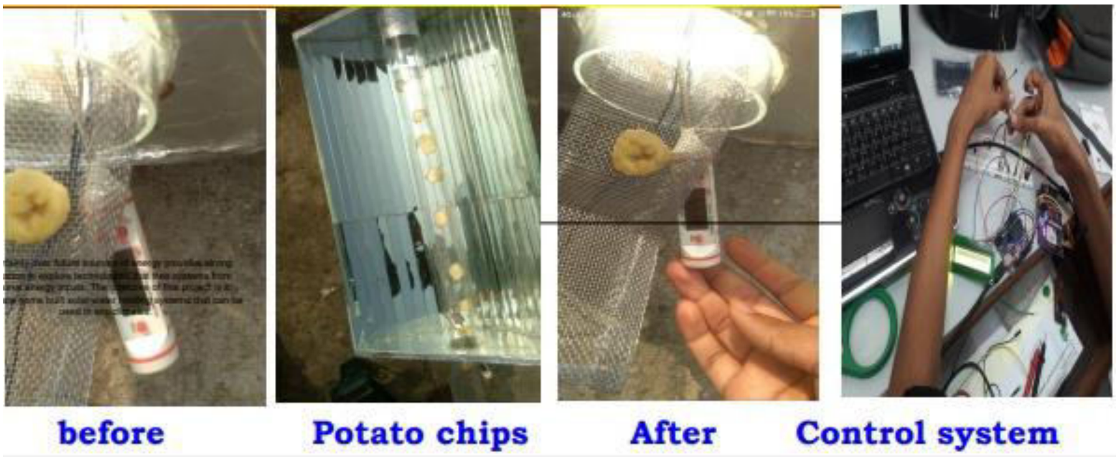


Figure 2. Experimental set up

5. Results and Discussion:

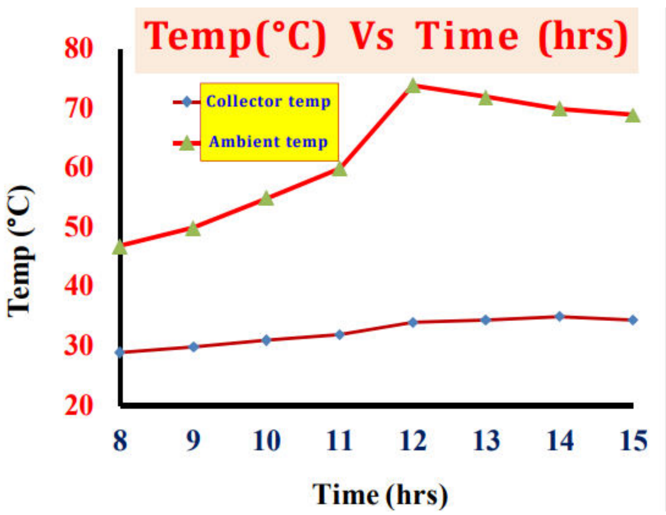


Figure 3. Graphical behaviour of Temperature of the system versus Time (Hours)

5.1. Performance Evaluation of the Smart Parabolic Trough Solar Dryer

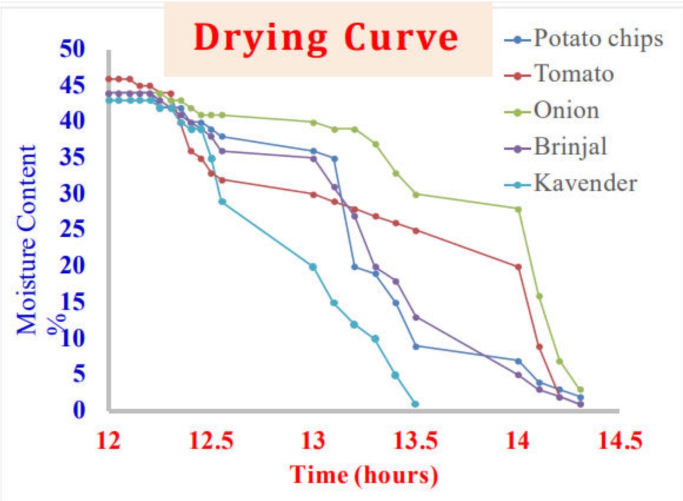
The experimental evaluation of the parabolic trough solar food dryer was conducted under real-time solar radiation conditions. The key performance parameters analyzed included drying temperature, moisture removal rate, drying time, and overall system effectiveness [8-10].

5.2. Temperature Distribution

- The temperature inside the drying chamber ranged from 50°C to 75°C, depending on solar intensity and ambient conditions.
- The absorber tube (receiver) reached temperatures up to 75°C, which effectively heated the air circulating within the drying chamber.

- A comparison with open sun drying showed that the parabolic trough dryer provided more consistent and higher drying temperatures, reducing drying time.

5.3. Drying Time and Moisture Removal Rate



- The drying time (Figure 4) for different food products was significantly reduced compared to traditional solar dryers and open sun drying.

- The parabolic trough solar dryer achieved faster drying rates and higher energy efficiency compared to other methods[11].

5.4. Challenges and Limitations

- Dependence on Weather Conditions: The system's efficiency drops during cloudy days, though thermal storage helps mitigate this issue.

- Maintenance Requirements: Regular cleaning of the reflector surface is needed to maintain high solar reflectivity.

5.5. Future Scope

- The smart integration of sensors and automation has significantly improved the drying process by maintaining optimal conditions.

- Future improvements can include hybrid operation (solar + electric backup) for continuous drying during nighttime or rainy conditions.

- Material optimization can reduce fabrication costs and improve heat retention efficiency.

6. Benefits:

- It can generate much high temperature more efficiently than a single flat plate collector.

- Very little collector adjustment is required during the day resulting in the solar trough always facing the sun at the noon time.

- They are modular, that is individual troughs can be connected together to give a large surface area of absorber.

• In these types of installations, the solar energy trapped by the solar troughs heats a special type of thermal oil to very high temperatures [12-13].

7. Conclusions:

1. From the collected data, in relation with the analysis and discussions, this research project investigation can be concluded that, the fabricated Parabolic trough collector is efficient. As the construction is very simple with locally available low-cost materials, it could be manufactured in educational institute / any workshop.

2. The maximum temperature obtained from Digital temp. was 59.7°C. Due to its low cost and simple technology, it is affordable by the all class of Society.

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