

Eco-Friendly Dry Cloth Chamber – A Solar-Powered Smart Drying System

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Abstract

Drying clothes during rainy seasons, winter months, and in poorly ventilated households remains a persistent challenge, particularly for low-income families. Conventional electric dryers consume high electrical energy, are expensive, and may damage fabrics due to excessive heat exposure. This research presents a moderately advanced, eco-friendly dry cloth chamber powered by solar energy and controlled using smart sensors. The system continuously monitors humidity and temperature using a DHT22 sensor and automatically regulates airflow through DC fans via an Arduino controller. To ensure fabric safety, the system prevents overheating by stopping fan operation beyond a safe temperature threshold. Additionally, a rainwater harvesting mechanism is integrated to promote water conservation and sustainable resource usage. Experimental observations from prototype testing indicate improved drying efficiency, reduced energy consumption, and enhanced hygiene. The proposed solution offers a cost-effective, sustainable, and scalable approach suitable for rural and urban households.

Keywords: Eco Dry Cloth Chamber, Solar-Powered Dryer, Smart Drying System, Humidity and Temperature Control, Sustainable Technology, Renewable Energy

Introduction

Cloth drying is an essential domestic activity that is highly dependent on climatic conditions. During monsoon seasons, winter months, or in densely populated urban areas with limited ventilation, drying clothes becomes difficult and time-consuming. Traditional sun drying methods are unreliable under such conditions, while electric dryers demand high electricity consumption and are often unaffordable for economically weaker sections. Moreover, prolonged exposure to high temperatures in electric dryers can lead to fabric discoloration and reduced cloth lifespan.

With increasing concerns about energy conservation and environmental sustainability, solar-powered domestic appliances have gained significant attention. Integrating renewable energy with sensor-based automation offers an effective solution for reducing energy dependency while maintaining performance. This research focuses on developing a solar-powered dry cloth chamber that intelligently controls internal conditions to ensure efficient and safe drying.

Literature Review

Several studies have investigated solar drying technologies for agricultural products and household applications. Research on solar clothes dryers highlights their potential to reduce electricity usage while maintaining drying effectiveness. Sensor-based drying systems using humidity control have been shown to optimize airflow and drying time. However, many existing designs lack integrated temperature safety

mechanisms and rarely address water conservation. The proposed Eco-Friendly Dry Cloth Chamber improves upon earlier systems by combining humidity-based airflow control, temperature protection, and rainwater harvesting within a single low-cost design.

System Design and Methodology

The proposed system consists of a closed drying chamber, sensing units, control electronics, airflow mechanisms, and a renewable power supply. A DHT22 sensor continuously measures internal humidity and temperature. The Arduino Uno processes the sensor data and controls DC fans through a relay module.

When the humidity level inside the chamber exceeds the predefined threshold, the fans are automatically activated to increase air circulation and accelerate moisture removal. Once the humidity reaches an optimal level, the fans are turned OFF to conserve energy. To prevent cloth damage, the system continuously monitors temperature and disables fan operation when the internal temperature approaches 60°C.

The entire system is powered using a 12V solar panel connected to a rechargeable battery, ensuring uninterrupted operation even during low sunlight conditions. A rainwater harvesting unit is integrated into the chamber structure to collect rainwater from the slanted roof surface. The harvested water can be reused for cleaning and maintenance purposes, reducing dependence on fresh water resources.

System Components

- Arduino Uno microcontroller
- DHT22 temperature and humidity sensor
- 16x2 LCD display with I2C interface
- 12V DC fans for airflow control
- Relay module for fan switching
- 12V solar panel and rechargeable battery
- Dry cloth chamber enclosure
- Rainwater collection pipe and storage tank

Results and Discussion

Prototype-level testing was conducted under varying environmental conditions. Compared to natural indoor drying, the proposed system significantly reduced drying time due to controlled airflow. The humidity-based automation ensured efficient operation without continuous power consumption. Temperature monitoring successfully prevented overheating, thereby protecting fabric quality. The use of solar energy eliminated grid electricity costs, while rainwater harvesting contributed to water conservation. Although the results are qualitative, the observed performance indicates strong potential for practical household deployment.

Conclusion

This study presents a moderately advanced, eco-friendly dry cloth chamber that combines renewable energy, sensor-based automation, and sustainable water management. The system effectively addresses common cloth drying challenges while minimizing energy usage and environmental impact. Its low cost, simplicity, and safety features make it suitable for widespread adoption in both rural and urban settings.

Future Scope

Future enhancements may include Internet of Things (IoT) integration for remote monitoring, adaptive control algorithms for improved efficiency, mobile application interfaces, and scaling the design for community-level or institutional use.