IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 21, Issue 5 Ser. 1 (Sept. – Oct. 2024), PP 31-37
www.iosrjournals.org

Drying Behaviour Investigation of Solar Dryer Using Polythene

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Abstract
Air is heated and any food item can be dried using the solar drying method, which also uses biomass energy. Drying aids in the preservation of agricultural products while reducing wastage. A solar-biomass hybrid dryer was consequently created to address the drawbacks of natural sun drying, including exposure to direct sunlight, risk of pests and rodents, inadequate supervision, and higher costs associated with mechanical dryers. In this project, a portable hybrid dryer is designed and built. It consists of a biomass combustion chamber integrated with a sun drying chamber that holds a rack of three trays.
Through the air inlet, air is supplied into the solar chamber, where it heats up and is used for drying (i.e., removing moisture content from the food ingredient or agricultural product loaded). It is a solar and biomass-based hybrid drier since drying is continued using biomass energy when solar energy is not available. Pune is the design's geographic location, and climatic data were gathered to ensure appropriate design specifications. Glass, mild steel metal bars, acrylic sheets, aluminum foil, and aluminum fabrication material for the trays were among the locally accessible materials utilized in the construction.

***Keywords**: Biomass, Solar dryer, Solar plate, Sensor*

Date of Submission: 18-09-2024 Date of Acceptance: 28-09-2024

I. Introduction

The complex process of drying involves mass and heat transmission at the same time. A number of variables, including the product's beginning and ultimate moisture contents, drying air temperature, relative humidity, and velocity, affect how much energy is needed to dry a given product [1]. In order to optimize the drying process and construct effective dryers, a number of mathematical models explaining the drying behavior of various food ingredients have been proposed.

Modeling is useful since it saves time and money when trying out various goods and drying system setups on a large scale. The conventional natural sun drying process needs to be replaced with contemporary drying techniques in order to increase the quality. To raise the caliber, the drying properties of particular goods should be identified…

Solar Energy

Solar radiation is the source of energy that can be obtained from the sun. Since ancient times, people have used a variety of constantly developing devices to capture solar radiation and heat. Solar energy technologies can significantly aid in resolving some of the most pressing issues the world is currently facing. These technologies include solar heating, solar photovoltaics, solar thermal electricity, and solar architecture. One of the simplest and cleanest ways to access renewable energy is through solar energy, which is widely available.

The way solar technologies capture, transform, and distribute solar energy determines whether they are classified as passive or active solar technologies. Utilizing solar thermal collectors with photovoltaic panels to capture sun energy is known as active solar approaches. Designing areas with naturally occurring air circulation, choosing materials with advantageous thermal mass or light dispersing qualities, and aligning buildings with the Sun are examples of passive solar approaches.

Solar Dryer

In fact, solar drying [2] technology has developed as a means of resolving the issues related to open sun drying. Although the precise date of its discovery is unknown, sun drying saw a major increase in interest and development during the 1973 oil crisis. The problem spurred research into renewable energy sources for a range of uses, such as fish and grain drying, which resulted in the creation of sun drying devices.

Direct Solar Dryers

Sun dryers that are direct in their design are the most basic and often used kind.

The drying material is directly heated by sunlight through a transparent cover on an enclosed chamber. By removing moisture from the material, the hot air within the chamber dries it out. Fruits, vegetables, harvests, and other agricultural items can all be dried using direct solar dryers…

II. Literarture

When designing, completing, and specializing the sonal panel, the information found in literature review papers is crucial. The review's sources are books, websites, and periodicals that have been gathered or examined.

Sharma et al. [3] explored various types of solar dryers, their design, development, and performance for different products. It emphasized the need for different drying environments based on the specific product. From this research paper we got an idea about how dryer should be work. By taking reference of this research paper, we covered inner area of Air collector and drying chamber by aluminum sheets which purpose is to reduce loss of heat. This will affect the efficiency of drying process. Here for maintenance of constant temperature electric heater and solar energy used simultaneously similarly we used this theory for our dryer by automate it by IOT circuit for maintaining same or constant temperature. Redha Rebhi et.al. [4] studied provides a concise summary of a comprehensive literature review on solar collectors and heat exchangers. The review incorporates experimental and numerical studies with different geometries and hypotheses. Traditional and innovative approaches to forced thermal transfer are explored, specifically in solar receivers and heat exchangers. The analysis considers parameters like wind speed, solar radiation intensity, and wall types. The study reveals suboptimal thermal performance due to low convective heat transfer, but the introduction of rib roughness improves heat transfer coefficients. The document highlights diverse applications for solar collectors and heat exchangers, including cooling electronic components, house heating/cooling, transpiration cooling, food drying, and cold storage, showcasing their versatility and potential benefits across various industries. Melike Sultan Karasu Asnaz et.al. [5] explored Solar drying is an effective method for preserving food, providing high-quality dried products regardless of seasonal variations. A study investigated the effects of slice thickness and pretreatment on mushroom drying using different solar dryers. Key findings include the reduced drying time with pretreatment in natural and forced convection dryers, while heat pump dryers showed no significant difference.

Suresh Bade Venkata et.al [6] found valuable insights into the design and manufacturing of a fruit solar dryer. Through a comprehensive study, the challenges, risks, and recommendations associated with its production have been identified. Manufacturing a solar dryer poses challenges such as intricate design considerations, material selection, and ensuring optimal energy efficiency. Risks can include equipment malfunctions, quality control issues, and potential cost overruns. To address these, recommendations encompass implementing robust safety measures, conducting thorough quality checks, and optimizing energy utilization. By heeding these insights during the manufacturing process, potential obstacles can be effectively tackled, risks mitigated, and the fruit solar dryer can be produced with enhanced performance, reliability, and sustainability. Lakshmi D. V. N., P. Muthukumar et.al. [7] focused on developing a mixed-type solar dryer. In line with the findings, we integrated an IoT-based data acquisition system into our design. This system enables us to accurately monitor temperature and humidity levels at various locations within the dryer. By utilizing IoT technology, we can collect real-time data and make informed decisions regarding the drying process. This integration enhances the efficiency and control of our project, allowing us to optimize the drying conditions and ensure the desired quality of the dried products.

III. Materials And Methods

Potato in cylindrical shape Low cost material (polyethylene) with high rigidity and long life has been used for construction of a solar dryer at the Department of Food Processing, Faculty of Engineering, Elimam El Mahdi, Sudan 2010. The metallic frame structure of dryer has been covered with polythene sheet. The polythene tent has a height of , in 2010 175 cm, top length of 180 cm and bottom length of 200 cm to fit over a metallic frame. The opening serves as air inlet into the solar tent and another, was made to serve as outlet of the hot air from the dryer. The frame work of the polythene tent is shown in Fig. (1).

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Fig (1)
Weight for potato

Fig (2)

Blower in hot air exhust

Fig (3)

Temperatura Sensor

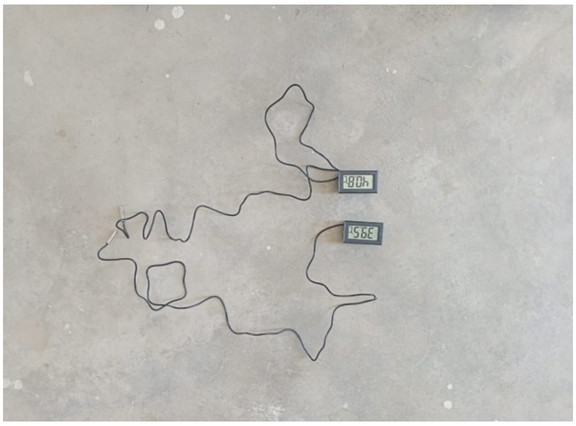


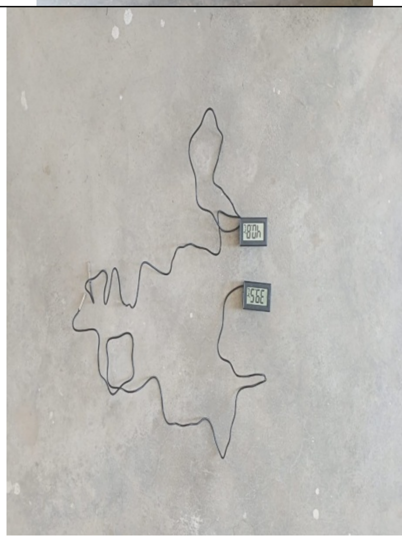
Fig (4)

Solar plate

Fig (5)

Model and Actual model of Force Circulation Solar Dryer
Major Components of Forced Circulation Solar Dryer-

Components	Description	Diagram
Collector	The solar dryer is composed of a solar collector [8] that absorbs solar radiation and transforms it into heat. Solar collectors are usually constructed of reflective materials like plastic or black metal. The collector's design aims to reduce heat loss and enhance sunlight absorption.	
Drying Chamber	The products that need to be dried are placed in an enclosed area called the drying chamber[9]. It is made to give the products as much exposure to sunlight and hot air as possible.	
Blower	Blowers[10] sometimes referred to as fans, are frequently used in solar dryers to improve airflow inside the drying chamber and speed up the drying process. Blowers facilitate faster drying, more equal heat distribution, and moisture removal from the material to be dried. They are essential for raising the effectiveness and efficiency of solar drying systems.	

		
Solar Plate	A solar panel can be incorporated into a hybrid solar dryer as part of the system to produce electrical energy from solar radiation. The dryer's numerous parts, including blowers, control systems, sensors, and, if needed, an electric heater, can all be powered by this electrical energy. The drying process is more flexible and dependable when solar energy and electrical energy from the solar panel are combined.	
Sensor	A solar dryer system must have temperature and humidity sensors[11] since they give vital information for observing and managing the drying process. These sensors assist in preserving ideal drying conditions, guaranteeing the integrity of the product, and averting problems like moisture retention or over-drying. A solar dryer's temperature and humidity sensors allow users to precisely monitor and regulate the drying environment and make modifications as necessary to maximize the process. This facilitates effective drying, guards against spoiling, and guarantees the creation of dried goods of the highest caliber. We employ Invento DHT 22 Humidity and Temperature Sensors. A well-liked temperature and humidity sensor made by Invento is the DHT22 sensor, sometimes referred to as the AM2302. It is frequently employed in numerous applications that call for precise environmental condition monitoring. The following details pertain to the DHT22 humidity and temperature sensor:	

Design Process

It seems like to provided a description of the fabrication process for your IoT-based force circulation solar dryer. Here is a summary of the steps you mentioned:

1) **Material Selection:** For our dryer, we determined that a 20 mm square bar would be the best material.
2) **Cutting:** Using a hacksaw blade, we cut the bars into the small, necessary portions.
3) **Base Frame Fabrication:** Arc welding was utilized in the fabrication of the foundation frame for the air collection and drying chamber.
4) **Finishing:** Following the fabrication process, a manual grinder was used to remove surplus material from the frames.
5) **Acrylic Sheet Installation:** Acrylic sheets were cut to the right size for the collection and drying chamber frames, and then attached onto the base frames.
6) **Chamber Assembly:** The drying and collection chambers were assembled, positioned, and three-hole passes were made for fastening.
7) **Airflow Holes:** Seven holes were drilled into the acrylic sheets: two for the blowers at the beginning, three for air flow on the collection and drying chamber, and two for the air outlet at the top of the drying chamber.

8) **Glass Fitting:** For the air collector to collect sunlight and provide a greenhouse effect, a separate frame for the glass fitting was built. Sliding door flag hinges were used to attach it.
9) **Heater Installation:** The heater was put in place on the side and in the proper location of the collector.
10) **Solar Plate Fixing:** Screws were used to secure a solar plate to the drying chamber's top.
11) **Net Attachment:** The top of the drying chamber had two air outlet openings, to which a net was fastened.
12) **Battery and IoT Circuit Placement** To house the battery and Internet of Things circuit, a tiny, stationary frame was made and welded to the collection frame.
13) **Wheels Addition:** To enable simple mobility, wheels were attached to both frames.

IV. Observations

Observation Table for 8 mm diameter sample

Specification: Diameter of potato sample is 8 mm and length 5 cm.

S. No.	Time	Weight of Tray 1 + potato (in gm)	Controller Box Temp. (°C)	Temp. of Tray (°C)
1	11:35	4174	46.6	50.8
2	11:45	4147	46.8	43.9
3	11:55	4143	49.3	42.3
4	12:05	4122	47.6	45.4
5	12:15	4115	48.8	44.6
6	12:25	4110	51.4	44.9
7	12:35	4100	52.9	47.2
8	12:45	4097	47.9	45.1
9	12:55	4086	48.9	46.3
10	01:05	4080	50.0	42.5
11	01:15	4078	51.0	43.2
12	01:25	4076	49.3	42.5
13	01:35	4071	50.1	57.2
14	01:45	4067	51.6	52.5
15	01:55	4062	52.4	56.2
16	02:05	4058	50.5	54.9
17	02:15	4055	52.5	49.8
18	02:25	4051	50.6	52.2
19	02:35	4049	52.7	57.2
20	02:45	4047	49.8	55.4
21	02:55	4045	52.5	54.8
22	03:05	4043	50.2	56.2
23	03:15	4041	50.9	55.9
24	03:25	4041	52.3	55.6
25	03:35	4041	48.9	54.8

V. Result

Using a solar dryer to dry papad can be a sustainable and successful solution. By using the sun's light, solar drying allows papads to be preserved for extended periods of time by removing moisture from them.

In certain areas, a popular technique for making homemade potato chips involves sun-drying the chips. The weather has a big influence on sun drying. To help with the drying process, the weather needs to be warm, dry, and sunny. The drying period may be greatly extended by overcast, muggy, or wet conditions. Sun drying typically takes longer than other drying techniques, such as using a dehydrator or solar dryer.

The time may differ according on the weather, and it could take a few days to a week for the chips to fully dry. The potato chips may dry unevenly if they are sun-dried. Certain chips may dry more quickly than others depending on variables such the strength of the sun, airflow, and where the chips are placed.

Potato chips [12]are gently dried in an environment created by solar dryers. While lowering the possibility of over-drying or burning, the low and steady temperatures of a sun drier can help maintain the chips' original flavors and colors.

Potato chips that have been dried in a solar dryer can produce goods of excellent quality. The potatoes' texture, flavor, and nutritional content are all preserved in the regulated drying atmosphere. Snacking can be made healthier by lowering the possibility of chemical additions or preservatives thanks to solar drying.

When food is dried outside, it is exposed to the elements and might become contaminated by dust, insects, birds, or other animals. Renewable solar energy,[13] which is freely and abundantly available, is used by solar dryers. You can dry potato chips without using traditional electricity by using the sun's energy, which is both economical and environmentally beneficial.

Potato chips from a solar dryer can last longer if they are properly dried and preserved. The chips can be kept in storage for a longer amount of time since the low moisture level attained through solar drying prevents microbiological growth and helps avoid spoiling.

VI. Future Scope

Force circulation solar dryers with Internet of Things capabilities can save and analyze data via cloud connectivity. This makes it easier for various stakeholders, including farmers, academics, and agricultural cooperatives, to share data. It is possible to develop best practices, group insights, and ongoing drying procedure improvement [14] through collaborative data analysis. A crucial component of any technological development is safety. Upcoming solar dryers might come equipped with sophisticated safety features like defect diagnosis capabilities, emergency shut-off mechanisms, and fire detection and prevention systems.

The drying system, the surrounding area, and the workers will all be protected thanks to these precautions. Artificial intelligence and machine learning algorithms may be used in future designs to create intelligent control systems that maximize drying times. In order to automatically modify factors like temperature, airflow, and drying period, these systems may analyze data from a variety of sensors, weather forecasts, and previous patterns. More accurate and reliable drying outcomes may result from this degree of automation.

VII. Conclusion

In terms of drying rate and efficiency, forced convection solar dryers[15] outperform traditional drying techniques. When forced convection is used instead of more conventional techniques, drying can be accomplished much more quickly and efficiently. It is imperative to acknowledge that the length of drying is contingent upon the characteristics of the product being dried as well as the nature of the application. our forced circulation solar dryer's incorporation of Internet of Things (IoT) technology. This integration enables accurate regulation and upkeep of particular temperature parameters according to the needs of the object being dried.

We are able to remotely monitor and modify the drying process by utilizing IoT capabilities, which guarantees ideal conditions and boosts total efficiency. Our paper's adaptability is one of its main benefits. Our solar dryer is a versatile and adaptable solution for a range of businesses because it can be used to dry a broad range of materials. This flexibility results from the capacity to modify drying conditions to meet the unique requirements of various products, hence increasing its possible uses. Furthermore, portability and user-friendliness were key design considerations for our solar dryer. It is practical for setup and movement to various locations due to its small size and simplicity of handling.

Because of this accessibility, it can be used in a variety of circumstances, such as isolated locations where access to traditional drying techniques may be restricted.

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