iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IV Month of publication: April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69204

# Design, Optimization and Analysis of Electric Heat Drier

Ajit Burade[1], Swapnil Chaudhary[2], Dr. Vijayashri Mohobiya[3]
[1]*Student of MTech CAD/CAM Mechanical Engineering Department, WCEM, Maharashtra, India*
[2, 3]*Assistant Professor, Mechanical Engineering Department, WCEM, Maharashtra, India*

***Abstract: The utilization of solar energy for food drying has long been a method of food preservation. Regrettably, certain methods that are implemented in rural areas have resulted in numerous drawbacks, including the inferior quality of the food that is produced and the extended drying time that is a result of numerous external factors. The Electric Powered Air Dryer is a novel technology that is derived from the combination of electric and thermal energy. The electric heater is employed in our endeavor to convert electric energy into heat energy through the use of a blower. We introduce the electric air dryer machine in our project for the primary purpose of dehydrating seeds, fruits, and other items with high moisture content. In our endeavor, the electric air dryer comprises four primary components: a blower, heat sensing element, 12v adapter, and electric heater. The blower is designed to transport heated air to the designated location, thereby eliminating the moisture content of the area. Additionally, our product is portable in size. Therefore, it is effortless to relocate the ground dehydrator to any location. This report includes a background on the project, with the first chapter introducing the topic of drying and our endeavor. The literature review is the subject of the second chapter. Chapter three comprises drier descriptions. The fourth chapter delves into the design of the dryer, while the fifth chapter provides an analysis of the dryer. The final chapter comprises references, while the sixth chapter compares conventional drying.***
***Keywords: Cad model, analysis, solid works, Drying Rate, etc.***

## I. INTRODUCTION

Energy is the primary measure of all kind of work by human beings and nature. Everything happening in the world is the of flow of energy in one of its forms. Over the last 200 years, people have become more and more dependent of the energy that they dig out of the ground. In 1700's almost all our energy came sources like wind, water, firewood. Our windmill and sailing ships were powered by wind. Water powered our water wheels. Cooking and heating of our homes were done using firewood. Man power did just about everything else. All these energy source came from sun since Electric energy drove wind and rain, grew trees and grew crops to nourish our animals and ourselves. All these energy sources are also renewable since wind kept blowing river kept flowing and the trees and the crops kept growing. By 1800, we get much of our energy from the coal dug out from the ground and by 1900; we began to drill for oil and natural gas. By 1950, this fossil fuel had mainly displayed the older energy sources. Some fuels like fossil fuels come from decayed remains of prehistoric plants and the animals, so their energy also comes originally from sun, in some parts of the world, new fossil fuels are being formed even today.

## II. LITERATURE REVIEW

Prashant Rewatkar, Mahesh Bawate, Chetan Metangale have done an experiment on the Electric drying process for the drying of the various commodities and resulted that Electric drying of various products is one of the most important potential applications of the Electric energy. In developing countries, such drying exercises are being carried out using conventional drying methods. But these methods are trapped with some severe drawbacks and cause loss of the products during their drying which is estimated to be 25–40% of the total production in developing countries. The best alternative to overcome the problems of traditional drying methods is the development of Electric dryers. Lalit M. Bal, Santosh Satya, S.N. Naik developed efficient and effective dryer using Electric energy with thermal energy storage system for drying of agricultural products at moderate temperature (40–75 8C) and has become a substitute for fuel in many developing countries. Storage of Electric energy has the power to reduce the time between supply of energy and the demand of energy, hence playing a great role in energy conservation. The rural and urban populations depend mainly, on fuels which are non-commercial to meet their energy needs. Electric drying is one possible solution but its acceptance has been limited partially due to some difficulties.

A great deal of experimental work over the last few decades has already shown that agricultural products can be dehydrated using Electric energy A.G.M.B.Mustayen, S.Mekhilef, R.Saidur presented a paper on the study on the design, performance, and application of different types of Electric dryers. The types examined are the direct, indirect, mixed-mode, active, and passive Electric dryers. It is performed either using fossil fuels in an artificial mechanical drying process or by placing the crop in the presence of direct Electric rays. The first method is costly and has a negative impact on the environment, while the second is completely depending on the climate. By contrast, using a Electric dryer is comparatively cheaper and more efficient. Some Electric dryers run without electrical energy or by the usage of fossil fuels.

## III. COMPONENTS AND DESCRIPTION

The components that are used in the **project ELECTRIC AIR DRYER** are as follows,

1) Electric coil,12-volt Adapter,
2) DC blower,
3) Frame,
4) Drying container.
5) 7sigma digital thermometer

## IV. WORKING

1) Heat Generation & Transfer
2) An electric heating element generates heat.
3) Heat is transferred through conduction, convection, or radiation to the drying chamber.
4) Air Circulation & Moisture Removal
5) A fan circulates hot air to ensure uniform drying.
6) Moisture evaporates from the product and is vented out efficiently.
7) Temperature & Humidity Control
8) Sensors monitor and regulate temperature & humidity.
9) Automated controllers optimize drying conditions for efficiency.
10) Energy Optimization & Safety Features
11) Thermal insulation prevents heat loss, improving efficiency.
12) Overheat protection & smart shut-off ensure safety and durability

## V. DESIGN OF ELECTRIC DRYER

The system is to be designed considering certain design parameters components wise and is fabricated with design specifications. The main components are blower, a Electric heater, and a drying chamber. The fabrication is done as per the design values and available materials in mechanical and welding workshop. The fabricated components are tested to check the operation and errors in design or fabricated which may damage the system; design of each component is explained below.

Material to be dried: handmade paper of A4 size (21.0×29.7) cm

Moisture content in wet sheet = 50% = 0.5

Moisture content to be obtained after drying = 7% = 0.07 Number of papers to be dried at a time = 20

Weight of 1 wet sheet, M =22g = 0.022 kg

Amount of moisture content to be removed from wet sheet,

$$Mm = (Wet\% - Dry\%) / (100\% - Dry\%) \text{ kg}$$

$$Mm = 0.022 \times (0.5 - 0.07) / (100\% - 0.07) \text{ kg}$$

$$Mm = 0.01 \text{ kg}$$

Therefore, we have to remove 0.01 kg of water from 1 paper in order to get the required value-added product.

The amount of heat required to remove the moisture content for 1 paper is given by,

$$QR = Mmhfg + Mmhf$$

Where, hfg= Specific enthalpy of water at latent heat of evaporation,

hf = Enthalpy of water,

At 100°C, hfg= 2256.4 kJ/kg, hf = 419.17 kJ/kg,

Therefore,

QR = Mmhfg+Mmhf
= [(0.01×2256.4) + (0.01×419.17)]
QR = 26.76 kJ of heat for drying 1 paper
That is, rate of energy Q = (26.75×1000) / (60×60) J/s
Therefore, Q for drying 20 papers in 1 hour = 7.4 × 20 = 148 W
Q = 7.4 W
Where
ṁ = Mass flow rate of air through the blower
Here, ṁ = Volumetric flow of air × Density of air = v × ρ
Where, ρ of air = 1.225 kg/m3
Therefore, above equation becomes, Q=Cp × v × ρ × ΔT
For drying 20 papers, (26.76×20) / (60×60) kJ/s
= 1.005×v×1.225×20

Therefore, Volumetric flow rate, $v = \frac{(26.76\times20)}{(60\times60\times1.005\times1.225\times20)}$
= 0.006 m3 /s
= 0.006×60

Therefore, v = 0.36 m3 /min
Drying chamber design
Our requirement is to dry 20 papers of A4 size in 1 hour.
As per our assumption, a chamber of 1.5 feet in length, breadth and height can accommodate 12 papers at a time to dry.
Therefore, if for 12 papers, chamber size is as said above, that is 0.45m in length, breadth and height, then for drying 20 papers of A4 size at a time,
Chamber size = (0.45 /12 × 20) × (0.45/ 12 × 20) × (0.45 /12 × 20)
= 0.75m × 0.75m × 0.75m
After adding enough space for air circulation, chamber size was decided as 0.9m × 0.9m × 0.9m.

## VI. ANALYSIS

At each hour starting from 9.00 AM to 5.00 PM various parameters tabulated below were noted. With the results obtained comparison between drying of paper using solar dryer and open sun drying were done.

### A. *Analysis with Paper*

It looks like you need help refining or organizing this text. Here's a clearer version with improved structure and readability:
Initially, the A4 sheets were weighed, and their weight was recorded as 22 grams. The sheets were then placed inside a drying chamber for the drying process. Testing was conducted four times a day to monitor the drying efficiency.
As per the design specifications, the drying process should be completed within one hour. To evaluate this, a set of 20 sheets was placed inside the drying chamber at different intervals throughout the day:

- 9:00 AM – First set of papers
- 11:00 AM – Second set of papers
- 1:00 PM – Third set of papers
- 4:00 PM – Fourth set of papers

For each set, measurements of inlet and outlet temperatures, as well as volume flow rate, were taken at three different time intervals:

1. At the time of placement in the chamber
2. After 30 minutes
3. After 60 minutes (completion of the drying process)

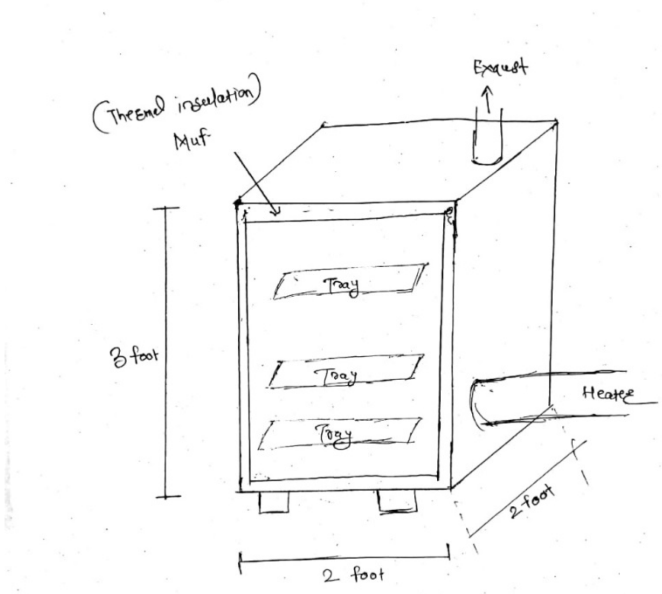
Observations were carefully recorded during each stage of testing, and company experts were present to ensure accuracy. It was noted that atmospheric conditions influenced the duration of the drying process.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue IV Apr 2025- Available at www.ijraset.com*

### *B. Comparison With Normal Drying*

A comparison between the drying of the papers using the Electric dryer and open sun drying was carried out in the company by the company experts. A set of 20 sheets were kept for drying in the solar dryer at 9.00 AM. At the same time another set of 20 similar A4 sheets were kept for normal drying. The normal drying includes the sun drying and drying by-hanging sheets under a fan.

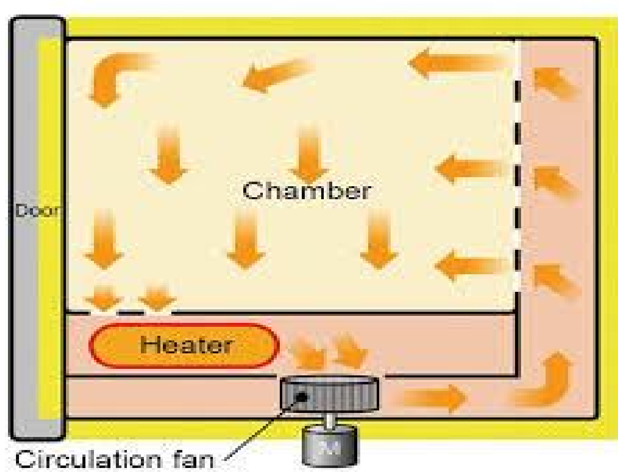
### *C. First Model of the Dryer*




## VII. COMPARISON OF RESULTS

A comparison of solar drying with normal drying was performed in the company. Two sets of A4 sheet with each 20 sheets were kept for drying in solar dryer as well as in open sun drying at 9.00 AM. The papers kept in the solar dryer got dried in 70 minutes and the papers were taken out from the chamber at 10.10 AM but the papers that were kept for open sun drying got dried after one day. On the next day at 10.00 AM the papers were removed after drying. The final weight of the papers in both case were found similar. Thus the solar dryer was found to be more effective than the open sun drying since the duration of time taking was much lesser when using the dryer.

### *A. Temperature Distribution Inside Drying Chamber*



## VIII. FUTURE SCOPE

1) Energy Efficiency Enhancements
2) Development of smart control systems for optimized power consumption.
3) Use of renewable energy sources like solar-assisted electric dryers.
4) Material & Structural Improvements
5) Integration of advanced heat-resistant and insulating materials.
6) Lightweight and portable designs for wider usability.
7) Automation & IoT Integration
8) Incorporation of AI and IoT for real-time monitoring and adaptive drying processes.
9) Remote control and automation for increased efficiency.
10) Cost Reduction & Sustainability
11) Research on low-cost manufacturing techniques for affordable dryers.
12) Eco-friendly innovations to minimize carbon footprint.
13) Industrial & Agricultural Applications

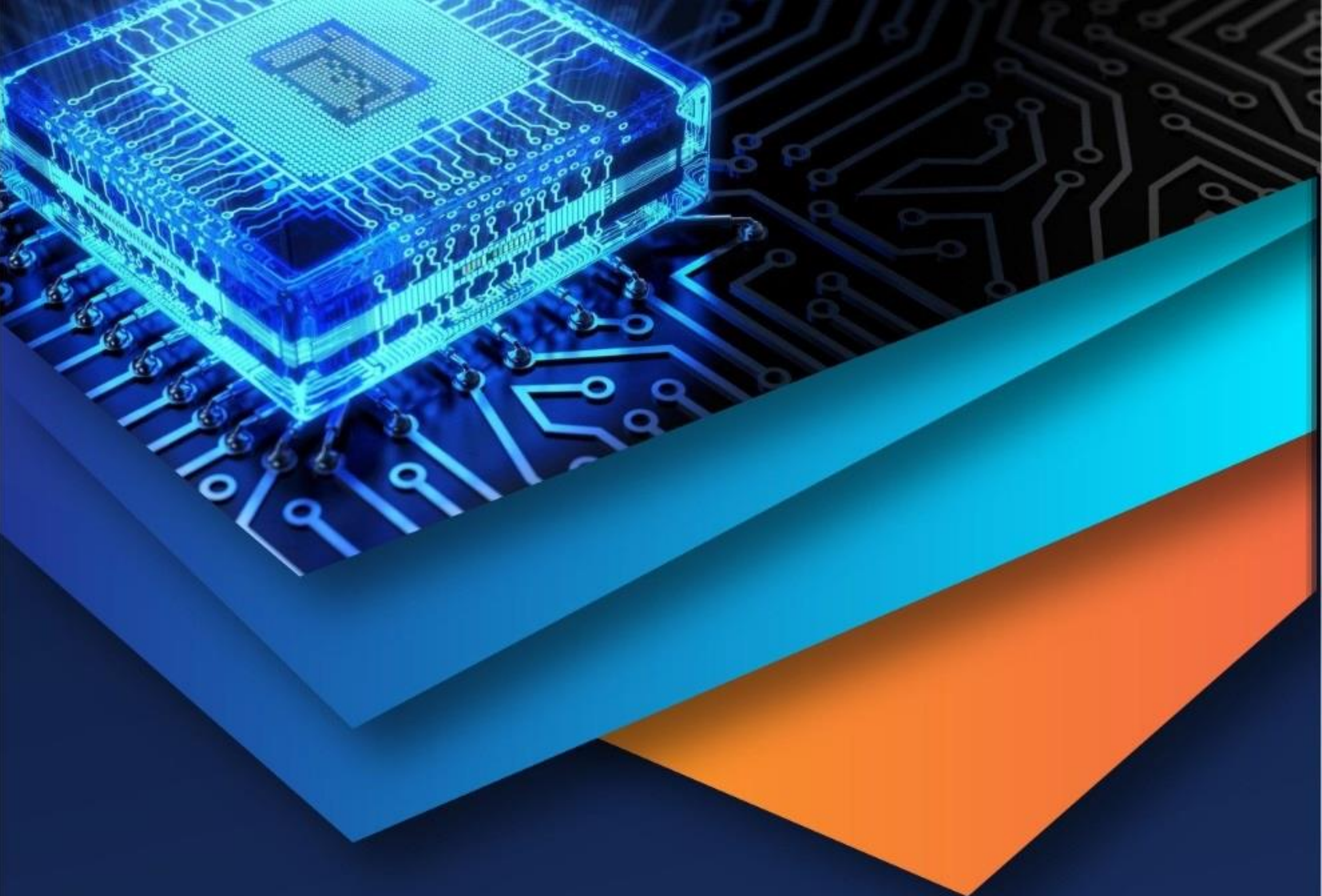
Expansion into large-scale industrial drying systems.
Customized solutions for different agricultural and food products.

## IX. CONCLUSION

The dryer was built to run one hour drying twenty A4 sized papers. Results came from the design, fabrication, and analysis done. The dryer dried the paper in 65 to 75 minutes; the open drying took one day to dry the same quantity of papers. The general quality of the paper was determined by the atmospheric circumstances. Larger the intensity of electric energy, the efficiency of the electric dryer will be more. Since the dryer's construction cost is reduced, it allows a better hand over the traditional electric dryer. Comparatively to the typical sun drying, the electric drying was rather efficient and the drying time was quite reduced utilizing the electric drier. Making several design changes will help this technology to be developed and improve the efficiency of drying.

## REFERENCES

[1] Lawand TA. A Solar cabinet drier. Solar Energy 1960; 10:4.
[2] Bhatia AK, Gupta SL. Solar drier for drying apricots. Research and Industry, India 21 (3): 188±191. 197
[3] Islam MN, Flink JM. Dehydration of potato: 1. Air and Solar drying at low air velocities. JFd Technol 1982; 17:373±85.
[4] Kalrg SK, Bhardwaj, Use of simple solar dehydrator for drying fruits and vegetable products, JFd Sci 18:23±29.
[5] Yanlai Z, Minglong Z, Hong Z, Zhandong Y. Solar drying for agricultural products in china. In: Proceedings of international conference on new technology of agricultural engineering; 2011.




10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429


# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY