Design and Fabrication of Petal Drying System (Air Drying)

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Abstract- In recent year every industry has revolutionized and productions are to be completed in lesser time than usual. For this purpose, every industry is focusing on obtaining an artificial way to complete natural phenomena in an artificial environment. This research presents design and fabrication of a petal drying system especially for rose petals, which is designed to dry petals efficiently and quickly, with an approximate drying time of 35 to 55 minutes. The system has various states according the temperature inside the chamber and The dryer's control system is implemented using an Arduino microcontroller and the includes an LCD screen for temperature and humidity monitoring. The system's virtual modeling is done using SolidWorks (for Structure Modelling) and Proteus (for Circuit Modelling). The system outperforms in terms of weight reduction, moisture content removal and maintaining the color and fragrance of the dried rose petals.

Keywords- humidity, rose petals, temperature, time, weight reduction.

I. INTRODUCTION

More advancements in life brings you to the edge of more problems in life. Our lives became more and more complex due to the advancements in technology. Because of technology we are able to solve problems in everyday life that's how our lives became very much fast and reliable.

Various natural phenomena happen every second. These phenomena are actually for our own good and plays an important role in keeping this world stable for us. We always learn from such situations and try to replicate those phenomena under our comfort level to get all those advantages in such place where those phenomena don't occur naturally. Air drying of rose petals is a traditional method of preserving them but is time-consuming and lacks consistency in the drying process [1]. People generally arrange all those conditions for such natural phenomena for example airflow, temperature, humidity so the productivity and the advantages can be obtained in such an environment where these phenomena don't occur naturally.

"Flower drying can be improved by controlling the temperature, humidity, and airflow in the drying chamber" (Roh et al., 2020) [2]. One of those phenomena is the dryness of plants and flowers in an outside environment, where there is heat and natural air flow due to which the flower Petals dries consuming a lot of time. Nejatian et al. (2018) focused on modeling the drying kinetics of red roses (Rosa damascena) under different drying conditions (Nejatian et al., 2018).[8] Also, there is no surety of the weather conditions such as it may be raining or there is no air flow outside or maybe there is overcast weather conditions or in such areas where there is snowfall for the whole year. Traditional air-drying methods of rose petals have been found to have limitations, such as uneven drying and loss of essential oil compounds [3].

If we talk about Sundari at el [4], they made a custom chamber for drying flowers. They obtained project efficiency of about 85% but in this experimental set of everything is manual also the temperature control is also manual there is no real time monitoring system.

II. LITERATURE REVIEW

Traditional Drying Methods:

The mechanisms of petal drying have evolved over time from traditional air-drying and sun-drying methods to modern microwave-drying, freeze-drying, and vacuum-drying methods. "The use of natural drying methods, such as sun drying, can lead to loss of color and quality in flower petals, but can be improved with proper pre-treatment and storage" (Ghimire et al., 2018).[7] Each method has its advantages and disadvantages, and the choice of method depends on the type of petals being dried, the desired end product, and the available resources. Some of the common traditional drying techniques include:

Air Drying: Air-drying is the most traditional and straightforward method of petal drying, where the petals are spread out in a single layer on a flat surface and left to dry naturally in a well-ventilated area. This method is suitable for flowers with thin petals, such as rose and lavender, and can take several days or even weeks to complete. "Air drying is the most common method for flower drying, but it can lead to loss of color and shape in the petals" (Amin et al., 2018) [5].

Microwave Drying: Microwave-drying is a modern and faster method of drying petals. It uses microwaves to heat up the petals and remove moisture. This method is suitable for flowers with thicker petals, such as sunflowers and marigolds, and can be completed within a few minutes to an hour.

Freeze Drying: Freeze-drying involves freezing the petals and then removing the moisture through sublimation. This method is suitable for delicate and fragile flowers, such as orchids and lilies, and can preserve the color, texture, and fragrance of the petals better. "Freeze-drying is a promising alternative to air drying for preserving the shape and color of flower petals" (Falcone et al., 2017). [6]

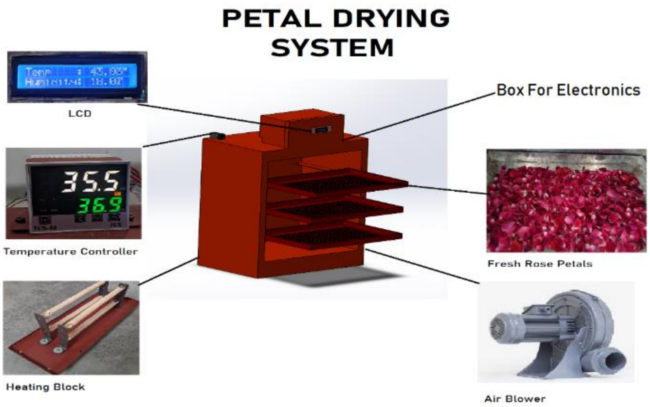


Figure 1. System Model of the Petal Drying System

III. METHODOLOGY

A. *Designing*:

I designed the model of the system in SolidWorks. I created individual components' models and then assembled together to complete the system.

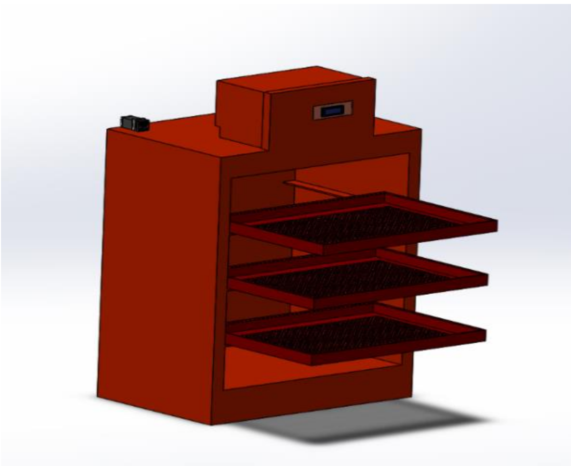


Figure 2: 3d Model of the Drying Chamber

B. *Fabrication*:

The Fabrication phase was completed with the help of Himmel Tech Engineering Solutions. Pvt. Ltd.

For this purpose, I used a 2 by 2-inch iron profile for the frame while a thick 3 mm sheet for the outer body of the system. We placed the Blower fan at back side of the System and connected its outlet directly to a metal box consisting of multiple heating elements. The outlet of the heating block is connected to the inlet of the drying chamber at the bottom.

Figure 3: Fabricated Prototype of Petal Drying System

Furthermore, the three meshed trays can be inserted and removed from the front side using the chamber's door. The humidity and Temperature Sensors are connected below the roof of the chamber near its exhaust outlet. The LCD, Controller, Magnetic Contactor, Temperature Controller and Power Switches are present at the top of the Chamber in a Separate box.

Drying Process:

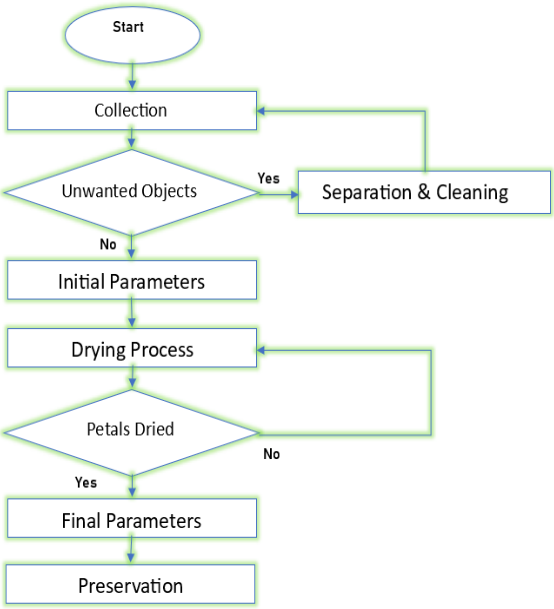
1. Power on the System.
2. Weigh the Fresh petals and place these evenly in the meshed trays.
3. Set the threshold temperature and note down the initial reading of the system parameters (i.e. humidity, temperature, time).
4. When the system reaches state1 *(i.e.* when the system temperature reaches the set temperature for the first time.*)*, then again note down the readings.
5. After 2 degrees drop of temperature the system will again continue in order to maintain the desired temperature.
6. The System will do the same several Times until it reached the desired humidity level.
7. Open the door and take out the Dried Products. (Normally it takes 30 to 55 minutes for one batch of flowers depending upon various moisture levels and initial temperature.)
8. Take out the Dried Petals' trays. Weigh these and find the weight difference.

Figure 4:Finding Initial weight of the fresh Rose Petals.

Figure 5:Finding Initial weight of the fresh Rose Petals.

C. System Working Principle:

- The System works in a way that the blower fan blows air into the heating block. The hot air then passes from heating block into the chamber where it first strikes the third meshed tray and correspondingly passes through the second and first into the exhaust outlet.
- When the hot air passes through the fresh petals it energizes the water molecules and thus resulting in its evaporation.
- This results in the decrease of moisture content in the petals.



Flow Chart 1 Petal Drying System

- The ratio of the temperature, moisture content and air flow are as follows.

$$Temperature\ \boldsymbol{\alpha}\ \frac{1}{Moisture\ Content}$$

$$Temperature\ \boldsymbol{\alpha}\ \frac{1}{Tolal\ Time}$$

$$Total\ Weight\ \boldsymbol{\alpha}\ \frac{1}{Tolal\ Time}$$

$$Total\ Time\ t_t\ \boldsymbol{\alpha}\ \frac{Temperature\ T\ (°C)}{Moisture\ Content\ H\ (\%)}$$

$$Weight\ Reduction, W_r = W_i - W_f$$

$$\because\ W_i = Initial\ Weight$$

$$\because\ W_f = Final\ Weight$$

IV. RESULTS AND DISCUSSIONS

In this section, I present the outcomes of my experiments on the petal drying system. I conducted a total of 14 experiments, through which for some I let the exhaust lid open, while for others I kept the exhaust lid closed which resulted in different readings, focusing on these two distinct statuses – preheated and cold state. The comparative analysis shades light on the systems performance under varying conditions, providing valuable insights for optimizing petal drying process.

The Chamber had two states:

1. For the first experiment of the day the initial temperature was room temperature or cold state of the system.
2. For the following experiments of the day, the chamber's initial temperature was near to state1 temperature or set temp. I named it the preheated state.

The results for both the states of the system are discussed below.

Preheated state Experiments:

- The results for the preheated state were good as compared to the cold state as all the experiments too less time to complete. (i.e., Avg t= 33 min with an average set temperature of Avg T_s=40° C)
- As for the color of the petals the quality was a little degraded with respect to the cold state.
- The humidity level also decreased rapidly because of the constant temperature from start to the end of the process.
- The time take for temperature to reach state1 is less (i.e., Avg t_s= 4 to 5 min for Avg W_i= 52 gm).
- The average weight reduction in this case was good but not better than the preheated state. (i.e., % Weight Reduction $W_{r=}$ W_f - W_i *100 =50.64 %)

Figure 6: K-Type Temperature Controller

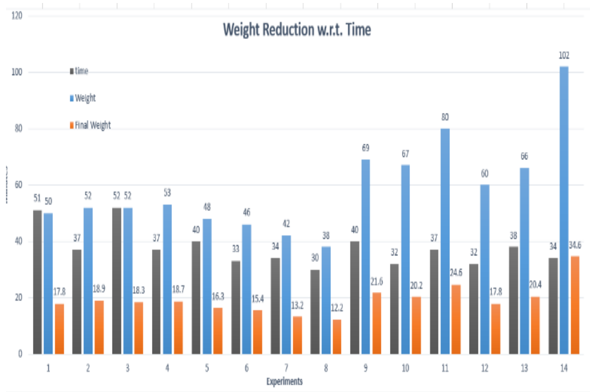


Figure 8: Comparison of Weight Reduced with respect to Total Time.

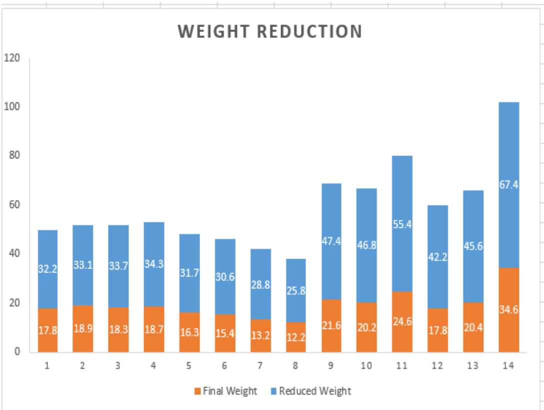


Figure 7: Comparison of the Initial Weight and Final Weight

Cold State Experiments:

- The results for the cold state were satisfactory as compared to the preheated state especially if we talk about the drying time because when the system was at room temperature it took more time to reach the set temperature for the first time. (i.e., Avg t=43 minutes as total drying time with an average set temperature of Avg T_s=42º C)
- As for the color of the petals, the quality was good as compared to the preheated state because of the variable temperature inside the chamber. For the state1 some of the cold air passes through petals due to which after state1 the constant temperature is maintained inside the chamber resulting in taking less time to remove the moisture content from the petals resulting in a good color and fragrance maintenance.
- The humidity level decreased slowly because of the gradual increase if temperature for the state1.
- The time take for temperature to reach state1 is high (i.e., Avg t_s= 15 to 16 min for Avg W_i= 52 gm).
- The average weight reduction in this case was less as compared to the preheated state. (i.e., % Weight Reduction $W_{r=} W_f - W_i$ *100= 50.46 %)

Comparative analysis:

1. Drying Time:
   Preheated State: Avg time = 33 min
   Cold State: Avg time = 43 min

2. Color Quality:
   Preheated State: Degradation observed
   Cold State: Maintained good color due to variable temperature

3. Humidity Level:
   Preheated State: Rapid decrease
   Cold State: Slower decrease, especially during state1

4. Temperature to Reach State1:
   Preheated State: Average time = 4-5 min
   Cold State: Avg time = 15-16 min

5. Weight Reduction:
   Preheated State: % Weight Reduction = 50.64%
   Cold State: % Weight Reduction = 50.46%

Concluded as, the preheated state offers faster drying and higher weight reduction, while the cold state excels in color preservation, albeit with slightly slower drying. The optimal choice depends on specific goals, and further experimentation is recommended for fine-tuning.

The exhaust lid had also two states:

1. Open
   Lid: When the lid was opened some of the fragrance was lost and the experiment took more time.
2. Closed Lid: When kept the lid closed and let the air exhaust through the narrow passage between the door and the chamber, due to increase in pressure it took less time to complete the process, and most off the fragrance was maintained.

For all the experiments, for Closed lid due to high pressure and thinner outlet, the fragrance was maintained well and process ended quickly with the time consumption of 26 to 38 minutes. Precise color control is a standout feature, achieving an impressive 85% accuracy in maintaining original hues, crucial for industries where color fidelity is paramount. It outperformed in terms of weight reduction and maintaining the fragrance and color of rose petals. The humidity level was dropped from above 50% to nearly 11%. Temperature regulation, maintained within an optimal range of 15°C to 50.1°C, guarantees petal integrity throughout the process.

DATA SHEET OF PETAL DRYING SYSTEM																			
		Temperature (°C)				Humidity (%)					Time (minutes)				Weight (gm)				
Exp No.	Date	Initial Temp	Chamber Temp State	Set Temp	Final Temp	Initital Humidity	State1 Humidity	Final Humidity	% Humidity Change	Lid State	Preheating Time	Drying Time	Total Drying Time	Time for State1	Initial weight	Final weight	Total Weight Reduction	% Weight Reduction
1	10/1/2022	15 °C	Room Temp	38 °C	39.1 °C	51.20%	36.30%	12.10%	39.10%	opened	20 min	31 min	51 min	20 min	50 gm	17.8 gm	32.2 gm	47.49%
2	10/2/2022	25 °C	Preheated	37 °C	37.8 °C	35.80%	35.80%	11.80%	24.00%	opened	0 min	37 min	37 min	7 min	52 gm	18.9 gm	33.1 gm	46.69%
3	12/1/2022	17 °C	Room Temp	39 °C	39.7 °C	50.80%	36.10%	12.00%	38.80%	opened	22 min	30 min	52 min	22 min	52 gm	18.3 gm	33.7 gm	47.94%
4	12/2/2022	26 °C	Preheated	39 °C	39.9 °C	36.20%	36.20%	11.85%	24.35%	opened	0 min	37 min	37 min	8 min	53 gm	18.7 gm	34.3 gm	47.84%
5	19/01/2023	16 °C	Room Temp	43 °C	43.2 °C	48.50%	36.30%	11.90%	36.60%	closed	14 min	26 min	40 min	14 min	48 gm	16.3 gm	31.7 gm	49.30%
6	19/01/2023	30 °C	Preheated	43 °C	43.3 °C	35.60%	35.60%	11.40%	24.20%	closed	0 min	33 min	33 min	4 min	46 gm	15.4 gm	30.6 gm	49.84%
7	22/01/2023	33 °C	Preheated	45 °C	45.1 °C	34.20%	34.20%	11.60%	22.60%	closed	0 min	34 min	34 min	5 min	42 gm	13.2 gm	28.8 gm	52.17%
8	22/01/2023	31 °C	Preheated	45 °C	45.3 °C	33.70%	33.70%	11.80%	21.90%	closed	0 min	30 min	30 min	5 min	38 gm	12.2 gm	25.8 gm	51.39%
9	28/01/2022	16 °C	Room Temp	48 °C	48.2 °C	49.60%	33.30%	11.20%	38.40%	closed	16 min	24 min	40 min	16 min	69 gm	21.6 gm	47.4 gm	52.32%
10	28/01/2022	33 °C	Preheated	48 °C	48.4 °C	33.20%	33.60%	11.30%	21.90%	closed	0 min	32 min	32 min	4 min	67 gm	20.2 gm	46.8 gm	53.67%
11	31/01/2022	18 °C	Room Temp	50 °C	50.1 °C	49.10%	32.70%	11.10%	38.00%	closed	15 min	22 min	37 min	15 min	80 gm	24.6 gm	55.4 gm	52.96%
12	31/01/2023	34 °C	Preheated	49 °C	49.3 °C	34.20%	32.90%	11.20%	23.00%	closed	0 min	32 min	32 min	3 min	60 gm	17.8 gm	42.2 gm	54.24%
13	9/1/2022	17 °C	Room Temp	46 °C	46.6 °C	48.80%	33.50%	12.30%	36.50%	closed	14 min	24 min	38 min	14 min	66 gm	20.4 gm	45.6 gm	52.78%
14	9/2/2022	31 °C	Preheated	46 °C	46.8 °C	33.50%	33.80%	12.10%	21.40%	closed	0 min	34 min	34 min	4 min	102 gm	34.6 gm	67.4 gm	49.34%
Note:		**State1** is the state of dryer when its internal temperature reaches the set Temperature for the First time.																	

Figure 9. Complete Datasheet of the Petal Drying Process for the course of 14 Experiments.

V. Conclusion

In summary, the petal drying system stands as a significant innovation in floral preservation, leveraging cutting-edge technologies to enhance efficiency and quality. Rigorous experimentation reveals a remarkable reduction in drying time from days to minutes, disrupting traditional timelines and ensuring rapid, efficient petal preservation. Similarly, our system effectively manages humidity levels, maintaining a consistent 11% to minimize the risk of degradation and mold formation. This research not only contributes to mechatronics but also establishes a more efficient, precise, and sustainable approach to petal preservation across diverse industries.

VI. Future Work

In future, pressure parameter and renewable energy resources can be integrated for better performance and lower consumption of electricity cost.

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