PERFORMANCE TESTING OF POLYHOUSE BAGASSE DRYER

Mr. Suyash Bhate[1], Ms. Shrutika Tathawade[2], Mr. Shriraj Shirole[3]
[4] Prof. Dr. P.G Kulkarni, [5]Prof .Dr. H.G Phakatkar

1,2,3 BE Mechanical Students, Mechanical Engineering Department, Pune Vidyarthi Griha's College of Engineering and Technology and G.K. Pate (Wani) Institute of Management, Pune – 411009
[4,5]Project Guide & Assistant Prof. Mechanical Engineering Department, PVG's COET & GKPIOM, Pune – 411009

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Abstract –*Sugarcane bagasse is a sugar industry by product that is currently underutilized in many parts of the world. The goal of this research is to design and build a polyhouse bagasse dryer to improve the utilization of sugarcane bagasse as a fuel for energy generation or as a feedstock for biofuel production. The polyhouse bagasse dryer is a low-cost, energy-efficient technology that uses solar energy to dry sugarcane bagasse to a suitable moisture content for combustion. The dryer is made up of a polyhouse structure that houses a drying chamber where sugarcane bagasse is loaded and exposed to sunlight. The design of the polyhouse bagasse dryer is created so to ensure efficient heat transfer and airflow within the dryer.*

Key Words: Polyhouse Bagasse Dryer , Relative Humidity, Heat Transfer , Moisture , Dry bulb temperature, Wet bulb temperature , Drying Efficiency , Drying Rate.

1.INTRODUCTION

In recent years, the increasing emphasis on sustainable practices and renewable energy sources has prompted the exploration of efficient methods for utilizing biomass waste. Bagasse, a byproduct of sugarcane processing, possesses considerable potential as a biomass fuel. However, to harness its energy efficiently, effective drying techniques are essential. The polyhouse bagasse dryer has emerged as a promising solution, offering advantages such as controlled environmental conditions and improved drying efficiency. This research paper aims to provide an in-depth analysis of polyhouse bagasse dryers, exploring their design, functionality, and potential contributions to the field of biomass drying. By investigating existing technologies, optimizing design parameters, and evaluating environmental and economic implications, this study seeks to contribute to the advancement of sustainable biomass utilization.

2. Literature Review

- Rokade, V. M., Jadhav, J. B., & Patil, M. N. (2016). "Design and development of polyhouse solar dryer for bagasse drying", International Journal of Scientific and Research Publications, 6(5), 582-589.This study describes the design and development of a polyhouse solar dryer for drying bagasse, which uses trays to hold the bagasse during the drying process.

- Anwar, S. I. (2010). "Determination of moisture content of bagasse of jaggery unit using microwave oven", Journal of Engineering Science and Technology, 5(4), 472-478. This study describes how calorific value is affected by moisture content in bagasse. Study proved that microwave drying can reduce the time to dry the bagasse also taking into consideration about the furnace performance

1. Kumar, A., & Tiwari, G. N. (2007). "Effect of mass on convective mass transfer coefficient during open sun and greenhouse drying of onion flakes", Journal of food engineering, 79(4), 1337-1350. Comparative study between open air drying and greenhouse drying was carried out. It is inferred that efficiency of convective mass transfer in greenhouse drying is much more than open sun drying.

3. Significance of the polyhouse bagasse dryer:

The polyhouse bagasse dryer represents a significant advancement in the field of biomass drying, particularly in the context of bagasse utilization.

Traditionally, open-air drying methods have been employed for bagasse, resulting in prolonged drying times, inconsistent moisture levels, and susceptibility to environmental factors. The polyhouse bagasse dryer addresses these challenges by providing a controlled drying environment that optimizes the drying process. By regulating temperature, humidity, and airflow, the polyhouse dryer accelerates the drying rate, reduces energy consumption, and ensures uniform moisture content. This improved efficiency has far-reaching implications for the sugarcane industry and bioenergy sector. Firstly, it enables sugarcane mills to more effectively manage the bagasse byproduct, reducing waste and potential environmental pollution. Secondly, the dried bagasse can serve as a valuable biomass fuel for power generation, contributing to renewable energy production and reducing reliance on fossil fuels. Therefore, the development and optimization of polyhouse bagasse dryers hold great significance in enhancing sustainability, resource efficiency, and energy independence

The main aim of this research paper is to thoroughly examine the design, functionality, and potential contributions of polyhouse bagasse dryers within the realm of biomass drying.

1. Analyze existing polyhouse bagasse dryer technologies: Conduct an in-depth review of the current designs, configurations, and operating principles of polyhouse bagasse dryers. Evaluate their advantages, limitations, and performance in comparison to traditional drying methods.

2. Optimize the design parameters: Identify key design parameters that significantly impact the drying efficiency of polyhouse bagasse dryers. Investigate methods for optimizing these parameters, such as airflow, temperature, humidity control, and drying time, to achieve improved drying performance.

3. Provide recommendations for future research and development: Based on the outcomes of this study, offer recommendations for further research and development in the field of polyhouse bagasse drying. Identify areas that require additional investigation and suggest potential avenues for advancing the technology.

4. Methodology:

A prototype of the polyhouse bagasse dryer was constructed to provide a controlled drying environment. The polyhouse bagasse dryer is characterized by dimensions of 12 meters in length, 9.2 meters in breadth, and a height of 4 meters. The dryer consisted of an enclosed structure with ventilation, temperature regulation, and humidity control capabilities. Essential equipment, including fans, heating elements, humidity sensors, and temperature controllers, were installed in the polyhouse dryer. Data logging systems were incorporated to capture relevant parameters, such as temperature, humidity levels, airflow rates, and bagasse moisture content, during the drying process.

We have conducted three experiments, outlined below:

Experiment 1 - : Determining the Percentage of Moisture Removal for Sugarcane Bagasse Inside a Solar Polyhouse Dryer and Comparing it with Percentage of Moisture Removal in Open Sun Drying

- A solar polyhouse dryer of dimensions 12m X 9.2m X 4m was installed at the plant location. The polyhouse was installed with ceiling fans with a velocity of 3.5 m/s and a table fan with a velocity of 6 m/s.

- Trays with the following measurements were used to position the trays within the polyhouse and outside the polyhouse for open sun drying: Length=0.75m, Breadth=0.55m, and Thickness=0.04m. A cannon precision weighing machine was used to weigh the bagasse to be kept in the polyhouse.

- Wet bagasse with 50% - 70% moisture content was spread on the trays with layer thickness of 4cm, and weighing 2.15kg.

- One tray containing wet bagasse was kept inside the polyhouse dryer while other tray with same quantity of wet bagasse was kept for open sun drying.

- Readings were taken between 11:00am - 2:00pm at 40 minutes intervals.

- The change in the weight of bagasse after each interval was measured.

- Percentage of moisture removal was calculated by the formula:

[(Initial weight bagasse — final weight of bagasse)/ final weight of bagasse] X 100

Table 1: Bagasse kept inside polyhouse dryer
Weight of bagasse: 2.15kg

Sr no.	Time	Initial weight of bagasse (kg)	Final weight of bagasse (kg)	Moisture removal (%)
1	11:00-11:40	2.15	1.78	17.2%
2	11:40-12:20	1.78	1.43	19.6%
3	12:20-1:00	1.43	1.12	21.6%
4	1:00- 1:40	1.12	0.96	14.2%

Overall percentage of moisture removal for the bagasse from 11:00am to 1:40pm = 55.3%.

Table 2: Bagasse kept for open sun drying
Weight of bagasse: 2.15kg

Sr no.	Time	Initial weight of bagasse (kg)	Final weight of bagasse (kg)	Moisture removal (%)
1	11:00-11:40	2.15	1.88	12.5%
2	11:40-12:20	1.88	1.72	8.5%
3	12:20-1:00	1.72	1.48	13.9%
4	1:00-1:40	1.48	1.31	11.4%

Overall percentage of moisture removal for the bagasse from 11:00am to 1:40pm = 39%

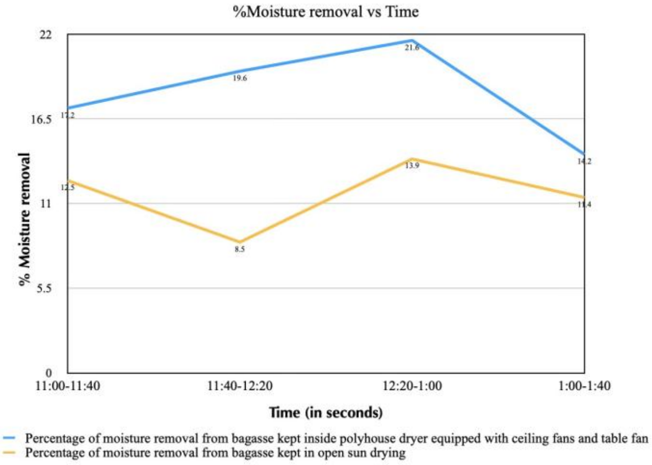

Chart 1. % Moisture removal vs Time

Experiment 2:- Sugarcane Bagasse drying by microwave.

- A circular plate with a diameter of 120mm and depth of 50mm was used to carry out the experiment the weight of the the bagasse and time period were monitored. The SRS310 precision scale was used for measuring the weight of bagasse at different time intervals. Moisture content of the sample was calculated after each time interval to obtain the drying rate of the microwave.

- Bagasse of initial weight equal to 10 grams, 20 grams was used for the experiment.It was then heated for 4 minutes in the microwave. We checked the weight of the bagasse after 4 minutes of drying.

- Further the bagasse was exposed to 30 seconds of drying at intervals till the weight of the bagasse remained constant.

- After five intervals of drying the bagasse in the microwave for 30 seconds each, we reached to a constant weight of bagasse.

- Drying rate was calculated by using formula:

(Initial weight of bagasse - final weight of bagasse) / time required (in seconds)

1.Initial weight of wet bagasse: - 10 grams

DRYING RATE 1 :-

- Initial weight of bagasse: 10 grams

Sr no.	Weight of bagasse (In grams)	Time period (in seconds)	Weight of bagasse after heating (in grams)
1	10	240	5.6
2	5.6	30	4.4
3	4.4	30	4.2
4	4.2	30	3.9
5	3.9	30	3.9
6	3.9	30	3.9

- Final weight of bagasse: 3.9 grams
- Total Time period of drying: 390 seconds

Drying rate = water lost / drying time

= 10 - 3.9 / 390

Therefore,

Drying rate = 0.0156 g/s

2. Initial weight of wet bagasse:- 20 grams

Sr no.	Weight of bagasse (In grams)	Time period (in seconds)	Weight of bagasse after heating (in grams)
1	20	240	12.5
2	12.5	30	9.7
3	9.7	30	8.2
4	8.2	30	7.8
5	7.6	30	7.6
6	7.6	30	7.6

DRYING RATE :- 2

- Initial weight of bagasse : 20 grams
- Final weight of bagasse : 7.6 grams
- Total Time period of drying : 390 seconds

Drying rate = water lost / drying time

= 20 - 7.6 / 390

Therefore,

Drying rate = 0.0317 g/s

The drying rate was higher in microwave drying as compared to polyhouse dryer. But the bagasse was of no use after microwave drying as it completely turned black or burnt after some intervals of heating.

Experiment 3: -Determining relative humidity in a polyhouse.

- ➢ Measurement of temperatures: Measure the dry bulb temperature (DBT) and wet bulb temperature (WBT) using thermometers to obtain accurate temperature readings
- ➢ Calculation of wet bulb depression: Calculate the wet bulb depression (WBD) by subtracting the wet bulb temperature from the dry bulb temperature: WBD = DBT - WBT. This quantifies the temperature difference between the two measurements.
- ➢ Determination of relative humidity: Utilize a psychrometric chart or the equation RH = 100 x (P_ws(T_wb) / P_ws(T_db)) to determine the relative humidity (RH). P_ws(T_wb) represents the saturation vapor pressure at the wet bulb temperature, and P_ws(T_db) represents the saturation vapor pressure at the dry bulb temperature.
- ➢ Interpretation of relative humidity: Interpret the obtained relative humidity value to assess the moisture content of the air.
- ➢ A relative humidity of 50% indicates that the air contains half the moisture it could hold at that temperature. Conversely, a relative humidity of 100% signifies fully saturated air that cannot hold any additional moisture.

- Between 10 am and 4 pm, we conducted temperature measurements using dry and wet bulb thermometers. Throughout the experiment, we documented both the highest and lowest relative humidity values observed

TIME	DRY BULB TEMPERATURE (°C)	WET BULB TEMPERATURE (°C)	RH %
10.30 AM	43.5	26.46	**23.5**
11.00 AM	44.4	25.25	18.9
11.30 AM	49.7	26.39	14
12.00 PM	49.9	26.93	14.8
12.30 PM	49.9	26.78	14.5
1.00 PM	51.9	26.90	**12.5**
1.30 PM	51.4	26.89	13
2.00 PM	49	25.74	13.6
2.30 PM	445	24.77	19.2
3.00 PM	43.4	25.21	18.8
3.30 PM	41	23.38	20
4.00 PM	38.5	22.3	**25.1**

Chart 2. Relative humidity vs Time

Based on the aforementioned observations, we can conclude that the maximum relative humidity (RH) was observed at 10 am & 4 pm, while the minimum RH was observed at 1 pm.

5. RESULTS

Drying Efficiency:

The drying efficiency of the polyhouse bagasse dryer was assessed by measuring the moisture content of the bagasse samples before and after the drying process. The results indicated a significant reduction in moisture content, indicating the effectiveness of the polyhouse dryer in removing moisture from the bagasse. Analysis revealed a strong correlation between the drying time and the moisture content reduction, with shorter drying times resulting in lower moisture levels.

6. CONCLUSIONS

The research focused on the design and optimization of a polyhouse bagasse dryer for efficient bagasse drying. The research objectives were achieved through a comprehensive methodology that involved analyzing existing polyhouse bagasse dryer technologies, optimizing design parameters, and providing recommendations for future research and development. This low-cost and energy-efficient technology employs solar energy to dry sugarcane bagasse to an optimal moisture level for combustion and enhance resource efficiency, reduces waste, and promotes renewable energy. Further research and development in this field will lead to enhanced performance and wider adoption of polyhouse bagasse dryers, ultimately contributing to a more sustainable and energy-independent future.

7. REFERENCES

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BIOGRAPHIES

Mr. Suyash Sunil Bhate
BE Mechanical student at PVG's COET, Pune.

Ms. Shrutika Pravin Tathawade
BE Mechanical student at PVG's COET, Pune.

Mr. Shriraj Suniel Shirole
BE Mechanical student at PVG's COET, Pune.