International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 03 | March – 2025 DOI: 10.55041/ISJEM02463
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Fabrication of Hybrid Dryer

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Abstract -The hybrid dryer uses both solar and additional heating to ensure effective drying. It includes a solar collector and an additional heat source to ensure stable operation. This technique allows for faster drying while maintaining the quality of the dried items. Vegetables require 50-55°C to dry properly, whereas fruits prefer 50-55°C. Millet is dried at 60–65°C and flowers at 35°C. Coconuts, unlike non-vegetarian items, require 60-65°C. Temperature control and airflow optimization both improve drying efficiency. It is suitable for small-scale applications due to its low cost and compact design. It ensures dryness throughout the year by operating in a variety of weather conditions. Farmers and small food processors benefit from this environmentally friendly decision.

***Key Words*:** Hybrid Drying, Temperature Control, Sustainable Drying, Small-Scale Drying, Efficient Drying, Quality Preservation.

1.INTRODUCTION

A solar dryer is an eco-friendly drying machine that exploits solar energy to remove moisture from a range of products, such as fruits, vegetables, herbs, spices, and non-vegetarian products. Solar dryers accelerate the drying process while preserving flavor, color, and nutrient content by collecting solar light and converting it to heat. Solar dryers enable improved product quality, faster drying duration, and contamination protection compared to traditional drying methods. They are a perfect choice for farmers, small businesses, and the food processing sector due to being cost-effective, eco-friendly, and energy-efficient. Solar dryers provide safe and efficient drying while reducing fossil fuel dependency through enhanced heat retention, controlled airflow, and weather resistance.

2. MATERIALS AND METHODOLOGY

UV-Stabilized Polycarbonate Sheet (6mm): Transmits light while protecting against harmful UV radiation. The 6mm thickness ensures durability and insulation.

GI Mesh with MS Frame: A galvanized iron (GI) mesh supported by a mild steel (MS) frame forms an effective and corrosion-resistant structure.

Solar Panel (10W & 12V): Produces electricity from sunlight to power the ventilation fan, thereby increasing energy efficiency.

Ventilation Fan: Moves air around the enclosure, helping to regulate temperature and humidity.

Galvanized Iron: Used in a variety of structural elements due to its strength and resistance to rust.

Heater (250W AC 230V): Adds heat as needed to maintain the desired temperature.

Climatic Controller (Temperature and Humidity Sensor): Monitors and regulates the temperature and humidity levels within the enclosure to maintain optimal conditions.

METHODOLOGY:

A solar dryer captures solar radiation through a transparent polycarbonate or glass cover, raising the internal temperature (50°C to 70°C). Insulated walls retain heat, and a DC solar-powered fan provides forced convection for continuous airflow. As warm air circulates, moisture from the food evaporates and is expelled through ventilation outlets, speeding up the drying process. A climatic controller regulates temperature to prevent overheating while preserving the nutritional value, color, and flavor of dried products. This mechanism ensures that various foods are dried efficiently, hygienically, and with minimal energy consumption.

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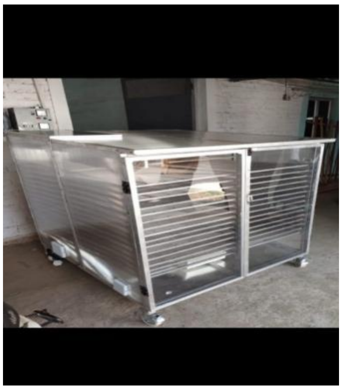
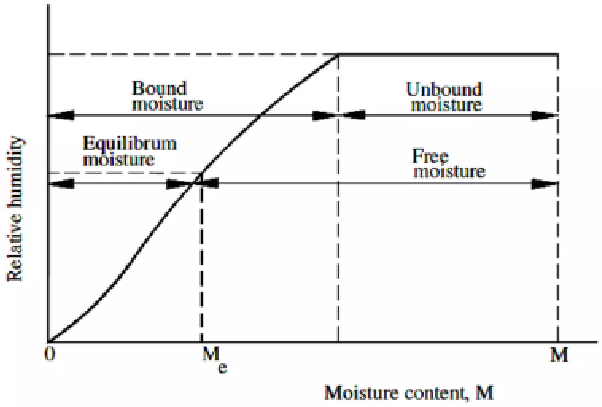


Fig -1: PROJECT SETUP

MOISTURE CONTENT vs RELATIVE HUMIDITY



GRAPH :1

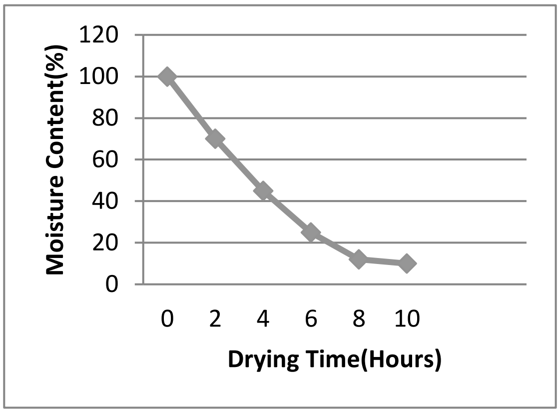
3. RESULTS AND DISCUSSION

The hybrid dryer can effectively reduce the moisture level of farm products within **35 to 40 hours**. The photograph illustrates the process of drying fresh green chilies under controlled conditions. The efficient heat retention and airflow of the dryer enable faster drying, retaining color, texture, and nutritional value while minimizing the risk of spoilage compared to conventional sun drying.

Drying Time (Hours)	**Moisture Content (%)**
0	100
2	70
4	45
6	25
8	12
10	10

Table :1

This table illustrates how the moisture content of chilies decreases over time in the mini hybrid solar drier, with most of the drying occurring between 35 and 40 hours. Please let me know if you need any adjustments!



GRAPH :2

4.CALCULATION

1. **Moisture Content Calculations:**

□**Mass of water removed (mw):**

mw = mp * ((Mi - Mf) / (100 - Mf))

mw = 15 kg * ((75 - 10) / (100 - 10))

mw = 15 kg * (65 / 90)

mw ≈ 10.88 kg of water.

2. **Solar Collector Calculations:**

□**Useful heat gain (Qu):**

Qu = Ac * I * ηc

Qu = 2 m² * 700 W/m² * 0.4

Qu = 560 W

3.**Drying Rate:**

Drying Time:

Drying time = Total moisture to be removed / drying rate.

Drying time = 7.65kg / 0.5kg/hour.

Drying time = 15.3 hours.

Q = m * Cp * ΔT

Where:

Q = Heat required (watts or joules/second)

m = Mass flow rate of air (kg/s)

Cp = Specific heat capacity of air (approx. 1005 J/kg°C)

ΔT =Temperature difference(desired temperature - ambient temperature) (°C)

m = 1.2 kg/m³ * 0.5 m/s * 0.1 m²

m = 0.06 kg/s

Calculating Mass Flow Rate (m): m = ρ * V * A

Where:

ρ = Density of air (about 1.2 kg/m³)

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V = Velocity of air (m/s)

A = Cross-sectional area of the air flow channel (m^2)

Q = 0.06 kg/s * 1005 J/kg°C * 30°C

Q ≈ 1809 W≈1.8kw

1.Latent Heat (Evaporation):

Qlatent = m * L

Qlatent = Latent heat (Joules)

m = Mass of evaporated water (kg)

L = Latent heat of vaporization of water (circa 2.26 x 10^6 J/kg)

Qlatent = 1 kg * 2.26 x 10^6 J/kg = 2.26 x 10^6 Joules (or 2.26 MJ)

2.Sensible Heat (Change in Temperature):

Qsensible = m * Cp * ΔT

Qsensible = Sensible heat (Joules)

m = Mass of the substance (kg)

Cp = Specific heat capacity (J/kg°C)

ΔT = Temperature change (°C) Mass of air = 1 kg

Cp of air = 1005 J/kg°C

ΔT = 30°C (say, from 30°C to 60°C)

Qsensible = 1 kg * 1005 J/kg°C * 30°C = 30150 Joules (or 30.15 kJ)

3.Total Heat :

Qtotal = Qlatent + Qsensible

Qtotal = 2.26 x 10^6 Joules + 30150 Joules

= 2,290,150 Joules

4. CONCLUSIONS

The hybrid dryer, with a combination of solar energy and a supplemental heat source, provides reliable and efficient functioning in all weather conditions. It is a realistic and eco-friendly option for small-scale agricultural drying. By reducing post-harvest losses, enhancing product quality, and decreasing the use of fossil fuels, this technology enables farmers to maximize the value of their crops while increasing sustainability.

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