RESEARCH ARTICLE OPEN ACCESS

DEVELOPMENTOF PHASE CHANGING MATERIAL BASED DEHYDRATOR

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Abstract:

This article presents the development and performance evalution of a Phase Changing Material based Dehydrator, designed for laboratory scale and household applications. The device features two removable trays for accommodating a variety of samples, providing users with flexibility in their drying process.

This dehydrator has a heating element, which has a variable power supply, is its central component. With the help of this features, it is possible to manage the drying temperature precisely and experiment with a variety of drying settings. This device can handle a range of materials with different drying requirements, from heat sensitive pharmaceuticals to robust agricultural products, thanks to variable power supply.PHASE CHANGING MATERIAL(PCM) stores thermal energy via latent heat of the phase transitions can be used to provide district cooling (sub ambient transition temperatures), to buffer thermal swings in buildings (near ambient transition temperatures), and to store solar thermal energy for short term or seasonal applications (higher transition temperatures).When thermal energy is from a intermittent source, such as solar radiation or waste heat, the ability to store energy in a compact form can provide a readily accessible source of heat. Issues concerning the thermal conductivity, stability, cyclability, phase segregation, supercooling, containment, cost, safety, and sustainability of PCM are addressed, and research challenges the, when solved, would allow wide spread use of PCM's are presented.

***Keywords*—Phase Changing Material, Heat Thermal Energy Phase, Transitions Supercooling Thermal Energy.**

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I. INTRODUCTION

Dehydrator are taken in use to dry the products in the industries where drying and heating plays a main role. In the processing of chemicals, foods, colours, and other goods, among other things, it is the most demandable drying method, Chemical and Physical properties can have a big impact on the final product.

II. MATERAILAS AND METHODS

Phase Changing Material Based dehydrator consist of several components including:

- Chamber: The main housing where the trays are stacked and drying occurs.
- Trays: Shelves where materials are placed for drying.

- Heating system: generates heat for drying process.
- Air Circulation System: Ensures even distribution of hot within the chamber.

RATTED WATTAGE	2000W
RATED VOLTAGE	230V, 50Hz, Ac
FAN MOTOR VOLTAGE	30W
FAN MOTOR RPM	2300RPM
THERMAL CUT-OUT/THERMOSTAT	YES
PRODUCT DIMENSIONS(LxWxH)	250mm x 118mm x 240mm

III. COMPONENTS USED

A. MILD STEEL(CHAMBER):

Mild Steel, also known as low carbon steel, is versatile and widely used materials in various industries, owing to its remarkable properties adaptability. Composed of iron and a small percentage of carbon, typically between 0.055 and 0.25%, mild steel strikes a balance between strength and ductility, making it an ideal choice for an array of applications.

The affordability of mild steel has contributed significantly to its widespread use. It serves as a cost -effective solutions without compromising on performance, making it accessible for both larger-scale industrial applications and smaller projects. From automobile manufacturing to construction,mildsteel finds applications in an extensive range of products, including pipes, wiring, and sheet metal.

Corrosion resistance is a notable feature of mild steel, although it is not corrosion resistant than stainless steel. To enhance its durability various coating techniques such as galvanizationemployed. This makes mild steel sustainable for food dehydrators.

In conclusion, mild steel's versatility, cost effectiveness and ease of fabrications contribute to its status as a foundational material in numerous industries. From the skeleton of skyscrapers to the chassis of automobiles, mild steel plays a crucial role in shaping the modern world.

B. STAINLESS STEEL(TRAY):

There are several types of stainless steel are available only less are considered as food grade. Nearly all food grade stainless steel comes under the 300 and 400 series.304 stainless steel offers an affordable option for any food processing environment.it can withstand corrosion from several oxidizing acids, meaning it is easy to sanitize. It also boasts great weldability and formability, allowing it to be manufacturing into various food processing equipment.

316 stainless steel is an austenitic alloy with high nickel and chromium content. Similar to other steel alloys, it can continuously used at temperature significantly higher than most food handling process require. This grade is also resistance to acids, chlorides, alkalis making it great for any food appliances.

C. PHASE CHANGING MATERIAL (PARAFFIN WAX):

Phase Changing Materials are latent heat storing materials. The thermal energy transfer occurs when a material changes from solid to liquid or from liquid to solid and this is called a change in phase or state.

However, PCMs to be used as a latent heat storage materials these materials must exhibit certain desirable thermal, physical,kinetic,chemical and economical properties absorbs and release energy. Paraffin Waxes in particular have been of interest due to their promising properties as phase changing material.

Paraffin wax is safe reliable, less expensive, and non-corrosive. They are chemically inert and show little volume change during melting and have low vapour in the melt. Apart from the favourable properties of paraffin wax, such as congruent melting and self-nucleatingproperties, they are not easy to be used directly in practical applications due to undesirable properties such as leakage. However, these undesirable properties can be eliminated by modifying the wax such as direct incorporation of wax into the polymer and encapsulation of wax by microencapsulation or microencapsulation.

D. THERMOSTAT:

Thermostat are used in system that heats or cools to a setpoint temperature. Examples including building heats, central heating, air conditioners,HVAC systems, waterheaters, as well as kitchen appliances including ovens and refrigerators, and medical and scientific incubators. In scientific literatures, thesedevices are often broadly classified and thermostatically controlled loads(TCL's).Thermostatically controlled loads comprise roughly 50% of the overall electricity demand in the states.

A THERMOSTAT operates a "closed loop" control device, as it seeks to reduce the error between the desired and measured temperatures. Sometimes a thermostat combines both the sensing and controlled systems, such as in an automotive thermostat. The word thermostat comes from Greek word "thermos" means "hot' and "statos" means "stationary".

E. FAN (Circulation purpose):

A dehydrator's heating element, fans and vents simultaneously work to direct hot air over the food, accelerate surface evaporation and warm the food causing moisture to be released from its interior. Thispurpose continues until the food is dried to a substantially lower water content, usually less than 20%.

The fan circulates warm air around the trays of the food. The Trays are made from plastic or metal and have a weaved, open pattern that allow air to move freely around the food, allowing the water inside to evaporate evenly from all the angles.

F. HEAT SOURCE (lamp based):

These are particularly used for supplementing central heating or for heating smaller rooms efficiently. Small rooms heaters come in various types, includingceramic, radiant, and fan-forced heaters, each with its unique features. Ceramic heaters employ a ceramic heating element that heats up quickly and provides a consistent, evenwarmth. They are energy-efficient and often come with adjustable thermostat and oscillating fans for better neat distribution.

A lamp-based heating system for a dehydrator is a practical and a energy efficient solution designed to facilitate the dehydration process. In this setup heat is generated by lamps strategically placed within the dehydrators to gently remove moisture from the food items.
Infrared lamps are commonly used for their adaptability to emit heat similar to the sun. These lamps generate radiant heat, which efficiently penetrates the food items, promoting uniform drying without causing overheating. The strategical placement of lamps provides even heating inside the chamber. That ensures uneven drying and consistent results throughout the products.

V.COST ESTIMATION

CABINATE (MILD STEEL) – 4500

ROOM HEATER – 1500

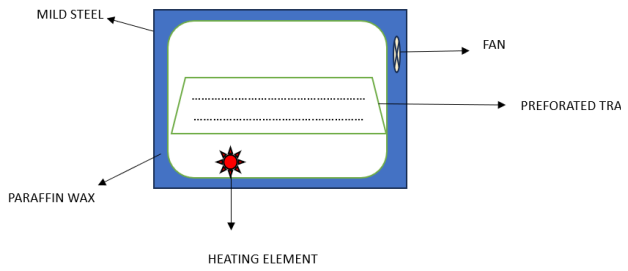
PERFORATED TRAYS – 700

THERMOSTAT – 500

FABRICATION – 800

TOTAL – 8000

VI. SCHEMATIC DIAGRAM



VII.ADVANTAGES OF PHASE CHANGING MATERIAL BASED DEHYDRATOR

1. ***Energy Efficient:*** Phase changing material-based dehydrators are excel in energy efficiency. The harness the latent heat of phase transitions, reducing overall energy consumption compared to traditional dehydrators, contributing to sustainability.

2. ***Precise Temperature Control:*** PCM offers precise temperature control during the dehydration process. This precision ensures that delicate materials, such as herbs or pharmaceutical compounds, are dried without degradation or loss of efficiency.

3. ***Gentle Dehydration Process:*** The gradual release of latent heat in PCM dehydrators results in a gentle and controlled dehydration process. This is particularly advantageous for preserving the nutritional content, flavour, and textures of food items, making it ideal of high quality food production.

4. ***Uniform Drying:*** PCM technology ensures uniform drying across all layers or trays in the dehydrator. This eliminates the constant rotation or rearrangement of items, streamlining the dehydration process and improving the overall efficiency.

5. ***Reduce Processing Time:***PCM dehydrators often exhibit fast processing times compared to conventional methods. The ability to deliver the consistent and controlled heat accelerates the removal of moisture, contributing to increased productivity in various industries.

6. ***Versatility in Material Types:*** PCM dehydrators are versatile and can be adaptive for the use of various materials, including foods, pharmaceuticals, textiles, and more. This versatility makes them a valuable asset for industries with diverse dehydration needs.

7. ***Cost Effective Operations:*** The energy efficient and reduce processing times of PCM dehydrators translate into cost savings into long term. Business benefits from low energy and increased productivity, making it a financially valuable investment.

8. ***Reduce Environmental Impact:*** With their energy efficient operation, PCM dehydrators contribute to reduce environmental impacts. Lower energy consumption aligns with sustainable practices, making them an eco-friendly choice for responsible manufacturing and production process.

VIII.APPLICATIONS OF PHASE CHANGING MATERIAL BASED DEHYDRATOR:

1. ***Food Preservation:*** Phase Changing Material based dehydrator finds extensive application in preserving food items by removing moisture. This technology ensures that the dehydrated products retain their nutritional content and flavour extended shelf life.

2. ***Pharmaceutical Industry:*** PCM dehydrators plays a crucial role in the pharmaceutical industry for drying herbs,

plant extract or pharmaceutical compounds. The controlled dehydration process helps maintain the potency and effectiveness pf the substances.

3. ***Herbal Medicine Production:*** The herbal medicine sector benefits from PCMdehydrators in drying and preserving herbs and plant materials. This technology ensures that the medicinal properties of the herbs are maintained, contributing to the production of high-quality herbal remedies.

4. ***Textile Industry:*** PCM dehydrators are utilized in the textile industries for drying fabrics, yarns, and dyes. The controlled and energy efficient drying process prevents damage to delicate textiles while enhancing the overall textile production.

5. ***Biotechnology and Research:*** In laboratories and research facilities, PCM based dehydrators are employed for drying biological samples, cultures, and reagents.The precise controlover temperature and gentle drying process are essential for maintaining the integrity of sensitive biological materials.

6. ***Space Exploration:*** PCM based dehydrators are valuable in space exploration scenarios for preserving and dehydrating food supplies of the astronauts. The efficiency and reliability of PCM technology make it well suitable for long term space missions.

7. ***Energy Efficient Industrial Drying:*** Industries that requires large scale drying processes, such as ceramics or paper manufacturing, benefit from PCM dehydrators due to their energy efficiency. The ability to store and release the thermal energy during the phase change contribute to sustainable and cost-effective drying methods.

8. ***Waste Reduction in Agriculture:*** PCM dehydrators can assist in reducing food waste in agriculture by providing farmers with a sustainable method to preserve their excess produce. This is particularly relevant for fruits and vegetables with limited shelf life.

9. ***Renewable Energy Storage:*** PCM dehydrators can be integrated into renewable energy systems for storing excess thermal energy. This integration enhances the efficiency of renewable energy sources by allowing them to be used for the dehydration process when the energy demand is over.

10. ***Climate Control in Greenhouses:*** PCM dehydrators contribute to climate control in greenhouses by efficiently removing excess moisture. This helps to create optimal environment for plant growth and prevents the growth of fungus and molds.

IX. RESULT AND CONCLUSION

In conclusion, the ongoing process of the Phase Changing Material based dehydrator underscores its potential as a transformative technology in the realm of controlled dehydration processes. The combination of energy efficiency, precise temperature control, and versatility positions this technology as a valuable asset for industries seeking sustainable and high-quality dehydration solutions.

The result obtained from the operational phase highlighted the practical benefits of incorporating phase-changing material into dehydration process. Although the entire utilization is still not possible, the PCM is being under research for the verification of any leaching into the foods.

However, the encapsulated PCM like macroencapsulated, microencapsulated, film or roll based paraffin wax are developed for the cooling purpose, those technology will be verified and

conduct research and introduce into PCM Based Dehydrators. And the currently developed paraffin can withstand heat up to 62 Degree Celsius, so the high temperature heating requirements cannot able to use PCM base dehydrator.

The fan speed can alter using the regulator setting in the fan, and the thermostat helps to keep the inside temperature under control, as per the reference the time taken for the dehydration of a potato and banana slices in PCM used drying method is lesser than the normal convectional method.

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