DESIGN AND FABRICATION OF SOLAR DRYER USING PHASE CHANGING MATERIAL

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ABSTRACT

Using phase change material (PCM) as an energy storage medium is one of the most efficient ways of storing thermal energy. The latent heat storage provides much higher storage density than sensible heat storage, with a smaller temperature difference between storing and releasing heat. In addition, phase change materials provide constant and moderate temperature which is needed for drying most agriculture crops sufficiently. This paper reviews the previous work on solar drying systems which implemented the phase change material as an energy storage medium. It is concluded that the solar dryer with a PCM reduces the heat losses and improves the efficiency of the system

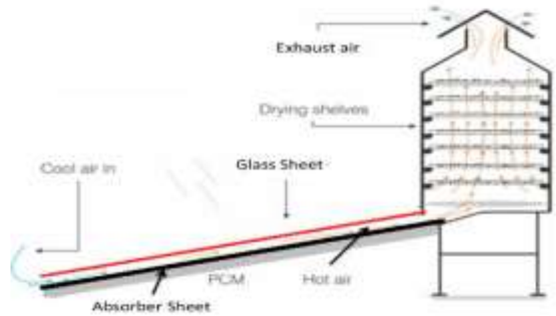
KEYWORDS :-*PCMOptions, Encapsulation,IncreasingThermalConductivity*

INTRODUCTION

Solar drying is generally considered to be the most promising alternative to traditional methods because the drying of agricultural products is usually carried out at low temperature. Compared with traditional direct solar drying or open-air drying, indirect solar drying has the following advantages: shorter drying period; best quality products; lower loss of raw materials, largerscale of production. Therefore, many solar dryer have been developed to dry agricultural products in recent years [2-5]

Solar energy is a renewable free source of energy in the earth systems. Our world today depends on energy. Energy is the ability to do work... A country like Nigeria depends heavily on possible fuels to cover its energy needs. This present an increasing burden as well as over-dependence on the availability and exhaustible energy source. In it, we must look forward to atmospheric resources such as solar energy. The potential for utilizing solar energy to a large extent can be said to be unlimited as these energy sources are infinite and non-polluting to the environment. This is unlike other energy sources such as fire wood, coal, petroleum and natural gas which are limited and non-renewable .When wood burns to produce energy, it’s an indirect utilization of solar energy. Solar energy gave rise to the minerals deposit which is mined in the mining industry. Solar energy has been increasingly important all over the world because of the rapidly diminishing supply of fossil fuels. The construction of this dryer is embarked upon to serve as the application of solar energy in assembling a drying, cooking and baking device that is beneficial to the society.Traditional solar fruit drying is often a slow process impeded by the high humidity, haze, and intermittent clouds experienced in tropical regions. In sunny, arid places, solar crop drying is a relatively simple process, and can often be accomplished without the need for a solar dryer. The warm, dry air's high capacity to take on moisture quickly removes moisture from fruits. Although simply exposing fruits to direct sunlight will often be sufficient for drying, crop dryers are often utilized to protect fruits from dirt, insects, and contamination. In humid, tropical climates, however, drying can be impeded with the humid air's reduced capacity to absorb moisture from the drying fruits, using a solar crop dryer coupled with a solar concentrator helps to improve the drying rate by increasing internal dryer temperature and radiation.

Above picture show the graphical working representation of the project

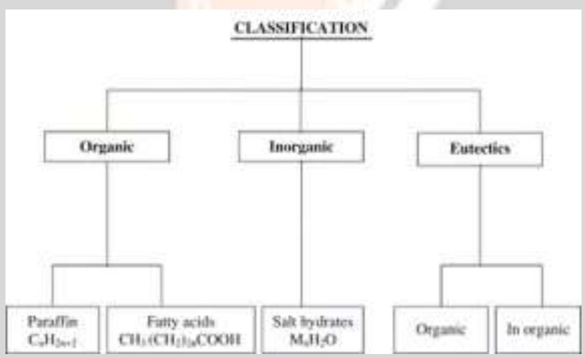


1.CONSTRUCTION

The proposed system consists of a blower which in take air then the sunlight fall in the inclined horizontally fixed glass sheet and at the bottom a latent heat storage (LHS) vessel. The used vessel is a rectangular steel with size (1.5ft*2.5ft*0.2ft). The heated air from the solar heat collector flows through dryer. the solar dryer which uses PCM to store solar energy during the daytime.then the hot air pass though the dryer which is made by the dimension
(2ft*1.5ft*4.5ft) and the shelves which is completely used five and placed by the distance 0.75ft each

1.1 PHASE CHANGING METERIAL(pcm)

The phase changing meterial that are various types and this may be classified as three types



Here we selected **paraffin wax** as a PCM to store excess solar energy during the daytime drying agricultural/food products at steady and moderate temperatures of 40–75 degree Celsius will get at the night from pcm. The dryer consists of a drying chamber, a solar air collector and another collector with a PCM. The design uses swirl elements in both the entrance and the inner part of the drying chamber to obtain a swirl effect in the air flow

1.2 PCM ENCAPSULATION METHOD

Encapsulation is very important. it leads to prevent the reactivity of the pcm towards environment and after the excess heat absorb the pcm material will became liquid state so this may cause leakage effect so to avoid this steps by tightly encapsulation the pcm using below materials

- stainless steel
- polypropylene
- polyolefin

In our project we selected the steel material to build a rectangular shell and filled the pcm with a 75 percentage of the shell and after change the phase of pcm needs more space so that we provide 25percentage free space

2 INDENTATIONS AND EQUATIONS

Drying characteristics of solar dryer
1)Amount of water content in product, Mtw Mtw= Wg*(Mi)/100 Where Wg= material weight Mi= moisture content present in product initially.

2) completely dried weight of material, Wcdw Wcdw= Wg*(1-(Mi/100)) Where, Wcdw= complete dried weight (kg)

3) Water removed while drying, Mw kg λλλ Mw= [(mi-mf/100-mf)]*W Where mf = moisture content after drying ,% mi= moisture content before drying, % W= product's mass, Kg

4) Amount of water removed per hour mw , Kg/h mw= Mw/Td Where, mw=mass of water to be removed during drying, Kg Td= assumed drying time, hr

5) Total energy required, Q(kJ) Q=(CDW*Cp(Tf-Ta))+(Mtw*Cw(Tf-Ta))+(Mw* λ) Where, CDW = complete dried weight of moisture, Kg Cp= specific heat of wet product, kJ/Kg˚C Tf= final temperature, ˚C Ta= ambient temperature, ˚C Mw= mass of water to be removed by drying, Kg Cw= specific heat of water, kJ/kg˚C Mtw= total quantity of water in product, kg λ = Latent heat of vaporization, kJ/kg

6) the energy required per hour, Qt, kJ/hr Qt=Q/Td Where, Q= total energy required, kJ Td= assumed drying time, hr

7) Area of collector, Ac Ac= Qt*100/(I*η) I= solar irradiance η= efficiency of collector Calculation of forced convection: Velocity of air coming out of blower is found out by anemometer. Velocity, c= 4.1 m/s (0.047kg/s) Atmospheric pressure of air, P=1.013*105 Pa

8) The mass flow rate of air entering the blower is given by M=ρ*Ac Where, ρ= density kg/m3 A=diameter of blower, cm2

9) Density, ρ=P/R*T R= gas constant T=ambient temperature

10) heat transfer, Q=m*Cp*ΔT 11) efficiency , η=Q/I*A A= Area of collector

3. METHODOLOGY.

The based on specification and the fact that received radiation from the sun through the collectors was used to fabricate the project as it was designed according to specification. The dimension has been put together through different construction sequences, i.e. it was carried out to form the construction which involves measurement, cutting of parts, planning, assembling and painting.

4. SCOPE AND LIMITATIONS

This study covered relatively the construction, importance and the effectiveness of the dryer. The concept of the solar dryer is wide and due to limitation in solar energy collection, the solar drying process is slow in comparison with dryers that use convectional fuels.

5. ADVANTAGE OF SOLAR DRYER

I. The drying is much faster than drying in the open space (i.e. because of the use of collector which concentrates the heat radiation).
II. Protection of food material from dust, insects, flies, birds and animals.
III. More spare time since less attention has to be given.
IV. Better quality and nutritious dry food.
V. Can be easily turned towards the sun for effective drying.

6.APPLICATION OF SOLAR DRYER

Solar dryer can be utilized for various domestic purposes such as drying of fruits, vegetables, grains, spices, cash crops, fish and meat. They also find numerous applications in industries such as textile, wood, fruits, food processing, paper pharmaceutical and Agro-industries.

7.TEST OF DRYING PERFORMANCE

7.1 DAYTIME (ENERGY FROM SUN).

TABLE(1):AMBIENT TEMPERATURE READING OVER TWO DAYS

SN	TIME	DAY1 (℃)	DAY2 (℃)	AVG
1	11.00-11.30	29.0◦c	32.0◦c	30.5
2	12.00-12.30	32.0◦c	36.0◦c	34.0
3	13.00-13.30	35.0◦c	35.0◦c	35.0
4	14.00-14.30	38.0◦c	34.0◦c	36.0

TABLE(2):ABSORBERTEMPERATURE READING OVER TWO DAYS

SN	TIME	DAY1 (℃)	DAY1 (℃)	AVG
1.	11.00-11.30	60.0◦c	70.0◦c	65.0
2.	12.00-12.30	66.0◦c	82.0◦c	74.0
3.	13.00-13.30	73.0◦c	78.0◦c	75.0
4.	14.00-14.30	80.0◦c	68.0◦c	74.0

TABLE(3):MEAN ABSORBERTEMPERATURE READING OVER TWO DAYS

SN	TIME	Mean daily ambient tempt (℃)	Mean daily absorber. (℃)
1	11.00-11.30	30.5	65.5
2	12.00-12.30	34.0	74.0
3	13.00-13.30	35.0	75.5
4	14.00-14.30	36.0	74.0

7.2 NIGHT TIME (ENERGY FROM PCM).

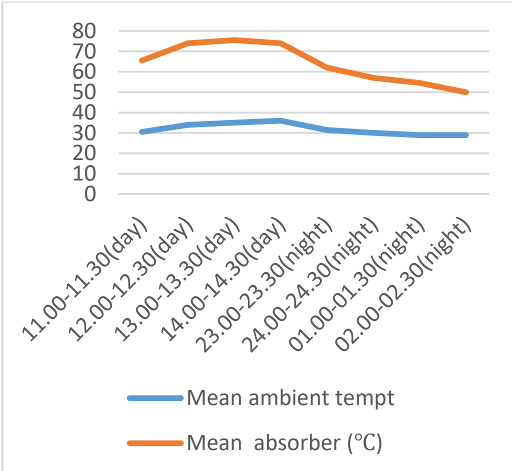
TABLE (4):AMBIENT TEMPERATURE READING OVER TWO DAYS

SN	TIME	DAY1 (℃)	DAY2 (℃)	AVG
1	23.00-23.30	31.0◦c	31.0◦c	31.5
2	24.00-24.30	30.0◦c	30.0◦c	30.0
3	01.00-01.30	29.5◦c	29.5◦c	29.5
4	02.00-02.30	29.◦c	29.0◦c	29.0

TABLE (5):ABSORBERTEMPERATURE READING OVER TWO DAYS

SN	TIME	DAY1 (℃)	DAY2 (℃)	AVG
1	23.00-23.30	63.0◦c	61.0◦c	62.0
2	24.00-24.30	57.0◦c	57.0◦c	57.0
3	01.00-01.30	54.0◦c	55.0◦c	54.5
4	02.00-02.30	51.0◦c	50.0◦c	50.5

TABLE (6): MEAN ABSORBERTEMPERATURE READING OVER TWO DAYS



SN	TIME	Mean daily ambient tempt (°C)	Mean daily absorber. (°C)
1	23.00-23.30	31.5	62.0
2	24.00-24.30	30.0	57.0
3	01.00-01.30	29.0	54.5
4	02.00-02.30	29.0	50.0

6. CONCLUSION

Solar food dryers function effectively via the use of pcm. The solar dryer has no smoke; soot or nauseating smell.It keeps the environment clean and conserved the precious resources of the country. The effect is obvious during a beautiful sunset then the paraffin wax material starts to changing its phase to solid then at the time it release the hot temperature this will spread over a large surface of dryer by help of blower . Thehot temperature passing through the dryer will not attained to stop because it is a cycleprocess

This paper reviews on solar dryers with the phase change materials (PCM) as the energy storage media. From this study, it is concluded that PCMs as energy storage media have higher thermal energy storage density of these materials compared with sensible heat storage materials this shows high thermal performance of solar dryers using a phase change material with high latent heat.TheSolar food dryers function effectively

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