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To Study design and drying operation of different materials in Solar Tunnel Dryer

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Small-scale dried food industries are growing very fast in Asia. Situated in favourable climate conditions, these Asian countries produce annually huge amounts of tropical fruits and vegetables. Drying is a major post-harvest processing of these food products. To respond to the demand of dried material from both domestic and international markets, a number of small scaled drying industries have been developed in India. Solar drying is a process where moisture content, air and product temperature change simultaneously along with the two basic inputs to the system i.e. the solar insulation and the ambient temperature. The drying rate is affected by ambient climatic conditions. This includes: temperature, relative humidity, sunshine hours, available solar insulation, wind velocity, frequency and duration of rain showers during the drying period. Also the government is promoting the maximum implementation of unconventional energy in every sector. In a year, we have about 8-10 months of sunshine with about 10-12 hrs a day. In this study, a greenhouse type solar dryer for College is developed and disseminated. The dryer consists of a parabolic roof structure covered with polycarbonate sheets on a concrete floor.
Keywords: Dryer, solar drying, unconventional energy.

INTRODUCTION

Solar drying is a continuous process where moisture content, air and product temperature change simultaneously along with the two basic inputs to the system i.e. the solar insulation and the ambient temperature. The drying rate is affected by ambient climatic conditions. This includes: temperature, relative humidity, sunshine hours, available solar insulation, wind velocity, frequency and duration of rain showers during the drying period. Open sun drying of various industrial and agricultural products is being practiced since age. Open sun drying is slow and exposes the produce to various losses and deterioration in quality. A number of industries have, therefore, accepted mechanical drying of the produce. Fuel wood, petroleum fuel, coal or electricity is used for air heating in the mechanical dryers. Solar dryers have great potential for replacement of industrial scale drying of industrial and agricultural products. Besides, effecting saving of precious fossil fuel, fuel wood or electricity, the solar drying may also is cost effective.

Presently mechanical methods are used for drying the material which is costly, time consuming and labour intensive. Looking to the power requirement and high cost of existing mechanical dryer, a solar tunnel dryer has been design and commissioned Solar radiation in the form of solar thermal energy is an alternative source of energy for drying especially to dry fruits, vegetables, agricultural grains and other kinds of material, such as wood. Drying by solar energy is a rather economical procedure for agricultural products, especially for medium to small amounts of products. It is still used from domestic up to small commercial size drying of crops, agricultural products and foodstuff, such as fruits, vegetables, aromatic herbs, wood etc. contributing thus significantly to economy of small agricultural communities and farms.

FACTORS AFFECTING THE SELECTION OF DRYERS:

1. Temperature and pressure in the dryer,
2. The method of heating,
3. The means by which moist material is transported through the dryer,
4. Any mechanical aids aimed at improving drying,
5. The method by which the air is circulated,
6. The way in which the moist material is supported,
7. The heating medium

CLASSIFICATION OF SOLAR DRYERS

Drying equipment may be classified in several ways. The two most useful classifications are based on
(1) The method of transferring heat to the wet solids or
(2) The handling characteristics and physical properties of the wet material.
The first method of classification reveals differences in dryer design and operation, while the second method is most useful in the selection of a group of dryers for preliminary consideration in a given drying problem.

WHAT IS SOLAR TUNNEL DRYER?

The dryer consists of a parabolic roof structure covered with polycarbonate sheets on a concrete floor.

- They give faster drying rates by heating the air to 10-30ºC above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects.
- Average temperature rise of this dryer is up to 60-65ºC.

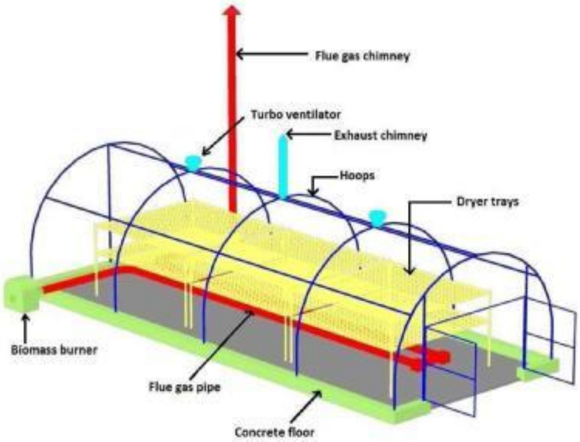


Figure: Graphical view of solar tunnel dryer

PRINCIPLE

Ambient air is drawn in and is heated by the floor and the products exposed to solar radiation. The heated air, while passing through and over the products absorbs moisture from the products.

Figure: Solar tunnel dryer

WORKING

In drying relative and absolute humidity are of great importance. Air can take up moisture, but only up to a limit. This limit is the absolute (maximum) humidity, and it is temperature dependent. When air passes over a moist food it will take up moisture until it is virtually fully saturated, that is until absolute humidity has been reached. But, the capacity of the air for taking up this moisture is dependent on its temperature. Higher the temperature, higher will be absolute humidity and larger the uptake of moisture.

EXPERIMENTAL SETUP

The most commonly seen design types are of cabinet form, some types are even improved making use of cardboard boxes and transparent nylon or polythene .For the design being considered, the greenhouse effect and thermo siphon principles are the theoretical basis. There is an air vent (or inlet) with guide ways to the solar collector where air enters and is heated up by the greenhouse effect, the hot air rises through the drying chamber passing through the trays and around the food, removing the moisture content and exits through the air vent (or outlet) near the top of the shadowed side.

The hot air acts as the drying medium, it extracts and conveys the moisture from the product (or food) to the atmosphere under free (natural) convection, thus the system is a passive solar system and no mechanical device is required to control.

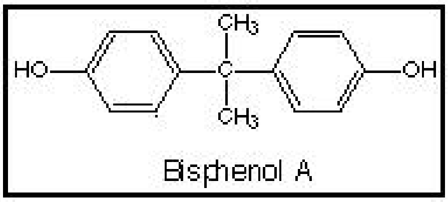
DESIGN CONDITIONS

- Ambient air temperature
- Ambient relative humidity
- Maximum allowable temp. –Tmax 70ºC
- Drying time(sunshine hours)- td 10 hours (Average for April)
- Incident solar radiation, I= 20MJ/m2/day (average for past 30 years)
- Collector efficiency
- Vertical distance between two adjacent trays.

MATERIAL OF CONSTRUCTION

Sheet material - UV stabilized polycarbonate film

Polycarbonates are long-chain linear polyesters of carbonic acid and dihydric phenols, such as bisphenol A.



PROPERTIES OF POLYCARBONATE

The above shown is the chemical formula of polycarbonate. The presence of the phenyl groups on the molecular chain and the two methyl side groups contribute to molecular stiffness in the polycarbonate. This stiffness has a large effect on the properties of polycarbonate. First, attraction between of the phenyl groups between different molecules contributes to a lack of mobility of the individual molecules. This results in good thermal resistance but relatively high viscosity (i.e., low melt flow) during processing. The inflexibility and the lack of mobility prevent polycarbonate from developing a significant crystalline structure. This lack of crystalline structure (the amorphous nature of the polymer) allows for light transparency.

Now for the clearer, less technical version of the properties, Polycarbonate is naturally transparent, with the ability to transmit light nearly that of glass. It has high strength, toughness, heat resistance, and excellent dimensional and colour stability. Flame retardants can be added to polycarbonate without significant loss of properties

The general properties can be summarized as follows:

- Excellent physical properties
- excellent toughness
- very good heat resistance
- fair chemical resistance
- transparent
- Moderate to the price
- fair processing

Advantages of polycarbonate

- Good thermal efficiency (R=1.54). Keeps the warmth in longer into the night and offers better frost protection
- Very tough and durable
- Good longevity (provided it is a premium grade polycarbonate)
- Produces a slightly diffused light which helps prevent burning/scorching the plants

Disadvantages of polycarbonate

- Prone to scratching
- Expensive than other material

WORKING PROCEDURE

1. The samples such as sawdust, onion chips and calcium carbonate are taken.
2. The weights of these samples are measured initially.
3. These samples are then kept in the solar tunnel dryer for drying.
4. These samples are checked and weighed after every 30 minutes and the readings are noted.
5. The samples are dried until the total moisture is removed from them.
6. Note their final weight.
7. According to the readings the moisture content v/s time, rate v/s time and rate v/s moisture content curves are plotted.

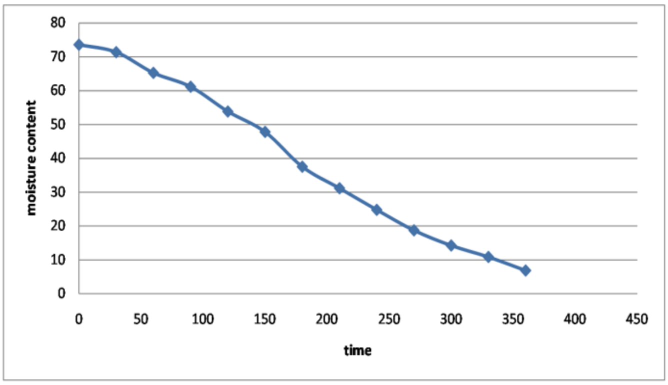
READINGS AND OBSERVATIONS

Time	Weight(gm)

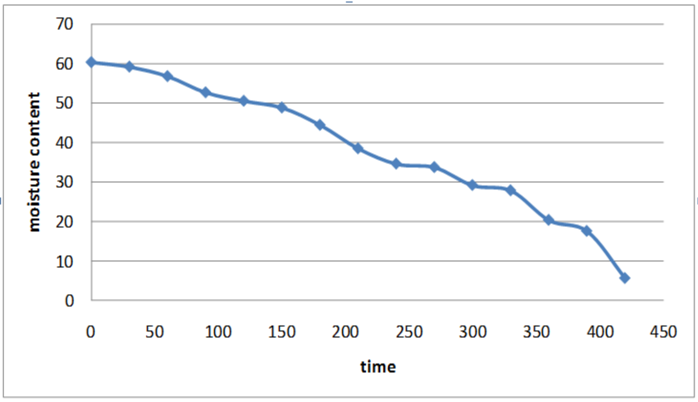
	Saw Dust	Onion Chips	$CaCO_3$
0	217.97	364.82	100
30	202.95	344..21	90.42
60	194.28	300.69	83.83
90	186.86	290.94	80.30
120	177.08	263.24	76.20
150	163.90	258.38	73.69
180	150.01	241.43	67.93
210	136.13	224.54	64.61
240	113.70	202.87	62.97
270	100.58	186.87	-
300	84.65	180.65	-
330	75.70	172.86	-
360	62.39	157.95	-
390	57.56	149.15	-
420	56.50	145.01	-

MOISTURE CONTENT V/S TIME CURVES

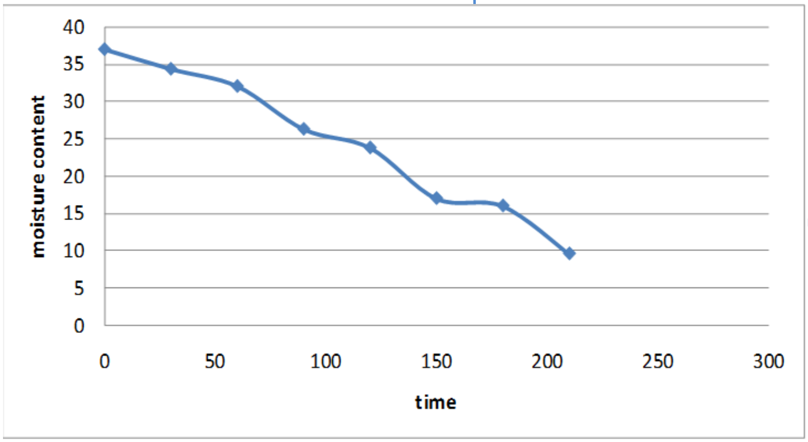
- **Saw Dust.**



- **Onion Chips**



- **Calcium Carbonate**



RESULTS

Saw Dust	Before Drying	After Drying	Time
Wt in gm	217.97	56.50	480 min.
Onion	Before Drying	After Drying	Time
Wt in gm	364.82	145.01	450 min.
Calcium Carbonate	Before Drying	After Drying	Time
Wt in gm	100	62.97	240 min.

CONCLUSION

Solar dryer is the best alternative technology. Improving of the drying operation to save energy, improve product quality and reduce environmental effect remained. Solar dryers have been proposed to utilize free, renewable, and non-polluting energy economically effective. It helps to improve rural industrialization and entrepreneurship development The drying equations as well as the drying curves were successfully obtained. The design of the model is also found to be very efficient as the semicircular shape gives the dryer all day long direct exposure to solar radiation and also the fabrication of model was cost effective. The higher drying rate enables a greater quantity of produce to be dried in a relatively short space of time. No special skills are required.

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