DESIGN AND DEVELOPMENT OF SOLAR AIR DRYERS FOR RAISIN

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ABSTRACT

Drying crops by solar energy is of great economic importance the world over, especially in India where most of the crops and grain harvests are lost to fungal and microbial attacks. These wastages could be easily prevented by proper drying, which enhances storage of crops and grains over long periods of time. India is blessed with abundant solar energy all the year round. The objective of this project is to modify design of a forced convection indirect solar dryer and its performance test on Grapes. The system consists of an air heating section (solar collector), a drying chamber and a centrifugal blower. In the process of drying, heat is necessary to evaporate moisture from the grapes. The solar collector is working as heat exchanger, which supply heat energy to air. Solar collectors are made of simple black painted aluminum corrugated plates. The solar air dryer consists of different components such as Solar Collector Plate, Air Blower and Insulating hot air Duct (wooden), the absorber plate is made up of aluminum and copper which has temperature range of 40 to 1200 C and its life is approximate 20 years. It is also highly recommended for photo-sensitive substance (crops) and have inherent tendency towards greater efficiency than direct solar drying.

Keyword: - *Solar air dryer, Performance parameter, Forced Convection, Absorber material*

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1. Introduction

Preservation of fruits, vegetables, and food are essential to keeping them for a long time without deterioration in the quality of the product. The more number of process technologies have been employed on an industrial scale to preserve food products; the important ones are canning, freezing, and dehydration. Among these, drying which is suitable for developing countries with low-temperature and less thermal processing facilities. Drying is a simple process of removing moisture from a product in order to reach the equilibrium moisture content. The main objective of drying apart from extended storage life can also improve the quality, ease of handling, further processing and is probably the oldest method of food preservation practiced by humankind.

Fruits and vegetables constitute a major part of the food crops in developing countries. Drying is one of the methods used to preserve fruit. This has been made possible by the process of drying. Grape is one of the world's largest fruit crops. The world production of grapes is presently 65,486 million tones out of which India accounts for 1.2 million tones. Drying the grape produces raisins. This project presents the background and possibilities of solar air drying, focusing on the technical needs of small farmers in the developing world. The theory section discusses the solar energy available in India and it also contains alternatives renewable resources. The literature section contains the work of some of the scientist in the same field and contains the different designs of solar air dryer. The background section explains the moisture content of foods, how moisture is removed and the energy require for drying process.

Design selected is a single circulating type, in which the exhaust air from the dryer box is drawn to surrounding. The collector box inlet is gradually increasing and outlet is gradually decreasing for uniform transfer of air through collector plate which is connected at inlet of dryer box and at inlet to blower. After the modification, performance test will be conducted to find the average dryer efficiency, extraction rate, reduction in the weight content, drying time. Solar air drying methods are usually classified to four categories according to the mechanism by which the energy, used to remove moisture, is transferred to the product.

(1) Sun or natural dryers: The material to be dryer is placed directly under hostile climate conditions like solar radiation, ambient air temperature, relative humidity and wind speed to achieve drying.
(2) Direct solar air dryers: In these dryers, the material to be dried is placed in an enclosure, with transparent covers or side panels. Heat is generated by absorption of solar radiation on the product itself as well as the internal surfaces of the drying chamber. This heat evaporates the moisture from the drying product and promotes the natural circulation of drying air.
(3) Indirect solar air dryers: In these dryers, air is first heated in a solar air heater and then ducted to the drying chamber.
(4) Mixed-type solar air dryers: The combined action of the solar radiation incident directly on the material to be dried and the air pre-heated in the solar air heater furnishes the energy required for the drying process.

1.1 Problem Definition
In India sun drying is most commonly used method. This form of drying has many drawbacks such as degradation by windblown, debris, rains, insect micro-organism, human and animals interference that will result in contamination of the product and drying rate is also low. So there is a need of development of solar air dryer for drying grapes under the methodological condition to protect the product from all the contaminants.

1.2 Objectives

- Design and development of solar air dryer.
- To study characteristics and performances of solar air dryer.
- Identify and evaluate the opportunities for further improvements, if time permits.

1.3 Scope of Project
Generally fossil fuels are used for drying system, but those fossil fuels are non-renewable sources. In future they goes vanished. The solar energy are renewable source, those are available easily. Solar air dryer will be use in various type of product to dry in short time. So use of solar energy is suitable or comfortable for drying system. Hence, in drying system solar energy have large scope.

2. Theory
Grapes are the most important raw material for making wine. A good understanding of grape composition is essential to understanding the process of raisins, production of wine making and making better quality wine.

2.1 Physical Composition
The fruit of the grape is a berry. Berries are attached to the stem. Many berries make up the cluster or bunch of grapes. The essential parts of the berry include the skin, pulp, and seeds. The skin consists of an outer layer covering the berry. It is made up of six to ten layers of thick walled cells. The outer surface of the skin is covered with a wax-like coating called the cuticle, which renders the berry waterproof. The main components in the skin are: coloring matter (red and yellow pigments), tannins, aromatic substances, and potassium and other minerals. Below the skin layer lies flesh or pulp which makes up most of the berry volume.
Cells in the pulp have large vacuoles containing the cell sap or juice. When the berry is gently crushed, the fragile cells in the pulp are broken and the juice is released. This juice is commonly referred to as the free run. The seeds are localized in the center of the flesh. The berry contains two to four seeds. They are rich in tannin which is extracted during fermentation (in red wines).

2.2 Chemical Composition

Freshly expressed grape juice consists of 70 to 80% water and many dissolved solids. These soluble solids include numerous organic and inorganic compounds. The important group of compounds, from the winemaking point of view, includes the following:-

1. Sugars

2. Organic acids

3. Phenolic compounds

4. Nitrogenous compounds

5. Aroma compounds

6. Minerals

7. Peptic substances

2.3 Solar dryer classification

2.3.1 Passive Solar Dryer

In a passive solar dryer, air is heated and circulated naturally by buoyancy force or as a result of wind pressure or in combination of both. Normal and reverse absorber Cabinet dryer and greenhouse dryer operates in passive mode. Passive drying of crops is still in common practice in many Mediterranean, tropical and subtropical regions especially in Africa and Asia or in small agricultural communities. These are primitive, inexpensive in construction with locally available materials, easy to install and to operate especially at sites far off from electrical grid. The passive dryers are best suited for drying small batches of fruits and vegetables such as banana, pineapple, mango, potato, carrots etc.

2.3.2 Active Dryer

These are indirect-type dryers with natural convection of air for drying. In order to increase the capacity of a dryer i.e. operate with more than one layer of trays with crops within the available area, the trays are generally placed in vertical racks with some space in between consecutive trays. The additional resistance generated for the air movement due to this arrangement of the trays is achieved by the “chimney effect”. The chimney effect increases the vertical flow of air as are suit of the density difference of the air in the cabinet and atmosphere. Active dryer is more efficient than passive dryer. In India mainly dryer are used by the farmers and Active dryer need electricity to run dryer but in India there is a shortage of electricity so it not economical to use active dryers.

2.4 Principle of Fruit Dehydration

The outer layers and surface of grape berries have physical and chemical mechanisms to resist water loss nature’s way of keeping the berry hydrated and turgid. The principal barrier is the berry cuticle, which includes the outer layer of epicuticular wax or bloom. This wax consists of partially overlapping flat plate lets that are irregular or lace like in texture. Their orderly spacing and arrangement and the chemical characteristics of the wax provide water repellence and vapor loss resistance.

3. Background

3.1. Background of food drying

Preservation of human and animal food by open-air drying in the sun was presumably one of the first conscious and purpose full technological activities under taken by humanity. Traditional open-air, solar drying methods are based on long term experiences and continue used all over the world to dry plants, seeds, meat, fish, and the agricultural products in order to preserve them. Over the last few decades, open-air drying has gradually become more and more limited because of the requirements for a large area, the possibilities of quality degradation, pollution from the air, infestation caused by birds and insects, and in here difficulties in controlling the drying sun energy, for drying, but excludes open air sun drying. A Solar dryer is an enclosed unit, to keep the food safe from damages from, birds, insects, and unexpected rainfall. The food is dried using solar thermal energy.

3.2. History of Solar collector

The invention of the liquid heating flat plate, solar water heater is credited to H.B. Saussure, a Swiss scientist, during the second half of the seventeenth century. However, the use of flat plate collector on a fairly large scale in the United States in Illinois was resumed in the early 1900s and later in Needles, California. Water was heated in relatively shallow horizontal troughs made of asphalt, usually double glazed, with desert sand as an insulator, and the heat thus collected was used to generate sulphur dioxide or Ammonia for operating pumps.

The most impressive array of the near-1900 era was that of Frank Shuman of Philadelphia, who, in 1907, built a flat plate collector to produce hot water which in turn evaporated ether, and thus, powered a vertical single cylinder engine. During the last fifty years scientists-all over the world have been trying to build and test different types of liquid flat plate collectors

4. SYSTEM DESIGN

4.1 Selection Characteristic of Absorber Plate for Solar Drying System

Since the temperature requirement is not too large is case of drying of industrial products (Range 80°C to 100°C). We have, therefore, selected type III air dryer in which the flow of air is on both the sides of the absorber. The air dryer of this kind the shorter plate length is more efficient than longer lengths. Suitable choice is between 1.5 m to 2.0 m. The optimum plate length is 1.5 m. The width of the collector is selected 1.0 m for structural convenience.

4.2. Selection and Analysis of Material for Solar Drying System

The whole manufacturing of project is done using water proof ply wood. As seal proof box is easy to made using Aerofoil tape & fevicol. Increasing number of transparent covers certainly improves the performance, as convective and radiative losses reduced. But for economical purpose single acrylic cover is selected. For insulation purpose glass wool is used, it is spreaded with the thickness of 18 mm between two layer of boxes. Also in dryer box glass wool insulation is done with the same thickness.

4.3. Collector Box

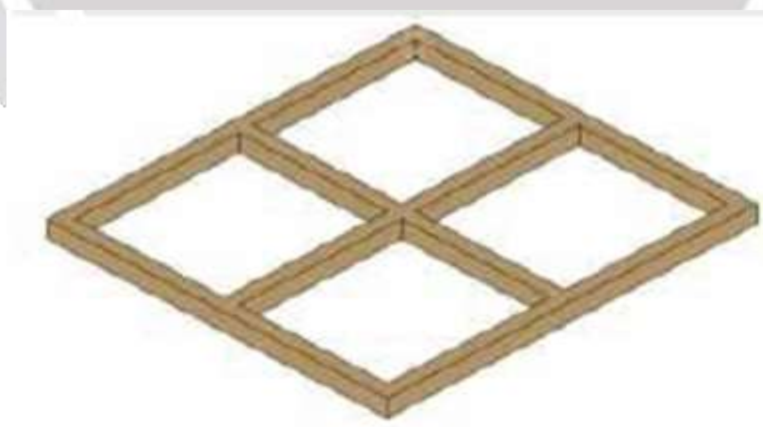
Collector box is made up of water proof ply-wood. It consists of two part external box & Inner box. Total length of collector box is 221.87 cm & its Width is 112 cm. Area available for Collector plate is 145 X 100 cm With the Depth of 9.5 cm.

4.4. Dryer box

It's made up of water proof plywood. Available cross section for dryer the material inside the box is 39X36cm. The height of dryer box is 57cm.Total four Trays can be fitted inside the box.

4.5. Trays

It's made up of wood with dimension of 39X36cm. Each tray is divided into four parts. There are total four trays inside the dryer box & one tray kept in atmosphere. There are total 16 sections whose reading is taken after every hour.



4.6. Collector Box stand

It's made of L angle bar, with cross section area 25x3mm.

4.7. Dryer box stand

It Supports the dryer box .Its height is 161cm.It also consist of a small box used to store Temp- Indicators.

4.8 Blower specification

A centrifugal air blower is a mechanical device for moving air or other gases. The terms "blower" and "squirrel cage fan" (because it looks like a hamster wheel) are frequently used as synonyms. These blowers increase the speed of air stream with the rotating impellers. They use the kinetic energy of the impellers or the rotating blade to increase the pressure of the air/gas stream which in turn moves them against the resistance caused by ducts, dampers and other components. Centrifugal fans accelerate air radially, changing the direction (typically by 900) of the airflow. They are sturdy, quiet, reliable, and capable of operating over a wide range of conditions. [04] Centrifugal blower is a constant CFM device or a constant volume device, meaning that, at a constant fan speed, a centrifugal fan will pump a constant volume of air rather than a constant mass. This means that the air velocity in a system is fixed even though mass flow rate through the fan is not.

- Company- Planet Power tools Pvt. Ltd.
- RPM: 13000
- 230 V, 50 Hz
- 650 W, 3m3 /min
- Single phase
- Blower impeller: Stainless steel to avoid corroding

5. Advantages of Solar Dryers

- Low investments, as compared to mechanical dryers.
- Minimize the problems associated with open sun drying.
- A variety of solar natural driers are available worldwide.

6. Limitations of Solar Dryers

- Moisture condensation inside glass covers reducing its transitivity.
- Sometimes the insufficient rise in crop temperature affecting moisture removes.

7. CONCLUSION

The solar air dryer can be widely used for agricultural purpose. The disadvantage in using solar air dryer is that it is not efficient. Using blower gives more efficiency than naturally recirculating the air in the dryer. But this efficiency is obtained at the cost of blower and electricity. The corrugated absorber sheets gave superior results than those obtained by the plane absorber sheets used in earlier solar air dryers

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