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Design and Development of Solar Dryer for Multiple Fruits

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Abstract

A solar dryer was modified with application of force convection to develop a more efficient drier by using a flat plate collector for multiple fruits. In the last decade or two, many solar dryers have been invented in which the span of drying is about 3 to 5 days, but these conventional methods don't maintain purity of fruits. In this paper, the invention of a new dryer, in which time span was reduced to some extent, is discussed. The solar dryer which we have fabricated reduces drying time by 1 to 2 days and also maintains purity and nutrition.

In our project entitled "Design and Development of Solar Dryer for Multiple Fruits", we used force convection method which differs from conventional methods. Solar dryer was fabricated with force convection in order to improve the efficiency and productivity of food crops to a large extent. In a solar dryer, when the sun rays are incident over flat plate collector, the black coated surface of the collector gets heated and temperature inside it increases. The fan placed in front of the collector blows the hot air from collector to the drying chamber. Due to this, the grapes placed on the first grate get heated, which in turn reduces the moisture of the fissured content in the grapes. The remaining hot air is then passed to the next grate and so on. After hot air passes from the third grate, this air is then recirculated with the help of a PVC pipe. The first end of this pipe is connected to the top of the drying chamber and last end is connected to the fan. All these modifications help to increase the efficiency of a solar dryer.

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Keywords: *Solar Dryer, Force Convection, Flat Plate Collector*

INTRODUCTION

Dried fruits and vegetables are vital sources of food and nutrition in human diet. They contain vital nutrients such as protein, carbohydrate, high density liquid (good cholesterol), vitamins and minerals. Since fresh fruits and vegetables are perishable, they are available for a short period. Among the important dry fruits available in markets that belong to the category of genus vitas, grapes are one.

Traditional drying, frequently done on the ground in the open, is the most widespread method used in developing countries, as it is the simplest and cheapest method of conserving foodstuffs. Some disadvantages of open air drying are: It requires both large amount of space and long drying time, exposure of the foodstuff to rain and dust, the crop is damaged because of uncontrolled drying and hostile weather conditions, infestation by insects and attack by animals. This could lead to slow drying rate, contamination and poor quality of dried products. A better understanding of the method of utilizing solar energy has given rise to a scientific method called solar drying. However, the availability of important information is lacking in many countries where solar food processing system is viable and much needed.

There are a large variety of solar dryers that can be classified basically into two types: natural convection type dryers and forced circulation type dryers. Natural convection dryers do not require a fan to pump the air through the dryer. The low air flow rate and the long drying time, however, result in low drying capacity. Where large quantities of fresh produce are to be processed for the commercial market, forced convection dryers should be used.

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Fig 1: Actual image of solar dryer

The present project was directed towards identification of possible areas of invention to bring new modification in the existing solar dryer with the primary objective to reduce time as well as enhancement in quality and productivity. We use force convection instead of natural convection to increase the efficiency of solar dryer. One more thing we added in our project model is the use of recirculation technique.

CONSTRUCTION

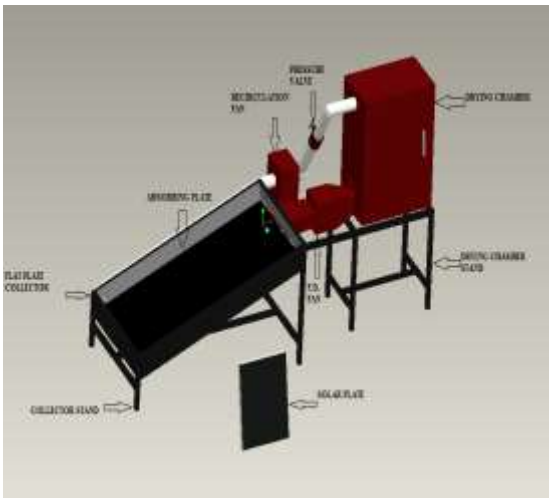

Fig 2: CAD Design of Solar Dryer

Components of a Solar Dryer

- **Flat Plate Collector**

  A flat plate collector collects solar radiation. It utilizes solar radiation without being slanted towards the sun, and requires little maintenance.



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Fig 3: Flat Plate Collector

- **The Drying Chamber**

  The drying chamber is made up of iron metal sheets that are having inlet at the bottom side for hot air and outlet at the top side for air removal. It has an insulation of thermocol at the outer side of the chamber.

The arrangements were done in the drying chamber to mount the drying trays. Door is provided in the front for loading and unloading the drying products in the drying trays.



Fig 3: Drying Chamber

1. DESIGN OF SOLAR DRYER

a) Assumptions:

i. Mass of Agricultural goods = 1kg (e.g. Grapes). Latent heat of vaporization of water = 2257 kJ/kg.

ii. Drying process is done on a sunny day.

iii. Efficiency of heater is assumed to be 0.25 or 25%

iv. Atmospheric pressure is 1.01325 bar

v. Ambient temperature of air is 300 C

vi. Exit temperature of air is 600 C

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vii. Initial moisture content is 80%.

viii. Final moisture content is 5%

b) Basic Energy Balance Equation:

Mass of water to be evaporated from 1 kg of grapes:

$m_w = w_i (m_i - m_f) / (100-1)$

$m_w = 1(80-1) / (100-1)$

$m_w = 0.7979$ kg of water

Where

m_w= mass of water

w_i= mass of agriculture product

m_i= initial moisture content

m_f= final moisture content

c) Quality of Heat Needed to Evaporate the H_20:

The quality of heat required to evaporate the H_20 would be -

$Q = m_w \times h_{fg}$

Where:

Q = the amount of energy required for the drying process, kJ

m_w = mass of water, kg

h_{fg} = latent heat of evaporation, kj/kg H2O

$Q = 0.7979 \times 2257$ K J

Q = 1800.86 KJ

d) Mass of Drying Air Required :

$Q = m_a \times c_{pa} \times (T_f - T_i)$

$1800.86 \times 1000 = m_a \times 1002 \times (60-30)$

$m_a = 59.90$ kg

For a time period of 8 Hours per day for 3 days, mass flow rate is ma / (3×8×60) kg/min.

ma= 0.041 kg/min

e) **Dryer Design**

$A_c \times I \times \eta = Q_u$

I is the total global radiation on the horizontal surface during the drying period, kj/m^2,

ŋ is the collector efficiency,

A_c is collector area in m^2,

Q_u = Useful energy which is same as total energy required.

$A_c = Q_u / (I \times \eta)$

$=(1800.86 \times 1000)/(650 \times 0.25 \times 3 \times 8 \times 3600)$

$= 0.128\ m^2$

f) Final Design:

Length of dryer = 762 mm

Width of dryer = 457.2 mm

Height of dryer = 914.4 mm

Collector length = 1828.8 mm

RESULT AND DISCUSSION

The variations of temperature of air at solar collector outlet, and ambient temperature for a typical day with recirculation and without recirculation are shown in Fig. 4.

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The average drying air temperature recorded at inlet of the drier was measured to be about 620o C and490 o C during peak and off sun sunshine hours respectively.

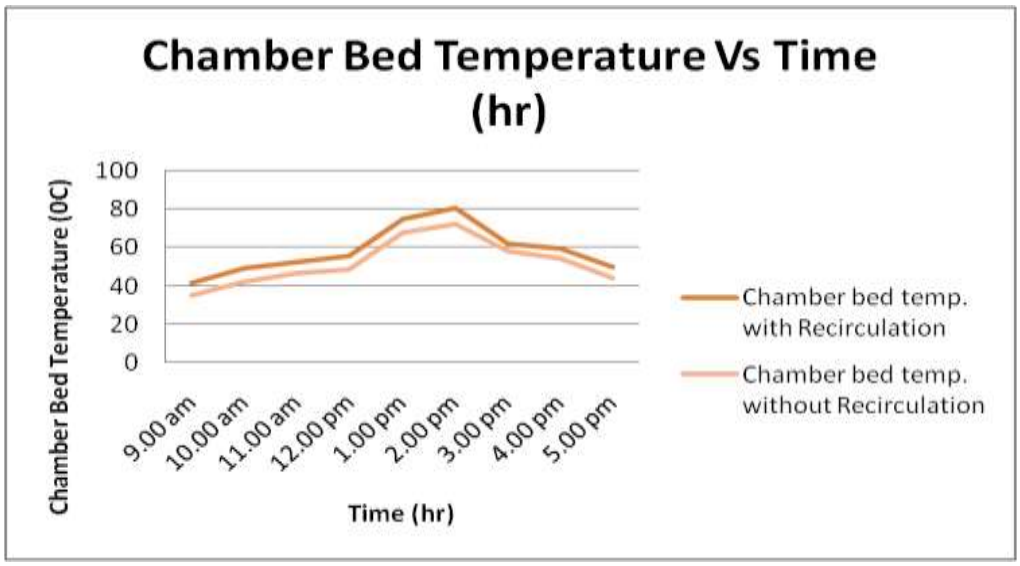

Fig 4: Variation of chamber temperature against time (hr)

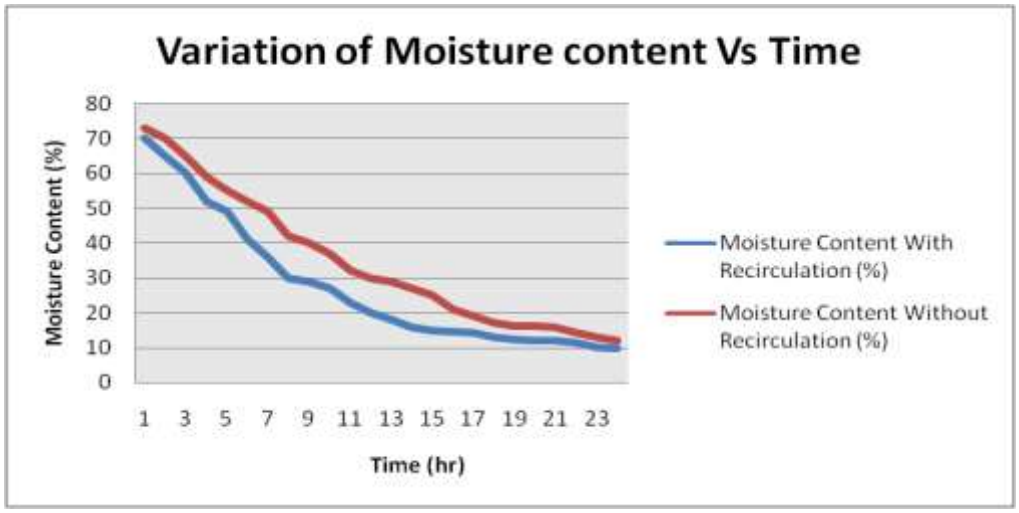

Fig 5: Variation of Moisture content (%) against Time (hr)

CONCLUSION

From the study of Design and Development of a solar dryer for multiple fruits, it is concluded that it is a good device to dry different agricultural produce. It reduces the time of drying by

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2-3 days. It also saves the product from spoilage due to birds, insects, micro-organisms and climate conditions. It also gives high returns due to high marketability. The fabrication discussed in this paper is achieved in reduced cost so as to make it available to common man and thus, divert the attention towards a renewable source of energy.

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