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FABRICATION, EXPERIMENTATION AND COMPARISION OF SOLAR AIR DRYER

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Abstract

Agriculture is considered to be the backbone of Indian economy as 65-70%of the population depend on agriculture for employment and livelihood. But, yet the national food production could not meet the needs of the population. It is found that, post-harvest loss of fruits and vegetables are high. Improper preservation of seasonal agricultural products and depleting energy reserves cause considerable loss, thereby reducing the food supply significantly. The solar powered air dryer is new technology basing on blending solar thermal. Our project solar panel is used to convert the light energy to heat energy by the flat plate collector method. The machine, solar air dryer, we introduce through our project is mainly useful for drying seeds, fruits and wherever moisture contents. In our project, the solar air dryer is mainly consists of four main parts such as solar panel, heating element, battery and blower. The blower is used to passing the hot air to the required place, so that the moisture contents in the place was removed. So we can move the ground dryer to any place very easily.

I. INTRODUCTION

Agriculture is considered to be the backbone of Indian economy as 65-70%of the population depend on agriculture for employment and livelihood. But, yet the national food production could not meet the needs of the population. It is found that, post-harvest loss of fruits and vegetables are high. Improper preservation of seasonal agricultural products and depleting energy reserves cause considerable loss, thereby reducing the food supply significantly. At the time of harvesting, most of the agricultural products have high moisture content. Agricultural products, if left as such will biologically degrade due to the growth of microorganisms. So, to preserve them for future purpose and to make it available throughout the year proper preserving technique is to be adopted. Drying is a method of food preservation which can improve the shelf life of agricultural products mainly fruits and vegetables. Drying reduces moisture content of a product to a level below which deterioration does not occur and thus prevents fermentation or growth of moulds. Products after drying process fetch a better market price. Thus, drying helps the farmers to secure a greater economic return which in turn enhance the economy of the nation.

The disadvantages of traditional sun drying are contamination by dirt, insects, dust, rain etc. Also, it requires continuous monitoring throughout the drying period, to safeguard the product when the weather becomes worse and to protect it from domestic animals. Also, the product dried is found to be unhygienic and the quality of the product is very poor [1].

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. It offers a most effective and practical way of preservation to reduce losses during postharvest and offset the shortages in supply. Drying is a simple process of removing moisture from a product in order to reach the equilibrium moisture content and is an energy intensive operation. 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 [2].

The most available source of renewable energy on earth is solar energy as the earth receives millions of watts of energy everyday coming from solar radiation. However, only a fraction of it in the form of day lighting and photosynthesis is used by the natural world, one third is reflected back into space and the rest is absorbed by land, oceans and clouds. Thus, it is very reasonable to collect solar energy and utilize it efficiently to generate electric power, heat and also for cooling purposes in a viable way. The effect of using solar energy on the environment for a variety of applications is minimal as it produces no harmful pollutants. Besides environmental consciousness, dwindling of traditional energy sources marks solar energy as the appropriate energy source to meet the increasing demand of energy worldwide. Researchers have investigated and developed technologies on how to harvest solar energy to serve human beings and are still considering new technologies to maximize the collection and utilization of solar energy[3]

The drying process takes place in two stages. The first stage happens at the surface of the drying material at constant drying rate and is similar to the vaporization of water into the ambient. The second stage takes place with decreasing (falling) drying rate. The condition of the second stage determined by the properties of the material being dried. Open sun drying is the most commonly used method to preserve agricultural products like grains, fruits and vegetables in most developing countries. Such drying under hostile climate conditions leads to severe losses in the quantity and quality of the dried product. These losses related to contamination by dirt, dust and infestation by insects, rodents and animals. Therefore, the introduction of solar dryers in developing countries can reduce crop losses and improve the quality of the dried product significantly when compared to the traditional methods of drying such as sun or shade drying. Solar 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 [4].

II. REVIEW OF LITERATURE

T.Rajagopal..et.,al has conducted experiment on indirect type forced convection solar dryer, and it is fabricate with the components like evacuated tube collector, drying chamber and blower. Solar drying of copra is carried for forced convection and is compared with natural convection solar drying. The temperature of the drying chamber ranges from 49ºC to 78ºC for natural and forced convection while the ambient temperature ranges from 28ºC to 32ºC. Initial moisture content of copra ranges from 51.7% to 52.3% and the final moisture content obtained about 7 to 8%. As the solar dryer using evacuated tube collector can perform better even during cloudy days and winter season. The designed indirect type solar dryer utilized the more solar thermal energy as a result obtained as reducing the time required to dry the copra and also improves the quality of the drying product[1].

M.A. Sabiha y..et.,al has conduct an experiment on Evacuated Tube Solar collector and found that the solar collectors and an evacuated solar collector is the most efficient and convenient collector type of collectors. Applications of evacuated solar collectors in water heating, heat engines, air conditioning, swimming pool heating, solar cooker, steam generation and solar drying for residential and industrial sectors. Collector efficiency of different types of evacuated collectors and their performance based on different working fluids were found to be well. It has been found that an evacuated tube collector has higher efficiency than the other collector. An evacuated tube collector is also very efficient to be used at higher operating temperature. Some recommendations are made on future research. It is expected that it will be very useful for energy producing industries as well as for research organizations.

B.O.Bolaji..et.,al has done an experiment on Box-Type absorber solar air collector, and performance of solar collector with the dryer was evaluated. The results show that high temperature can be achieved in the dryer with the use of the box-type absorber collector. The maximum average temperature obtained (during the sunshine hours) inside the collector and the drying chamber were 64°C and 57°C, respectively while the maximum ambient temperature observed was 33.5°C.The heating temperature inside the dryer was higher than the ambient temperature by an average of 15.3°C(50.7%) throughout the daylight. Comparison has made between the performance of the existing system with other system having different types of absorber showed that the existing system is more efficient and with a maximum collector efficiency of 60.5%.
Oliver St C Headley..et.,al has described the design and operation of two medium scale solar agricultural dryers, one with a capacity of ten tonnes of hay, the other with a capacity of seven tonnes of onions, and compares them with two other medium scale solar dryers which are used for fruit and timber. The solar dryer with the least initial capital cost is one which uses an existing farm building or adds a solar air heater to an existing conventional crop dryer. While multi-crop dryers may seem to be an ideal solution, the fact is that most operators prefer to have a dryer which is dedicated to one or two crops or to a specific kind of crops or fruits, since the compromises inherent in a multi-purpose dryer often result in reduced efficiency for its primary product.

Ahmed Abed Gatea..et.,al has conducted an experiment on solar drying system of a cylindrical section which consists of a solar collector flat plate, drying chamber cylindrical section and a fan was built and designed for the purpose of drying 70 kg of bean crop. And there was an analysis of a thermal solar collector with flat plate absorption being obtained at the maximum temperature outlet of 71.4°C at 11 am. At radiation intensity, 750 W/m^2 for air flow rate of 0.0401 kg/s was obtained at ambient temperature of 34°C. The maximum average value of thermal efficiency of the solar air collector obtained from the calculation is 25.64% at air flow rate of 0.0675 kg/s, the maximum daily efficiency drying system was 18.41% at air flow rate of 0.0405 kg/s.

Joshua Folaranmi..et.,al has carried out project on solar maize dryer and they have designed, constructed and tested a simple solar maize dryer. They design in such a way that solar radiation is not incident directly on the maize, but preheated air warmed during its flow through a low pressure thermosphonic solar energy air heater or collector in order to contributed heating. The test results gave temperature above 45^{O}C in the drying chamber, and the moisture content of 50kg of maize reduced to about 12.5% in three days of 9hours each day of drying.

III. EXPERIMENTAL SETUP

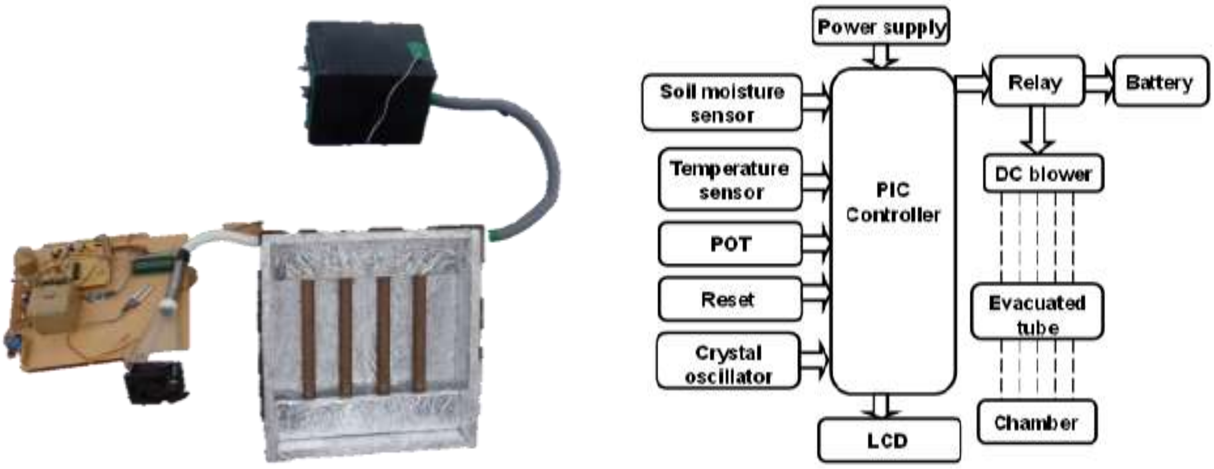

Fig-1: Solar Air Dryer with Evacuated Tube collector and Microcontroller along with block diagram

Evacuated tubes:
Evacuated Tubes are the heart of the Apricus AP solar collector, responsible for absorbing sunlight and converting it into usable heat.

Tube design:
The evacuated tube design used by Apricus was originally developed in the 1980s and has proven to be extremely robust. Referred to as the "Sydney" tube, "twin-tube" or "all-glass", the tube is essentially two glass tubes that are fused at the top and bottom. The inner tube has a solar absorbing coating, and the space between the two tubes is evacuated to form a vacuum. Let's look at the design features of the evacuated tube in more detail.

Strong glass:
The tubes are made from a type of glass called Borosilicate, the same base material as used in many Pyrex glass products used in kitchens around the world. Borosilicate glass has the characteristic of being very strong and also has excellent light transparency (>92% @ 2mm thick). The wall thickness of the glass greatly impacts the strength, longevity and naturally also the cost. Apricus evacuated tubes are custom made to strict requirements that exceed the industry standards, including a 1.8mm thick wall ensuring excellent strength and resilience to hail impact.

Vaccum insulation:
The name "evacuated" is used to describe the process that expels the air from within the space between the tube tubes, forming a vacuum. A vacuum is an excellent insulator against heat loss, and so evacuated tubes are able to operate very efficiently when there is a big difference between

the inside of the tube and the outside ambient air. For this reason evacuated tubes are the ideal choice for high temperature hot water applications or locations that get cold in the winter.

Barium getter:

In order to help maintain the vacuum over the 15-20 year life of the evacuated tube, a barium getter "soaks up" any remaining gases in the evacuated chamber plus any fresh gases such as Nitrogen that can slowly permeate through the glass over time, a process known as out-gassing. This barium layer also provides a clear visual indication of the vacuum status; the silver-coloured barium layer turns white if the vacuum is lost making it easy to identify a fault tube.

Solar absorber:

The absorber coating comprises a base layer of Aluminium on the outside of the inner glass tube followed by thin layer of the dark coloured AL/N material. These coatings are applied using a method called dc reactive sputtering which is extremely reliable after having been finetuned over the past 20 years since it was developed.

Efficiency:

The combination of the highly efficient absorber coating and the vacuum insulation means that the coating can be well over 200°C / 392°F and the outer glass is cool to touch. In strong sunlight, each evacuated tube can provide over 60 Watts / 204 Btu of water heating output.

Extracting Heat:

The heat produced by an evacuated tube can be extracted in a number of ways, depending on the design. The most common methods include direct water flow, U tube pipe, pipe-in-pipe or heat pipe. Apricus AP solar collectors use a heat pipe to extract the heat from within the evacuated tube and transfer it to heat exchanger part of the collector.

Evacuated Tube Solar Collectors

Apricus ETC evacuated tube solar collectors convert energy from the sun into usable heat in a solar water heating system. This energy can be used for domestic and commercial hot water heating, pool heating, space heating or even air conditioning

Evacuated Tube (ET):

Absorbs solar energy and converts it to usable heat. A vacuum between the two glass layers insulates against heat loss.The Heat Transfer Fin helps to transfer heat to the Heat Pipe.

Heat Pipe (HP):

Copper vacuum pipe that transfers the heat from within the ET up to the manifold.

Manifold:

Insulated box containing the copper header pipe. The header is a pair of contoured copper pipes with dry connect sockets that the heat pipes plug into.

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IV. RESULT AND DISCUSION:

Tabular Column

Results on 18th May 2016

Table 1. Variation of Temperature with Time on the First day for Peases

Time	2 Pm	2 30 pm	3 Pm	3 30 pm	4 pm	4 30 pm	5 pm	5 30 pm
T_a (°C)	38	38	38	38	38	38	38	38
T_i (°C)	38	42	44	47.06	41.18	39.22	37.25	37.25
m_a (gm)(solar dryer)	38	36	30	28	26	24	24	24

m_a -mass of peases at 2:00 pm m_b-mass of peases at 5:30pm

(Dryer)Moisture removed $=m_a-m_b=38-24=14$gm

Results on 18th May 2016

Table 2. Variation of Temperature with Time on the First day for Grapes

m_a -mass of potato at 12:00 pm m_b-mass of potato at 4:00pm

Time	2 pm	2 30 Pm	3 pm	3 30 pm	4 pm	4 30 pm	5 pm	5 30 pm
T_a (°C)	38	38	38	38	38	38	38	38
T_i (°C)	38	42	44	47.06	41.18	39.22	37.25	37.25
m_a (gm)(solar dryer)	40	40	39	39	38	38	37	37

(Dryer)Moisture removed $=m_a-m_b=2.25-1.69=0.56$kg

Results on 19th May 2016

Table 3. Variation of Temperature with Time on the Second day for peases

Time	12 pm	12 30 pm	1 pm	1 30 pm	2 Pm	2 30 Pm	3 pm	3 30 pm
Ta (°C)	39	39	39	39	39	39	39	39
Ti (°C)	39	47	45.10	44.22	43.6	42.33	41.8	40.4
ma (gm)(solar dryer)	24	18	17	17	16	15	15	14

m_a -mass of peases at 12:00 pm m_b-mass of peases at 3:30pm

(Dryer)Moisture removed $=m_a-m_b=38-24=14$gm

Results on 19th May 2016

Table 4. Variation of Temperature with Time on the Second day for Grapes

Time	12 Pm	12 30 pm	1 pm	1 30 pm	2 pm	2 30 Pm	3 pm	3 30 pm
T_a (°C)	39	39	39	39	39	39	39	39
T_i (°C)	38	42	44	47.06	41.18	39.22	37.25	37.25
m_a (gm)(solar dryer)	40	40	39	39	38	38	37	37

m_a -mass of peases at 2:00 pm m_b-mass of peases at 5:30pm

(Dryer)Moisture removed $=m_a–m_b=38-24=14$gm

Peases **Grapes**

Fig 2: Before drying

Fig 3: After drying

V. CONCLUSION

In this experimental study, the drying of Pease's and Grapes was investigated under the forced convection. The indirect type forced convection solar dryer with evacuated tube collector generates air temperature higher inside the chamber and enhance drying rate thereby reducing the drying time required to dry a product. The time taken by the solar dryer with forced convection to reach desired moisture content is less than the time required in natural convection. As the solar dryer using evacuated tube collector can perform better even during cloudy days and winter season. The designed indirect type solar dryer utilized the more solar thermal energy as a result obtained as reducing the time required to dry the Peases and Grapes. And also improves the quality of the drying product. The obtained result is compared with the solar air dryer of flat plate, whose efficiency is dependent on the area of the flat plate collector, Flow rate, solar radiation etc. But in case of Evacuated Tube Collector efficiency is depends on only the performance of Evacuated Tube and Flow rate.

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