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Mechanical Design of Smart Solar Tunnel Dryer

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Abstract: *Solar energy is an important source of renewable energy and is the most readily available non polluting source of energy. The objective of this paper is to develop a highly intelligent solar tunnel dryer incorporated with sensors and controllers for large scale agricultural drying purpose. Temperature and humidity sensors are used for detecting the current atmosphere inside the dryer. A blower fan is also used for delivering the hot air to the surface of the product to be dried. Solar dryer gives faster drying rates, reduces humidity and risk of spoilage and improves the quality of the product.*

IndexTerms*: PV panel, auxiliary heating coil, controlled blowers, humidity sensor, solar collector, temperature sensor, microcontroller****.***

I. Introduction

The intermittent nature of solar energy is the main problem faced by the conventional solar dryer without storage system. It is important for a solar dryer to be operational in partially cloudy, hazy and sunny environments. Thus the conventional dryer is not reliable. Increasing the collector area increases the area available for insolation and thus reduces the drying time. However increased collector area subsequently leads to increased capital cost and more space required for a larger solar dryer. By incorporating storage system along with the conventional solar dryer this mismatch between supply and demand can be solved to an extent. The aim of this paper is to improve the existing methods of solar drying by using energy storage system and to determine if there is an improvement in the drying performance of products. The prime objective is to design a solar dryer for drying products. With drying most agricultural products can be preserved and this can be achieved more efficiently through the use of solar dryers. An auxiliary heating coil is also provided for operation on rainy or cloudy days. So that allows the operation of solar dryer during the off sunshine day. Our project mainly focuses on design of a solar dryer for drying the products efficiently and economically. In rural areas, farmers can easily dry their products for competing with industrial products. This is more economical for them. We can design the size and shape of the dryer as per our need. The product cost is dependent on the size of the dryer.

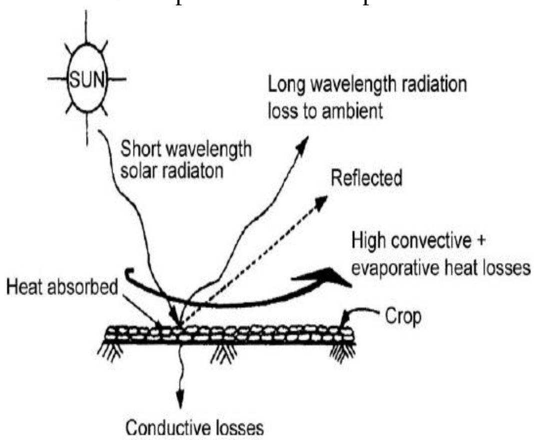

Fig 1 Working principle of open sun drying

Food drying is one of the oldest methods of preserving food products. High moisture content is one of the reasons for its spoilage during the course of storage at time of harvesting. High moisture crops and other products are prone to fungus infection, attack by insects and the increased respiration of agricultural products. There is spoilage of food products which could be prevented using dehydration techniques. Solar drying is in practice since the time of immemorial for preservation of food and agricultural crops. This is done particularly by open sun drying. This process has several disadvantages like spoilage of product due to adverse climatic condition like rain, wind, moist, loss of materials due to birds and animals. Also the process is highly labour intensive, time consuming and requires large area. With cultural and industrial development artificial electrical heating came into practice to increase the drying speed. This process is highly energy intensive and expensive which ultimately increase product cost. Thus solar drying is the best alternative solution for all the drawbacks of traditional drying and electrical drying. Additionally, the solar energy is a promising energy source despite its daily and seasonal fluctuations that represent a severe drawback. The energy necessary for drying usually comes from fossil fuels whose prices are continuously rising and their negative impact due to CO2 emissions is challenging the environment. Concern about global warming is universal and bringing our attention to the energy-intensive processes such as drying, where the fossil fuel can often be replaced by renewable and non polluting source of energy. The traditional sun drying is not much effective technique. The solar dryer has considerable advantages over the traditional sun drying method in terms of less risk of spoilage because of the speed of drying. Drying is faster because inside the dryer it is warmer than outside. So the quality of the products dried inside the dryer is better in terms of nutrients, hygiene and color. In conventional tunnel drying, the crop is spread in an even layer on tables or drying racks inside the tunnel which is exposed to sun. But this conventional method of drying is not an effective method of drying during rainy or cloudy climate. An improved technology in utilizing solar energy for drying is the use of solar tunnel dryers along with solar collectors and other auxiliary equipments like blowers. Air is heated in a solar collector and this heated air blown to the chamber by blower.

II. Lay Out

Smart solar tunnel dryer consist of solar panel, drying chamber blower fan, heating coil, temperature and humidity sensor. Solar panel provides the power supply for the whole system. Drying process is carried out in the drying chamber. The heated air flows through the drying chamber whose walls are coated with aluminum foil which helps in retaining the heat inside the chamber. Trays are arranged inside the drying chamber to carry the products to be dried. An auxiliary heating coil is used along with a blower fan. This arrangement helps in the uniform circulation of hot air through the chamber. Drying of the product occurs because of the movement of the hot air inside the chamber. The drying time depends on the amount of sunlight intensity, temperature within the chamber, air circulation, humidity, and the nature of product. Humidity and temperature play an important role in the drying process. When the hot air is blown through the product to be dried, it will take up the moisture until absolute humidity is reached. The rate of drying is directly proportional to the temperature and the circulation speed.

Solar food drying can be used in most areas but how quickly the food dries is affected by many variables especially the amount of sunlight and relative humidity. Typical drying times in solar dryers range from 1 to 3 days depending on sun, air movement, humidity and the type of food to be dried. The principle that lies behind the design of solar dryers is as follows: 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 means until absolute humidity has been reached. But the capacity of the air for taking up this moisture is dependent on its temperature.

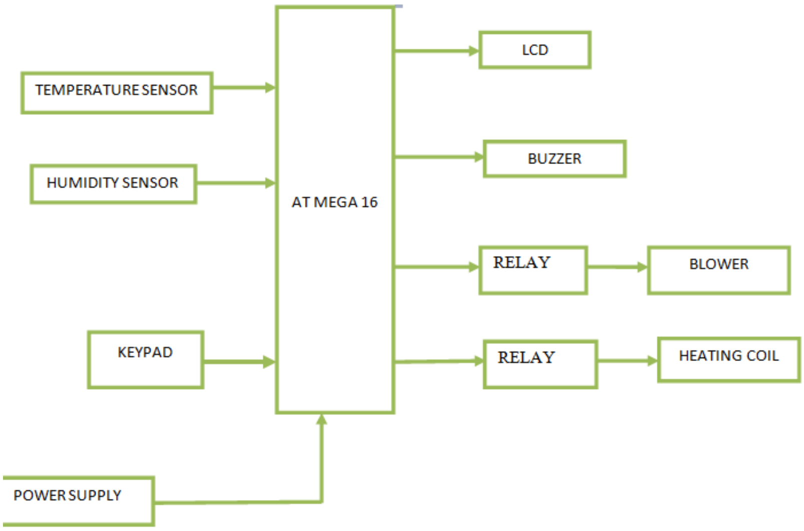

Fig.2 Block Diagram of solar tunnel dryer control unit

III. Hardware Description

The hardware model of solar tunnel dryer consists of both mechanical and electrical parts. The mechanical parts consist of drying chamber, solar collectors, trays, blower and heating coil. The electrical part consists of solar PV panel, temperature sensor, humidity sensor and micro-controller.

A. Mechanical Components.

A. Drying chamber

The drying chamber is an air tight chamber where the drying process is carried out. A cubical drying chamber having a capacity of 250 liters is used in this project. The dimension of the chamber is 70 *70*70cm. Marine plywood is used for fabrication purpose to minimize heat loss. The advantages of marine plywood as a material are that it is a poor conductor of heat and it has smooth surface finish. Also they won't catch fire also heat loss by radiation is minimum. Matte black is the color chosen for the outer portion of drying chamber. Aluminum foil is coated on the inside portion of the drying chamber. This type of foil generally has a silvery finish along with high reflectivity. Hollow transparent polycarbonate sheet is used to cover the upper most part of the drying chamber. The heat energy from the solar rays is trapped by the polycarbonate sheet. This energy heats up the air inside the tunnel. The density of the air decreases as the air gets heated. This heated air passes through the tunnel and circulates inside the drying chamber causing uniform drying of the product.

B. Solar collector

Solar collector collects heat by absorbing sunlight. A collector is a device for capturing solar radiation. Solar radiation is energy in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The quantity of solar energy striking the Earth's surface (solar constant) averages about 1,000 watts per square meter under clear skies, depending upon weather conditions, location and orientation.The heat transfer rate from absorber plate to air flowing in the duct of solar air heater can be increased to improve the solar air heater. The enhancement of convective heat transfer can be done by creating turbulence at heat transfer surface with the help of artificial roughness on absorber plate. Hence in this dryer, we use a solar collector employing baffled aluminum sheet. It's dimension is 70*52*4.2 cm (l*b*h). The air follows a winding path due to the baffles, thereby doubling the length of the air passage through the collector. The baffles are positioned vertically upward pointing to the polycarbonate sheet, such that they create turbulence which forces the air to come in close contact with hot surface of the absorber and decreases the thermal sub layer. Air vents are provided on one vertical side of the collector, whereas the opposite side is connected to the blower which is placed inside the chamber.

C. Trays

Drying chamber designed in a such a way that it consists of 4 trays which would hold drying products. Its dimension is about 70*52*4.25 cm (l*b*h). About 12 liters of product volume can be placed in each tray. Hence the total capacity of the trays is approximately 50 liters. Rusting can be avoided by using aluminum as the material for trays. The main reason for using aluminum is because aluminum meshes are light weight, strong and there is significant resistance for atmospheric corrosion. Wooden frames are used for each tray. Due to the usage of wire mesh heated air passes through these trays and the product gets evenly dried on both sides.

IV. Solar Drying Working Principle

Drying involves the application of heat to vaporize moisture and some means of removing water vapor after its separation from the food products. It is thus a combined and simultaneous heat and mass transfer operation for which energy must be supplied. The removal of moisture prevents the growth and reproduction of micro-organisms like bacteria, yeasts and moulds causing decay and minimizes many of the moisture-mediated deteriorative reactions. Indirect solar drying differ from direct dryers with respect to heat transfer and water vapor removal. The crops in these indirect solar dryers are located in trays or shelves made of aluminum wire mesh(for uniform drying) inside an opaque drying cabinet and a separate unit termed as solar collector is used for heating of the entering air into the cabinet. The heated air is allowed to flow through/over the wet crop that provides the heat for moisture evaporation by convective heat transfer between the hot air and the wet crop. Drying takes place due to the difference in moisture concentration between the drying air and the air in the vicinity of crop surface.

Fig.3.Fully constructed solar tunnel dryer and collector

Several advantages of indirect solar drying are that it offers a better control over drying and the product obtained is of better quality than sun drying. Localized heat damage do not occur as the crops are protected. Solar dryers can be operated at higher temperature, recommended for deep layer drying. They are highly recommended for photo-sensitive crops. Solar drying of agricultural produce permits several traits such as early harvest, planning of the harvest season, long-term storage without deterioration, maintenance of the availability of seeds and finally sells a better quality product. Numerous types of solar drying systems have been designed and developed in various parts of the world. Improving of the drying operation to save energy, improve product quality as well as reduce environmental effect remained as the main objectives of any development of solar drying system. Solar dryers have been proposed to utilize free, renewable, and non-polluting energy source provided by the sun.

Fig 4 Dryer experimental results

V. Conclusion

In this Dryer air from the surroundings is taken in through the air vents provided at the bottom of the chamber set-up. Beneath the solar collector metallic tunnel arrangement is provided. This design helps to trap the collected air within, and heat the air. Additional solar collector is set 1m away from the model, for enhanced working. It contains aluminium baffled conductors and air vents. The blower uses the heated air from this arrangement. Light, hot air rises to the inside of the chamber, within which it is circulated throughout for efficient drying. When the blowers are not working, the air circulation is by virtue of air current; the denser air which is cooler settles down and hot air rises up to drying materials. The constructed dryer can be used to dry agricultural products under controlled and protected conditions. The drying system proved efficient and economical for drying agricultural products. The experiments were conducted on some products. The dryer exhibited sufficient ability to dry food items rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product. Since the product was not directly exposed to solar radiation, the color and quality of the product and was retained even after complete drying. The capital cost of the dryer is dependent on the size as required for the use and application.

References

[1]. Aiswarya .M.S, “Economical analysis of solar dryer with PCM for drying agricultural products”, International Journal of Scientific andResearch Publications, Vol. 3,2015.

[2]. Jyoti Singh and Pankaj Verma, “Fabrication of Hybrid Solar Dryer”, International Journal of Scientific and Research Publications, Vol. 5, pp..1-8, 2015.

[3]. Ashish D. Chaudhari and Prof. Sanjay P. Salve, "A Review of Solar Dryer Technologies", International Journal of Research in Advent Technology, Vol.2, pp.218-232, 2014.
[4]. Abhishek Saxena, "Design and Performance of a Solar Air Heater with Long Term Heat Storage",International Journal of Heat and Mass Transfer,Vol. 22, pp.8-16,2013.
[5]. Korbinian S. Kramer, "White Paper on Solar Heating Collectors", Solar Heating and Cooling Programme International Energy Agency,pp.2-31, 2013.
[6]. A. Sreekumar," Evaluation of A Roof-Integrated Solar Air Heating System for Drying Foodstuffs", International Journal of Emerging Technology and Advanced Engineering, Vol. 3, pp.209-213, 2013.
[7]. R.J.Fuller, "Solar Drying-A Technology for Sustainable Agriculture and Food Production", Solar Energy Conversion and Photoenergy Systems, pp.3-9, 2002.