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Performance and Developmentof Ventilation Controller For Solar Tunnel Dryer

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ABSTRACT

Drying, as a post harvest processing step is an important task to preserve agricultural product for future use. Solar tunnel dryers are used for drying agricultural products but the uncontrolled rise in temperature in summer lowers the quality of dried products. The air flow rate is also crucial to the overall system performance of a solar tunnel dryer (STD). Too high air flow rate will reduce the temperature than required thus increasing drying time and non-uniformity in drying whereas too low velocity would be insufficient to control temperature which results in high temperature and low quality produce. A proper controlled constant temperature is required for effective drying of the produce which may vary from produce to produce. The temperature inside the STD can be controlled by controlling the ventilation. So, a ventilation controller was designed and developed using temperature sensing device and fan speed controller for controlling the ventilation for achieving the desired temperature. As temperature rises above the desired temperature, the ventilation fan is switched on/off automatically by using variable thermostat based controller which can be adjusted at desired temperature level. Also the speed of the fan is controlled by using solar photovoltaic (SPV) panel which supplies the DC current proportionate to the sunlight intensity to the ventilation fan. The temperature inside the solar tunnel dryer was above 63°C when there was no ventilation used during peak sunshine hours and it remained below 54°C with uncontrolled fan running continuously. With the ventilation controller, the temperature inside the solar tunnel dryer was set for 60 °C to keep the temperature inside the chamber between 59°C to 61°C at an air flow rate between 8.0 to 14.2 km/h and the solar insolation varied between 300 to 910W/m².

Key words: Solar tunnel dryer, Ventilation fan, Ventilation controller

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INTRODUCTION

Drying is one of the essential unit operations performed to increase the shelf life of agricultural produce. It is a common method of food preservation, as fruits, vegetables, fish,grains, agricultural products [2]. If the drying process is not completed fast enough, growth of microorganisms will take place as a result of the high relative humidity. This often leads to severe deterioration of the quality of the product. Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in agriculture application [4]. Energy consumption for drying in many developing countries is a major portion of the total energy consumption and this energy requirement for drying is fulfilled by fossil fuels such as coal and natural gas [7]. In many rural locations in most developing

countries, grid-connected electricity and supplies of other non-renewable sources of energy are either unavailable, unreliable or, too expensive. In such conditions, solar dryers appear increasingly to be attractive as commercial propositions [6]. Most beautiful advantage of Solar drying systems is pollution free method and reducing emission of carbon particles in atmosphere [8]. Solar drying systems to dry food and other crops can improve the quality of the product, while reducing waste produce and saving traditional fuels - thus improving the quality of life. However the availability of good information is lacking in many countries where solar food processing systems are most needed.

Drying, as a post-harvest processing step is an important task to preserve agricultural product for future use. It is necessary to dry fruits and vegetables to enhance storage stability, minimize packaging requirement and reduce transport weight. Drying foods can be moved easily as less weight [5]. Sun drying is commonly used but it is more time consuming and affect the quality of product. The solar tunnel dryers have been used for field conditions in about 30 countries under different climatic conditions for drying numerous agricultural commodities [3]. Natural convectional solar tunnel dryer is used for drying agricultural products but in this system high rise in temperature in summer months lowers the quality of product. Therefore, a ventilation controller is required in solar tunnel dryer which controls the temperature inside solar tunnel dryer. The controller with the thermostat system will switch on and regulate the speed of fan at higher temperatures and keeping it off at lower temperatures thus maintaining a favourable environment inside the solar tunnel dryer for optimum drying.

In a Solar tunnel drier a fan is provided to flow air required to remove the evaporated moisture. The electric power requirement of the fan is low and can be operated by one photovoltaic module (12V, 40W) independent of electric grid. Numerous tests in the regions of different climatic conditions have shown that fruits, vegetables, cereals, grain, legumes, oil seeds, spices and even fish and meat can be properly dried in the solar tunnel drier.

A new solar tunnel drier was required to be designed and developed to meet the drying requirements of small farmers and smaller co-operatives. The new design should realize the demand for higher drying capacity and better moisture removal. Instead of forced ventilation it is required to control ventilation for optimum performance. The air flow rate is crucial to the overall system performance. Too high air velocity will reduce the temperature than required thus increasing drying time and non-uniformity in drying where too low velocity would be insufficient to control temperature which results in high temperature and low quality produce.

An on-off controller is the simplest form of temperature control device. The output from the device is either on or off, with no middle state. An on-off controller will switch on the output only when the temperature crosses the set point. For temperature control the fan is on when the temperature is above the set point, and off below set point. This controller uses a latching relay, which must be manually reset, and is used to shut down a process when a certain temperature is reached.

Photovoltaic system used one or more solar panels to convert sunlight into electricity. It is used to operate the ventilation fan. When insolation is high than current in PV system is more and corresponding fan speed is high providing more ventilation.

MATERIALS AND METHOD

The development and testing of ventilation controller for solar tunnel dryer will be carried out in the premises of Renewable Energy Lab, Division of College of Agricultural Engineering at Choudhary Charan Singh Haryana Agricultural University, Hisar during 2011-2012, which lies at latitude 29.10^0 N and longitude 75.46^0E.

Solar Tunnel Dryeris a natural convection type dryer useful for bulk drying of agricultural & industrial products at moderate air temperature, consists of a hemi-cylindrical metallic frame (10m x 3.8m) covered with UV stabilized transparent polythene sheet of 200 micron thickness, five chimneys on the top and an exhaust fan on one side of the tunnel remove the moist air, insulated wall on north side, product spread on trays, trays put on trolley and trolleys moved inside the dryer. When solar radiations more fall on the upper surface of the solar tunnel dryer. The inside temperature in STD is increased than the ambient temperature.

Table 1.The dimensions and other parameters of Solar Tunnel Dryer

Parameters	Specifications
Length of solar tunnel dryer	10 m
Diameter of solar tunnel dryer	3.8 m
Ceiling height	2.0 m
Floor area of solar tunnel dryer	30.08 m^2

Suryamapi is used to note the solar insulation. The instrument was calibrated to give readings of solar intensity in the range of 0-1200 W/m^2. Electronics Humidity Meter or Hygrometer was used for measuring relative humidity.
A fan controller using thermostat was designed for on/off control and change of rotational speed of the fan proportional to the isolation falling on photovoltaic system. A multimeter or a multitester, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance.
The portable anemometer provides fast, accurate readings, with digital readability and the convenience of a remote sensor separately. Multi-functions for air flow measurement m/s, km/h, ft/min, knots. A sensitive balanced vane wheel rotates freely in response to air flow. Built - in lowbattery indicator. Data Hold function for stored the desired value on display. Large LCD display, easy to read.
The glass based mercury Thermometers are used to measure the temperature inside the Solar Tunnel Dryer at various places and the ambient temperature for evaluating the performance of Solar Tunnel Dryer and the effect of ventilation controller.
A photovoltaic panel is used to convert the solar energy into electrical energy to operate the ventilation fan. A ventilation controller will be designed to on/off the ventilation fan and control the speed of the fan to optimize dryer energy efficiency. Controller will consist of a thermostat which will sense the temperature and switch on/off the fan with help of control circuit at desired temperature level. The ventilation controller will be controlled by the sunlight intensity falling on PV panel. The fan speed will be controlled by PV panel as the sunlight intensity will increase the temperature will go higher also when solar intensity is high PV panel will send more current to the fan thus increasing its speed which will bring the temperature down inside the solar tunnel dryer. As the temperature come down, thermostat will break the circuit thus switch off the fan.

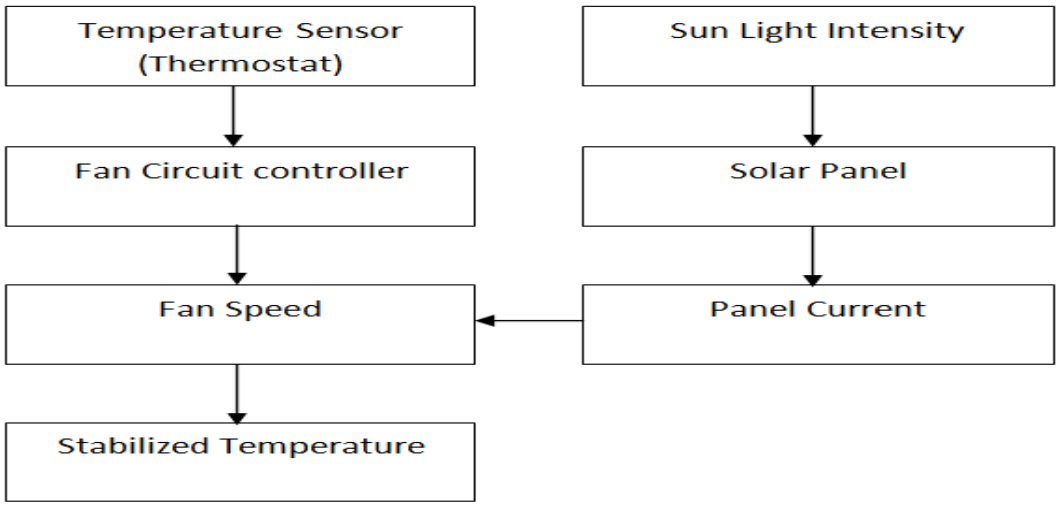

Fig.1. Block Diagram of ventilation controller of STD

RESULTS AND DISCUSSION

Nidhi and Verma [9] was observed that as similar to our research the greenhouse dryer gives a very high quality product than open sun drying and it reduces the crop losses and use of greenhouse dryer under forced convection reduces moisture content in a very less time as well as drying rate is very fast and relative humidity is less than natural convection mode.

Khawale and Thakare [10] was similar studied and concluded that It is necessary to develop a large scale and economically attractive solar dryer, to improve the acceptability of the solar dryer among the farmer. The forced convection are recommended for assuring reliability and better control respectively, for large scale agricultural food drying.

Bagheri *et al.* [1] was similarly designed, constructed and evaluated a controller for forced convective solar dryer. The dryer fan speed was chosen to be the controlled variable. Based upon the mathematical relations and a monitoring of the air inlet temperature to the collector, the air outlet temperature from the collector and the air outlet temperature from the drying chamber, the dryer efficiency was determined. The dryer equipped with the designed control system worked with its highest efficiency throughout the day. Statistical analysis showed that the control system highly improved the dryer efficiency throughout its operation at a 1% probability level.

Performance of solar tunnel dryer with natural convention of air

The maximum temperature inside dryer was 63°C while minimum temperature inside dryer was 28 °C in the typical day of April 2012 against the maximum and minimum ambient temperature of 40 °C and 29 °C respectively. It was also observed that the maximum solar insolation during the period of study was 890 W/m^2.

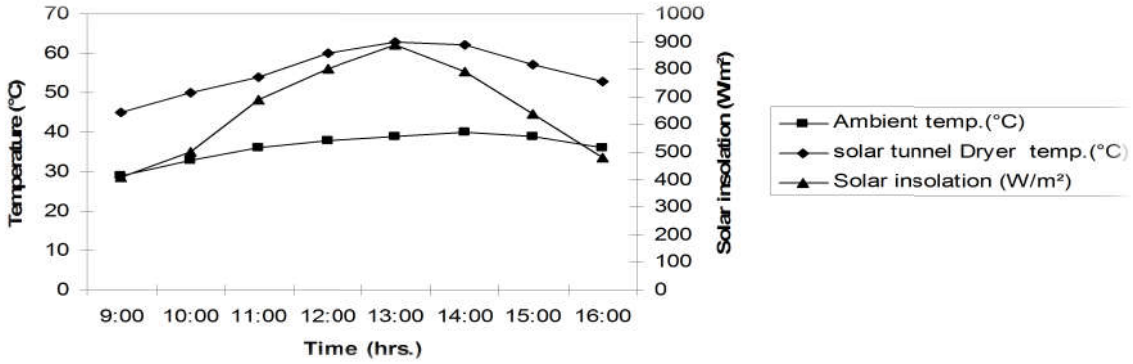

Fig.2 shows variation of solar insolation and dryer temp with time with natural ventilation

Performance of solar tunnel dryer with fan (DC) running continuously

The maximum temperature inside dryer was 54 °C while minimum temperature inside dryer was 41 °C in the typical day of April 2011 against the maximum and minimum ambient temperature of 40 °C and 29.5 °C respectively. It was observed that the maximum solar insolation during the period of study was 910 W/m^2. It was also observed that current produce in solar photovoltaic panel was in range 1.95A and air flow rate of fan was in range 8-14.2 km/hr.

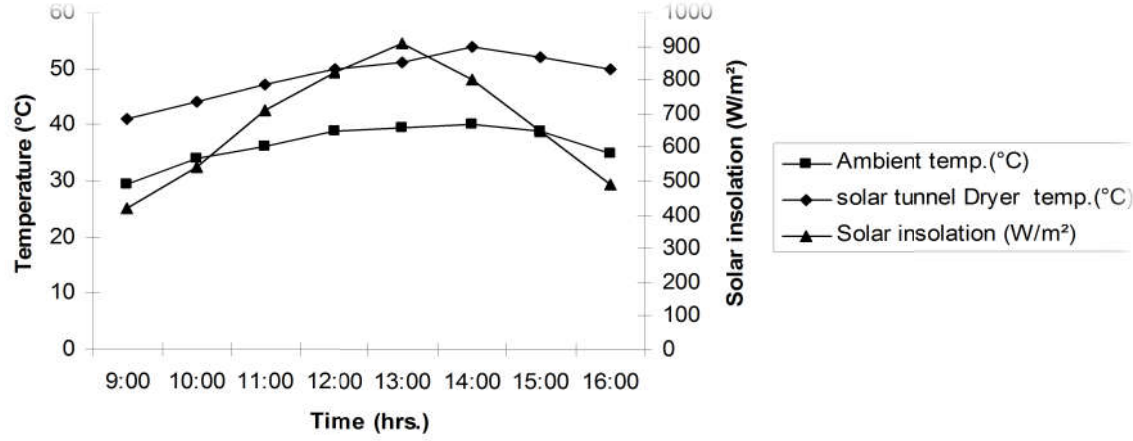

Fig.3 Shows variation of solar insolation and dryer temp with time uncontrolled ventilation fan.

Performance of solar tunnel dryer with controlled fan (DC)

The maximum temperature inside dryer was 60 °C while minimum temperature inside dryer was 45 °C in the typical day of summer against the maximum and minimum ambient temperature of 39.5°C and 28 °C respectively. It was also observed that the maximum solar insolation during the period of study was 900 W/m^2.

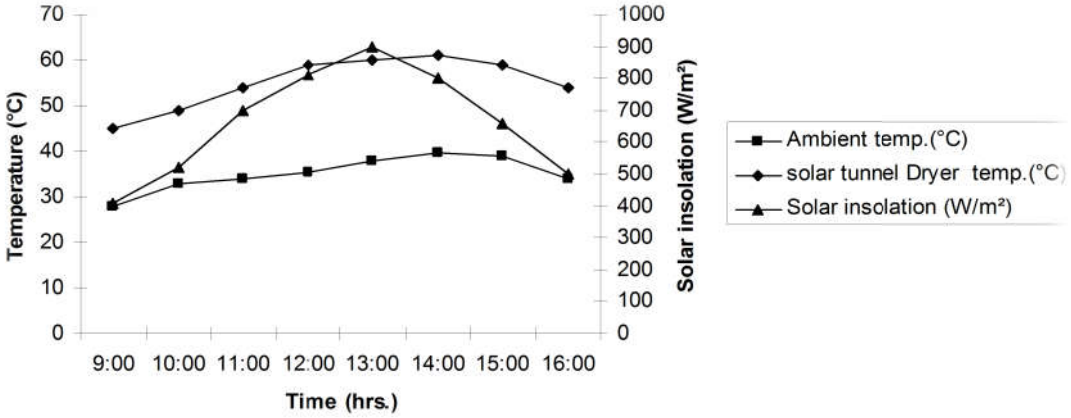

Fig.4 Shows variation of solar insolation and dryer temp with time with controlled ventilation fan.

Pv panel characteristics at particular insolation:

Insolation = 810 W/m^2, V_{oc}= 18.72 V, I_{sc}= 3.66 A, V_{op}= 15.12V, I_{op}= 1.87 A

Operating Power of fan = 15.12 * 1.87= 28.27 watts

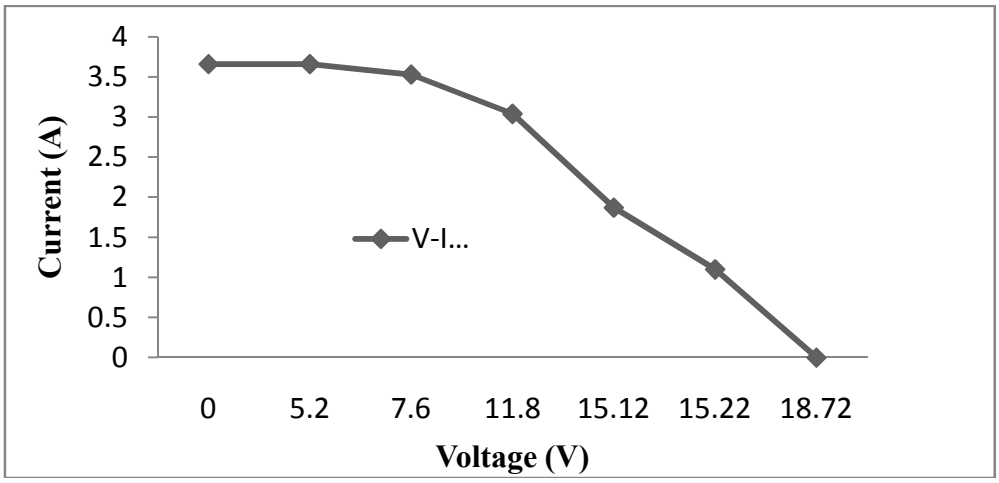

Fig. 5 shows V-I characteristics of pv panel.

CONCLUSIONS

In case of solar tunnel dryer with natural convention of air**,**The temperature inside the solar tunnel dryer chamber rise above 63°C when there is no ventilation in used during peak sun hours.

In case of solar tunnel dryer with fan (DC) running continuously, The temperature inside the solar tunnel dryer chamber remains 54 °C with uncontrolled fan running continuously.

In case of solar tunnel dryer with controlled fan (DC),The temperature inside the solar tunnel dryer chamber set for 60 °C keep the temperature inside the chamber varying from 59 °C to 61 °C which is very near to controlled point. Fan air flow rate (8-14.2 km/hr) increase with increase of insolation (300-910W/m^2).So the efficiency of solar tunnel dryer with controlled fan (DC) is best for agricultural products .

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