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Automatically Controlled Solar Tunnel Dryer using Arduino for Potato

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ABSTRACT:- Sun drying of agricultural products is the traditional method employed in most of the developing countries. Sun drying is used to denote the exposure of a commodity to direct solar radiation and the convective power of the natural wind. Solar drying can be considered as an advancement of natural sun drying and it is a more efficient technique of utilizing solar energy due to it's renewable, environmentally friendly technology. Nowadays drying agricultural products have great attention and there are various methods of drying fruits, vegetables such as dehydration, canning etc. due to this the quality of such product is degraded so solar dryer is used to avoid wastage, increase the productivity of agriculture, also the production in terms of quality and quantity. This project describes a controlled environment which is suitable for small scale agricultural products drying process within a closed chamber, using Arduino. To start with, the sun rays are used to internally heat the fruit to remove the water content within the agricultural products. Then to maintain the humidity below a specified level, exhaust the humid air out of the chamber. Arduino is used to control the functions of heating, controlling the speed of exhaust fan and giving time indication & maintain constant temperature throughout the chamber. The graphs of time versus drying process obtained show that the automatic drying unit designed has worked as per the expectation by consuming less time compared to conventional drying process.

Keywords : Arduino, Sensor, Foldable Solar Tunnel Dryer, LCD Display.

INTRODUCTION

Drying is an excellent way to preserve food and solar food drying is an appropriate food preservation technology for a sustainable world. The high moisture content in fresh agricultural product (produce) is the basic cause for spoilage. If water is removed, then the shelf life of produce increases. Traditional open sun drying methods often yield poor quality, since the produce is not protected against dust, rain and wind, or even against insects, birds, rodents and domestic animals while drying. The solution of all these problems is the use of solar dryer instead of open sun drying.

Solar dryers are the devices that use free solar energy to dry agro products. The studies indicate that cost of drying with solar energy is only one-third as compared to the cost using a dryer based on conventional fuels. Adequate drying helps to preserve the flavor, texture, and color of the food, which leads to a better quality product.

Potato is one among the foremost common food materials, consumed as main course with meat and vegetable in the form of mashed potato widely in many countries. Production of potato in India is about 46.61 million MT in year 2016. Potato consists of 63-83% moisture content. Raw potatoes can last for one to two weeks at traditional temperature.

To maximize the shelf life, potatoes were dried up to moisture level of approximately 10-12% under tropical ambient temperature. The solar dryer is used to avoid wastage, increase the productivity of agriculture, also the production in terms of quality and quantity. Different food types require different temperature for drying conditions in order to maintain their quality. In solar tunnel dryer we cannot control various drying parameters like temperature, relative humidity etc. due to that quality and quantity of product degraded. To overcome this problem we can use automatically controlled solar tunnel dryer. The temperature inside the solar tunnel dryer can be controlled by using microcontrollers like 8051, PIC, ARM, Arduino etc These solar dryers allow for controlled drying by managing the drying parameters such as moisture content, air temperature, humidity, and air flow rate.

METHODOLOGY

The design used for agro products drying chamber needs the temperature to be controlled throughout the drying process by using solar energy. Variable temperature conditions during drying are harmful for agro

products. Over drying causes discoloration and reduction in quality. On the other hand, under drying causes fungal infection and bacterial action. Thus main objectives are to design the solar tunnel dryer and to design a controlling circuit to control various drying parameters inside it.

1) Solar Tunnel Dryer:

The material used for construction of folding type small size passive solar tunnel dryer is given in the following table 1:

Table 1: Material required for solar tunnel dryer

Sr. No.	Item	Specification/ Quantity
1.	GI Bar	8.92 m
2.	GI Sheet	26 gauge
3.	PVC Pipe	5.49 m
4.	UV stabilized polythene sheet, thickness 200 microns	5 × 5 m^2
5.	Insulation(Plywood)	2
6.	Binder Clips	28

The schematic design of solar tunnel dryer is shown in fig 1: All dimensions in mm

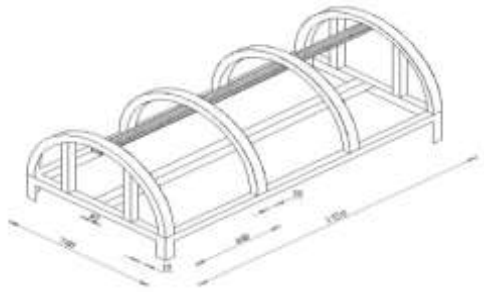

Fig. 1: Schematic diagram of solar tunnel dryer

2) Solar Tunnel Dryer with Controlling Circuit:

The above solar tunnel dryers parameters are tested and controlled using Arduino as shown below

BLOCK DIAGRAM

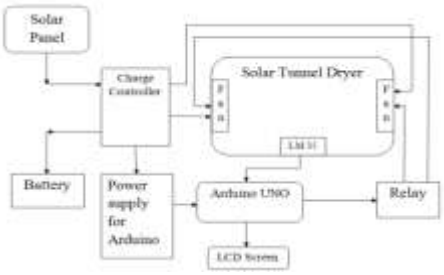

Fig. 2: Block diagram of solar tunnel dryer

CIRCUITRY

1. Arduino Uno

Table 2: Specifications of Arduino Uno

Operating Voltage	5V
Input Voltage	7-12V
Digital I/O	Pins 14
Analog Input	6 Pins
Length	68.6 mm
Width	53.4 mm
Weight	25 g

2. Temperature Sensor LM 35

Table 3: Specifications of temperature sensor LM 35

Supply Voltage	+35 V to -0.2 V
Output Voltage	+6 V to -1 V
Temperature Range	-55 °C to 150 °C

3. Relay

Table 4: Specifications of relay

Operating Voltage	5 V DC
Nominal Current	70 mA
Quantity	2

4. Liquid Crystal Display

Table 5: Specifications of liquid crystal display

Operating Voltage	5 V DC
Module Dimension	60 mm x 36 mm x 15 mm
Viewing Area Size	64.5 mm x 16 mm
Displays	2 lines x 16 characters

5. Exhaust Fan

Table 6: Specifications of exhaust fan

Operating Voltage	5 V
Dimension	100mm×100 mm×10 mm

6. Solar Panel

Table 7: Specifications of solar panel

Rated Power	10 Watt
Open circuit voltage (Voc)	21.5 Volt
Short circuit current (Isc)	0.65 Ampere
Voltage at maximum power (Vmp)	17.7 Volt

Current at maximum power (Imp)	0.57 Ampere
Maximum system voltage	600 lt

7. Battery

Table 8: Specifications of battery

Voltage	12 Volt
Capacity	7 Ah
Type	Sealed Lead Acid Battery
Rechargeable	Yes

8. Charge Controller

Table 9: Specifications of charge controller

Voltage	12 Volt
Max. PV charging Current	5 Ampere
Max. load	5 Ampere

Fig. 3: Actual View of circuit diagram

The measurements of the parameters were taken after every half hour.

Table : 10 Parameters measured and instruments used

Parameter	**Instrument**
Temperature	Digital Thermometer
Relative Humidity	Hygrometer
Air Velocity	Digital Anemometer
Solar Radiations	Pyranometer

Flow chart of potato drying is given below :

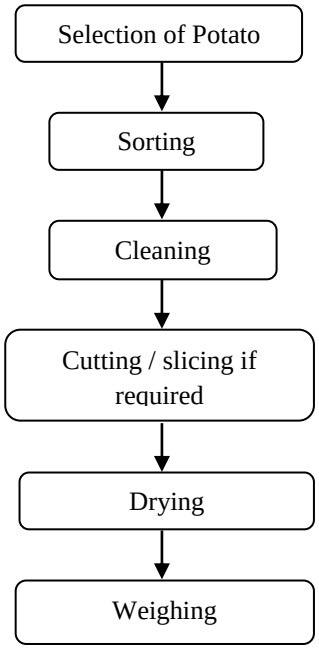

Fig. 4: Process of drying potato

Flow chart of controlling solar tunnel dryer is given below:

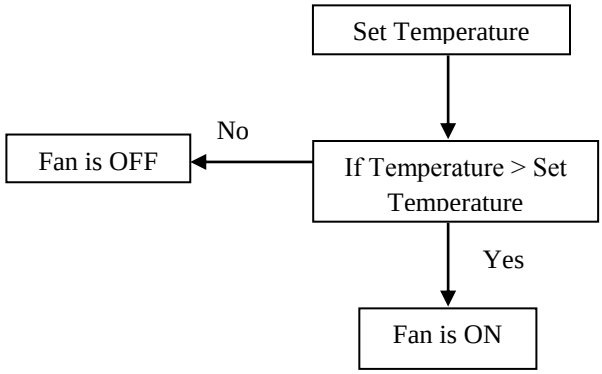

Fig. 5: Process of controlling solar tunnel dryer

The effect of drying air temperature that is 50ºC on drying kinetics of potato was investigated using solar tunnel dryer.

Determination of Moisture Content:

$$\text{Moisture content \% (wb)} = \frac{W_2 - W_3}{W_2 - W_1} \text{X } 100$$

Where,

W_1= Weight of empty box, g.

W_2=Weight of sample before drying, g.

W_3=weight of sample after drying, g.

RESULT AND DISCUSSION

Evaluation of Solar Tunnel Dryer for No load Condition

Evaluation and testing of the solar tunnel dryer was carried out under no load conditions.

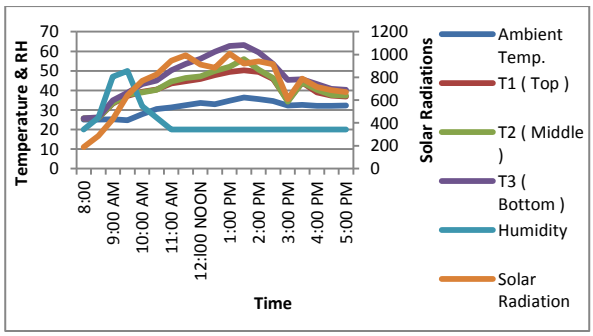

Fig. 6: Variation of Temperature, Humidity and Solar Radiation with Time at No load Condition

It was observed that the minimum inside temperature was 25.7^{0}C at 8:00 am and also observed that the minimum and maximum dryer humidity was 20 % and 32% from 08:00 am to 5:00 pm respectively. The minimum and maximum base temperature is 25.7^{0}C at 08:00 am and 63.2^{0}C at 1:30 pm respectively. The minimum solar radiation was observed at 08:00 am and maximum at 1:00 pm were 189 and 1008 W/m^2 respectively.

Fig. 6 shows that minimum and maximum temperature of dryer, ambient temp, humidity, solar radiation. It was observed that the minimum and maximum ambient temperature of air was observed at 8:00 am and 01:30 pm that is 25.0^{0}C and 36.2^{0}C respectively.

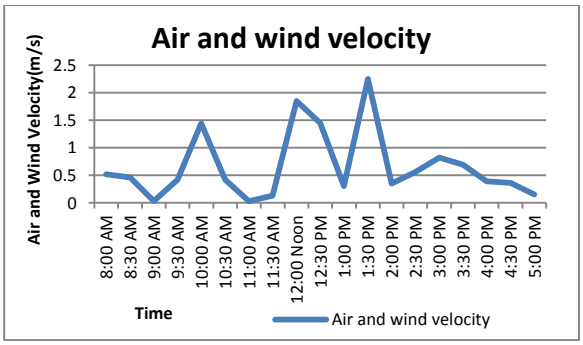

Fig. 7: Variation of Air Flow Velocity with Time at No Load Condition

Fig. 7 shows that the variation of air flow velocity of wind velocity with respect to time. The minimum & maximum air flow velocity was observed at 09:00 am and 01:30 pm, 0.03 m/s and 2.25 m/s respectively.

Evaluation of Solar Tunnel Dryer for Potato

Evaluation and testing of the solar tunnel dryer was carried out under load conditions for drying of potato slices.

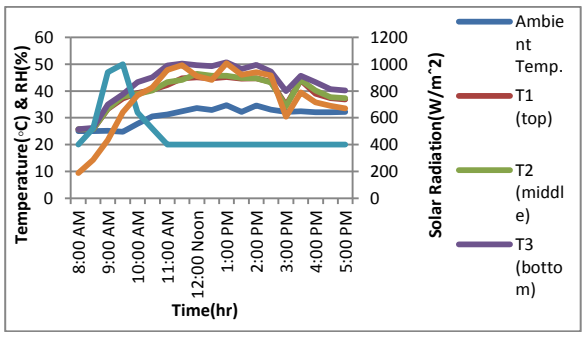

Fig. 8: Variation of Temperature, Humidity and Solar Radiation with Time

On the first day of drying it was observed that the minimum inside temperature was 25.60C at 8:00 am and also observed that the minimum and maximum dryer humidity was 20% and 50% from 08:00 am to 5:00 pm respectively. The minimum and maximum base temperature is 25.70C at 08:00am and 50.770C at 01:00 pm respectively. The minimum solar radiation was observed at 08:00 am and maximum at 01:00 pm were 189 and 1008 W/m2 respectively.

Figure 8 shows that the minimum and maximum temperature of dryer, ambient temp, humidity, solar radiation. It was observed that the minimum and maximum ambient temp of air was observed at 08:00 am and 01:00 pm that is 25.00C and 34.70C respectively.

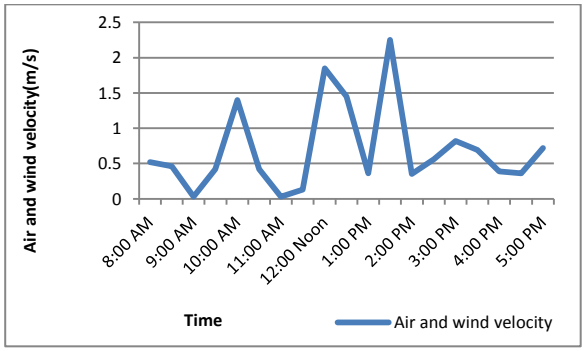

Fig. 9: Variation of Air Flow Velocity with Time at 1st Day

Fig. 9 shows that the variation of air flow velocity of wind velocity with respect to time. The minimum & maximum air flow velocity was observed at 09:00 am and 1.30 pm, 0.03 m/s and 2.25 m/s respectively.

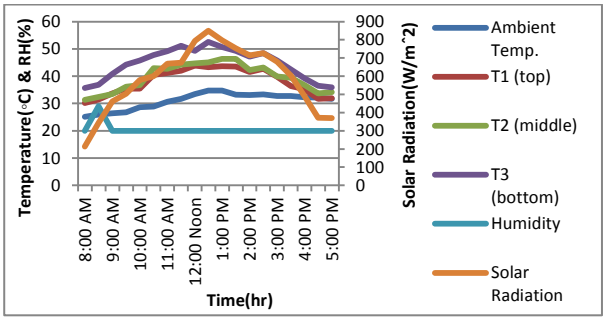

Fig. 10: Variation of Temperature, Humidity and Solar Radiation with Time at 2nd Day

On the Second day of drying it was observed that the minimum inside temperature was 30.20C at 8:00 am and also observed that the minimum and maximum dryer humidity was 20% and 29% from 08:00 am to 5:00 pm respectively. The minimum and maximum base temperature is 35.70C at 08:00 am and 52.600C at 12:30 pm respectively. The minimum solar radiation was observed at 08:00 am and maximum at 12:30 pm were 212 and 850 W/m2 respectively.

Fig.10 clearly explains the minimum and maximum temperature of dryer, ambient temp, humidity, solar radiation. It was observed that the minimum and maximum ambient temp of air was observed at 08:00 am and 01:00 pm that is 25.10C and 34.80C respectively.

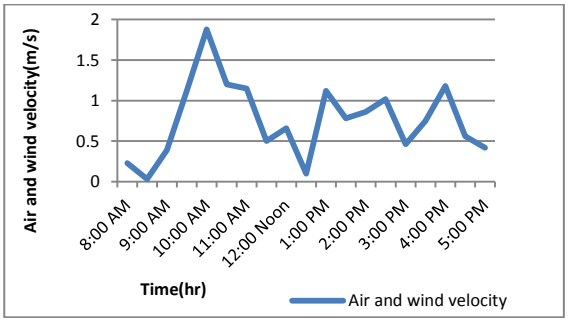

Fig. 11: Variation of Air Flow Velocity with Time at 2nd Day

Fig. 11 shows that the variation of air flow velocity of wind velocity with respect to time. The minimum & maximum air flow velocity was observed at 08:30 am and 10.00 pm, 0.03 m/s and 1.88 m/s respectively.

Fig. 12: Potato before drying

Fig. 13: Potato after drying

Table 11: Initial moisture content of potato slices

Weight of empty box (W_1)g	Weight of empty box + Weight of sample before oven drying (W_2) g	Weight of empty box + Weight of sample after oven drying (W_3) g	Moisture content % (wet basis)
59.3	68.42	60.91	82.34

Table 12: Moisture content of potato slices after 1st day of drying

Weight of empty box(W_2) g	Weight of empty box + Weight of sample before oven drying (W_2) g	Weight of empty box + Weight of sample after oven drying (W_3) g	Moisture content % (wet basis)
59.3	67.10	65.72	17.59

Table 13: Moisture content of potato slices after 2nd day of drying

Weight of empty box(W_1) g	Weight of empty box + Weight of sample before oven drying (W_2) g	Weight of empty box + Weight of sample after oven drying (W_3) g	Moisture content % (wet basis)
59.3	66.49	66.18	4.26

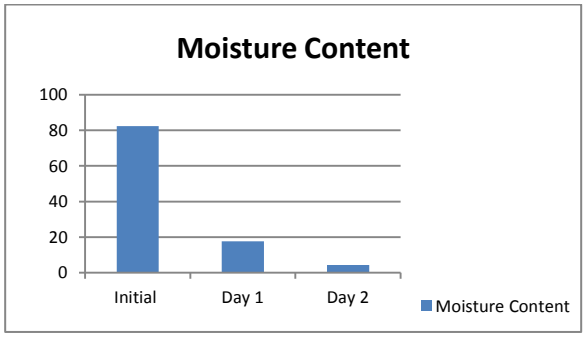

Fig. 14: Removal of moisture from potato per day

From the fig. 14 it is observed that potato require 2 days for drying. The drying rate is high. It is found that the initial moisture content of potato was 82.34% which

was reduced to 17.59% on first day and on next day it was reduced to 4.26%.

CONCLUSIONS

Using the concept of basic solar conduction dryer and implementing the automation and design enhancement, quality of agro products has been increased. By utilizing large amount of solar heat to maintain the quality of the food products is also achieved. From the experiment performed, the dryer accomplishes the temperature control at desired temperature.

The overall reading observed that the maximum inside temperature was 52^0C. Corresponding average ambient temperature was 32.52^0C. It was also observed that the average solar radiation was 787.52 W/m^2, average humidity was 20 % and average the air flow velocity was 0.89 m/s. The initial moisture content of Coriander was 82.34% which was reduced to 17.59% on first day and 4.26% on the next day.

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