Solar Based Temperature Controlled Fruit Drying System

Ravi Hosamani, Dr.Satish.R.Desai

Abstract: Fruits are seasonal crop and get spoilt quickly. To make their usage efficient, they can be dried and preserved so that fruits can be used over a long period. The natural drying process has many drawbacks, such as requiring more time, large investment on space requirement and infrastructure for drying process, which cannot be afforded by a middle class farmer. The financial up gradation of a former in developed countries is possible by providing him the modern, automatic and low-cost fruit drying unit.

This paper describes a controlled environment which is suitable for small scale fruit drying process within a closed chamber, using Microcontroller (PIC16F877). To start with, the infrared light is used to internally heat the fruit to remove the water content within the fruit. Then the air is blown inside the chamber to maintain the humidity below a specified level and exhaust the humid air out of the chamber. Microcontroller (PIC16F877) is used to control the functions of heating, blowing the air and giving time indication & maintain constant temperature throughout the chamber. After the completion of the drying process a buzzer is activated for the duration of ten seconds to indicate the end of the drying process. A text message is also sent to the farmer through GSM to intimate him if he is not around. 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 compare to conventional drying process.

Keywords- Drier, GSM, Microcontroller, Sensors,

I. INTRODUCTION

As the population in the world increasing, there is demand for more production of different kind of fruits in the world. It also requires the transportation of fruits from the food production areas to the fruit consumer areas. This needs a proper preservation of fruit during transportation, as the transportation period may be greater than the natural life of the fruit [1]. To avoid fruit damage and long usage, fresh fruits are converted to dry fruits. Healthy and nutritious fruits can be given to people to enjoy dry fruits as snack. Dehydration is also used to lower the cost of packing, storing and transportation as it reduces weight and volume of the final product. Dried food can be made from lower quality fruits and vegetables that might otherwise be wasted. If kept cool and dry after dehydration, the product will remain edible for several months.

Ravi .Hosamani is working as Assistant Professor in Department of Electronics and Communication, K.L.E.Institute of Technology Hubli, India Email:ravishosamani@gmail.com

Dr. Satish.R.Desai is working as associate Professor in Department of Agriculteral Engineering,College of Agriculture, University of Agricultural Sciences, Dharwad, india. Email:srdesaicae@gmail.com

The problem in the conventional drying process, it is carried out manually and does not have any control. A strict monitoring of every process is thus required to ensure the quality of the product supplied as dried fruit. This process may lead to inconsistency in the production, product quality and man power, leading to economic losses to the farmer. Other problems are associated with it, area required to dry the fruit is quite large, fruits are not dried uniformly, drying is not possible in a humid environment and the exposure of the product to the open air for a long duration can be considered risky due to birds eating fruits and dust from the external environment.

After going through the various details of the process and considering all the factors above, there arises a need of fruit drying unit and automation of it. This will ensure drying even in the poor weather conditions because of an enclosed chamber. The accurate control over the drying process due to a closed loop, control system reduces the drying time. Higher temperatures and the penetration of infrared rays used in the compact drying chamber facilitate the confinement of heat energy.

This paper describes a design idea to produce small scale with good quality dry fruit product to the consumer which is perseveres with its original taste without leading to caramelization (Sugar Burning) and reduction in the nutritional value. The quality and color of the dried product depend upon the techniques used for drying process. Another parameter used in analyzing the drying process is drying rate which is referred to as time taken to dry the fruit. The drying rate affects the color and quality of the dried product.

In this paper first part gives introduction with problems in conventional method of fruit drying. Methodology and implementation is explained in second part. Results and conclusion are presented in third part.

II. METHODOLOGY

The design used for fruit drying chamber needs the temperature to be maintained constant throughout the drying chamber and also removal of moisture content from the fruit. This automation process when completed is informed to the farmer. Solar energy is utilized for dehydrating the fruits and vegetables. Over drying and under drying are harmful [2], [3] for agricultural products. Over drying causes discoloration due to caramelization and reduction in nutritional value. On the other hand, under drying or slow drying results in deterioration of the food quality due to fungal and bacterial action. High temperature can be used only in the beginning of the drying process, in the first phase (60% of the total drying time) the drying rate is faster. While in the second phase (40% of the total drying time) the drying rate is slowed down due to a thick collapsed outer surface and IR heat plays a very important role in penetrating this layer and removing the moisture in the second phase.

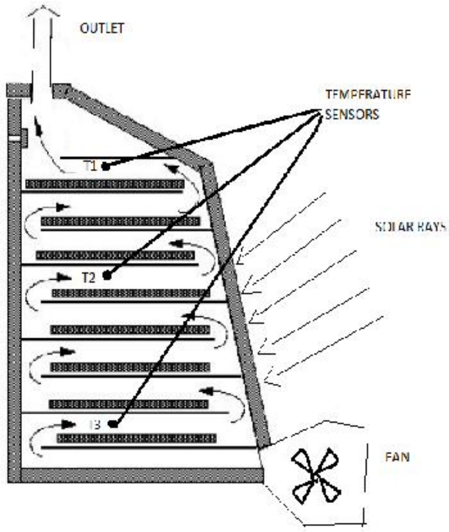

Fig.1. Solar cabinet dryer

The solar dryer chamber in its simple form comprises of a wooden box with certain length and width, insulated at its base and preferably at the sides and covered with a transparent roof .The inside surfaces of the box are coated with black paint and the product to be dried is kept in the trays made of wire mesh bottom. These trays are made up of metal coated with black pent loaded with product are kept through an open able door provided on the rear side of the drier. The air exit end of the dryer is raised and supported above the inlet side to provide a slope of some degrees to the horizontal, with the cover facing the south [7]. Holes are provided on the upper sides of the dryer through which moist warm air removed as shown in Fig.1.

The microcontroller is used and programmed to control and manage the overall process of the unit. Different fruits and vegetables will have different temperatures to dry. The buttons are used to set required temperature. Sensors are used to read the temperature in the cabinet connected to microcontroller through ADC. A display is use to see the process continuously for the temperature value and time to dry the particular fruit. If the monitoring temperature is greater than the set temperature value, turn on the fan else turn off. Once the process is completed generate the alarm and send SMS to the farmer as shown in fig.2.

The process of drying a wet object involves the transfer of heat to cause evaporation of the moisture. The rate of drying of fruit with an initial moisture content above 82 % [6] during the early drying period is a function of external drying parameter that is, air temperature. To calculate the amount of heat required to dry a given quantity of fruit for storage, the following equation is used [7].

$$W1\ (100 - M1) = W2\ (100 - M2) \quad (1)$$

where W1 is weight in Kg of fresh fruit, M1 is % initial moisture content in fresh fruit,W2 is weight in Kg of dried fruit and M2 is % final moisture content in dried fruit.

A cabinet dryer is a device that can dry a substance using a heat source. The source of heat is the largely available solar energy. It consists mainly of dryer chamber, ducting chamber and exhaust fan.

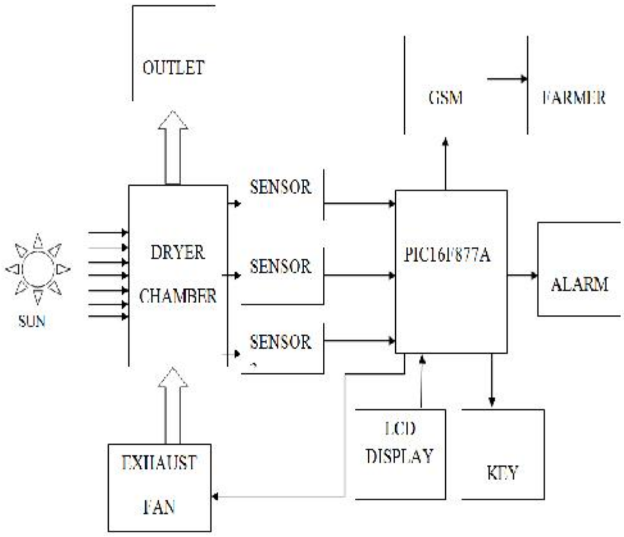

Fig.2. Automatic dryer system

A. OPERATION

A part of incidence solar radiation on the glass cover is reflected back to atmosphere and remaining is transmitted inside the drying chamber. Further, a part of transmitted radiation is reflected back from the surface of the crop on the wire mesh. The remaining part is absorbed by the surface of the crop. Due to the absorption of solar radiation, crop temperature increases and the crop starts emitting long wavelength radiation which is not allowed to escape to atmosphere due to presence of glass cover unlike open sun drying. Thus the temperature above the crop inside drying chamber becomes higher. The glass cover serves one more purpose of reducing direct convective losses to the ambient which further becomes beneficial for rise in crop and drying chamber temperature respectively[3]. However, convective and evaporative losses occur inside drying chamber from heated crop. The moisture, that is the vapor formed due to evaporation, is taken away by the air entering into the drying chamber from one end and escaping through the hole provided at the top with the aid of the supplied dc fan As shown in Fig.1

B. CIRCUIT CONSTRUCTION & WORKING

The 5v power supply given to the monitoring and controlling unit with microcontroller (PIC16F877A) as central console using basic full wave rectifier and regulator. Once unit is turn on, reference temperature is set to get good quality of dried fruit, date and time for monitoring process duration by using four switch connected to input pins 33,34,35,36 and 37 of microcontroller .The temperature is continuously sensed by temperature sensors i.e. LM35 ,which does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and

±¾°C over a full -55 to +150°C temperature range. Three sensor are mounted to different place of cabinet and interfaced with PIC16F877A microcontroller, The microcontroller has 8 channel 10bit ADC with dedicate ADCON register for configures the functions of the analog input port pins [4]. This in turn helps to compare the reference chamber temperature and display on LCD connected to PIC16F877A microcontroller as shown in fig.3. Based on comparison of reference temperature value and average of three sensor value the fan will be run to glow the air in the chamber to maintain uniformity and reduce the chamber temperature, by automatically turning on the fan through triggering the relay circuit which is connected to output pin. No 15 of microcontroller [4]. The hot air created in the chamber, passes over the trays where it comes into contact with the substance to be dried and carries away the moisture. The humid air, is thus expelled out from the chamber through a moisture exhaust.

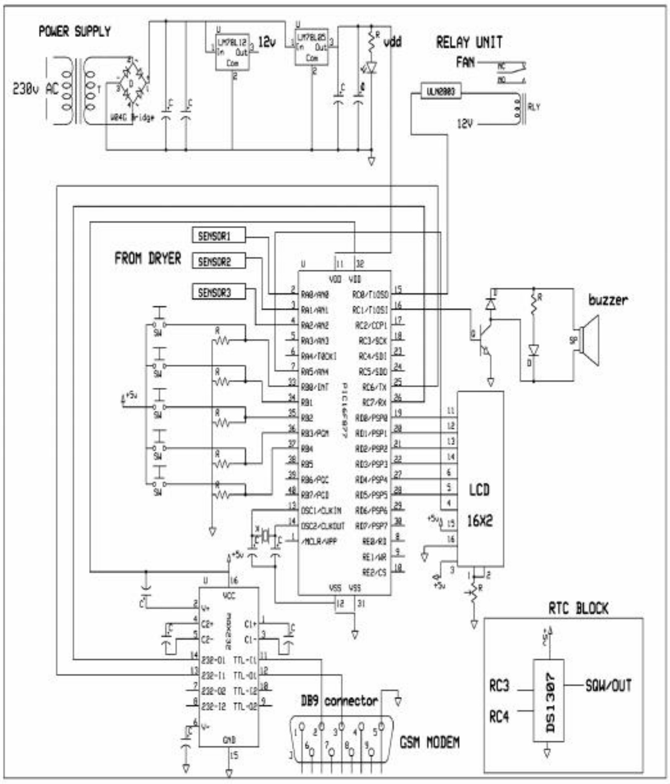

Fig.3. Drying controlling and monitoring circuit diagram

Once the process is completed, generate the alarm by turning on buzzer circuit and send SMS to the farmer to indicate status of the drying process through GSM module which is interface with UART module of microcontroller as shown in fig.3.

III. RESULTS

The dryer chamber is of a wooden box with Y_Length 36"X Width 24" inner surface with 9 track plats are cotted with block color. Distance between each plate 3"_Distance from the first plate to top 5"_Distance from the last plate to bottom 4" for proper inlet and oulet of air. Top surface is coverd with glass of thickness 2cm .The fan is connected to chamber with pipe as shown in fig.4. Experiment was conducted and the drying unit was tested by taking grapes and tomato's as sample fruit.

Test was conducted for a day and the results of moisture content and time were recorded. A graph was plotted as shown in Fig.4. In Fig.4, the moisture content of the fruit with respect to time of the natural drying process is compared with designed automatic drying unit. It was observed that automatic drying unit gives better performance in terms of drying rate compared to conventional method. The temperature to be maintained within the chamber depends on the initial contents of the fruits and the effect of temperature on the contents. The temperature and humidity are dependent on the user requirement. Humidity gradient to remove the water content in the fruit was varied by varying the fan speed.

Fig. 4. Fruit drying unit

It was thus observed that the temperature gradient plays an important role in the initial period of the drying phase and the humidity gradient plays an important role in the later part of the drying phase to retain the original flavor of the fruit and to avoid caramelization.

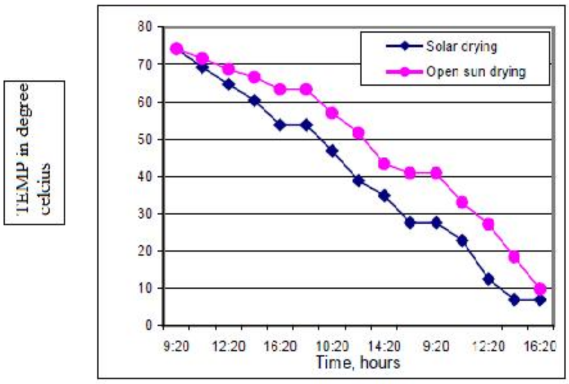

Fig.4. Observed drying curve

IV. CONCLUSION

The system requires lower space and minimal installation time, less time to dry the product (as compared to natural drying), is durable with minimal maintenance. Unit can be made available in varied capacities, depending on the effective tray area and user requirement. Dust does not come in contact with the produce thereby ensuring good quality of the dried product.

The system can be made more economical by making a provision for drying variety of fruits in a single unit. This arrangement can be made possible by using sensor networks for various fruits. To make it economically viable for farmers, an application specific integrated circuit by embedding the digital circuit into a chip, can be produced in a large scale. This can also used to dry the sea fish, prawns and cashew.

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