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Power Optimization and Temperature control in Solar Powered Automated Dryer Using Fuzzy Controller

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Abstract : Drying is an exceptional way to defend food and solar food dryers are appropriate food preservation technology for sustainable development. The main objective of this paper is to design a solar powered Automatic drier which has solar as well as electric heater for efficient and quality drying in an economical way. This work is split up into two stages, initially an efficient drier has to be designed and modelling and conventional PI controller and Fuzzy controller has to be designed for maintaining temperature in the heating chambers for drying process and the efficient usage of solar energy and solar powered electrical energy for heating process has to be studied in detail.
Keywords: PI controller, Fuzzy logic, solar dryer, heating process.

I. Introduction

In many parts of the world there is a growing awareness that renewable energy have an important role to play in extending technology to the farmer in developing countries to increase their productivity and be more economical when compared with any other energy resource. Drying of fresh fruits is one of the most energy-intensive processes in the food industry and a promising method of reducing post-harvest losses. Improving energy sufficiency by only 1% could result as 10% increase in profits. Now a day's, optimization of solar system is used to reduce total cost of the system, increase life cycle savings and improve thermal efficiency of the process. It is very demanding for optimal utilization of solar resources to meet the energy demands.

Several designs are available particularly cabinet type solar drier suitable for drying fruits and vegetables and indirect natural convection solar drier for paddy drying [1] and Many different drying methods exist in the food industry. Some of these include: Vacuum drying, solar drying, contact and air drying, cocoa bean drying and copra drying. Recent cardamom fruit drying process has lot of disadvantages like high cost; require large space and manual heating etc.

Some review article prepared PID controller not provide sufficient control action for solar powered Automated dryer [2-7]

In this research work, we have compared two existing solar driers like cardamom drier and copra drier. And these comparison portraits the efficiency, time, consumption, quality of the drier and an alternate source is also being included in tit to make it as constant continuous process.

The objective of the research is to develop the efficiency and economical solar drier for getting good quality and occupy less amount of space. Now a day's new design and development of Automatic solar Powered drier is essential and our work is proposed to drying the cardamom fruit without destroying its color and flavor by using a basic PID controller and compare its performance with advanced intelligent controllers like Fuzzy logic is developed control action for a non linear process based PID controllers and Fuzzy tuned PID controllers.

II. Drying of Fruits

Drying of fresh fruits is one of the most energy intensive processes in the food industry and a promising method of reducing post harvest losses. Improving energy sufficiency by only 1% could result as 10% increase in profits. Nowadays, optimization of solar system is used to reduce system total cost, increase life cycle savings and improve thermal efficiency. It is very demanding for optimal utilization of solar resources to meet the energy demands.

Drying is removing a large portion of the water contained in a product in order to considerably reduce the reactions which lead to deterioration of the products. The removal of moisture arrests the growth and reproduction of micro-organisms that would cause decay and minimizes many of the moisture-mediated deterioration reactions. This can be done by simultaneous heat and mass transfer and is a classical method of food preservation that provides longer shelf life, reduced weight and volume. There are three phases in the drying process.

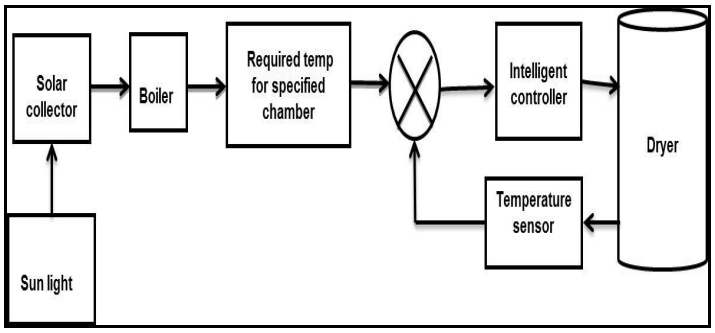

Figure 1. Schematic diagram of the process

II. Solar Drying

Sun drying is a common farming and agricultural process used universally. Solar Energy is environment friendly and it is renewable and can serve as sustainable energy source. Solar energy is free, environmentally clean, eco-friendly and therefore is accepted as one of the most promising alternative energy resources options [8-9]. Solar drying is a possible replacement for electric drying. A typical solar dryer improves upon the traditional open-air sun system in five important ways, it is faster, and materials can be dried in a shorter period of time. The flexibility of enlarging the solar collection area allows for greater collection of the sun's energy. It is more efficient since materials can be lost to spoilage.

III. Alternate Source

Alternate source is one which is used in the process of fruit drying when there is no source of solar energy in rare cases then the alternate electric source is used.

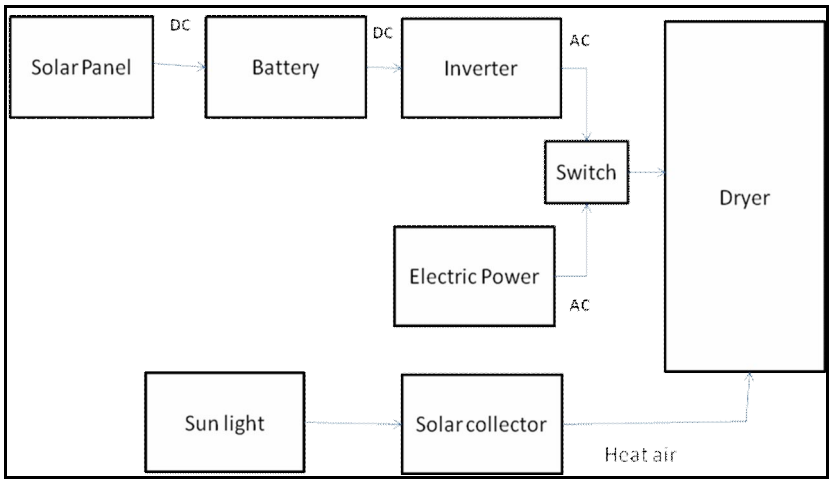

Figure.2. Schematic Diagram to show the alternative power source

IV. PI Controller

The basic Controller which is going to be used in the process is PI controller. It is to control the temperature in the boiler and then the controlled temperature is given to the dryer for the process of drying the fruits. The P and I terms are added together to produce a control signal that is applied to the system being controlled. Integral action enables PI controller to eliminate offset also avoids a major weakness of a P-only controller. Thus, the PI controllers provide a balance of complexity and capability that makes them by far the most widely used algorithms in process control applications.

V. Fuzzy Controller

The schematic diagram of a fuzzy based control system as depicted in Fig.4.It consists of fuzzification, Knowledge base, defuzzification, Inference system. The following procedure is followed for design of fuzzy controller.

- Inputs of fuzzification process are taken as change in error and error.
- Rule base is formed using Five linguistic variables
- Rules are manipulated from the rule base.

The knowledge based fuzzy system contains IF-THEN rules [10], [11] compiled of linguistic variables. The fuzzy set is defined semantics linguistic labels; all rules are included in the knowledge base, thus easily read the system for humanity. The basic fuzzy structure consists of two dissimilar components, fuzzy rule and membership function. Fuzzy rules primarily contingent on the consequential arrangement straightly impacted through the outputs.

VI. Results and Discussion:

The real time data are taken from the experimental cardamom and Copra driers fig (1) and fig (2) shows that response of input and output of the process. The PI is adjusted by the Ziegler Nichols (Z-N) method. Both the PI controller and Fuzzy controller for the Dryer validated using MATLAB environment and the result is obtained. The Cardamom dryer response of PI and Fuzzy shown in fig (3) and the positive disturbance response of PI and Fuzzy shown in fig (4) and the negative disturbance response of PI and Fuzzy plotted in the fig (5) .The Copra dryer response of PI and Fuzzy shown in fig (6) and the positive disturbance response of PI and Fuzzy shown in fig (7) and the negative disturbance response of PI and Fuzzy shown in fig (8) from the responses. The comparison between the two dryer Tabulated in Table (1). we prove that Fuzzy gives fast response and quick setting time of the PI controller and Cardamom dryer gives better performance to Copra dryer.

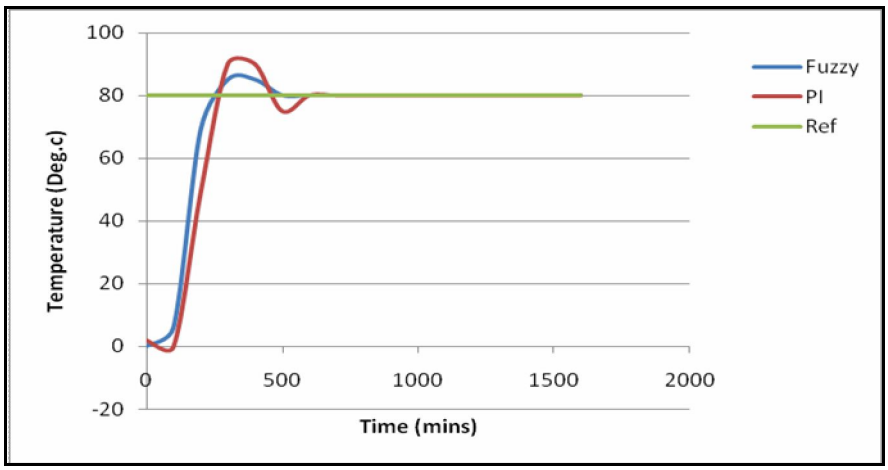

Fig .3. PI and Fuzzy controller response of Cardamom Dryer

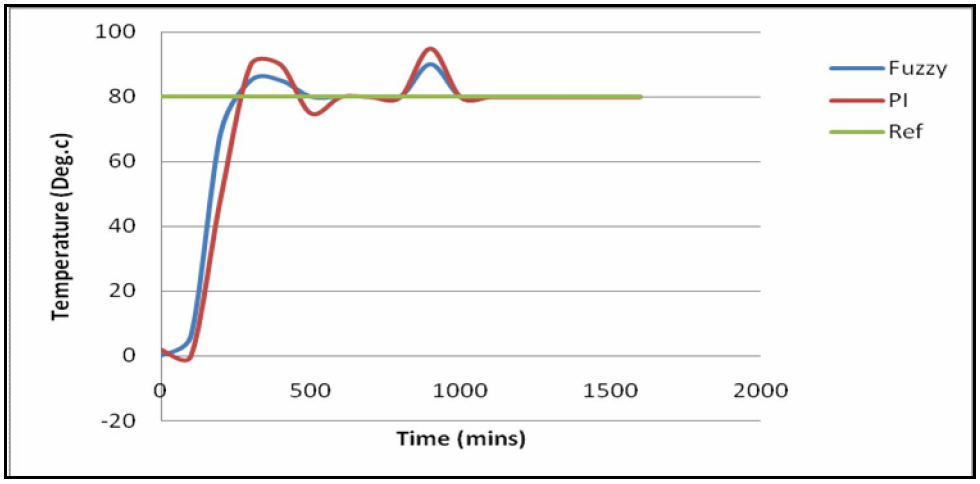

Fig .4. PI and Fuzzy controller positive response of Cardamom Dryer

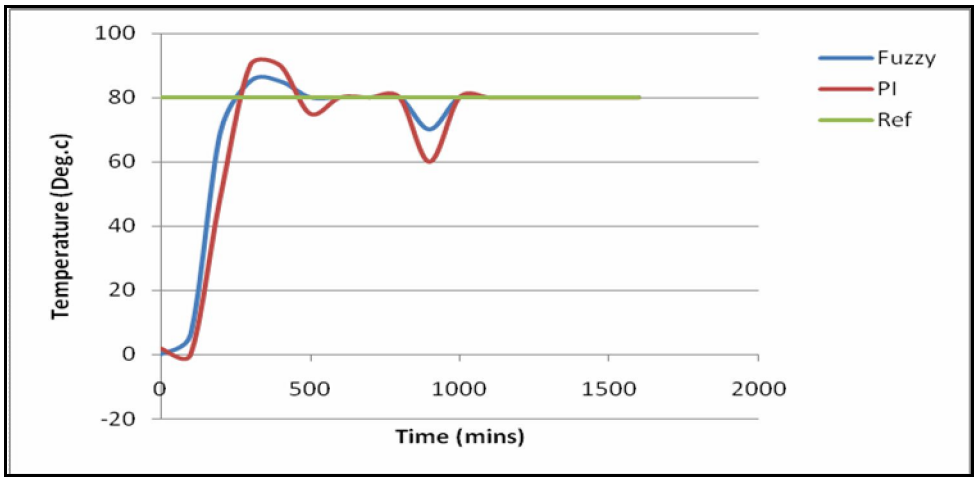

Fig .5. PI and Fuzzy controller negative response of Cardamom Dryer

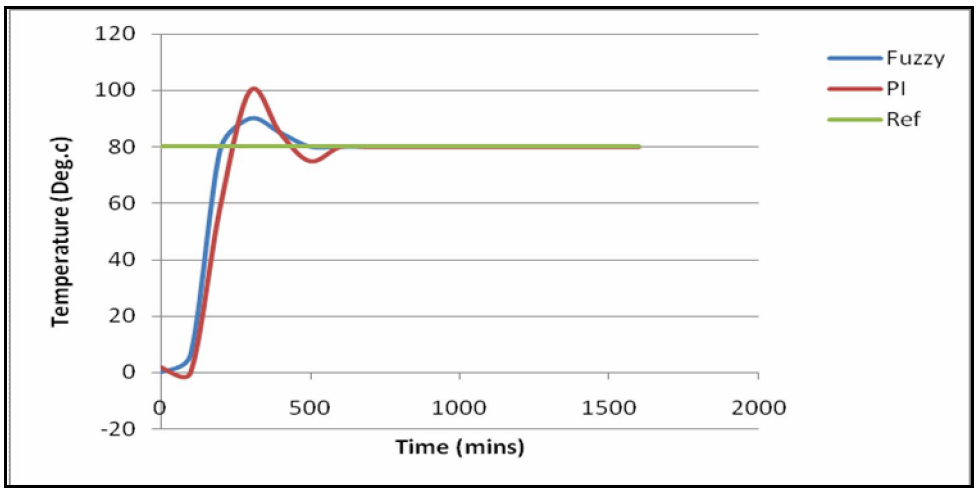

Fig.6 . PI and Fuzzy controller response of Copra Dryer

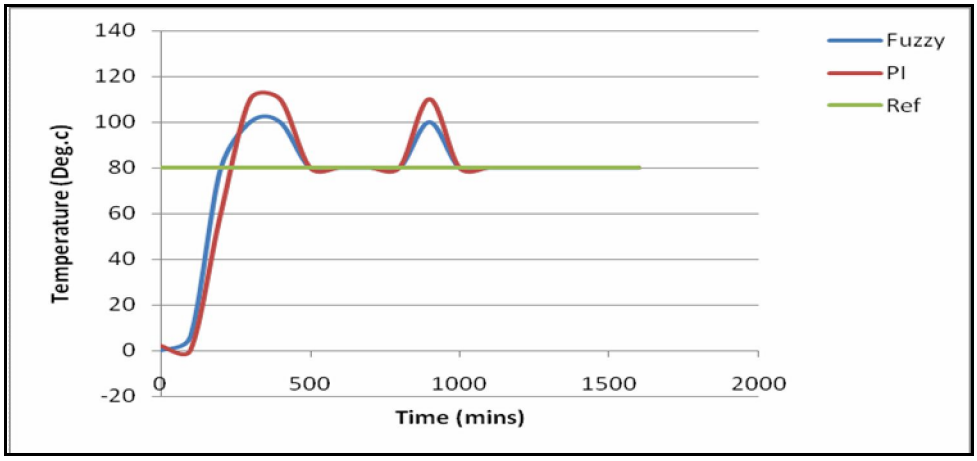

Fig .7. PI and Fuzzy controller positive response of Copra Dryer

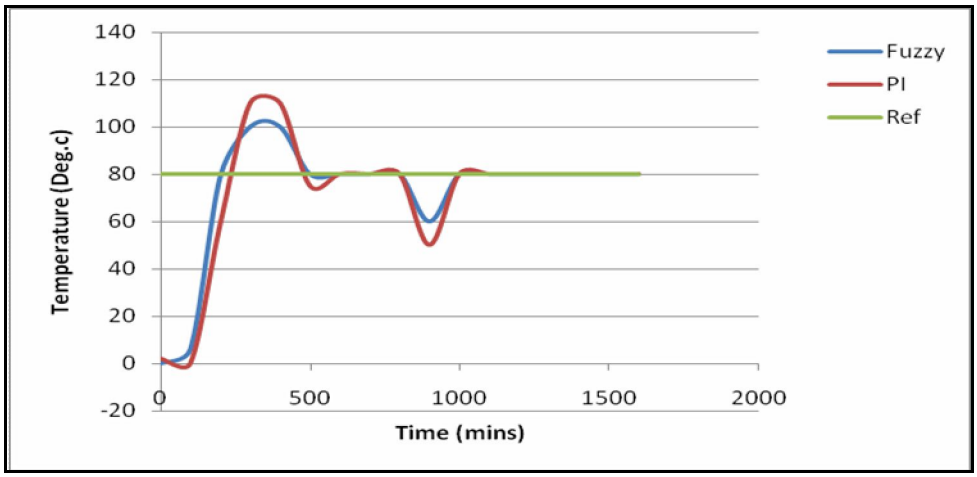

Fig .8. PI and Fuzzy controller negative response of Copra Dryer

Table-1 : Comparison between Cardamom dryer and Copra dryer

Cardamom Dryer			Copra Dryer	
Response	PI Controller	Fuzzy Controller	PI Controller	Fuzzy Controller
Rise Time	200	100	300	200
Overshoot	90	70	100	90
Settling Time	700	500	900	700

VII.Advantage of this Approach

1. To replace the conventional method of drying fruits; which cost more and time consuming.
2. Using a cheap supplementary supply of solar heat, so reducing conventional fuels demand can result in significant cost savings.
3. No corrosion problems.
4. The system will not malfunction if there are small leaks.
5. Air is nontoxic.
6. It requires less technical equipment.
7. Sustainable reduction in wastage.
8. Hygienic method of drying.
9. The quality, color, flavor of fruit is good.

10. Requires less man power.
11. No pollution.
12. The area required is less.
13. The area required for drying the fruit is less.
14. Low Manpower.
15. No pollution.
16. Designed in such a way the device runs in AC and DC power supply.
17. Time required drying the cardamom fruit is less.
18. Acceptable color and flavor after drying.
19. The quality of the resulting Fruits is good.

VIII. Efficiency

1. A small change in boiler efficiency (even 1%) can represent a significant economic impact.
2. The cost of the process includes water treatment, boiler, personnel services, equipment maintenance, typically these cost combine to be much lesser than the fuel cost.
3. The proposed drier will ensure uniform drying, in much lesser time, through maintenance of the chamber temperature within the desired limit. In this process, the heated air is not let out and it is recycled. Thus it results in high efficiency of operation.
4. The space required drying for the Chamber and the total time of drying will also be highly reduced with increased capacity for drying.

IX. Conclusion

This paper predicts and had proposed a cheap way of designing and constructing an efficient drier through which the solar energy can be tapped and stored in batteries and the plant can be run without a shut down even during cloudy days and even at dark nights. By using this technology we can increase the output power of solar energy and can use in much more applications. In this work Fuzzy is designed and control temperature of a cardamom and copra dryer and its response compared with PI. The comparison has been done between Fuzzy and PI, it shows that Fuzzy provided better performance than PI and Cardamom dryer provide better performance than Copra dryer.

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