Performance Analysis, Modeling and Power Optimization in Solar Powered Automated Drier

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Abstract — Drying is an excellent way to preserve 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 modelled and an basic PI controller and an intelligent control system 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, Intelligent control system, solar drier, heating process, heater.

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 [3] and manydifferent 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.

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. 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 PI controller and compare its performance with advanced intelligent controllers like Fuzzy based PID controllers and Fuzzy tuned PID controllers.

I. IDEOLOGY

"The sun rays that reaches the Earth's surface delivers 10,000 times more energy than what humans consume every day." The idea proposed is that if just 0.1 percent of area of Earth's surface is cover with [very efficient] Large-area solar cells, then this can replace all the existing method of power production and can power a large energy which is clean and renewable.

II. DRYING OF FRUITS

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.

The first phase is short and it is the phase during which the drying velocity increases and corresponds to the rise in temperature of the product until it reaches and settles in equilibrium state. This is the time when theproduct receives as much heat as possible from the hot air which is used to vaporize the water molecule from the product. The second phase works as the constant drying velocity period. It corresponds to the evaporation of the free water on the surface of the product, which are permanently remains as the moisture coming from inside of the product settles over the surface. The third phase is

the slowing down phase and it corresponds to the evaporation of bond water. The technique of drying, mainly sun drying, is probably the oldest method of food preservation practiced by humankind. The fruit drier is used to dry the fruit resulting in the best quality. In this drying process the maintenance as well as the quality from the solar collector the hot air is transported to the boiler through a well-constructed transparent PVC and the aluminum support offers good heating and transport conditions.

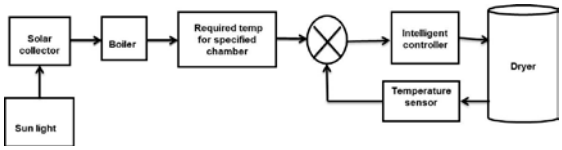

Figure 1. Schematic diagram of the process

III. 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. 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. Furthermore any direct exposure to the sun during high temperature days might cause hardening, where hard shell develops on the outside of the products, trapping moisture inside. Reliability of solar energy can be increased by storing its portion when it is in excess of the load and using the stored energy whenever needed. Solar drying materials at optimum temperatures and in a shorter amount of time enables them to retain more of their nutritional value such as vitamin C. Fruit is enclosed in the dryer and therefore it is protected from dust and other organisms. Dryers can be constructed from locally available materials and are relatively low cost. Air is drawn through the dryer by natural convention. It is heated as it passes through the collector and then the fruit is heated both by the air and directly by the sun. The solar air collector is designed to heat air when irradiated by the sun. The basic components are: cover, absorber, air passage and insulation solar radiation transmitted through the cover heats the absorber, which in turn heats the air in the air passage.

IV. WATER TUBE BOILER

Water tube boiler is a special type of boiler in which water circulates insidehot tubes which are heated externally by the fire. The hot air comes from the furnace will heat the water in the water tubes and steam generation takes place inside the water tubes. The heated water then rises into the steam drum. Here, saturated steam is often drawn off the top of the drum as it rises from the water tube. As it is a continuous process the water cooled at the bottom of the steam drum again goes to the boiler. The water tube boilers can accommodate even small water content in a small diameter tubes and can produce a steam of high pressure. water tube boilers are needed when a high pressure or temperature is requiredwater-tube boiler arrangement will incorporate an upper steam-drum that allows the liquid water and steam to separate. A lower drumis referred as mud-drum, will serve as the lower collection header for the tubes. Hundreds of smaller diameter tubes will connect the mud-drum to the steam drum. As the water gets heated and boiling occurs the fluid rises in the tubes to the steam drum.

There are many advantages of using a water tube boiler; it has a small diameter tubes and steam drum which will make it to be to produce superheated steam even with small water content, and it has the facility of customizable design (flexibility).

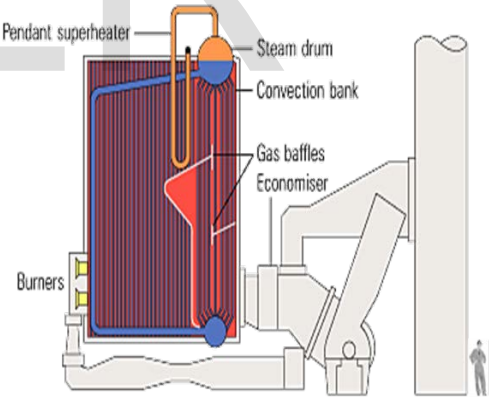

Figure 2. A typical Water-tube Boiler

V. 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.

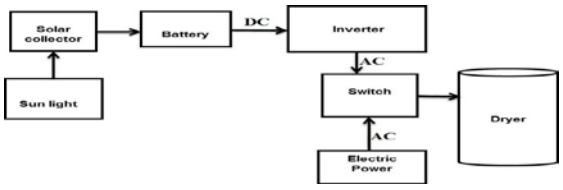

Figure 3. Schematic Diagram to show the alternative power source

VI. 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.

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.

VIII. EFFICIENCY

1. A small change in boiler efficiency (even 1%) can represent a significant economic impact.
2. The cost of the process includes watertreatment,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.Also,results showed that the control system could improve energy efficiency during the drying process.

X. REFERRENCES

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