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Control of Tray Dryer Using PID Controller

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Abstract: Tray drying is the important unit operation in food industry. There are three important variables to control (air-temperature, air-velocity and relative humidity) and likewise to achieve the high efficiency of the dryer. Drying of corn was performed in tray dryer in which the temperature and fan speed which could be adjusted. Temperature controller which it is used to control the temperature and the regulator which it is used to adjust the speed. The experiment was done with various temperatures with different fan speed and it is to investigate the control of air temperature in a tray dryer by implementing the PID controller. This study explains the basic approach used to explain the batch drying process was to divide the process into many small processes(varying different speed) and simulate them by consecutively calculating the changes occurs during different temperatures.

Key words: Tray dryer · Moisture content · PID controller

INTRODUCTION

Drying is a process to eliminate water or other liquid from the solid material till an adequate low value of moisture is achieved [1]. According to several authors the word 'drying' is used to portray the process of water removal on the disclosure of the sun [2] whereas 'dehydration' as the artificial drying conceded out in controlled conditions [3]. Drying is doubtless the oldest method of food preservation. Earlier foods such as fruits and vegetables were conserved using sun-drying techniques [2]. These days, drying are considered not only as a preservation process, but also used for mounting value added foods. Tray Drying has simplest design and has ability to dry higher volumes of products. In 1795 first hot air dehydrator was used to dry fruits like prune, raisins, apricots etc. Tray dryer has identical airflow circulation over the trays and it is the key for thriving operation[4]. Implementing the proper design of a tray dryer system is the only way to eliminate or reduce non-uniformity of drying and its efficiency. However, to overcome the drawback of the tray dryer is uneven drying i.e) poor airflow distribution among the chambers. Most of the dryer systems have been developed using solar energy because of low operating cost [5]. Cabinet Drying is simplest dryers and were mainly used to dry fruits and vegetables [4] They are used for drying fruits (grapes, dates, apples), vegetables and also the equipment cost is less, but its operating cost is high. [6] for grapes, apricot, beans and developed different models. Tunnel dryers are considered as developments of the tray & cabinet dryer in which the trays are move through an insulated tunnel where the heat is applied and the vapours are removed [7]. It was introduced as hot air dryer which it overcomes the drawbacks of sun drying. This method is often used to dry corn, banana, coffee beans, black pepper, apples, figs, dates and so on in form of pieces. Tray Dryers is used in the small scale industries and also for the pilot work.

Nowadays, control of drying plays major role and various sensors are used for many purposes. (Moisture level sensor). In commercial dryers there were conventional control strategies but in industries computer controlled techniques were used and moreover there are some parameters which drying air temperature, drying air velocity and type of food materials used. The basic approach used to explain the batch drying process was to divide the process into many small processes (varying different speed) and simulate them by consecutively calculating the changes occurs during different temperatures. Single rack tray dryer is trouble-free in

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construction and operation and can be easily modified for drying. None of the reported works on control of drying of corn has been carried out in tray dryer. The experiment was carried out between 50°C and 80°C.

The present study which is about the control of the laboratory tray dryer with conventional methods and the results were discussed.

Experimental Apparatus: The laboratory model of a tray dryer consists of the following components:

- Drying chamber
- Heating chamber
- Control panel

Drying Chamber: The drying chamber which it consists of two trays. The distance between the trays is 10cm for good air flow.

Heating Chamber: The heating chamber is also made of steel and is fitted with 6 heating element and each element is 400v, to heat the fresh air from ambient temperature to 70°C. A digital temperature controller is fixed over the control panel to control the heater.

Control Panel: The control panel consists of digital temperature controller, switches and sockets.

Fig. 1: Tray Dryer

MATERIALS AND METHODS

Dryer which consists of trays, co-axial fan, thermocouple, temperature controlled unit, cabinet and heating coils. Hot air is circulated through the cabinet. Fresh air enters the cabinet, is drawn by the fan through the heater elements and then blown across the food trays to sap. In this case the air is being heated by the indirect method. It passes across and between the trays. The air is done in to the atmosphere after one pass rather being re-circulated within the system. Thermostats were installed along side of the heating elements directly in the main air current imminent the drying trays.

It is possible to control the drying air temperature by adjust the temperature controller. The drying air velocity is also possible to control by adjusting the speed of the fan. For higher efficiency, we need sufficiently high velocity of the air.

Corn were peeled and placed on the tray. The initial weight was recorded.

The change in the moisture level is calculated by;

$$MC = \frac{m1 - m2}{m1} * 100$$

where MC- Moisture content

m1 - Initial weight of the food material before drying
m2 - Final weight of the food material after drying

S.No	Weight before Drying (gm) M1	Weight after Drying (gm) M2	Temperatureo (°C)	Fan Speed (rpm)	Time Taken (min)	Moisture Content (%)
1.	100	29	65	1300	145	71
2.	100	30	70	1300	129	70
3.	100	30	75	1300	110	70
4.	100	29	80	1300	90	71
5.	100	30	85	1300	75	70
6.	100	28	65	1040	176	72
7.	100	26	70	1040	160	74
8.	100	25	75	1040	145	75
9.	100	28	80	1040	110	75
10.	100	27	85	1040	92	73

Control System Synthensis: In which the dryer control system, the plant which is based on input variable and output variable. Mostly, the input variable to be chosen is temperature and the output variable is moisture content. The proposed controllers used are PI and PID controllers. The real task is to choose the gain values (K_p, $K_{i,}$ K_d). For tuning this is done with Ziegler Nichols tuning method. The tuned parameters are k_p = 3.0375, k_i = 0.0333, k_d = 28.3675. The block diagram which is shown below:

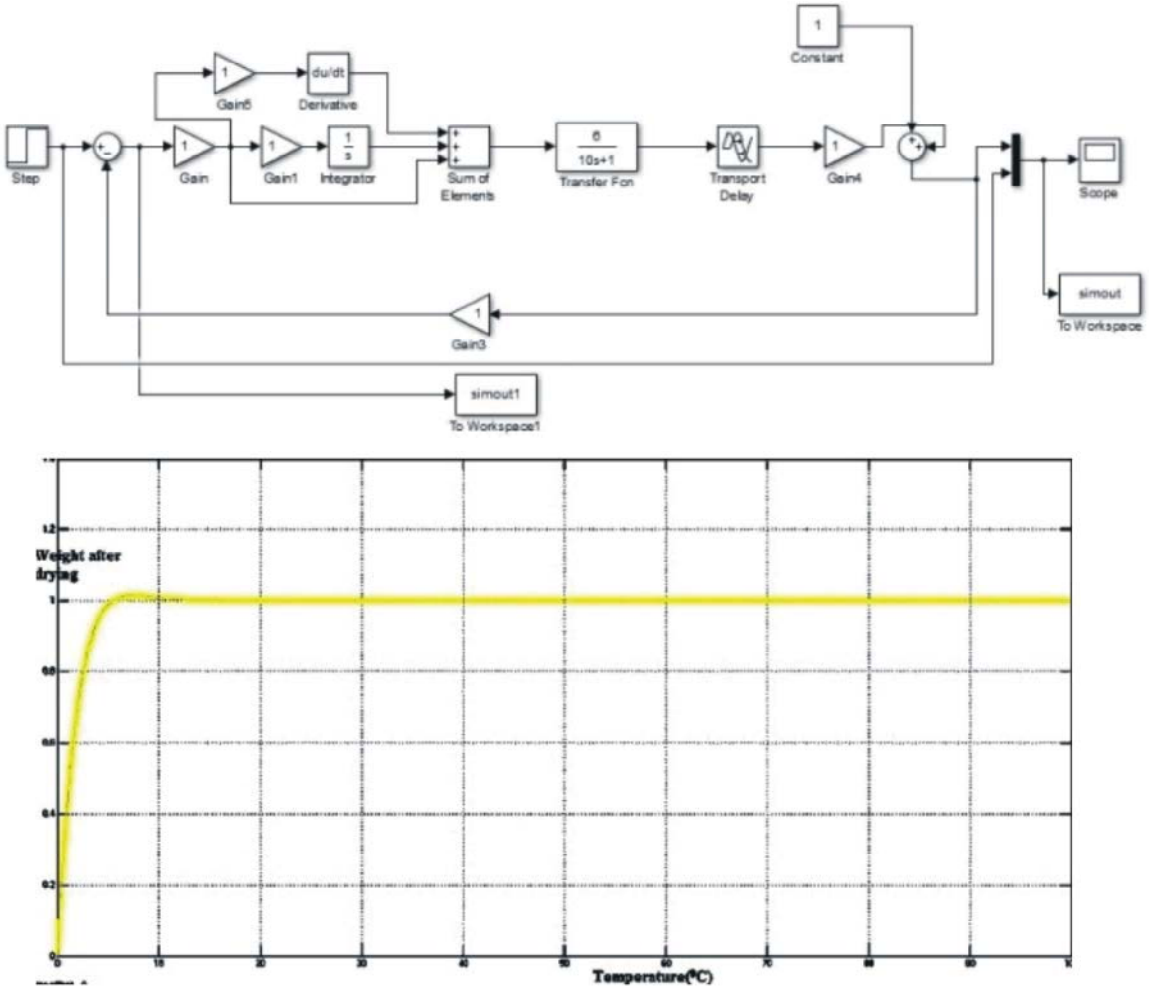

Fig. 2: Simulation Result (Temperature vs Weight after drying)

RESULTS AND DISCUSSIONS

The output for PID Controller and the graph which is between temperature and weight after drying are shown above. There were many operating parameters are highly influenced for the desired dryer performance.

Previously, there were many of them done the experiment with various fruits and vegetables [2, 4, 5, 6, 8-36] at different conditions with CFD simulation and some of them investigated semi industrial type and batch tray dryer microprocessor based control along with the support of LAB view [37]. Here at present the work is done with MATLAB.

CONCLUSION

The present study which are made with the control of tray dryer in laboratory scale. Initial work was done PID Controller. Thus, at hand are many artificial intelligent controllers like ANN, FLC, etc. Future investigations are made with intelligent controllers.

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