ANALYSIS OF LABORATORY MODEL OF CORN RESERVOIR DRYER WITH FIXED BED

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ABSTRACT: Drying of agricultural products is one of the most important steps in whole production process. In order to ensure the safety of final product storage and increase storage life, drying agricultural products is necessary. The purpose of this study is to evaluate the function of laboratory dryer with fixed bed. To achieve this goal, some experiments were performed at different temperatures, heights and initial moistures. The experiments at five different temperatures (70, 80, 90, 100 and 110 °C) and the height of product in the reservoir in four different levels (20, 40, 60 and 80 cm) were performed and the effect of temperature and height of product layer on the duration of drying was investigated. Furthermore the effect of these factors on changes of water content was checked. The results showed that by increasing the inlet air temperature, duration of experiments decreases and gradient of water content changes increases while by increasing height of product layer, duration of experiments increases and gradient of water content changes decreases.

Keywords: dryer, temperature, product layer, duration, water content

INTRODUCTION

Corn is one of the important cereals and its origin has been the continent of America and is one of the oldest crops that directly used as the main ingredient in big groups of human food and livestock feed. Moreover it is used for producing energy in some industries (unknown, 2011). We can obtain starch, sweeteners, corn oil, beverage, industrial alcohol, Ethanol and fuel from corn. Sometimes, farmers harvest corn at high moisture early because of bad weather. Corn harvested at high moisture content requires rapid drying for safe storage to prevent respiration, germination, insect infestation and etc (Gursoy , 2013). Drying agricultural products is one of the most important steps in whole production process. In order to ensure the safety of final product storage and increase storage life, drying agricultural products is necessary (Kocsis , 2011).

Advantages of reservoir dryer with fixed bed:

- Fast drying
- Useful for short-term and long-term storage of product
- High drying capacity in lieu of consuming power
- Useful for the products kept in dryer for long period of time
- Flexible for choosing various dryer equipment

Generally, reservoir dryer is used in systems in which the amount of harvested products varies from 5000 to 35000 tons per year and from 500 to 2500 tons per day. The purpose of this study is to evaluate the function of laboratory dryer with fixed bed. To achieve this goal, some experiments at different temperatures, heights and initial moistures were performed and the results of experiments has been investigated.
MATERIALS AND METHODS

Laboratory equipment
Laboratory dryer with warm air flow and fixed bed was used for doing experiments. The dryer is made of a blower for airflow, two heating units to heat the inlet air (each unit heaters are 4 elements turned on by an electric dimmer so that the amounts of flow into each element are equal. One of the heaters is primary. It is on from start of the test until the end and another one is secondary whose elements is controlled by two dimmers. If the temperature reduces to below the specified limit, the secondary heater will enter the circuit by a contactor and set the temperature on the specified limit. As soon as the temperature reaches the set temperature, the secondary heater leave the circuit.), thermocouples and an indicator for measuring and controlling temperature. Furthermore an alcohol thermometer mounted on the other side of the dryer (before reservoir) to indicate accuracy of thermocouple function, the linear airflow for uniform velocity of heated air of reservoir dryer in cross-section, a digital scale for reading the weight loss during testing, cylindrical reservoir for product placement and flow meters to measure the electricity consumption has been used. Some parts of the dryer is covered by fiberglass to reduce heat loss. The sample's initial moisture content was calculated by drying in an oven. This means that 100 g of wet sample were put into the oven at 130°C for 24 hours (unknown, 1982). A schematic diagram of this dryer is shown in figure 1.

Test method
Drying experiments were conducted at temperatures (70, 80, 90, 100 and 110°C) and the height of the seeds in reservoir (20, 40, 60 and 80 cm). To perform the test, the samples were kept in laboratory place for 2 hours to reach equilibrium with the ambient temperature. Then we turned on the dryer and set the temperature of inlet air on desired temperature. After that we waited until the condition reached the steady-state. At the end, the certain height of corn was poured into the reservoir and the experiments were conducted. When the moisture of corn after drying reached certain moisture, the experiments were finished. The weight of Product that losses moisture was calculated by drying in an oven. This means that 100 g of wet sample were put into the oven at 130°C for 24 hours (unknown, 1982). A schematic diagram of this dryer is shown in figure 1.


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\[
MR = \frac{M - M_e}{M_i - M_e}
\]

Where \( M \) = moment moisture, \( M_e \) = equilibrium moisture (that is equal to 14 percent in this study), \( M_i \) = initial moisture All of these parameters are in kilogram of water per kilogram of dry matter (ASAE D245).

Desired final moisture for corn storage is 14 percent, so each experiment continued until moisture of corn in the reservoir reached this moisture (Desired final moisture) and the time for reaching this moisture percent was recorded for each trial.
RESULTS AND DISCUSSION

The effect of temperature and height of product layer on duration of drying

In this part, covariance analysis in factorial experiment was done using SAS Programming. In order to compare the effect of inlet air temperature and the height of product layer on duration of drying, we used same samples in three iterations. It is clear that initial moisture affect the main characteristic (duration of drying) but since it changes irregularly, its effect on the experiment is irregular. The effect of initial moisture is less than the effect of inlet air temperature and the height of product layer so initial moisture is called covariate and the analysis of it is covariance. The purpose of covariance is to purify the effect of samples if in time covariate measurement is done. When the covariance analysis is done, coefficient of variation (CV) of experiment and error reduce while accuracy increases but in variance analysis these changes are less than the changes in covariance analysis. The results of covariance analysis in factorial experiment are in table 1.

Table 1. covariance analysis of effect of temperature and height of product layer on drying duration

<table>
<thead>
<tr>
<th>Sources of changes</th>
<th>Number of decision</th>
<th>The sum of squares</th>
<th>The average of squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>The height of product layer</td>
<td>3</td>
<td>90997520.6</td>
<td>303326173.5</td>
<td>120.94**</td>
</tr>
<tr>
<td>Inlet air temperature</td>
<td>4</td>
<td>276703428.4</td>
<td>69175857.1</td>
<td>27.58**</td>
</tr>
<tr>
<td>Covariate</td>
<td>1</td>
<td>2506482.5</td>
<td>2506482.5</td>
<td>1***</td>
</tr>
<tr>
<td>Temperature ×height</td>
<td>12</td>
<td>30712368.6</td>
<td>2559364</td>
<td>1.02***</td>
</tr>
<tr>
<td>error</td>
<td>37</td>
<td>92798064</td>
<td>2508056</td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>57</td>
<td>1341193151</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CV=15.36
*Significant difference at probability level of 5 %, **Significant difference at probability level of 1 %
And n.s = The lack of Significant difference

The results of table 1 show that changing the height of product layer and inlet air temperature has significant effect on duration of drying but there are not any significant differences between the temperature’s effect on duration of drying and the height’s effect on it.

The comparison of the average of different level of temperature and height at 1 % Probability level was done using Duncan test, and the results of them are shown in the figure 2 and 3:

Figure 2. comparison of average of the height of product layer’s effect on drying duration

The letters show the significant difference at 1 % level. According to figure 2, the least average of drying duration is related to height of 20 cm and by increasing product layer, the duration of drying increases.

According to figure 3, a highly significant difference between the effects of different levels of inlet air temperature on the duration of the experiments is observed and increasing inlet air temperature decreases the time required for drying process. According to this diagram, the least average of drying duration is related to 110C, but there are not any significant differences between 100C and 110C.
Figure 3. comparison of average of the inlet air temperature’s effect on drying duration

The effect of temperature and product layer height on water content changes

As an example, changes in water content at height of 20 cm is shown in figure 4. According to this diagram by increasing drying temperature, evaporation rate and the gradient of diagram (time-water content) increase.

Figure 4. effect of temperature changes in water content changes

As an example, changes of height at temperature of 90°C is shown in figure 5. According to this figure, by increasing the height of product layer, evaporation rate and gradient of diagram (time-water content) decrease.

Figure 5. effect of height changes in water content changes

CONCLUSION

- By increasing the inlet air temperature, drying duration decreases
- By increasing the height of product layer, the drying duration increases
- Increasing inlet air temperature has greater effect on water content changes
- Increasing the height of product layer has less effect on water content changes
REFERENCES


