Proceedings of the First International Exergy, Energy and Environment Symposium
13-17 July 2003, Izmir, Turkey
IEEES-1
pp.673-676

USAGE OF FLUİDİZED BED FOR PEA DRYING

Parlak N[1]. , Gur,M[1]. and Topuz, A[2].

[1]Mechanical Engineering Department, University of Sakarya, Esentepe Campus, 54187, Sakarya, Turkey
[2]Mechanical Engineering Department, University of Zonguldak Karaelmas, Incivez, 67100, Zonguldak, Turkey
Emails: naydemir@sakarya.edu.tr, atopuz@karaelmas.edu.tr , gur@sakarya.edu.tr

ABSTRACT

In our country, agricultural industry is in troubled period in comparison with past. New studies and projects must be done in this industry. Our country contains very productive agriculture fields, but enough development cannot be provided. Therefore, all kinds of development in this industry must be sponsored.

In the agricultural industry, after harvesting of the products, storing of them is very important. They should be dried enough to store. In our country, the products are usually dried with spreading out and aided the solar energy. In this study, the fluidized bed drying system was used to dry the product. By using this system, homogeny drying was obtained in less time than other systems.

A fluidized bed drying system has been constructed and velocity, temperature and humidity of bed air have been measured at the different points of the system by using measurement elements. In the experiments, frozen, boiled and fresh peas have been used as drying material.

INTRODUCTION

In the food industry, harvesting and storing the agricultural products and providing the enough condition to store are very important. Agricultural products should be dried enough to store for no molding and losing the specialties.

Drying process varies in accordance with physical, chemical and other characteristics of agricultural products. Drying with solar energy is common used but this method cannot be used everywhere. Also all kind of agricultural products are not suitable for drying with solar energy and then, rain, dust and insects may cause to losing the food quality. Therefore, new drying methods have been developed.

Dryers for agricultural products down a few groups. For drying the vegetables, fruits and secondary products that are puree and juice, cabin type, tunnel type, infinite band tunnel type, rotary cylindrical type, fluidized bed type and spray drying type dryers are used. Because of high heat and mass transfer and easy controlling, fluidized bed systems are usually used for combustion process. Also these systems have been used for drying process and obtained good results.

In this study, fluidized bed drying system that has been previously used to dry the hazelnut, was used. Pea was selected for drying material in the experiments. Because, in the food industry, 22 percent of vegetal proteins and 7 percent of carbohydrates are provided from the leguminous. Around the world, producing of pea is 26.5 percent of leguminous, and it is important in the food, tinned food and starch industry.

The moisture in the agricultural products is defined by dry based and wet based moisture content. Wet based moisture content is shown as follows,

$$\%M_{yb} = \frac{W_S}{W_S + W_K}.100 \qquad (1)$$

Dry based moisture content is the ratio of amount of water and dry mass.

$$\%M_{kb} = \frac{W_S}{W_K}.100 \qquad (2)$$

Drying rate is defined by equation 3,

$$\frac{dM_{kb}}{dt} = \left[\frac{M_{t+dt} - M_t}{dt}\right]_{kb} \qquad (3)$$

EXPERIMENTAL STUDY

Fluidized Bed Dryer: As shown in fig. 1, fluidized bed drying system contains that climate center, valve, perforated plate, Plexiglas bed column, thermometers, humidity sticks, pitot tube, pressure cells, fittings and insulation materials.

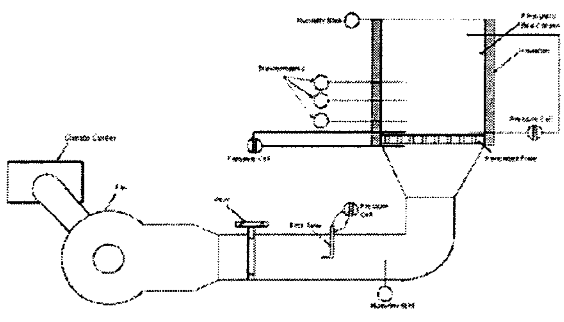

Fig. 1. Schematic diagram of fluidized bed dryer.

Climate Center: Air conditioning Laboratory Unit was used for heating the bed air. It consist of 4 stripped electric elements have 3000 watt total power. Owing to high flow rate of bed air, addition electric elements were used in the suck of unit.

Blower: The bed air was provided by centrifugal blower. Power of blower motor is 1500 watt.

Frequency Controlled Driver: For driving the blower motor Siemens Micromaster frequency controlled driver was used. During the run, current, voltage, frequency, cycle, and moment values are obtained by this driver.

After blower, the bed air flows in the pipe that 100mm diameter then, perforated plate and bed column.

Pitot tube: Pitot tube was assembled on the pipe to measure the velocity of the bed air. It is made of chromium-plated brass, 350mm length, 7mm diameter. A pressure cell was used with pitot tube to measure the difference between total and static pressure.

Humidity Sticks: Inlet and outlet humidity of the air were measured by using humidity measurement stick that Testo 605-H1, 125mm length, 12mm diameter, 5 to 95 %RH, 0.1%RH resolution.

The bed column was made of Plexiglass with 196mm inner diameter, 8000mm height and 2mm thickness. A perforated distributor plate with 2mm thickness and 4mm holes was used to obtain uniform distribution of the fluidizing air.

Pressure Cells: Pressure difference between two side of distributor plate and distributor plate and fluidized bed height were measured with electronic pressure cells that Testo 505-P1, mbar, mmH_2O units, $1mmH_2O$ resolution.

Thermometers: The temperature distribution through the bed was measured by thermometers (Testo 905-T1, type K thermocouple) at different heights above the distributor plate (2,4,6cm).

Also, Testo 350M/XL and Testo 454 measurement elements were used to test the thermometers, pressure cells and humidity sticks. Five different values can be obtained and converted to the computer by using these elements.

EXPERIMENTAL RESULTS

Firstly, minimum fluidization velocity of the pea has been obtained and then, experiments were conducted under batch fluidization. Drying particles were assumed to be a spherical with an average diameter of 10mm.. Initial moisture content of pea was observed with using Sartorius moisture analyzer. Initial moisture content of those is in the range of 70% wet basis. Drying process was performed with 2m/s velocity and 38 C temperature of the air in the experiments. After 180 minutes of drying process, moisture content of particles has been reduced to 14% wet basis.

The bed pressure drop versus gas velocity in the bed column was shown in fig. 2.

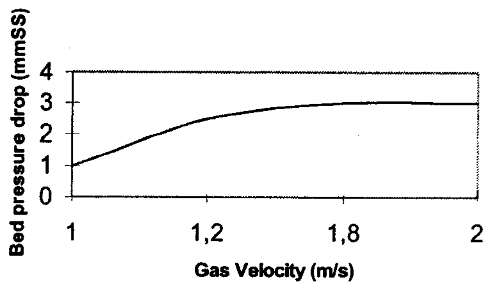

Fig. 2. Minimum fluidization velocity.

Temperature distribution through the bed versus time can be seen in fig. 3. During the run, temperature distribution in the bed is nearly uniform.

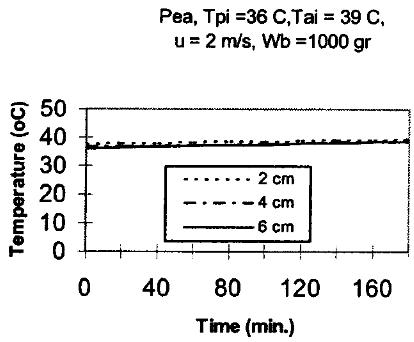

Fig. 3. Temperature time profile for a drying run of pea.

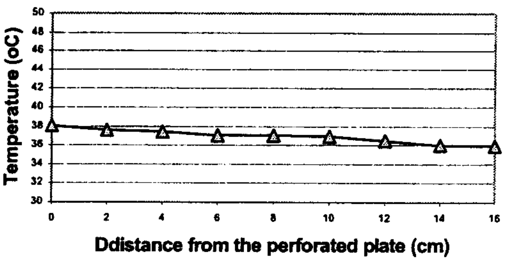

Fig. 4. Mean temperature distribution versus distance from the perforated plate.

At the beginning of the drying, increasing the bed height, reducing the temperature of the air in the bed column.

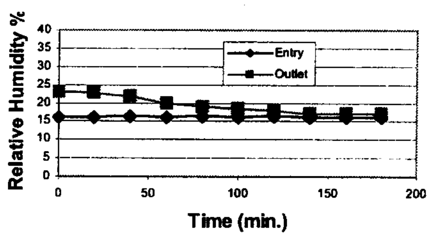

Fig. 5. Inlet and outlet relative humidity of the bed air versus drying time. (40 C temperature and 40% RH of the air)

In the experiments, frozen, boiled and fresh peas were used as drying material. Scope of this study that investigation of fluidized bed drying characteristics of the pea which is usually dried by using tunnel and band dryer.

Drying curves of the particles were presented as follows,

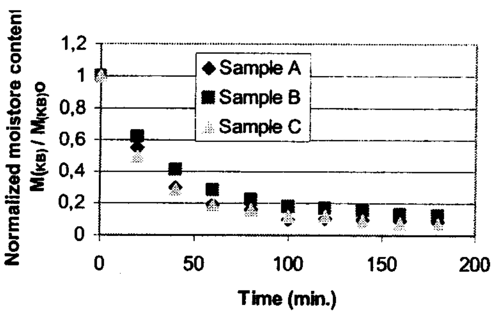

Fig. 6. Drying curves. (A: Boiled pea. B: Frozen pea. C: Fresh pea)

Peas form a smooth curve during drying. Drying rate is obtained by taking the derivative of variation of moisture content with respect to time and the graph according to drying rate and time is given.

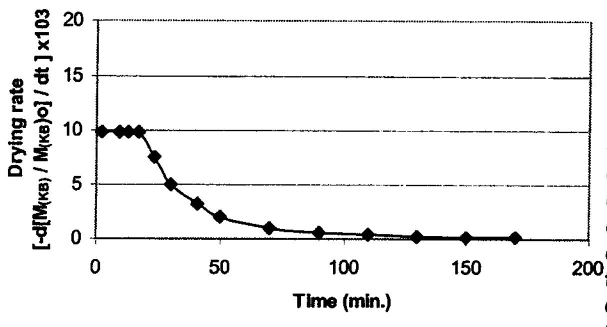

Fig. 7. Drying rate curve.

Peas dry with a constant rate in fluidized bed for certain time and then drying continues with falling rate.

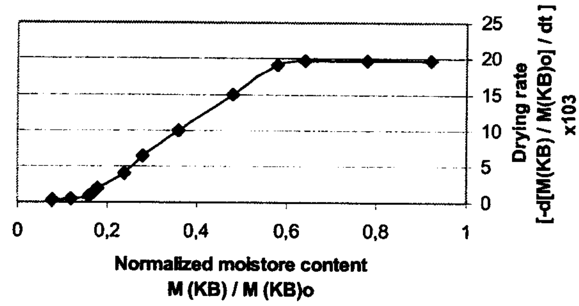

Fig. 8. Relationship between the drying rate and the moisture content.

Water content can be obtained from weight loss of peas. Similarly, wet based moisture content can be calculated ratio of water content to total material content. Normalized moisture content is shown in fig. 8. Four hours are passed for peas reach to storage condition (4% wet based moisture content). The reason is decreasing drying rate during drying. Because this product contain rich starch content.

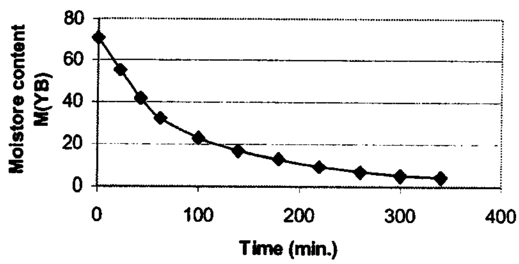

Fig. 9. Wet based moisture content versus time.

GENERAL RESULTS

As a results of this study, drying characteristics of peas were obtained. At the first stage of drying, peas lost the moisture, quickly. The peas lost half of the their weight after 40 minutes. Therefore, the cycles of blower motor must be decreased to prevent the peas fly out. Increasing the height from the perforated plate, decreasing the air temperature. Because of peas have rich moisture content, the difference between inlet and outlet humidity of the air is excess value. This difference reduces by the time. Shrinkage and collapse occur at the surface of the peas and rough crust forms on the surface. Therefore, decrease in drying rate was observed. As a result of increasing velocity and temperature of the air, drying rate increased. After drying the peas for 180 minutes, the moisture content of the particles decreased 14%. The peas must be dried for 3 hours to reach the moisture content of 4%.

During the experiments with boiled sample, due to stroke, failure takes place about 2%. As a result, fluidized bed is not suitable for drying of boiled sample.

In addition, seed peas can be dried in fluidized bed at 38 C temperature.

NOMENCLATURE

W_s : Weight of water (g)
W_k : Dry weight of product (g)
$\%M_{yb}$: Wet based moisture content (%)
$\%M_{kb}$: Dry based moisture content (%)
dM_{kb}/dt : Drying rate (kg moisture/kg dry solid.min)
M_t : Moisture content in the time t (kg moisture/kg dry solid)
M_{t+dt} : Moisture content in the time t+dt (kg moisture/kg dry solid)

REFERENCES

1. Yağcıoğlu A. 1996. Techniques on product processing ,E.Ü. Ziraat Fakültesi .
2. Topuz, A.. 2002. Fluidized bed drying of hazelnut and investigation of heat and mass transfer, PhD Thesis ,SaÜ ,Fen Bilimleri Enstitüsü, Doktora Tezi.
3. Cemeroğlu, B.1986. Technology of fruit and Vegetable, Gıda Teknolojisi Derneği, Yayın no:6, Böl: 9, Ankara.
4. Kavak Akpınar and E. ,*Biçer, Y.2002* , Using of cyclone type dryer for agricultural products, Mühendis ve Makine, Aralık 2002 – 515.
5. Davıdson, J.F. , Clınt R. and Harrison D. 1985. Fluidization 2ND Edition , Academic Pres
6. Kunii D. and Levenspiel O. 1977., Fluidization enginering ,Robert E. Krieger Publishing Company Huntington , Newyork.