THE DRYING PROCESS OF CORN SEEDS IN THE MICROWAVE FIELD

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***Abstract*:**
The purpose of this work is to study the variation parameters in the drying process of the corn seeds, type Kornelius KWS. Our aim is to dry the corn seeds until the optimum moisture content is being reached for storage, taking into consideration that the structure of the material is not affected.

Keywords: corn seeds, germination rate, electromagnetic waves, thermal heating

INTRODUCTION

Microwaves are high frequency electromagnetic waves composed of an magnetic and electric field. The electric field, noted (E) and magnetic field-(H) components are perpendicular to each other. The frequency range of microwaves is from 300MHz to 300GHz, equivalent to wavelengths of 1mm to 1m (Shivhare, 1991), (Metaxas and Meredith, 1983).

When using microwaves to dry grains, the heat generation inside the kernel is instantaneous and causes a relatively rapid mass transfer of moisture emerging out. Researches have studied the drying behavior of particulate food materials in a microwave field: Hall in 1963, Fanslow and Saul in 1971, Bhartia et.al. in 1973 and Shivhare et.al. in 1991 (Eric St.Denis, 1998), (Fanslow and Saul, 1971).

In 1991 Shivhare studied the drying behavior of corn in the microwave field. He established a diffusion model based on varying surface conditions. The model describes very well the microwave drying behavior of corn over a wide range of initial moisture contents, inlet air conditions and absorbed powers. Seed quality grains could be dried with power levels below 0.75W/g (Eric St.Denis, 1998).

MATERIAL AND METHODS

The most important factors that influence the dielectric properties of seeds are the moisture content, the temperature and the frequency. At a temperature of 24^0C and a frequency of 2.45GHz the dielectric constant of corn increased with the increase in moisture, whereas the dielectric loss factor was less regular in its dependence on moisture content (Nelson, 1979). For given moisture content, the dielectric constant was found to decrease with increasing frequency where as the dielectric loss factor didn't show a regular pattern. At temperatures below 60^0C and a moisture content below 20% (dry basis), the temperature dependence of the dielectric constant was found to be nearly proportional, but non-linear at higher moisture content (Shivhare, 1991).

In 1963, Hall, tried drying corn samples in a microwave oven with initial moisture content (dry basis) from 34 - 42% to 18%. There were used 500 g of corn seeds that were dried for 6.5 minutes, resulting in damaged kernels due to high drying rates. He observed damages ranging from discoloration of a few kernels to severe cracking and burning of grains (Eric St.Denis, 1998).

The volumetric dissipation of microwave power into heat in the dielectric material is dependent upon the intensity and frequency of the field as well as on properties of the material such as temperature, specific heat, dielectric loss factor, density and volume. The relationships are (Eric St.Denis, 1998), (Datta, 2001):

$$P = 55.63 * 10^{-12} f\varepsilon'' E^2 v \qquad (1)$$

$$\frac{dT}{dt} = \frac{P}{\rho v C_p} = \frac{55.63 * 10^{-12} f\varepsilon'' E^2}{\rho C_p} \qquad (2)$$

Where:
P=power dissipation (W); E=electric field strength (V/cm)
f=frequency (Hz); v=volume of material (cm^3)
ρ=density of the material (g/cm^3); T=material temperature (^{0}C)
C_p=specific heat (J/g^0C); t=time (s)

For determining the percentage of humidity of the dried seed sample we used the mass of the seed before drying, mi, and after drying mu (Maghiar and Soproni, 2007) (*STAS 10349/1-87)*:

$$\text{U [Humidity]} = \frac{m_i - m_u}{m_u} \times 100[\%] \qquad (3)$$

In the research we made in the Electrical Engineering Lab, using lab installation with microwave system we analyzed the variation of parameters – temperature, humidity, power – in the process of drying the corn seeds that were preliminary moisturized using a mixed process microwave /cold air stream.

This microwave system has three base components: a microwave generator with a maximum power of 850W, waveguide and applicator. The microwave system also has an absorbent charge (in this case we talk about an artificial charge - the water), a directional coupler and an impedance adapter with 3 divers.

The stand is supplied at the tension of 220V±5%, 50 Hz frequency.

During our study, we analyzed with the help of the measurement devices the next parameters: the initial and final mass of the seeds, the humidity and the temperature from the seed bed, the humidity eliminated from the seed bed, the direct and reflected power, the temperature of the cold air stream which is set so that it doesn't exceed 55^0C±5%, the energy consumption.

During our studies we used rewetted corn seeds, in the absence of fresh harvested seeds (Manickavasagan, 2006).

RESULTS AND DISCUSSIONS

Accordingly to McDonnell Aircraft Co. - 1977, Ken Bratney Co. – 1982, microwave installations were made and tested for drying grains in 1970 and 1980. These installations with continuous flow consisted of large stationary units which could dry the dielectric material from harvest moisture content of 25-30% wet basis to safe storage levels 14-18% wet basis.

In our experimental data we chose three drying samples:

1. Using a variable power of 0.1w/g≤0.5W/g≤2.5W/g/ 10 minutes and cold air stream;
2. Using a variable power of 0.1W/g≤0.5W/g≤1W/g/10 minutes without air stream;
3. Using a variable power of 0.02W/g≤0.2W/g ≤0.5W/g/10 minutes without air stream;

The samples were achieved on corn grains, type Kornelius- KWS. In order to see and study the influence that the microwaves have on the seeds treated in a microwave field the corn grains were placed for germination and the rate of germination was measured after 14 days and compared with the rate of a witness sample (Thierer, 1971). Thus, we want to determine which conditions of temperature, power and humidity are favorable to the germination of the corn seeds treated in microwave field.

Before each experiment, the balance was adjusted so the mass of 0.0g (tare) may be displayed with the weighing bowl placed on the platform. The measurements were performed every 30 seconds without interrupting the functioning of the installation.

1. For the first experimental data we had an initial weight of corn seeds of 100 g that were dried in the microwave field, using a variable power of 0.1W/g≤0.5W/g≤2.5W/g for 10 minutes with cold air stream (See Fig.1). After the period of drying we obtained 90.44 g of dried grains. The difference between the initial and final mass of seeds is 9.56g, value that represents the water that evaporated from the seed bed during drying period. The humidity calculated with formula (3) is U= 10.57%. The output air humidity had constant values from 56% to 24.7% and the output air temperature from 24^0C to 38.8 ^{0}C. Because we used cold air stream in seed bed was created an airing which decreased the seed bed temperature, keeping it at normal values.

The germination percentage obtained for this sample is G=75%, the witness sample having G=91%.

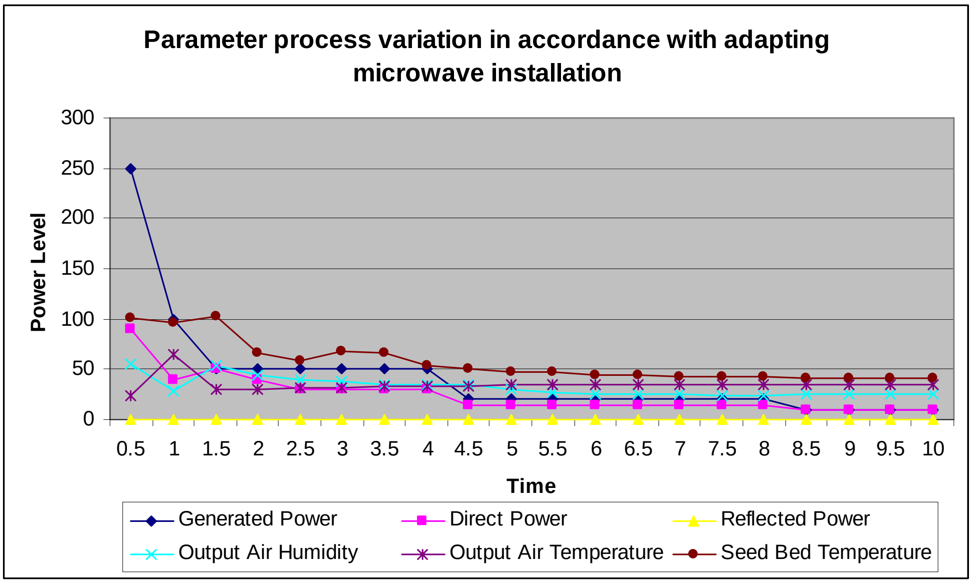

Fig.1 Parameter variation in variable heating
0.1W/g≤0.5W/g≤2.5W/g/10 min., U=10.57%, G=75%
Using microwave power/cold air stream

2. For the second sample we had a variable power of 0.1W/g≤0.5W/g≤1W/g/10 minutes without air stream using 100 g of corn seeds (see Fig.2). The final mass of seeds was 97 g, so we noticed a difference of weight of 3 g. Because we didn't use air stream to eliminate the water from the seed bed the difference of weight has a low value and the humidity eliminated from the seed bed is only: U= 3.09%. We noticed a film of water, after the period of drying finished, this phenomenon is being explained by the fact that the process of "boiling water" appeared in the

seed bed, because we didn't used air stream to eliminate the water from the dielectric material (Molnar et.al., 2008).

Because we didn't use air stream, the variation of the output air humidity had noticeable differences from 36% to 61% and than back to 38% (see minute 9).The output air temperature and seed bed temperature had constant values. The rate of germination for this sample is G=79%.

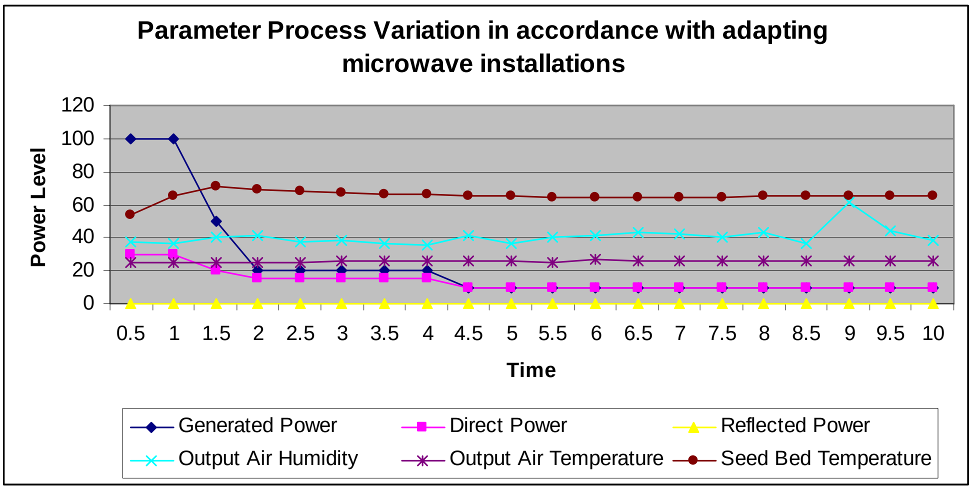

Fig.2 Parameter variation in variable heating
0.1W/g≤0.5W/g≤1W/g/10 minutes., U=3.09%, G=79%
Using microwave power

3. For the last sample we had an initial mass of corn seeds of 100 g that were dried in the microwave field using only the power of the microwaves : 0.02W/g ≤ 0.2W/g ≤ 0.5W/g /10 minutes (See Fig.3). The final mass of dried seeds is 99.8 g. The difference of weight is of only 0.2 g because we didn't use air stream and we had a low power for the processing of the dielectric material. The humidity eliminated from the seed bed is U=0.2%. During the period of testing the output air humidity had constant values of 33.3% to 52% and the output air temperature had values from 23^0C to 26.7^0C. The seed bed temperature presented high values from 67.1^0C to 94^0C. The rate of germination for this sample is G=99%.

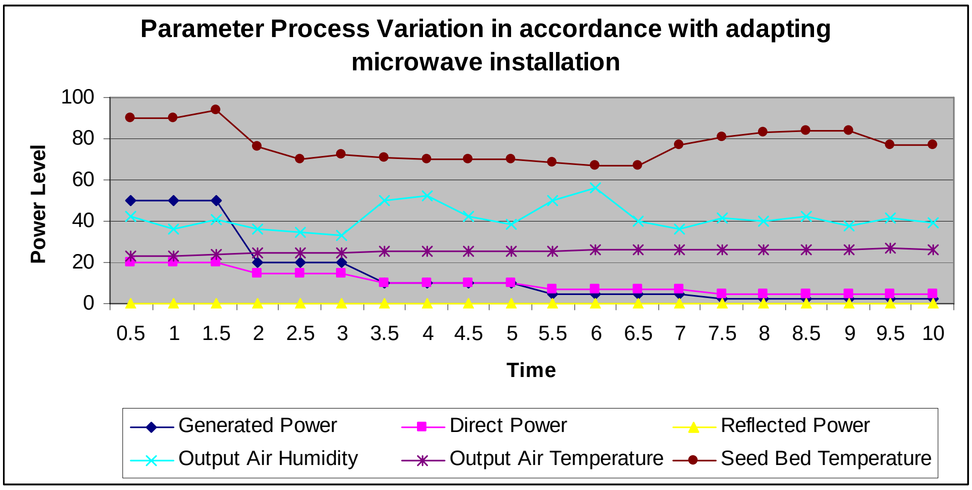

Fig.3 Parameter variation in variable heating
$0.02W/g \leq 0.2W/g \leq 0.5W/g$ /10 minutes., U=0.2%, G=99%
Using microwave power

The germination was determined with germinators of type Linhard, sterilized; one uses filter paper moistened with tap water, kept under niche at $20^0C\pm2\text{-}3^0C$ (Boldor et.al, 1981), (Davidescu, 1981).

We used 160 seeds of each sample, which we distributed evenly in straight, equidistant rows; the germinators were covered with bottle lid, they were labeled and placed in a glass drawer at constant humidity and temperature.

The germination is considered finished when the root has a length equal to the length of the seed, and the stem has ½ this length (Boldor et.al, 1981), (Davidescu , 1981).

CONCLUSIONS

Our aim is to help agriculture producers by determining the optimum drying parameters in the microwave field, taking care so that the structure of the seeds is not affected.

Using air stream is important to eliminate the water from the seed bed and to avoid the hot spots, so there could be a homogenous medium in what concerns the temperature in the whole mass of the seeds.

The highest rate of germination was obtained for the last sample, where G=99%, where we used a low power of the microwaves with no air stream.

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