GERMINATION PERCENTAGE OF CORN GRAINS PROCESSED IN MICROWAVE FIELD

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Abstract:
The purpose of this study is to help agriculture producers by determining the optimum drying parameters in the microwave field, following so that the seeds have the best develop and increase concerning the rate of germination.

Keywords: grain drying, corn seeds, germination rate, electromagnetic waves, dielectric properties

INTRODUCTION

Dielectric materials' drying is a complex technological process that is based on the heat and mass transfer, the purpose being not only the material properties but also their improvement. In most cases, the intensity of the drying process is determined by the movement of the humidity speed from the interior layers of the material to the outer layers (E. da Silva, 2001), (Metaxas and Meredith, 1983).

Microwave heating and drying of grain is a volumetric process which is distinctive from other conventional drying mechanisms. The heat is generated inside the material by the absorption of electromagnetic energy by water molecules, creating an instantaneous moisture transfer out the material where as most of the other drying techniques involve slower conduction heat transfer through and inside the kernel to generate the moisture transfer (Arun S. Mujumdar, 2006).

MATERIAL AND METHODS

The use of the energy of the high frequency electromagnetic field in the heating of the dielectrics offers multiple advantages, such as: the reduction of the energetic consumption, the reduction of the procesing times, the quality of the heating as well as economic advantages regarding the production costs (Eric St. Denis, 1998).

Using air as a heating medium is a very used method for artificially drying grain. A fan is usually used to force heated air through a fixed bed of grain, producing a moisture diffusion process which results in drying (Nelson, 1995). The convection drying is a relatively inefficient process since the air will reach saturation before using all its heat for moisture removal. Using higher air temperatures may increase the drying rate, but also results in kernel damages and moisture gradient through the grain bed. In 1968, Chacellor reported the fact that there was made research on grain drying using conduction heating. He suggested the use of a granular medium, such as sand to reduce localized heating. The potential use of drying media such as sand, salt, steel balls, aluminum has been examined by Lapp and Manchur in 1974, by Raghavan in 1984, Sotocinal in 1997.

Radiation heating exists in different forms among which induction and dielectric heating have been gaining in popularity in recent decades.

Induction heating is the result of the interaction of an electromagnetic field with a conducting material at frequencies below high frequencies. It is governed by principles which rely on current theories and is of less interest here due to the insulating properties of grain materials.

When the energy in the form of high frequency electromagnetic waves is applied to an insulating material, radiation heating also occurs. This is caused by the ability of the electric field to polarize the charges in the material and the inability of this polarization to follow extremely rapid reversals of the electric fields, resulting in the dissipation of power within the insulating material- accordingly to Metaxas and Meredith, 1983.

The “lossy” materials are those which easily absorb microwaves – Shivhare, 1991. At microwave frequencies, the free and bound polar water molecules present in grain kernels are heated when subjected to electromagnetic energy. Variables affecting the absorption of the energy are the frequency and the dielectric properties of the material, which are themselves frequency dependent, Nelson, 1987 (Eric St.Denis, 1998), (Juming Tang, Feng Hao and Ming Lau, 2002).

The dielectric properties of a material also affect the power attenuation of the electromagnetic waves as they penetrate the lossy material (Funebo, 1999). Penetration depth is defined as the distance from the surface of the material at which the power drops to 1/e (36.8%) from its value at the surface and is expressed by:

$$pd = \frac{\lambda_0 \sqrt{\varepsilon'}}{2\pi\varepsilon''} \qquad (1)$$

Where:

pd =penetration depth; λ_0 =free space wavelength;

ε' = dielectric constant; ε'' =dielectric loss factor.

The penetration depth increases with longer wavelength or in other words decreases with increasing frequency. The effect of temperature on the penetration depth of different foods has been studied by Ohlsson et.al., in 1974. They reported higher penetration depths at lower temperatures and frequencies, but this effect was less important at temperatures above 0^0C, than for frozen conditions (Eric St Denis, 1998).

In the case of corn seeds, the irregular changing of the dielectric loss factor with temperature and moisture content makes the prediction of the penetration depth during the drying process a tedious task.

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

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, and the energy consumption.

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

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)*:

$$U\ [\text{Humidity}] = \frac{m_i - m_u}{m_u} \times 100[\%] \qquad (2)$$

The humidity content of the corn grains is a very important characteristic of the seeds. If the seeds have a high level of the humidity the quality of the grains decreases, this is why the drying process of agricultural products is an important issue. The humidity of the grains is being influenced by the area crop, the method and time used for harvesting, the storage and preservation conditions and the surrounding air humidity. When the fresh harvested seeds have a high percentage of humidity, the breathing and sweating process is more intense and there is being relieved a high quantity of carbon dioxide. If the grains are not dried so that the humidity content decreases, the seeds will depreciate through over heating, mouldy and alteration (Thierer, 1971).

RESULTS AND DISCUSSIONS

The effects of the microwaves on the characteristics of drying were studied using constant powers without air stream with values of:

1. 0.1W/g / 10 minutes;
2. 0.2W/g / 10 minutes;
3. 0.3W/g / 10 minutes.

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 sample we had an initial mass of 100 g of wet corn seeds that were dried for 10 minutes in the microwave field, without air stream, using a constant power of 0.1 W/g (see Fig.1). After drying we obtained a final mass of 96 g, being registered a difference of weight of 4 g of evaporated water from the seed bed. The humidity eliminated from the seed bed, calculated with formula (2) is U=4.16 %. The output air humidity and the output air temperature presented constant values. Even though we used a low constant power of 0.1W/g for 10 minutes the seed bed temperature increased till the value 93.5^{0}C. We observed that the seed bed absorbed a high level of microwave power, of 0.3W/g to 0.5W/g, even though we used a generated power of 0.1W/g. This could explain the high temperature measured in the seed bed. The rate of germination for this sample is only G=25 %. The 25% of the seeds were very well developed, but the others were anomalous. On another experimental data, using the same drying parameters, we obtained a very good result of the germination, of G=99%. This big difference of the results could be explained by the fact that for these three samples, we used seeds that were kept longer in water, so that it could be like the natural, fresh harvested grains; the seeds absorbed too much water and during the period of drying, due to the high level of

humidity, of the seed bed, it absorbed much more microwave power, in this way increasing the temperature and destroying the structure of the seeds (Molnar et.al., 2008). The rate of germination of the witness sample is G=91%.

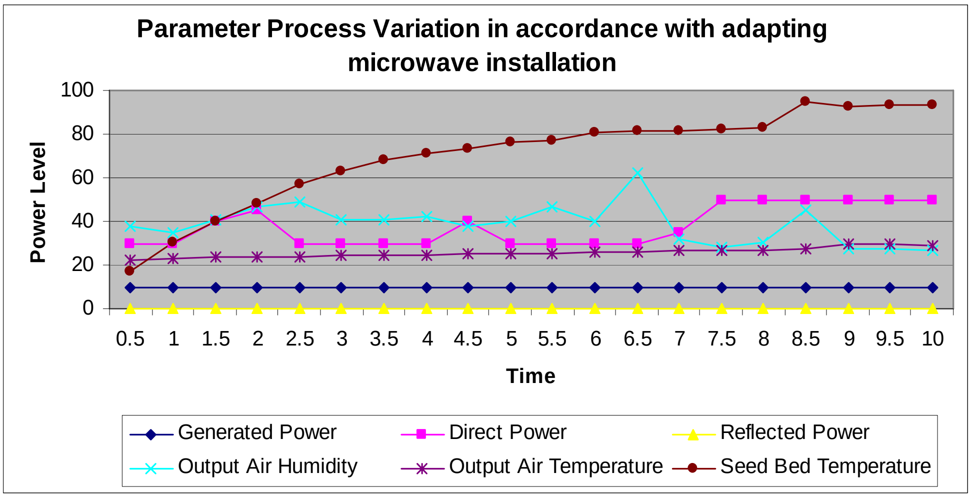

Fig. 1Parameter variation in constant heating
0.1W/g/10min, U=4.16%, G=25%
Using microwave power

2. For the second sample we had an initial mass of 100 g of wet corn seeds that were dried in the microwave field for 10 minutes using a constant power of 0.2W/g (See Fig.2). After drying we obtained 95 g of dried corn seeds. The humidity eliminated from the seed bed is U=5.26%. Like the previous sample we observed the high value of the microwave power that led to the increased of the seed bed temperature of 117^0C. The direct power that was absorbed by the seeds is between 0.4W/g – 0.5W/g. The output air humidity grew from 44% to 77%, and the output air temperature had a constant growth from 25.2^0C to 46^0C. The rate of germination of this sample is G=30%.

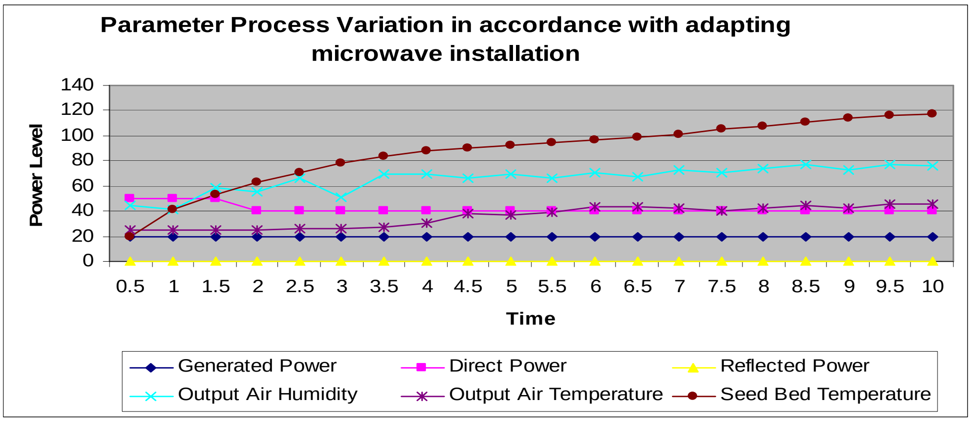

Fig.2 Parameter variation in constant heating
0.2W/g/10min, U=5.26%, G=30%
Using microwave power

3. For the third sample we increased the constant power of the microwaves at 0.3W/g for 10 minutes (see fig.3). After drying 100 g of grains we obtained 93 g of dried seeds. The humidity eliminated from the seed bed is U=7.52%. Because we used a higher power the seed bed temperature increased to 198^{0}C, destroying the structure of the seeds.
The output air humidity and the output air temperature had a constant growth. The rate of germination, taking into consideration the drying parameters, and the high value of the seed bed temperature is of only G=15%.

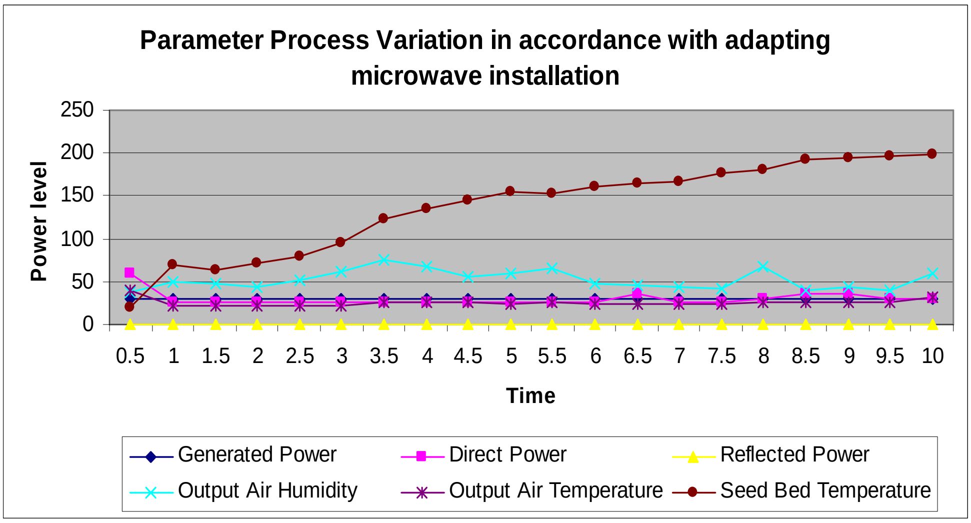

Fig.3 Parameter variation in constant heating
0.3W/g/10min, U=7.52%, G=15%
Using microwave power

As a result of the experimental data one may notice the necessity of the variation of the power generated by the magnetron for the adaptation of the charge impedance by modifying the position of the divers 1, 2 and 3 so that the reflected power would be zero or would tend towards 0. The maximum reflected power for an adapted enclosure must not exceed 20% of the direct power.

The variation of the absorption of the microwave energy by the seeds bed appears due to the variation of the properties of material with temperature and humidity (Manickavasagan, 2006), (Maghiar and Soproni, 2003).

The germination was determined with germinators of type Linhard, sterilized; one uses filter paper moistened with tap water, kept under niche at $20^0C \pm 2\text{-}3^0C$ (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

We could say that a constant temperature and humidity has a good influence on the germination rate of the corn seeds. Because the humidity of the seeds was too high, the grains absorbed a high level of power, which caused the increasing of the seed bed temperature that destroyed the corn beans.

In the future experimental data it is recommended that we use air stream, to have a better uniformity of the temperature in the dielectric material, and to evaporate the water that is being formed on its surface.

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