THE USE OF HIGH FREQUENCY FIELD IN ORDER TO DESTROY PESTS

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Abstract

The use of microwave energy in the process of killing the insects that infest the crops has become an important fact nowadays. The common methods of using insecticides proved to have a harmful effect on the humans and animals. In order to come with a new, innovative method, the scientists have conducted experiments that show the behavior of insects under microwave power.

Key words: insects, microwaves, drying, numerical modeling, infestation, grains.

INTRODUCTION

Vadivambal Rajagopal presented in his thesis called: "Disinfestation of stored grain insects using microwave energy" important data regarding the effect of high frequency field on the grain's insects. During his studies he used a microwave dryer with the work frequency of 2.45 GHz in order to see the mortality of three different type of insects: Tribolium castaneum, Cryptolestes ferrugineus and Sitophilus granarius. The samples were subjected to microwave power levels from 200W to 500W with an exposure time of 28 and 56 seconds. The best results were achieved when using higher power level (Vadivambal, 2009).

Brader and his team work revealed in their studies that in United States of America were reported economic losses due to the insects that affected the crops, losses there were estimated to one billion dollars per year (Brader et al., 2000).

As stated before the quality of grains is being affected by the use of insecticides, due to the contamination with chemical residues. Innovative methods like high frequency field represent a solution for eliminating the pests without affecting the quality of grains (Muir, 2001; Muir, Fields, 2001).

The use of microwaves in order to eliminate the insects that destroy the storage grains was an important area of study for many researchers: Ahmed, 2001; Bedi, Singh, 1992; Campanone, Zaritzky, 2005; Gudrups et al., 2001; Gunasekaran, Yang, 2007; Halverson et al., 2003; Kaasova et al., 2002.

MATERIAL AND METHODS

Microwaves are electromagnetic waves with the frequency ranging from 300×10^6 Hz to 300×10^9 Hz (Suhm et al., 2003). When using microwaves the process of heating takes place due to the polarization of the materials molecules. The relation that expresses the conversion of microwave energy into heat is:

$$P=2\pi E^2 f\varepsilon_0\varepsilon'' V \quad (1)$$

where:

P represents the power [W];

E is the electric field strength [V/m];

f is the frequency [Hz];

ε_0 is the permittivity of free space [F/m];

ε'' is the dielectric loss factor;

V represents the volume of the material [m^3].

In order to dry grains and pests in microwave field there have to be known and studied some important parameters, like electrical and thermal ones. The electrical parameters are given by the dielectric constant ε' and the dielectric loss factor ε'':

$$\underline{\varepsilon}=\varepsilon' - j\varepsilon'' \quad (2)$$

where $\underline{\varepsilon}$ is the complex permittivity and $j=\sqrt{-1}$.

The research made by many scientists revealed the dependency of the dielectric properties on the frequency of the applied field and the material's temperature.

In the case of hygroscopic materials, like for example grains, the dielectric properties depend also on the content of humidity of the dielectric material. The first experiments on finding out the dielectric properties of grains were made by Nelson and his colleagues, the dielectric material being the rice weevils, using a frequency of 40 MHz. Experiments revealed the fact that at temperatures of 55°C the mortality of grains insects, T. Confusum, was 70% and at 65°C the percentage of dead insects was 100% (Vadivambal, 2009). When drying or heating the insects in high frequency field there has to be paid a lot of attention to the highest limit of temperature supported by the grains, so their properties are not affected, destroyed. For some of the grains a temperature of 50-60°C represents the highest value, beyond that the grains quality is being affected and the germination percentage decreases significantly.

RESULTS AND DISCUSSION

In the present study the author followed the absorption of electric field intensity by the grain's insects. The numerical modeling, made with

Ansoft HFSS software, consisted in placing S.Oryzae insects in a microwave oven, having the next dimensions: 300×300×400 [mm]. The insects were placed in the applicator in a Teflon tray (with a rectangular shape, that is transparent to the microwaves), being represented by spheres with the specific dielectric properties of S. Oryzae insects (see Fig. 1).

The boundary conditions were considered to be Perfect E on the walls of the cavity and waveguide, excepting the entrance of the port. The port was defined to be rectangular with the specific waveguide excitation setup.

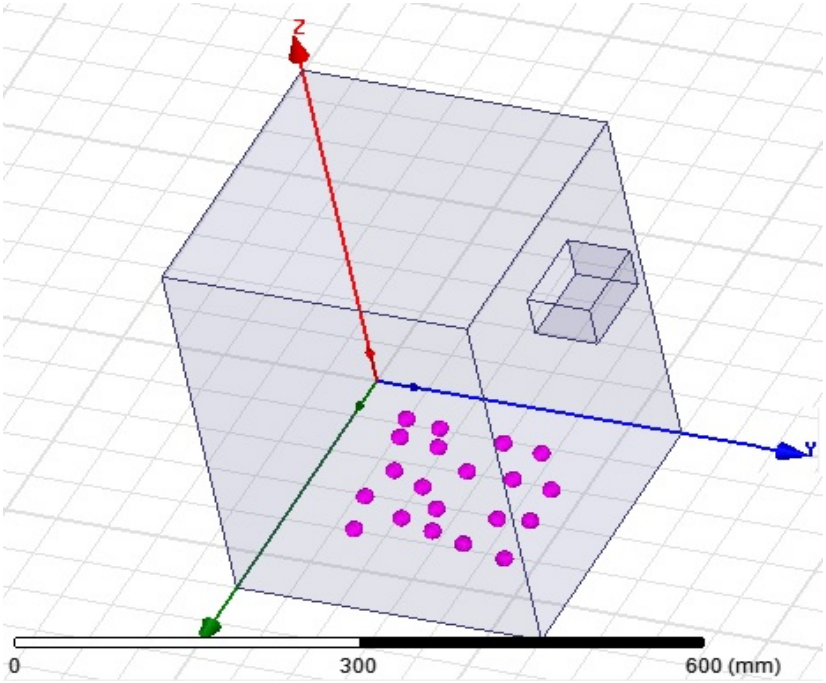

Fig. 1. The position of the insects in the applicator

As it can be seen in Fig. 1 the insects, represented by spheres in the geometry, were placed randomly in the teflon tray. The intensity of the electric field at the entrance of the waveguide can be observed in Fig. 2.

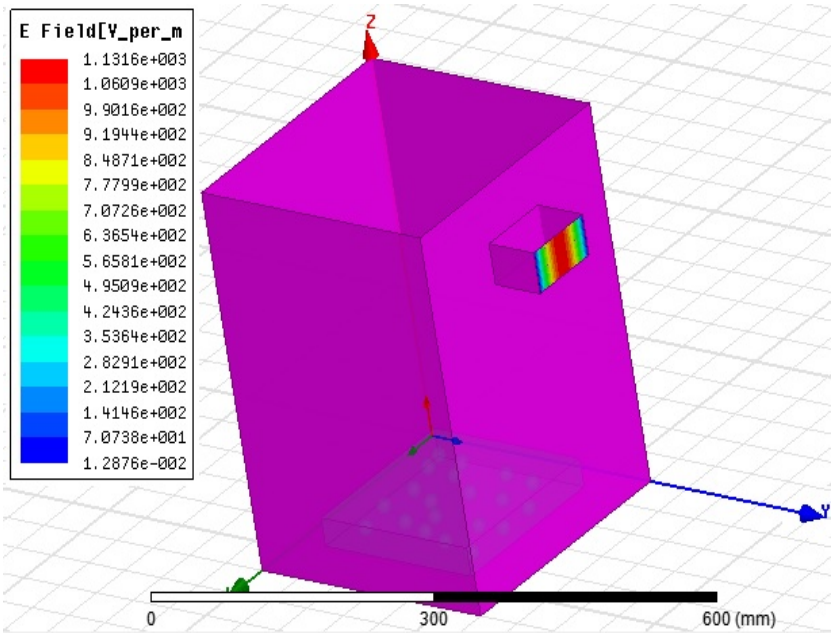

Fig. 2. Electric field intensity in the port

The distribution of the electric field through the pests described by the spheres is being presented in Fig. 3.

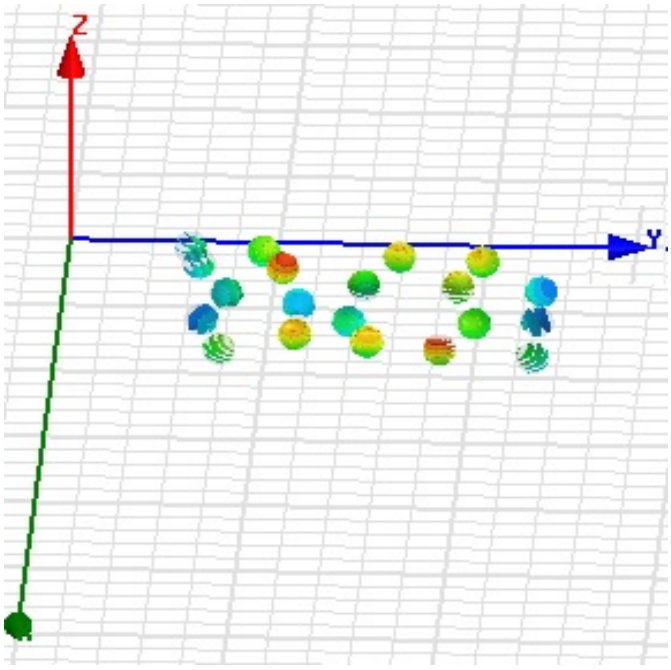

Fig. 3. Electric field distribution through the dielectric material

Using the numerical modelling we can draw planes on Oy, Ox and Oz axes, through which we can represent and study the electrical field distribution. In order to observe the intensity of the field through the dielectric material, waveguide and cavity we drew a plane, as it can be seen in Fig. 4.

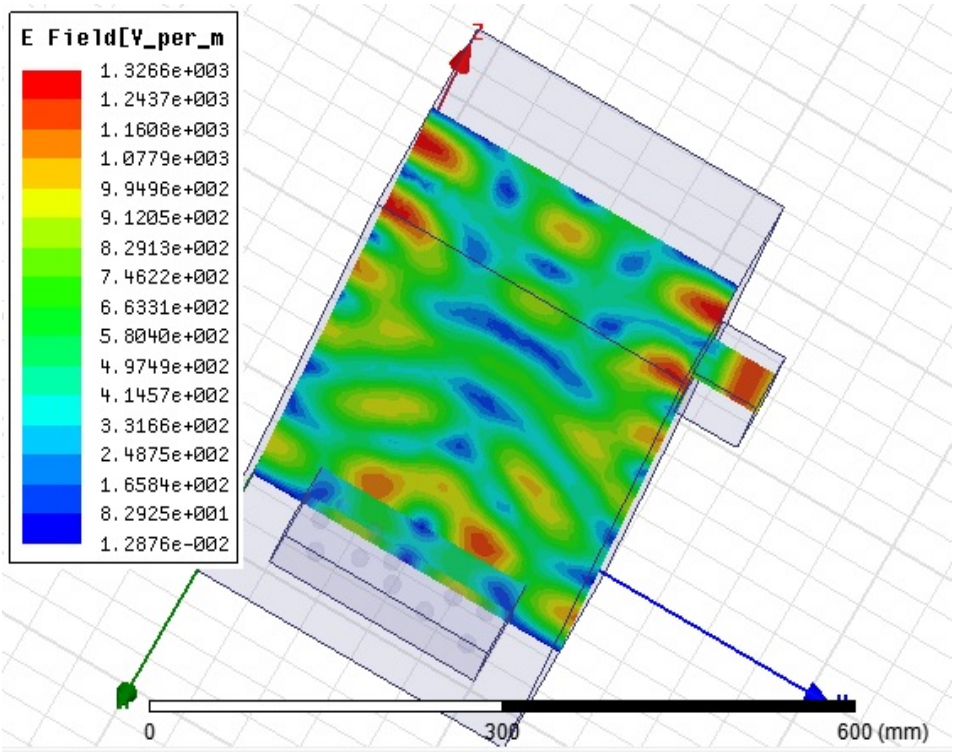

Fig. 4. Electric field through the waveguide, dielectric and cavity

CONCLUSIONS

The use of microwave energy for destroying the pests that damage the crops is an important research domain. Numerical modelling made with specific software brings significant and valuable information on how the insects can be destroyed without damaging the structure of the grains. The study of electrical and thermal properties of the insects represents the key when analyzing the distribution and absorption of electromagnetic field.

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