THE BEHAVIOUR OF APPLE FRUITS DRIED IN MICROWAVE FIELD

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Abstract

The distribution of electric and thermal field is being discussed within the present paper. During the study was considered a microwave cavity in which was placed the dielectric material, apple slices. Considering various positions of the absorbent charge within the cavity and values of the processing time and microwave power, the distribution of thermal and electric field is being studied.

Key words: high frequency field, apple slices, microwave power, distribution field

INTRODUCTION

The process of drying fruits and vegetables has become nowadays a necessity. Through reducing the water percentage within products, fruits and vegetables can be sold and not thrown away due to spoilage. By drying the fruits, the moisture will removed from the interior of the fruit to its surface (Metaxas and Meredith, 1983), (Metaxas, 1981). Conducted research has proved that is important to remove the water quickly from the fruits (Nabiha, 2008).

Nabiha H. has presented in his work conclusions regarding the research made by others in the domain of drying fruits and vegetables (Nabiha, 2008):

- the drying process was significantly improved by using microwave power and hot air;
- drying foodstuffs is a complex process due to the changes in quality of products;
- when drying leaf materials researchers observed that using a high microwave power of 900[W], instead of 360[W], the processing time was reduced by 64% without affecting the quality of product;
- Contreras C. and his colleagues have dried apple slices using two procedures: by vacuum impregnated with an isotonic solution and without vacuum impregnated at 30-50[°C] and by using or not the microwave power of 0.5 W/g. His conclusion upon experiments was that dried fruits were harder when pectin solubilization increases and got softer when dehydrated (Contreras et al., 2005).

- Funebo T. said that the most important balance is between quality products and processing time. He stated that when using the microwave power in combination with air ventilation the drying time of apple slices was reduced to 60%, from 7 h to 4h (Funebo and Ohlsson, 1998).

MATERIAL AND METHOD

A microwave cavity in which were placed 4 slices of apple fruits was used to simulate the distribution of electric and thermal field. In order to complete the simulation Comsol Multiphysics software was used. In order to create the model next steps were done:

- choosing Microwave Heating 3D model and a Frequency Transient study type;
- defining two blocks for the cavity and waveguide;
- defining 4 blocks that symbolize the apple slices;
- assigning material properties proper for each defined domain;
- assigning the proper boundary conditions;
- defining an Extremely Fine mesh for the domain set to be dielectric material and a Normal mesh for the rest of the geometry (Fig.1).

The purpose of the numerical simulation is to observe depending on the dielectric's material position in the cavity the best placement in order to have a good distribution of the electric and thermal field (Sutton, 1993).

To achieve this the slices of apple where placed equally in the cavity and were numbered from 1 to 4 (Fig.2).

The absorbed power by the dielectric material is being defined by the next relation (Nelson and Datta, 2001), (Nelson et al, 1991), (Schiffmann, 2001):

$$P = \frac{1}{2}[(\sigma + \omega\varepsilon'')\boldsymbol{E}^2 + \omega\mu''\boldsymbol{H}^2] \qquad (1)$$

where σ is the electrical conductivity

ε'' is the imaginary part of permittivity

μ'' is the imaginary part of permeability

E is the electric field strength, H is the magnetic field. When processing dielectric materials in microwave field is important to study the electric parameters of the material, described by dielectric constant ε' and dielectric loss factor ε", with the next relation (Bandici L, 2003), (Mujumdar, 2006):

$$\varepsilon_r = \varepsilon' - j\varepsilon'' \qquad (2)$$

where ε_r is the relative permittivity.

The microwave cavity used within the present study has the next dimensions: Width - 42 [cm], Depth - 39 [cm], Height - 21[cm]. The four slices of apple fruit have the same dimension: Width - 8[cm], Depth - 6 [cm], Height -1[cm]. The dielectric properties defined in the numerical model are: for the interior of the cavity and waveguide we defined Air, for the exterior boundaries it was defined Copper and the dielectric material is being described by dielectric properties specific for apple slices at 2.45 [GHz] (Santos et al, 2010).

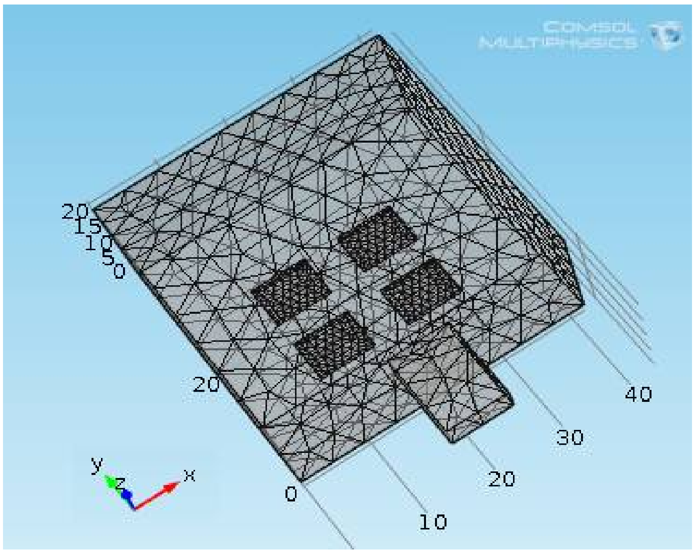

Fig.1 The mesh of the geometry

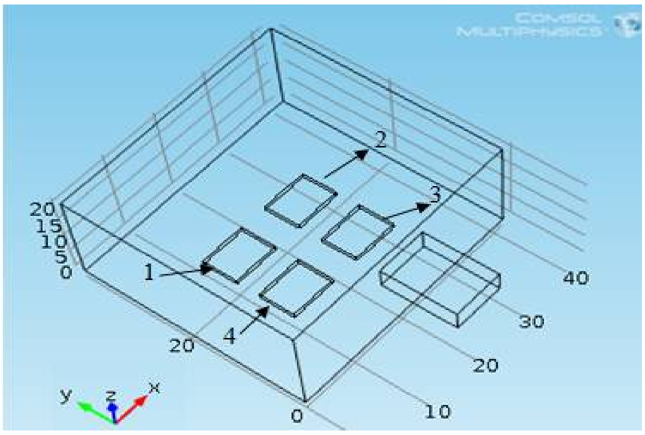

Fig.2 The geometry of the cavity, waveguide and dielectric material

RESULTS AND DISSCUSIONS

In order to complete the numerical simulation the next data was considered:

•the constant value of the microwave power - 200 [W];

•processing time of 300 [s], with the option of calculating data at each 100 [s];

•microwave frequency of 2.45 [GHz].

Using the post processing options, the maximum value of the temperature in the dielectric material and total power dissipation was calculated for each slice of apple. The variation of the temperature calculated in the apple slices according to time[s], measured every 100 [s] for a processing time of 300 [s] is being presented in Fig.3.

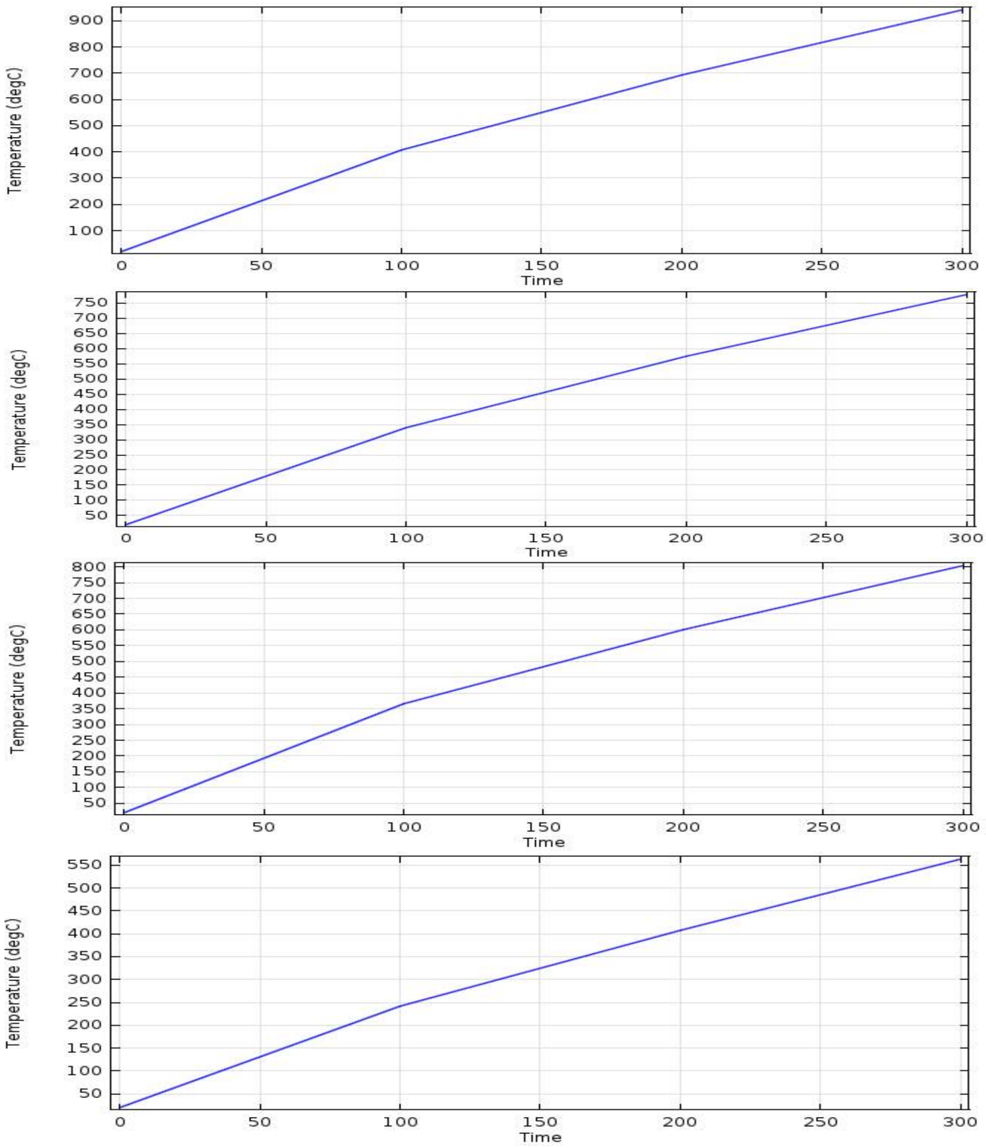

Fig. 3 The temperature variation for the four apple slices

The distribution of the electric field through the entire geometry is being presented in Fig.4

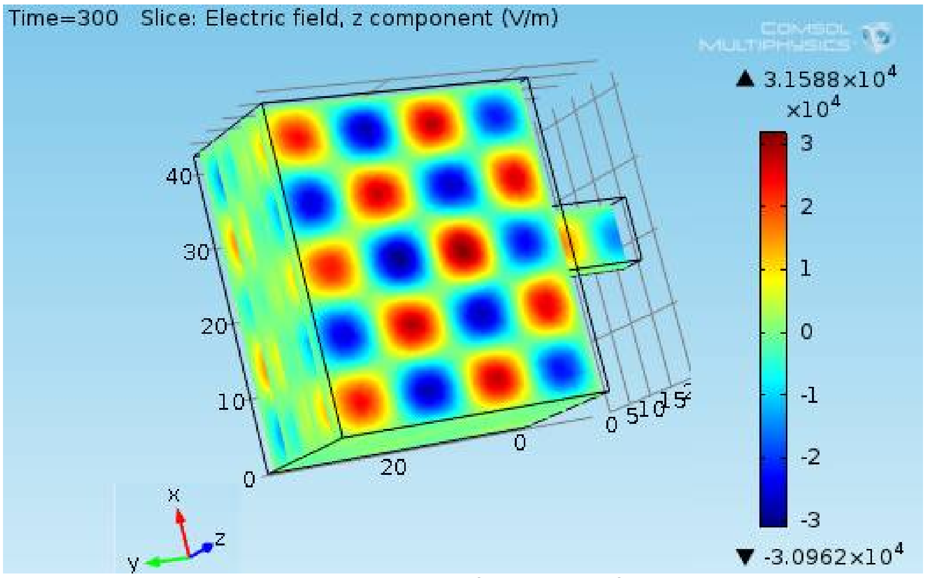

Fig.4 Distribution of the electric field

Fig. 5 presents the distribution of the thermal field through the dielectric material, described by an XY plan using a deformation setting.

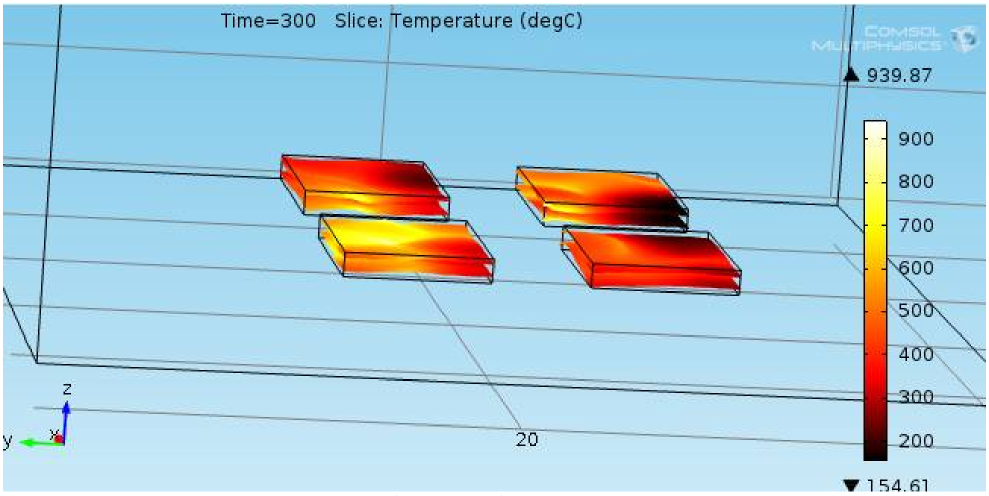

Fig.5 Distribution of thermal field through the apple slices

CONCLUSIONS

Considering the results obtained through numerical simulation the highest value of the temperature calculated in the dielectric material was noticed for the slice numbered with 1 - 941, 25[°C] and the lowest value for number 4 - 563, 03[°C]. The highest value of the total power dissipation was obtained for the slice 1 and the lowest for slice 2. At the end of the simulation was calculated the S parameters, having the value of -0.23918, meaning there is no reflection of power.

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