NUMERICAL MODELLING OF MICROWAVE DRIED WOOD

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Abstract

During the research was developed using the commercial software Ansoft HFSS (High Frequency Structure Simulation) a numerical modeling of a microwave system having as a dielectric material the wood. Using numerical modeling software's there can be simulated the dielectric products to test appropriate microwave treatment control strategies.

Key words: Ansoft HFSS, microwave drying, dielectric properties, numerical modeling

INTRODUCTION

Wood is a complex material composed of cellulose, lignin, hemi cellulose and minor amounts of extractives.

There are different methods of drying wood, and the most common is conventional air-drying. One of the methods that have been investigated in recent years is drying wood by microwave heating (A.L. Antti, 1999, L. Hansson*, A.L. Antti, 2002).

Microwave processing of wood involves many complicated physical phenomena. The process includes absorption of the electromagnetic energy, transport of the generated heat, shape and dimension changes of the wood, phase changes in water, water transport through the wood material, etc.

In order to optimize and control this process, the understanding of the various phenomena involved is needed. (Georgiana Daian, et al 2006).

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 (Metaxas and Driscoll, 1974), (Metaxas and Meredith, 1983).

MATERIAL AND METHOD

Dielectric properties wood depend on many factors, including frequency of the microwaves, temperature, moisture content (Juming Tang, 2012).

The dielectric properties of materials are being described by the complex relative permittivity, ε^*, which is represented with the next relationship:

$$\varepsilon^* = \varepsilon^{'} - j\varepsilon^{''} \quad (1)$$

where $j = \sqrt{-1}$;

$\varepsilon^{'}$ represents the dielectric constant and is the ability of the material to store electric energy when in an electromagnetic field;

$\varepsilon^{''}$ represents the imaginary part, it is the dielectric loss factor and influences the conversion of electromagnetic energy into thermal energy.

The ratio of the real and imaginary parts of permittivity represents the tangent of loss angle tan $\delta = \varepsilon^{'}/\ \varepsilon^{''}$ which along with the dielectric constant determines the attenuation of microwave power in wood.

In the electromagnetic field, the amount of thermal energy converted in wood is proportional to the value of the loss factor $\varepsilon^{''}$. The increase in temperature (ΔT), without consideration of heat transfer, can be calculated from:

$$pC_p \frac{\Delta T}{\Delta t} = 5.563 \times 10^{-11} fE^2 \varepsilon^{''} \quad (5.563*10^{-11} = 2\pi\varepsilon_0) \quad (2)$$

where

$C_p (Jkg^{-1\,0}C^{-1})$ is the specific heat of heated material;

ρ(kg m^{-3}) is the density;

E(Vm^{-1}) is electric field intensity

f(Hz) is frequency

Δt(s) is time increment

ΔT(^{0}C) is the temperature rise (Schubert and Regier, 2005).

RESULTS AND DISSCUSIONS

In the process of developing technologies based on microwave energy, an important step is creating experimental models, lab, that could permit a real analyze of the phenomenon's in any moment and conditions of the heating process with microwaves and also determining the specific parameters of the problem.

The existence of special software's permit that before practically making an installation, it can be numerical simulated. In this way when creating the installation there will be known a part of the phenomenon's that characterize the installation, and so there will be eliminated some of the unknown's of the problem.

The existing resonant cavity was numerically simulated using the commercial software Ansoft HFSS, and the obtained results are being presented below.

The monomod aplicator has a parallelipiped shape, made of aluminium walls and is being excited by a magnetron at a frequency of 2.45GHz.

Electromagnetic waves transmission from the magnetron to the cavity is being made through a rectangular waveguide, in which prolongation is placed the applicator.

The commercial software Ansoft HFSS is a interactive software that allows electromagnetic field determination inside passive structures at high frequencies. ANSYS is the leading provider of electromagnetic field, circuit and system simulation software for the design of high-performance electronic equipment and electromechanical devices.

For analyzing the electromagnetic field inside the microwave installation, was introduced into a wood sample.

Accordingly to the specialty literature the values for the relative permittivity and loss factor for wet wood are $\varepsilon' = 7$ and $tg\delta = 0{,}2$.(Bandici Livia 2003)

Below are being presented the obtained results after simulating the heating process of the wet wood in the microwave field.

For a clearer outline of HFSS software settings made in Figure 1 shows the boundary conditions and the position of the port.

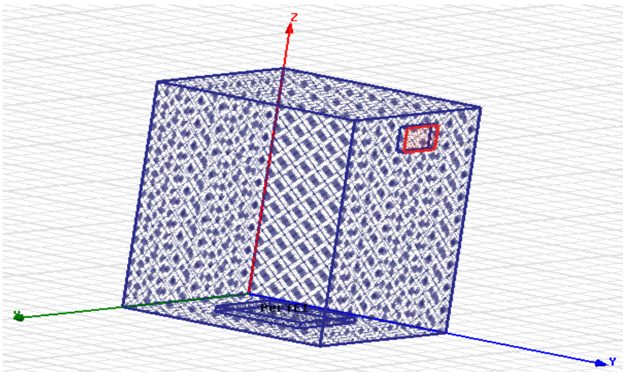

Fig.1 Settings related to the boundary conditions

Figure 2 shows the electric field distribution on the faces of the cavity and the dielectric.

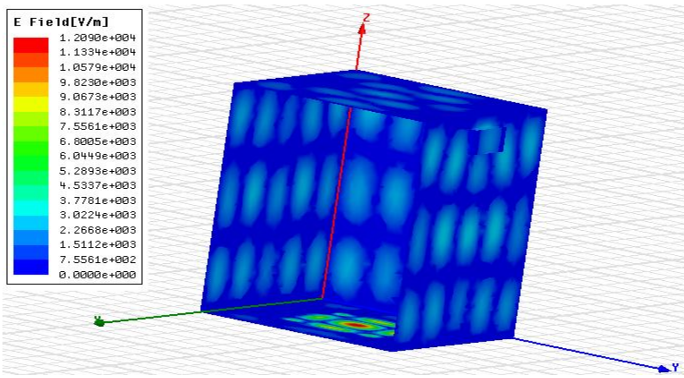

Fig.2 Electric field distribution on cavity faces

Maximum and minimum points of the electrical current on the bottom of the cavity are shown in Figure 3.

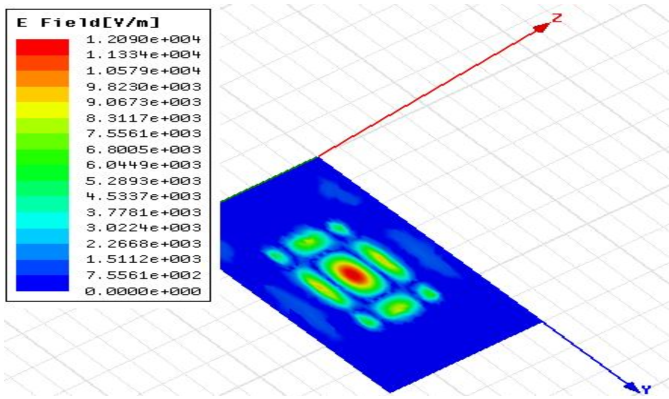

Fig. 3 Electric field distribution on the bottom of the cavity

In the next figure it shows the distribution of the magnetic field on the faces of the cavity and the dielectric.

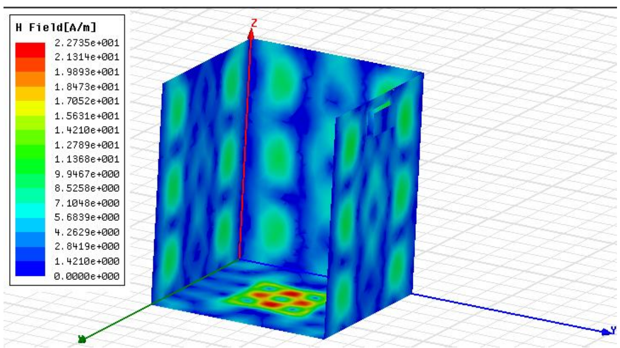

Fig.4 Magnetic Field Distribution in the cavity faces

Figure 5 shows the maximum and minimum magnetic field.

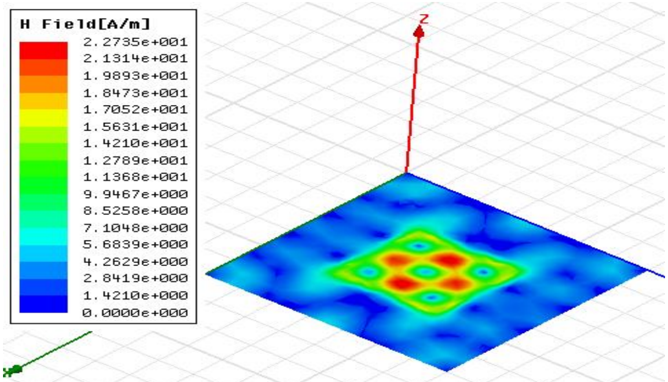

Fig. 5 Magnetic field distribution on the bottom of the cavity

CONCLUSIONS

In the timber with a moisture content there is a final orientation structure dielectric properties depend strongly on the orientation of the electric field. Influence the orientation of the electric field on dielectric properties is especially important in the process of drying of materials in sheet form, for which the humidity must remove all material section.

Determination of loss factor depending on the moisture content is what makes optimal choice of frequency-working and orientation of the electric field, providing information on critical moisture impose certain restrictions on the design of microwave systems.

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