ASPECTS REGARDING THE BEHAVIOUR OF WOODY MATERIAL OF LIME ESSENCE IN MICROWAVE FIELD WITH MONOMODE APPLICATOR

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Abstract
This paper presents the variation of lime essence wood humidity depending to the microwave generator power and also the importance of using the high frequencies techniques combined with the conventional technologies of electrical installations that are used for mixed drying microwave – air stream.

Key words: wood, dielectric properties, microwave generator, monomode applicator, impedance adapter

INTRODUCTION

Microwave field processing of dielectric materials has become an important and developed technology used in a large area of applications. Due to the complex interaction phenomenons of the microwave field within the materials, the success of these applications requires knowledgements on material properties and also on the way that processing equipments are being designed.

The knowledgement of dielectric properties of materials and their development during microwave field processing is essential in all industrial applications, for better design of the applicator in which is going to be treated the dielectric material. It is being focused on the behavior study of non homogenous dielectrics and a mixture of these kinds of dielectrics.

The development of measurement techniques created new ways of investigation that allow obtaining with a bigger precision of the data concerning the dielectric properties of materials.

Thermal processing of dielectric materials exists because of the polarization of high frequency electrical field loaded from the material and also due to Joule effect determined by the free loads conduction under electrical field action.

MATERIAL AND METHOD

Heat generated within dielectric materials during microwave treatment is used to obtain desired changes in the product (Simpson, 2001). Microwaves have been used in wood research for various applications such as drying and disinfestations. The conduction and the dipolar rotation are the two representative parts of the oscillating electric field energy (Bandici and Molnar, 2007). These two mechanisms make inter and intra molecular friction that generate heat throughout the volume of the material.

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The conventional dryers with hot air stream are technically well designed, being often used in industry. For the improvement of the classical drying process, which has its limitations, there is the possibility of optimizing the drying by using a mixed process which combines the drying with microwaves/hot air when the drying conditions are monitored and adapted (Molnar et.al., 2008).

The hot air injected in a high frequency dryer usually insures the transfer of the vapors from within the enclosure to the exterior. By recirculation the evacuated vapors which insure the heating of the air pumped into the drying enclosure, a large part of the latent heat of the vapors can be transferred to the air flux which enters the applicator, determining a substantial increase of the efficiency of the used drying chamber (Nelson, 1995).

The most important factors that affect the dielectric properties of materials are the moisture content, the bulk density, the temperature and the frequency.

Measurement of dielectric properties involves measurements of the complex relative permittivity (ε_r) and complex relative permeability (μ_r) of the materials. The permittivity of a dielectric is important to study in microwave drying processes because of its relation with process variables, described in the previous paragraph. A complex dielectric permittivity consists of a real part and an imaginary part. The real part of the complex permittivity, also known as dielectric constant is a measure of the amount of energy from an external electrical field stored in the material.

During our research we used the stand within the laboratory of microwave Technologies, EMUEE department, faculty of Electrical Engineering and Information Technology, University of Oradea

This installation is composed of the following:

Microwave generator with maximum power of 850 W, waveguide, monomode applicator, absorbent charge, hot air source with regulation of the temperature, electrical inter-blockage, impedance adapter with 3 divers, directional coupler.

The stand is supplied at the tension of 220V±5%, 50 Hz frequency. The microwave generator has adjustable power and an included potentiometer for adjusting the power of the microwaves. The monomode applicator has parallelepiped form with interior sizes of 109.22*54.6*150mm.

The monomode applicator is designed so that the air stream may enter from downwards upwards in the dielectric's material bed in order to eliminate the water on the surface of the wood, to avoid the hot spots from the bed and so to insure the homogeneity of the temperature in the entire mass of the dielectric (Hathazi and Maghiar, 2003).

The absorbent adapted charge situated at the end of the installation eliminates the energy of the residual high frequency electromagnetic field. In case the dielectric material does not absorb efficiently the energy of the microwaves, a sizable quantity of energy may be reflected towards the microwave generator (Metaxas and Meredith, 1983). The excessive quantities of reflected energy may deteriorate the microwave generator. The circulator protects the equipments of the system with microwaves by determining the movement of the microwaves in a single direction. There are three ports in the circulator: one is connected to the microwave generator, the other is connected to the applicator and the last to the artificial charge.

With the help of the measurement devices we monitored the parameters of the process: the power of the microwaves, the direct power, the humidity of the air stream at exit, the position of the divers at the adaptation of the charge impedance, the temperature of the air stream which is set so that it doesn't exceed 55^0C±5%, the temperature from the microwave bed and in the close proximity of the system. The temperature of the wood was taken with a special device - Material Moisture Wood Building Materials- Type Testo 616.

RESULTS AND DISSCUSIONS

For determining the percentage of humidity of the dried wood sample we use the mass of the wood before drying, m_i, and after drying m_u (Maghiar and Soproni, 2003):

$$U\ [\text{Humidity}] = \frac{m_i - m_u}{m_u} \times 100[\%] \qquad (1)$$

Our study was made using two types of wood, oak and lime, natural moisturized.

For the first sample we chose two pieces of lime, of different sizes. The samples were dried in the microwave field for 10 minutes, using a variable power of the microwaves with cold air stream. During the experiment we followed the reflected power to not reach more than 20% of the direct power and so the temperature of the wood to be kept at normal values. The data obtained for this experiment is being presented in table 1. The first piece of wood was named Sample 1 and the second piece was called Sample 2. We noticed a big difference between the initial and final value of the humidity in the case of sample 2 from 21.4% to 5.7%. We may say that this result is very good, the size of the sample made it easier for the microwaves to penetrate the dielectric, and the cold air stream helped on evaporating the water from the wood.

Table1

Drying Parameters	***Sample 1***	***Sample 2***
Variable Power	200W-100W-20W/10 minutes	
Initial Weight	35.3 g	8.6g
Final Weight	31.06 g	7.53g
Initial Humidity	41%	21.4%
Final Humidity	30.5%	5.7%
Humidity calculated with formula (1)	13.65%	14.20%
Initial Output Air Temperature	22^0C	
Final Output Air Temperature	25.1^0C	
Initial Output Air Humidity	60%	
Final Output Air Humidity	41.9%	

In figure 1 is being presented the variation of the drying parameters and figure 2 shows the divers variation on reflected power.

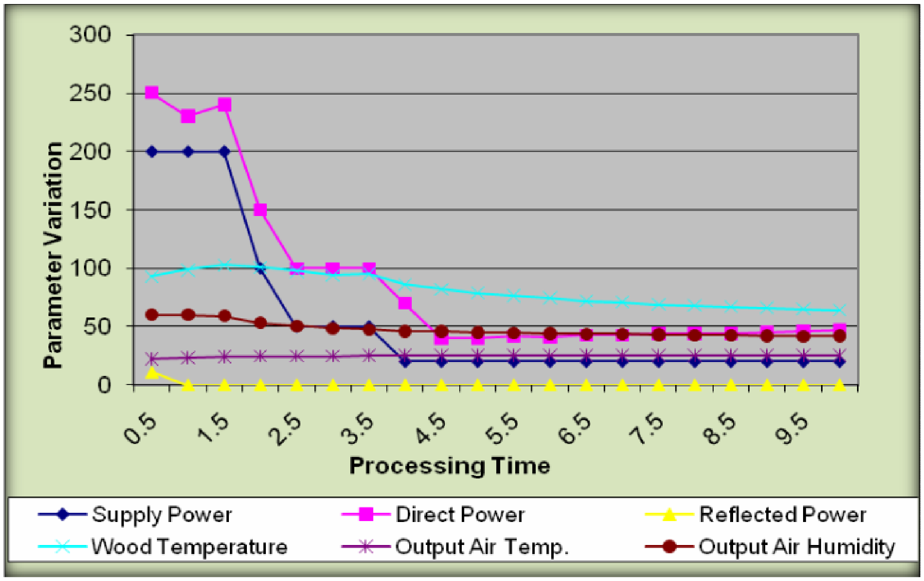

Fig. 1 Parameter Variation in Variable Heating using cold air stream

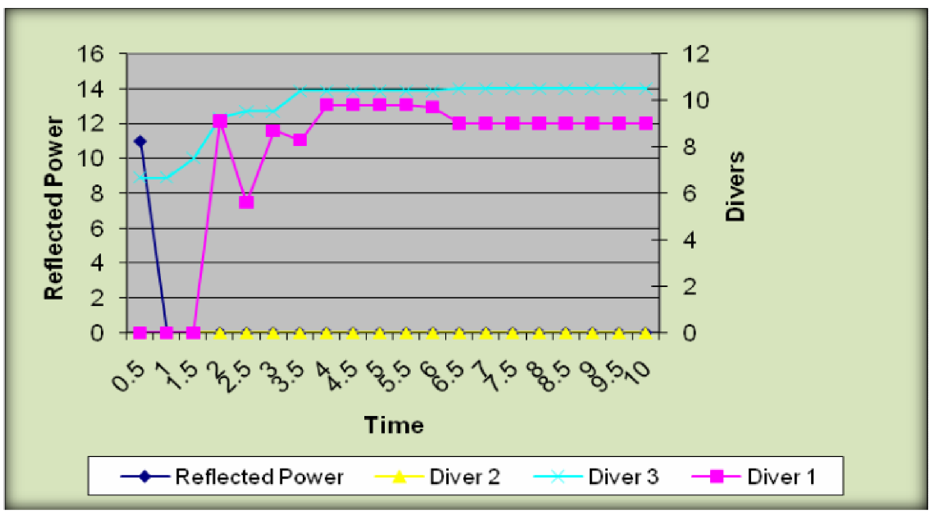

Fig. 2 Divers Variation depending to Reflected Power

We continued our study using the same parameters: variable power of the microwaves with cold air stream to dry two pieces of oak. At the end of the experiment we noticed the same observations like in the previous case, the sample with little sizes had a bigger evaporation of the water. The data obtained is being presented in table 2. The variation of the drying parameters is shown in figure 3 and figure 4 presents variation of the divers according to the reflected power.

Table 2

Drying Parameters	*Sample 1*	*Sample 2*
Variable Power	200W-50W-40W/9 minutes	
Initial Weight	32.2 g	14.46g
Final Weight	28.13 g	12.58g
Initial Humidity	49.9%	47.1%
Final Humidity	38.7%	18%
Humidity calculated with formula (1)	14.46%	14.94%
Initial Output Air Temperature	25.5^0C	
Final Output Air Temperature	28.38^0C	
Initial Output Air Humidity	47.74%	
Final Output Air Humidity	38.84%	

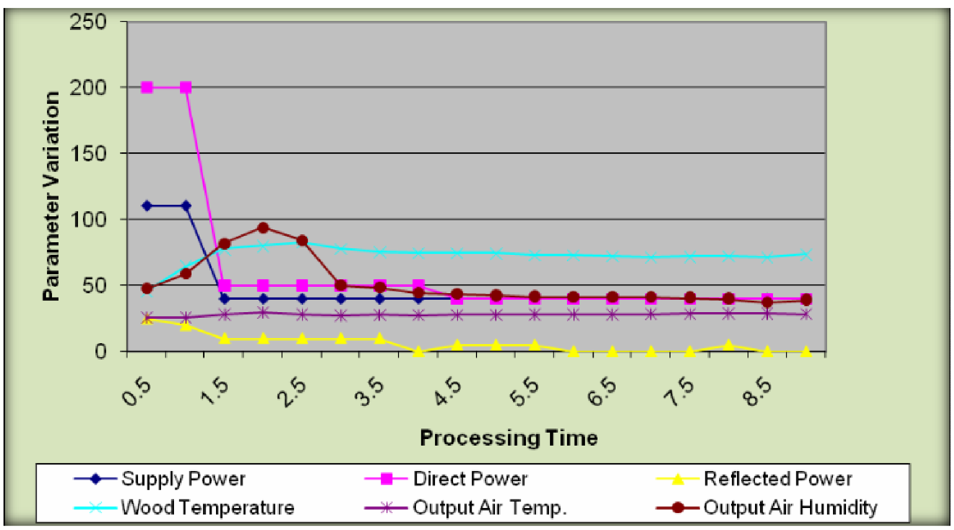

Fig. 3 Parameter Variation in Variable Heating using cold air stream

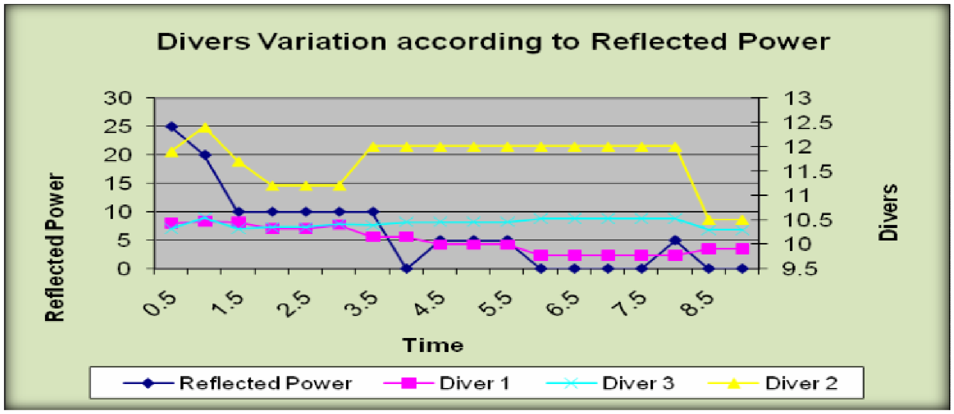

Fig. 4 Divers Variation according to Reflected Power

CONCLUSIONS

The new technology with microwaves that is being proposed in this experiment opens new research areas in creating new composite materials, used in high class domains of the economy, for which the conventional forms of energy are proved to be hard to use. The problems that appear during practical realization of the microwave applicators are being related with choosing the shape and sizes of the cavity, so that the heat is being made uniform, rapid, and efficient and it doesn't destroy the quality of the dielectric material heated or dried. For these reasons, sometimes, in the cavity are being introduced auxiliary devices capable to perturb the field, and when it is possible, the body that is being exposed to heat to move. At resonance the system's behavior is pure resistive in terms of the supply source: there takes place an exactly compensation of the electrical energy with the magnetic one in the interior of the system, and the intake of active power provided by the source is compensate by the active power consumption in the dissipative elements of the system. At frequencies different of the resonance frequency, over the resistive behavior is being add the reactive behavior determined by the imbalance between medium electrical energy and the medium magnetic energy from the system, in the oscillating process maintained by the source. In the process of promotion the electro-technologies based on microwave energy, an important step represents the creation of some experimental models, lab, that would permit a real analyze of the phenomenon in any moment and any circumstances of the heating process in the microwave field and once with this, the determination of some specific parameters of the problem.

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