MEASURING THE DIELECTRIC PROPERTIES OF AUSTRALIAN WOOD SPECIES

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Through its potential industrial applications, such as: drying, stress relief, structural modification for impregnation, bending and surface treatments to enhance coating, microwave processing could offer a powerful material-processing tool to wood industry. In order to scale up a microwave process, one has to perform the development of the exploratory process to production scale which basically depends on microwave material interaction understanding. The main effect of microwave-material interaction is the conversion of microwave energy into heat within the material, due to the absorption of the electromagnetic energy through the dielectric properties of the material.

Due to the wood thermal conductivity and permeability, under industrial conditions, temperatures within wood range from 100 - 170ºC giving rise to internal wood pressure of up to 7 atm. Variety of methods for measuring the relative complex permittivity has been described in the specialized literature but in order to obtain the dielectric properties of wood which are relevant to microwave heating, one has to perform the measurements at elevated temperatures and pressures. Measurements of the dielectric properties under these conditions are essential for understanding commercial microwave processing of wood. Such research has not been undertaken before and requires the design of new equipment.

Since accurate dielectric properties are crucial for modeling microwave material interactions, the aim of this paper is to present a device and a measuring procedure suitable for measuring the dielectric properties of wood under high temperatures and pressures, and explain the required numerical solver which automatically extracts the final result from the measured quantities.

Firstly, in this paper, the experimental set-up and a special designed high-pressure cavity used in dielectric properties measurements as waveguide sample holder is described. A microwave cavity, made from stainless steel waveguide with build-in pressure applicator and Pyrex pressure windows transparent to microwave radiation and resistant to the above-mentioned temperature and pressure conditions, was special designed and produced. Secondly, a measuring procedure of the dielectric permittivity of wood at microwave frequencies suitable for high temperatures and high pressure is presented. The method is based on measuring the impedance change caused by the presence of the wood within a rectangular waveguide. To extract the value of the dielectric permittivity out from this measurement, one has to solve a transcendental equation in the complex plane. As in many other cases, there is no analytical solution and a numerical procedure should be applied. Since the number of solutions is infinite, one has to make sure that the "right" physical solution is one of the numerical solutions obtained, and to know how to select the correct solution. Also, the paper contains the principle of the experimental method and the software developed to extract the permittivity from the measured impedance. Finally, several measurements performed on different Australian wood species and the results obtained for the permittivity in the different directions and for different temperatures and related pressures are given.

To sum up, this work describes a technique and the appropriate method for measuring the permittivity of relatively large pieces of wood, suitable for experiments at elevated pressure and temperature. The method is used for mapping the permittivity of different Australian wood species as a function of moisture content, electric field direction, temperature and pressure. The results of several performed measurements show a strong directionality of the dielectric permittivity and the expected sensitivity to addition of a small amount of water.