TA006
MW AND RF APPLICATIONS
CASE HISTORIES

NEW MICROWAVE TECHNOLOGY AND EQUIPMENT FOR WOOD MODIFICATION

*G. Torgovnikov, P. Vinden
Cooperative Research Centre for Wood Innovations, University of Melbourne,
Creswick, Victoria 3363, Australia

ABSTRACT

The low permeability of many wood species, particularly hardwoods, causes problems during timber manufacturing. The shortcomings include: very long drying times, large material losses after drying, expensive drying processes. Extreme difficulties take place in impregnating timber with preservatives and resins. Also growth stresses in wood and collapse lead to drying defects and high losses in recovery of sawn timber. Therefore it is essential for the timber industry to have a technology that can provide an increase in wood permeability, reduce internal stresses, and minimize down-grade due to drying defects.

The main structural elements or cell types in wood include tracheids, libriform fibers, vessels and ray cells. Ray cells, which occupy 5 to 35% of the total wood volume, have thinner walls than the cell walls of the main tissues of wood (fibers) and run in a radial direction from the pith to the bark of the tree stem. Ray cells are the weakest cells in wood, and under high internal pressure can be ruptured preferentially, forming pathways for easy transportation of liquids and vapors. The net result is a substantial improvement in radial wood permeability.

Green or freshly sawn wood has moisture contents ranging from 35 to 250%. Therefore green wood readily absorbs microwave (MW) energy. Intensive MW power applied to the wood generates steam pressure within the wood cells. Under high internal pressure the weak ray cells are ruptured to form pathways for easy transportation of liquids and vapors in the radial direction.

An increase in the intensity of the MW energy applied to the wood increases the internal pressure, resulting in the formation of narrow voids in the radial-longitudinal planes. The number of cavities, their dimensions and distribution are controlled by the intensity of MW energy supplied. A several thousand-fold increase in wood permeability in the radial and longitudinal directions can be achieved in species previously found to be impermeable to liquids and gases. Other physical properties and technological attributes are also improved. These include:

Physical properties: improved permeability, reduced density, reduced heat conductivity (better heat insulation), reduced shrinkage and swelling, and improved acoustic properties (better sound insulation).

Technological properties: improved impregnation and liquid uptake, improved sawing, improved drying, and internal stress reduction.

Microwave wood modification as a pre-conditioning process enhances existing processes and facilitates the development of entirely new processes and product options for wood. It establishes opportunities for developing a number of new industrial applications including rapid treatment of impermeable wood species with preservatives, rapid drying of hardwoods, growth and drying stress relief in timber, and new wood-based materials for example “Vintorg”.

The practical application of MW to wood requires high intensity power, applied in short duration to provide the required degree of the modification. Industrial facilities require high MW power because of the need to deal with large volumes of timber (as a rule thousands and tens of thousands of cubic meters per year). Raw material whether round or sawn timber can have large cross sections and a wide range of sizes. In some cases it is necessary to modify the full cross section of timber. In other cases only some zones in the cross section (surface layers or core) will need modification. These requirements demand the development of special MW plant and applicators.

Special MW installations have been designed using frequencies of 0.922 and 2.45 GHz for different industrial applications: timber preservative treatment, fast lumber drying, stress relief in logs, and the new material "Vintorg". For sawn timber and small round wood the waveguide systems are being used at a frequency of 0.922 and 2.45 GHz. For round timber up to 220 mm in diameter, a round chamber with different irradiators at frequency 0.922 GHz has been utilized .

Two industrial prototype MW facilities have been developed. The first pilot plant (frequency 0.922 GHz) has 60 kW MW power. The second facility (frequency 2.45 GHz, MW power 60 kW) is used for sawn timber processing.

A 300 kW MW plant with an output of 10,000 m3/year has been designed and can be used for processing logs up to 400 mm in diameter.

Research results indicate that the technology can be applied to any wood species. The cost of MW conditioning varies from AU$ 30 – 70/m^3 depending on the wood species, its moisture content and the degree of structural modification required. These costs are acceptable to industry and provide new opportunities for the commercialization of these technologies.