Structure Based, Two-dimensional Anisotropic, Transient Heat Conduction Model for Wood

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(Abstract)

The importance of precise values for the parameters used in heat and mass transfer models has been demonstrated by many research studies. Thermal conductivity values used in previous models are usually empirical and fluctuate. Theoretical analysis and estimations of wood thermal conductivities in the radial and tangential directions were conducted with the geometric models built up from the macro- and micro-structure observations. Theoretically, thermal conductivity in the radial direction is about 1.5 to 2.5 times of the tangential direction for softwood species with moisture content (MC) below Fiber Saturation Point (FSP). When MC is over the FSP, tangential radial thermal conductivity both increase dramatically and are linear function of MC. The two thermal conductivity values are close with a ratio of near one estimated by the model for MC above the FPS. In hardwood species, radial thermal conductivity estimated by the model is 1.5 times of the tangential thermal conductivity. Validation tests for model estimations of thermal conductivities in the radial and tangential directions for three wood species showed the reliability of the geometric models developed in this project. Correlations between the wood thermal conductivity and structure parameters, such as latewood percentage and cell wall percentage, were examined. Linear relationships for the thermal conductivity and average temperature in wood were established in both radial and tangential directions of three wood species.

A two-dimensional transient heat conduction model was developed utilizing thermal conductivity values derived from geometric models. The anisotropic material property affect on heat transport in radial and tangential directions was discussed using an assumed situation. The simulation run showed slightly faster heat flow in the radial direction than in the tangential direction due to higher thermal conductivity in the radial direction. Validation tests on practical wood blocks showed the 2D model with the use of theoretical thermal conductivity values can predict good temperature distribution in wood during the heating process. However, in the

practical wood samples with curved rings on the cross section, no significant difference was found in the two transverse directions.

Mathematica software was introduced in this study for the intense and complicated math calculations and model programming. *Mathematica* was found to be a powerful technique for solving sophisticated math problems. It had abundant and flexible plotting options for providing optimized presentations for the results. These advantages make *Mathematica* popular for engineering modeling research.