WIRELESS MICROWAVE BASED MOISTURE SENSORS FOR HARDWOOD DRYING KILNS

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ABSTRACT

This goal of this project was to develop a prototype microwave based moisture sensor system to be used in a hardwood dry kiln. The individual moisture sensors are battery powered and will communicate with the host kiln control system via spread spectrum wireless communications. To the present we have developed 2 separate designs of launcher/receiver systems working at 4.5 GHz to 6 GHz that give a linear response to moisture content (MC) over a range of 90% MC to 6% MC. These sensors allow us to make a swept frequency transmission measurement through a small area of a board.

We have developed electronic circuit boards that provide the microwave excitation and read and store the microwave signal returned through the wood. We are currently testing the "second generation" prototype electronics to go into the kiln mated with these launchers to produce a prototype MC measurement system design to be tested in kilns. We are able to obtain the same MC accuracy with our small circuit boards as we did with the laboratory network analyzer. We are proceeding to a 3rd generation micro-circuit design that will provide gains in reliability and lower the eventual commercialization cost.

BACKGROUND

Hardwood lumber drying is a process that consumes a large proportion of the energy required to produce hardwoods. During the drying process, hardwood lumber is at risk through out the entire drying process to either complete loss or partial degradation (degrade). Potential kiln drying defects include mold, collapse, end checking, surface checking, honeycomb and other internal checking, warp, chemical and biological stains, and internal stress development.

Current hardwood lumber drying technology relies on the manual determination of the moisture content (MC) of a small number of "kiln samples" cut from the load of lumber being dried. The small number of samples generally used does not adequately reflect the range of variation of MC within the kiln load during the drying process. The result of not having adequate MC sensors working in real time for drying control is that drying schedules are generally developed to dry very conservatively (slowly), expending large amounts of excess energy to the atmosphere through "venting losses". Essentially in the drying process excessive energy consumption (and reduced drying speed) is traded for a lower risk of degrade.

Most hardwood lumber kilns are now equipped with a PLC based or computer based control system that operates in real time. But there are currently no wood moisture sensors for these control systems that provide adequate moisture content determination over the needed range of 60% MC down to 6% MC. Existing resistance moisture sensors for a dry kiln are accurate only over the range of 25% MC to 6% MC. Current load cell (weight based) moisture content sensors work over a wider range of MC, but generally must be located outside the lumber stack in the plenum area and read short "kiln samples" rather that taking readings from the actual lumber being dried. Current capacitance based kiln moisture sensors are used mainly to determine the "shut down" point in high temperature softwood kilns but have never been shown to determine MC adequately for their use in hardwood drying. As a

consequence of this lack of sensors, many of the computer based control systems still rely partially or totally on the manual determination of the weights of the kiln samples.

The prototype sensors developed in this project have shown a linear response range over a range of 90% MC to 6% MC for two different species of wood. The prototype sensors are sized so that they will slip onto boards at the edge of a pack of lumber. Though the prototype sensors tested and reported on in this paper require wired connections for power supply and data output, the final form of the sensor will include battery power and wireless data transmission. The final form of the wireless sensors will allow the operator to be able to place the sensors at different locations and levels with a kiln load. The sensors will provide accurate measurement of the real time MC at different locations within the kiln load from the initial turn on to the final equalization. Using an adequate number of these sensors we estimate that the kiln operator should be able to reduce drying time and energy consumption up to 30% over present drying practices for most species and thickness of lumber.