In-Line Moisture Measurement for Precision Radio Frequency Heating

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Introduction

This paper presents a new technique for in-line moisture measurement during radio-frequency (“RF”) heating.

RF heating of timber is well known but at times has had problems.

Some of the problems have been caused by poor process control.

One key parameter for process control during RF heating is moisture content.

Low-powered RF signals can measure moisture, so what about high-powered signals?
Dielectric Permittivity is the material constant that governs how RF energy passes through and is absorbed by timber.

It is composed of two quantities:

**Dielectric Constant:** How the energy is stored and released

**Loss Factor:** How the energy is converted into heat

Both parameters are important for RF heating and can be used for moisture measurement.

Keam Holdem has compiled a data-base of measurements of the dielectric permittivity over a range of timber properties.
**Dielectric Permittivity of Timber**

### Dielectric Constant (perpendicular) vs Moisture

- **Linear with moisture content**

### Loss Factor (perpendicular) vs Moisture

- **Transition at the fibre saturation point**
RF Heating Properties

The RF Heating Equation:

\[ \text{Power} = 2\pi f \varepsilon' \tan \delta |E|^2 \text{ (watts)} \]

The RF power dissipated in the timber is proportional to:

1. \( |E|^2 \), the square of the RF electric field strength,
2. \( f \), the frequency of the RF signal,
3. \( \varepsilon' \), the dielectric constant (ie. moisture content)
4. \( \tan \delta \), the loss factor (which has a transition at the FSP)

KHA / Mattersmiths RF Pilot Kiln

FI Clinics 2006
Potential for Moisture Measurement

The timber inside the kiln represents an electrical impedance at the terminals of the kiln.

The impedance is a strong function of the dielectric constant and loss factor of the timber (and hence moisture).

An external tuning network is used to transform the timber impedance to an impedance suitable for the RF generator.

In principle the external tuning network can also be used to measure moisture content.

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RF Heating / Moisture Experiment

Two timber packets (A and B) were treated with RF energy at 40.68 MHz and 4 kW.

Packet A differed from Packet B in volume and initial moisture content.

Impedance was recorded during treatment.
RF impedance measurement offers a way to measure moisture during heating.

Impedance can be correlated to a process characteristic such as moisture.

Keam Holdem is commercialising this technology and will keep the industry posted as progress is made.

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