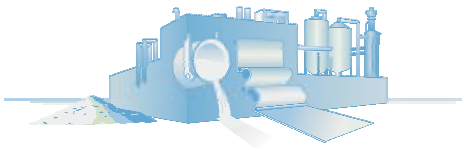
Wood Chip Moisture Content

An Exploration of NMR-Based On-line Instrumentation for the Pulp and Paper Industry

The NMR signal from hydrogen atoms is used to quantitatively determine the molecules present in cellulose. Using a magnetic field to initially excite the hydrogen atoms and then pulsing the wood with radio frequency (RF), researchers can measure the radiated RF as the hydrogen nuclei, restore to their unexcited position. Researchers then obtain a direct and accurate assessment of hydrogen in water versus cellulose and other constituents. Each composition constituent has a different time constant for the hydrogen atom to return to its original rest state. The hydrogen in water typically has a short time constant, while the hydrogen in cellulose, lignin or other hydrocarbons have longer time constants. The overall strength of the decay RF signal is proportional to the total mass of the pulp or paper present within the measurement region. The strength of the water peak with respect to the peaks of other constituents is proportional to the amount of moisture present in the pulp or paper. It is possible to uniquely measure the various constituents in chips, pulp or paper while in-process, and possibly characterize the feedstock between soft and hardwood by resolving the signal response of each constituent.



Benefits for Our Industry and Our Nation

An on-line wood chip moisture monitor accurate to 1%. This would be deployed at chip conveyors prior to the digestor or chip silo.

Applications in Our Nation's Industry

The project aims to develop a commercially viable on-line, non-invasive, real-time sensor based on the nuclear magnetic resonance (NMR)/magnetic resonance imaging (MRI) technique, concentrating on wood chip moisture sensor development.

Project Description

Goal: To explore NMR-based on-line instrumentation for the pulp and paper industry.

Researchers conducted preliminary experiments to establish the feasibility of the measurement concept. They used a homebuilt narrow-bore spectrometer operating at 300.511 MHz proton frequency and optimized for studies of polymeric liquids and a commercial probe designed for proton studies with 5 mm sample tubes. Samples were prepared by cutting slivers of fir, pine, or alder chips; commercial software (MacNMR) was used for pulse programming and data acquisition.

Following proof of principle work, a benchscale prototype was utilized. The project yielded data including information regarding pulse lengths, pulse sequences, and the percent of moisture content.

Results

Proof of principle work:

- Provided a firm base of understanding of moisture content determination via proton FIDs of wood samples. Each step was transferrable to a benchscale system in which identical measurements were made on a larger sample volume at a lower frequency of operation.

Benchtop NMR system for the measurement of moisture content of wood chips:

- Constructed the benchscale system around a .47 T Samarium cobalt permanent magnet.
- Conducted nutation experiments using both tap water and wood chip samples; resulting FIDs were used to obtain amplitude of the dry wood and water components.
- Determined the moisture content of the wood chips for comparison to the NMR result using gravimetric data.
- Major considerations in wood chip drying are the geometry of the sample container, the drying time, and the drying temperature.
- The chip dimension dependence of drying time depends on the moisture content regime of the sample.
- For chip sample with a %MC twice the FSP and a characteristic dimension of 1 mm, in the absence of mass transfer barriers in the sample bed, the drying time was 1 to 2.5 hours for 55% MC pine and 38% MC fir samples, with slightly shorter times for 33% MC alder samples.
- Drying times at 105 ± 3°C were kept between 1.5 and 2.5 hours to prevent "overdrying."

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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