Improvement of Pulping Uniformity by Measurement of Single Fiber Kappa Numbers

New Instrumentation Will Analyze Individual Fibers for Kappa Number at High Speed

Ideally, a commercial pulp mill would consistently produce uniform pulp with low kappa numbers that respond easily to bleaching without compromising pulp strength. However, tests show that pulp uniformity and kappa number distribution varies greatly under normal operating conditions. Non-uniform pulp is weaker than uniform pulp and is more difficult to process using chlorine-free bleaching sequences.

A major impediment to producing uniform pulp is the lack of good tools for rapidly and accurately measuring kappa numbers of individual fibers. The kappa number, a measure of the pulp fiber’s lignin content and chemical requirement for bleaching, is presently measured on composite pulp samples containing thousands of fibers. A device that could measure single-fiber kappa numbers at a rate of hundreds per minute would allow a large number of fibers to be examined to generate a precise pulp uniformity measurement. Pulp mill operators can use this information to determine which of the alternative pulping technologies and operating strategies produces the most uniform, low-kappa pulp given their chip furnish. Up to 50 percent of the lignin that must be removed in bleaching comes from high-kappa fibers, and as more bleaching is required, the strength of the pulp decreases. This new technology permits development of pulping scenarios that help to eliminate high-kappa fibers, reducing bleaching load and facilitate the implementation of chlorine-free bleaching sequences which require a more uniform, low-lignin pulp.

Benefits for Our Industry and Our Nation

- Elimination of high-kappa fibers
- Production of an improved, more uniform pulp
- Determination of which digester types produce the most uniform pulp for a given feedstock
- Less required bleaching
- Reduction in undesirable environmental effluent of the bleaching process
- Improved mill efficiency

Applications in Our Nation’s Industry

The prototype instrument will be tested and evaluated on commercial pulp samples provided by industry partners. Improvements will be made to the instrument on the basis of the evaluation results, and the improved device will be demonstrated on-line in mill trials.
Project Description

**Goal:** To develop a single-fiber kappa measurement device based on flow cytometry technology.

Investigators developed a flow cell that causes pulp fibers to orient and present singly as they flow rapidly past a measurement station. A fluorescent stain, Acridine Orange, has been identified that specifically stains the lignin in the fibers and emits a strong, easy to measure signal that can be translated into a kappa number. The data generated was used to produce a histogram of the distribution of kappa numbers in the sample. Among the specific research tasks anticipated was determining optimal staining conditions for Acridine Orange and determining the entire fluorescence spectra of stained fibers in order to correlate kappa numbers with wavelengths. Both softwood and hardwood fibers were included in the studies, and other types of fibers such as oxygen-delignified wood were also examined. Additional stains were also studied for their lignin specificity.

Results

- Developed a method which uses the lignin induced red-shift fluorescence of the stain Acridine Orange to measure the kappa number of single wood fibers. The ratio of red to green fluorescence correlates well with kappa number for a given pulp type.
- Developed an instrument that uses this method to measure pulp uniformity.
- Confirmed the accuracy of the instrument by comparison pulp of uniformities measurements with the flow-through instrument with those made with a static fluorescence microscope. Also compared the kappa distributions measured with those made by a density gradient column with excellent results.
- Made pulp uniformity measurements on many laboratory and commercial pulps, which lead to a deeper understanding of the nature of pulp uniformity and the relationships between pulping conditions and pulp uniformity.
- Continue to provide service to mills and research laboratories that want to measure pulp uniformity.
- The technology developed is being used to make other single fiber measurements such as single fiber surface charger.

Project Partners

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