A PPI SPECIAL REPORT

Alternative applications for FT-NIR technology are emerging, including possible opportunities in the biofuel area

FT-NIR TECHNOLOGY CONTINUES TO EVOLVE

For more than three decades, pulp mills have moved from manual titration-based methodologies to cutting edge Fourier Transform-Near Infrared (FT-NIR) technology for process automation and control. The increased sophistication of online liquor analyzers has enabled leading pulp mills to progressively measure liquor properties throughout all areas of the mill. As the technology evolved, mills are experiencing improved reliability, more efficient business processes and significant cost savings.

EARLY ADVANCEMENTS IN ONLINE LIQUOR ANALYZERS

Initially, mills utilized manual lab titration methods for liquor measurement and analysis. Not only was manual titration prone to errors, but it was also time consuming. Mills were looking for a solution to allow for more frequent testing throughout the day to enable continuous control of the liquor.

Responding to that need, MoDo-Chemetics began installing online liquor analyzers as a part of a digester control package within North America in the late 1970s. At the heart of the control system was an automated black liquor titrator. Over the next 20 years, this early online technology was installed throughout North America, but users were experiencing issues with the auto-titrators including scaling, hazards associated with the required acid solution, and measurement drift.

In the early 1990s, FPInnovations (formerly the Pulp and Paper Research Institute of Canada or PAPRICAN) and MoDo-Chemetics began the development of a mid-infrared (MIR) analyzer that used vibrational spectroscopy to replace the online titrator. The objective was to develop a more robust technology that could measure more liquor properties and that would not require the use of chemical reagents. Even though their initial objectives were achieved, there were many challenges related to the maintenance of the sampling apparatus: frequent cleaning was required, less than precise reassembly offset the results, and the models needed to be tweaked each time the apparatus was cleaned. Furthermore, changes in the refractive index of the samples affected measurement consistency. These problems led to the exploration of other techniques and by 2000 the FT-NIR analyzer was developed for commercial application.

Originally developed by FPInnovations, and now distributed by Fitnir Analyzers, FT-NIR technology uses infrared light to penetrate the liquor sample and the resulting pattern of light absorbance is identified by spectroscopic analysis. It was found that the FT-

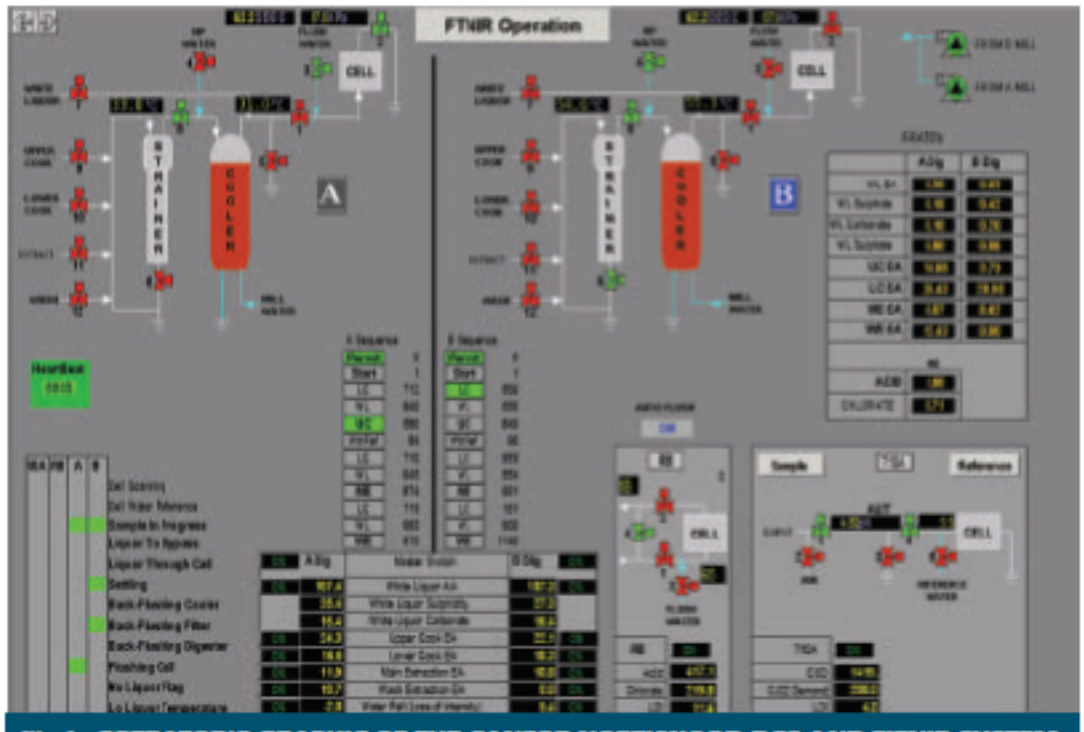

Fig. 1 - **OPERATOR'S GRAPHIC OF THE CANFOR NORTHWOOD DCS AND FITNIR SYSTEM**

NIR technology has many advantages over the MIR technology:

- Fiber-optic connection between the spectrometer and the sampling cell enabled remote analysis
- Transmission measurement using a sample flow through cell that eliminated offset results
- Potential plugging was eliminated while the sensitivity of the measurements was enhanced
- Several cells could be multiplexed into a single spectrometer.

FT-NIR COMMERCIAL APPLICATIONS

The early adopters of FT-NIR were integral in taking the technology to the next level; the experience gained and lessons learned have been invaluable to its evolution. In 1996, the first commercial installation of the online version of the analyzer received sample streams from two continuous digesters at a northern Ontario, Canada, pulp mill. The mill benefited from the FT-NIR technology when used in combination with the newly designed proprietary fiber-optic flow cell. A large path length was incorporated to enable further accuracy of sample measurements. This implementation quickly led to the development of other chemical property models and, subsequently, additional applications of the technology within the mill environment including complete recausticizing liquor chemistry, ClO_2 generator acid and chlorate strength, and dissolving tank raw and clarified green liquors.

By 2000 the first commercial ClO_2 generator application was installed at a Prince George, BC, mill. By this time, new software had been developed incorporating all of the necessary functions to sample, analyze and report the results to various programmable logic controller (PLC) and distributed control systems. New models to measure the acid and chlorate properties had been developed and the computer and spectrometer rack could be separated from the sampling system as it was now possible to transfer data via fiber optic cable.

During the same year, a pulp mill in Texas installed the first analyzer to measure liquor streams from the recausticizing area. The measurements of this application set out to improve green liquor quality, control overliming and reduce deadload. One final application was also developed for the smelt dissolving tank of the recovery boiler. Implementations in the recovery system have demonstrated significant cost savings resulting from the efficiencies gained.

INNOVATIVE SOLUTIONS TO EARLY CHALLENGES

Even though these early implementations were receiving benefits above and beyond the methodologies previously being utilized, there were challenges associated with the first generation FT-NIR system. What was learned from the installed base was incorporated into the next development of the technology.

The most advanced version of the system corrects sampling cell design issues originally encountered, as well as introduced a number of key improvements:

- Improved window construction using sapphire eliminated cell window damage caused by hydraulic shock
- Sapphire window was fused to the metal to eliminate leaks
- The fibre optic connection no longer requires optimization when the windows are cleaned or replaced
- Trouble-free maintenance and sampling, and calibration only upon implementation.

The original custom software also tended to be

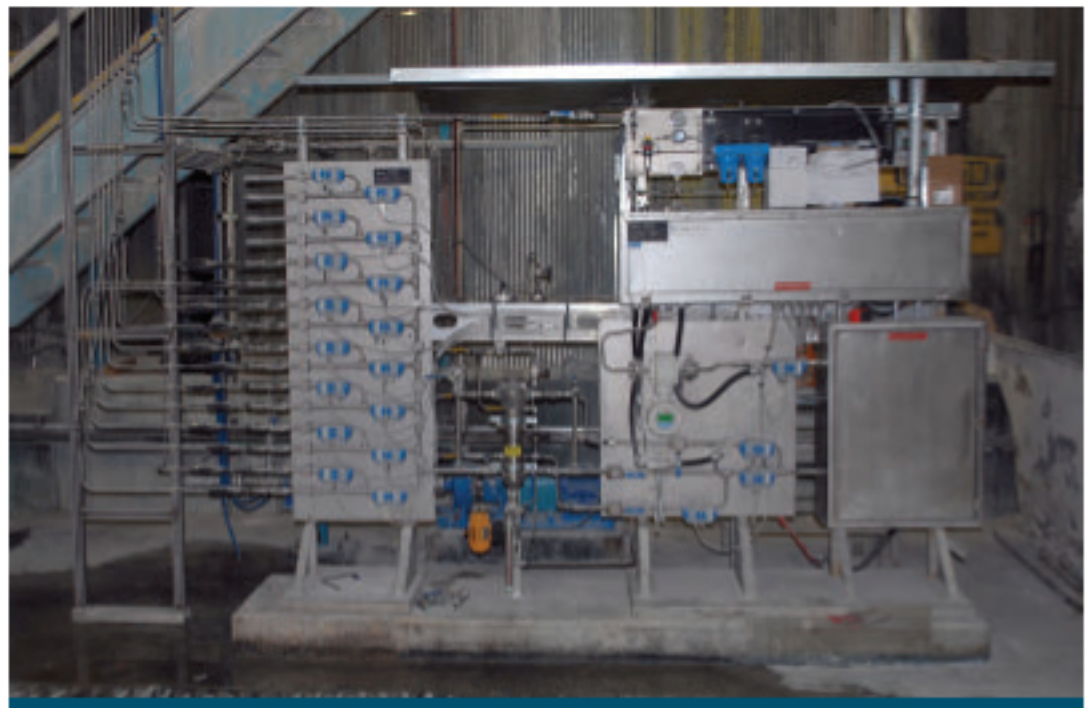

Fig. 2 - **RECAUSTICIZING SAMPLING STATION**

inflexible and challenging for users to modify configurations, troubleshoot and obtain access to spectral data for analysis. The upgraded software program for the Fitnir analyzer is now much more reliable and maintainable:

- A user-friendly graphical user interface (GUI) simplifies troubleshooting in the rare event that a problem does arise
- ABB's robust proprietary software adapted to control the Fitnir analyzer ensures reliability and continued support
- The system can operate in multiple formats and standard protocols are used to communicate with the DCS
- Programmable diagnostic features allow alarm con figuration and ad-hoc optimization of parameters.

Furthermore, vital to the success of the FT-NIR technology are the advanced property models. The result of many years of experience and development, these models facilitate the precision and accuracy of analysis as well as the ability to compare and interpret measurements. Each time a system is installed, the mill's unique liquor properties are used to optimize the property model for each component. Once the analyzer has been calibrated, no further calibration is necessary for periods sometimes exceeding 10 years.

MODERN FT-NIR IMPLEMENTATIONS

Implementation of a new FT-NIR system is relatively straightforward, with a simple configuration consisting of a computer/spectrometer rack situated in a stable environment and a sampling station located in the field. Sample stations bring the liquor streams to the sample cell for analysis.

Each sampling skid can accept liquor from multiple sources, depending on which area of the

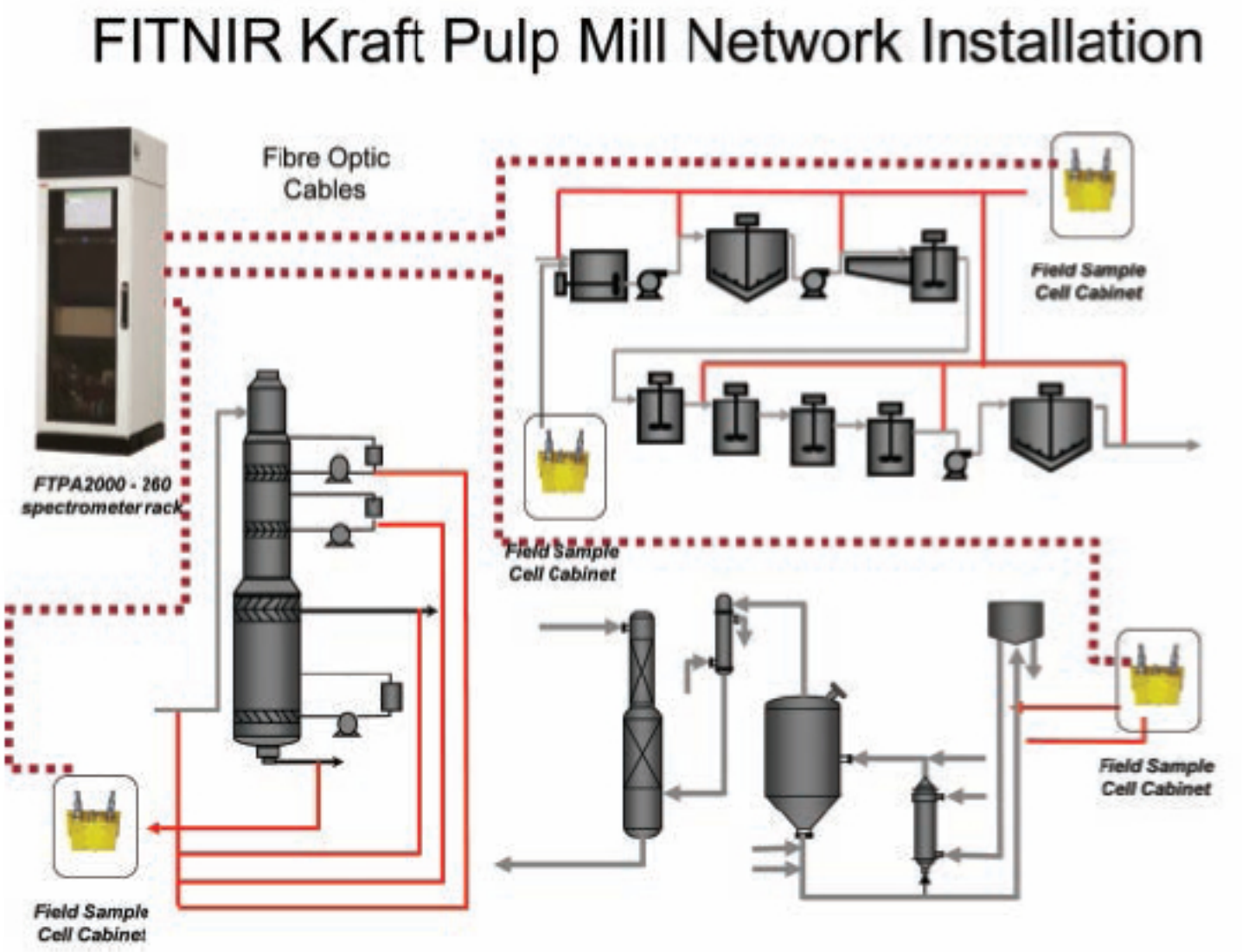

Fig. 3 - **SCHEMATIC OF A FT-NIR CONFIGURATION WITH MULTIPLE SAMPLE CELLS FOR THREE APPLICATIONS**

pulp mill is being analyzed. Fibre optics linking the cell sends the signal to the spectrometer. The spectral data is translated by the software on the Fitnir terminal. Mills measure a number of key components (e.g., active alkali, effective alkali, sulfidity, sodium carbonate, sodium sulfide, sodium chlorate and acid strength) which are then communicated to the mill's DCS controls accordingly for process optimization.

FT-NIR technology as process analyzers for the pulp industry has matured significantly since its inception. The main advancements have led to improved sampling, reliability and accuracy.

Fitnir analyzers have had a real effect on pulp mills using the technology. To mills such as Canfor Pulp Limited Partnership's Northwood mill in Prince George, BC, which recently undertook an upgrade, the results are meaningful:

- Nearly 100% uptime of the FITNIR analyzer: A chief source of savings is from the improved uptime of the FITNIR analyzer, consequently increasing uptime for more white liquor controls to the digester.
- Continuous control: Highly precise and accurate results and an increase in test frequency made it possible to achieve continuous control of the liquor and associated properties such as sulfidity and chlorate and acid concentrations. The uptime of the R8 generator supervisory controls has also improved, further reducing chlorate and acid concentration variability.
- Increased production: The accurate and frequent measurements have led to more efficient processes and operating conditions. For example, reduced alkali to wood charges has helped to off-load the recovery boiler.
- More consistent product quality: Improved reliability of black liquor measurements has reduced the kappa number variability, leading to more consistent product quality.
- Cost reductions: Eliminated chemical reagents needed for sample testing and lower soda carryover have reduced chemical costs. Improved kappa number variability has also lowered off-grade and bleach costs.

CONCLUSIONS

FT-NIR technology has been implemented in more than 25 mills. The knowledge gained from the early adopters has been integral in the development of the Fitnir analyzer of today; one that practically solves the operational challenges faced by pulp mills through reliable and rapid measurement of chemical compositions. The current economic environment has made it essential for these businesses, as well as the pulp industry as a whole, to embrace new innovations that offer both process optimization and a strong ROI.

As the technology continues to evolve, alternative applications emerge. For example, with more emphasis being put on opportunities in the biorefinery business, the need to understand black liquor as a valuable source of "green energy" will become increasingly important in advancing it as a biofuel. The role that FT-NIR technology can play in this area has proven potential to help the pulp industry open up to new possibilities. **PPI**

For more information visit www.fitnir.com or contact Tom Sands at tom.sands@fitnir.com.

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