Process Engineering

DELIVERING STATE-OF-THE-ART SOLUTIONS FOR EVERY AREA OF THE PULPING PROCESS

Comprehensive knowledge

Unique tools and expertise

Science-driven approach
Fibre Line Mass Balance
A Tool for Accurate Fibre Accounting in a Kraft Pulp Mill
Identifies high fibre loss operations in mills, by breaking the process down into specific production modules allowing each to be evaluated separately for fibre input, loss and output.

Our expertise and advanced pilot-plant pulping systems can be used to maximize operating capability and product quality at your mill.

Identify newer and better operating choices to improve performance and reduce costs.

Optimize the combined brownstock washing and digester washing zone
Our advanced tools and comprehensive methodology allow pulp and paper mills to mitigate bottlenecks when increasing production, reduce process variation, and increase cost competitiveness.

Optimize bleach plants tailored to the needs of specific mills
Improve performance of one or more bleaching stages and reduce costs.
Near-neutral chlorine dioxide brightening (NNB) technology
Our technology is an effective way to decrease bleaching costs by maximizing chlorine dioxide bleaching efficiency.

Optimize fuel and air distribution to maximize power and recovery boiler efficiencies
For those plants where electricity generated from biomass can be sold at >$100/MWh, improving hog fuel firing could increase green power sales by $1 million per year. Increasing recovery boiler throughput and reducing boiler plugging could generate a profit of $1 million per year in incremental pulp production.

Paprilox™—polysulphide generating technology
FPInnovations discovered a process that can be retrofitted into an existing pulp mill’s causticizing system to improve pulp yield and tensile strength. The benefits of this technology include low capital investment and simple operation.

Fourier transform near-infrared (FT-NIR) optically based technology
Reduce costs and increase process efficiency and product quality. This technology uses the unique spectral signature generated by the absorption of light through a process liquor to simultaneously determine the concentration of liquor chemical constituents.

Causticizing control system
This system, in combination with the FT-NIR technology, can help reduce energy consumption and chemical losses, maintain equipment capacity, improve mud settling rates, reduce free-lime in white liquor, and reduce digester and evaporator scaling.
Forty years of experience helps us identify the impact of process changes on corrosion
- Knowledge and expertise to maximize the lifespan of process equipment from pilot to industrial scale.
- Identify the right materials for new process technologies.
- Effectively simulate nearly any process stream in existing or novel biomass processing operations, including high-temperature and pressurized environments.
- On-line monitoring to assess impact of process operations and variability.

Our advanced process integration expertise helps optimize energy management
Our unique approach towards process integration allows you to identify short-, medium-, and long-term projects that can substantially improve the energy efficiency of your process. Our methodology has helped several mills generate profits of $1-4 million year.
In kraft pulp production, wood chips are typically the major part of the total production cost. Fiber accounting in a mill requires accurate measurements of mass balance for incoming wood chips, digester throughput, pulp yield, bleaching and drying process. However, this fiber accounting is heavily impacted by wood chips moisture content, non-wood debris (rock, metal, ice and snow), chip size distribution, bark content, process fiber loss and fiber degradation throughout the process.

FPInnovations offers a potential solution; we have developed an Excel®-based fibre line mass balance tool to help kraft mills improve determination of their gate-to-gate fibre losses. The application identifies high fibre loss operations in the mill, by breaking the process down into specific production modules allowing each to be evaluated separately for fibre input, loss and output. Mill data, data from both open and FPInnovations literature is used to determine fibre use at each unit operation. The complete fibre loss balance can then be obtained and integrated within the mill’s net fibre yield calculations to support their budget in relation to wood costs. Easily modified, the Fibre Line Mass Balance (FLMB) tool can be customized to reflect various fibre inputs and processes at a given mill, changes at the mill. The FLMB can also be used as a modeling tool to predict the outcome of process changes before implementation. It will at the same time enable each mill to measure the fiber balance in each unit operation for benchmarking if desired.

This tool has been used by our member companies to provide better fiber accounting which results in cost reductions in the kraft pulp mill.
Pulpability in Kraft Mills

Fibreline analysis

To ensure that kraft pulp mills maximize operating capability and product quality, pulping systems must be run at peak efficiency. Optimizing “pulpability” is the goal, including these factors: best wood and chip quality, fast rate of delignification, optimal use of additives and advanced techniques, highest yield of unbleached pulp from wood, and best possible strength and bleachability.

Our chemical pulping expertise ranges from solving material or process problems to conducting comprehensive pulpability studies. We have performed research and contract work in chemical pulping for several decades, and have tackled a wide range of challenges by finding solutions and developing useful techniques. Our specialties include:

• Pulping with additives (AQ, polysulphide, etc.)
• Simulating advanced digester operations
• Determining how chip size and quality affect pulpability
• Doing precise yield measurements
• Auditing pulp strength delivery in mills

Our capabilities for research-scale characterization of the material/process combination could identify newer and better operating choices.
Pulp Strength Delivery in Kraft Mills

Pulp quality and performance depend on several factors, such as wood species and quality, pulp mill fibrefine equipment and processes, operating practices in mills, and stock preparation equipment and operations.

How good is the pulp that you produce? Could it be better?

Our pulp strength delivery system compares the physical performance of mill-made pulps with the potential inherent in the original wood. The technology requires systematic sampling and analysis of pulp being produced in a mill. Our Chemical Pulping Group has 25 years of such experience and a large database of reference cases.

A strength delivery audit includes planning, a pulp/chips sampling campaign, reference pulp making, physical testing work, data analysis, reporting, and recommendations. We can train mill people in these procedures. The physical testing can be done at our laboratories, at the mill, or at a third-party contract laboratory.

A wealth of useful information comes from pulp strength delivery analyses. Examples:

• Digester systems differ greatly in their ability to convert potential fibre strength in wood to real fibre strength in unbleached pulp.
• Softwood and hardwood kraft pulps are very different in strength delivery.
• Elemental chlorine-free (ECF) bleaching affects the strength of kraft pulps only marginally.
Brownstock Washing

Many kraft pulp mills are running their brownstock washers over the design capacity and have issues with operating stability. They then require a process optimization of the combined brownstock washing and digester washing zone.

FPInnovations uses different approaches to evaluate and debottleneck the process, including:

- Conducting an audit of fibreline and chemical recovery to develop strategies for brownstock washing
- Collecting historical brownstock washing data from a mill and using the mill’s brownstock washer configuration for simulation
- Conducting brownstock washing mapping and validating the simulation with mapping data
- Identifying potential brownstock washing improvements and conducting mill trials

Our unique methodology and tools allow pulp and paper mills to mitigate bottlenecks when increasing production, reduce process variation by identifying key control points and parameters, and increase cost-competitiveness by compromising weak black liquor solid content and unbleached pulp cleanliness.
Chemical pulp bleaching

Bleach plants of chemical pulp mills are often not fully optimized, and as a result there is an increase in the bleaching costs. In addition, sometimes pulp quality is compromised because of the poor performance of one or more bleaching stages. Bleaching problems are specific to a particular mill so mills need to be optimized separately.

We draw from our extensive experience, knowledge, and research to tailor the bleaching needs of each mill by offering a range of bleaching services and by optimizing the bleaching process. Our specialties include:

1. Oxygen delignification – Get a balance of pulp quality and delignification from your system.
2. Optimization and modification of ECF and TCF bleaching – Check if your chemical consumption is much higher compared to your competitor.
4. Explore enzymes in bleached kraft pulp production – Get an insight into the effect of pre- and post-treatments with xylanases and cellulases on your kraft pulp.
5. Chemical pulp bleaching yield measurements – Determine the impact on pulp yield after you change or introduce a new bleaching chemical or process.
6. Automated laboratory kappa number testing - Use this methodology to cut costs of laboratory kappa number testing with improved confidence in test results.
Near-Neutral Brightening (NNB)

Chemicals consumption reduction

Pulp mills are looking for ways to decrease the operating cost of their processes, including those in the bleach plant.

Our near-neutral chlorine dioxide brightening (NNB) technology is an effective way to decrease bleaching costs by maximizing chlorine dioxide bleaching efficiency. Chlorine dioxide brightening is most effective when operated at a final pH close to neutral by generating sodium bicarbonate in situ by adding carbon dioxide to alkaline pulp (or sodium carbonate to acidic pulp). This technology can be used on hardwood, softwood, and sawdust kraft pulp and is applicable to 3-, 4-, and 5-stage bleaching, with or without O₂ delignification.

The technology has been proven optimal with any bleaching sequence containing one or more ClO₂ brightening stages and has been successfully implemented at multiple mills in the U.S. and Canada.

With this technology, the ClO₂ demand is reduced (up to 5 kg/MT [10 lb./ST]), the caustic consumption can potentially decrease, the need for antichlor is eliminated, and the variability of brightness is decreased.
Biomass Power Boilers

Optimization

Wood waste (hog fuel) is considered to be a carbon-neutral energy source, and electricity generated from it is green-power, sellable at much higher prices than from fossil fuel in many jurisdictions. There is a real need to maximize hog fuel firing but there are often challenges in doing so. Issues with power boiler operations include poor combustion, poor mixing, low efficiency, high carryover and ash production, formation of clinkers on the grate or in the bed, slagging and fouling, erosion and corrosion, and air emissions like particulate and acid gases.

FPInnovations can solve these operating issues. The most cost-effective approach is optimizing the fuel and air distribution of your boiler in order to improve combustion. We have developed novel methods and unique probes and instruments, including a heavy-duty portable continuous emission monitoring (CEM) system, to sample, measure, and analyze your system’s key operating parameters. We identify bottlenecks and provide guidance for adjustments to the air splits, fuel feeding system, and overfire air set-up. Additionally, we have developed a detailed database on technical specifications, operating conditions, and combustion and emission performance useful to benchmark your boiler.

Previous results have shown that for a power boiler with a steam capacity of 100 t/h, a 5% increase in the hog fuel firing rate could increase green power sales by $1 million per year at a price of >$100/MWh.
Chemical Recovery Boilers

Optimization

Many mills want to increase their pulp production but find that the recovery boiler is the bottleneck, and they often face challenges when trying to maximize the boiler’s liquor firing rate.

Issues with recovery boiler operations include poor liquor and air distribution and poor mixing that cause high carryover, rapid boiler plugging, low reduction efficiencies, and smelt spout plugging problems.

FPInnovations can solve these operating issues. The most cost-effective approach is optimizing the fuel and air distribution of your recovery boiler in order to improve combustion. We have developed novel methods and unique probes and instruments, including a heavy-duty portable continuous emission monitoring (CEM) system, to sample, measure, and analyze your system’s key operating parameters. We identify bottlenecks and provide guidance for adjustments to the air splits, air distribution, and liquor spray patterns. Additionally, we have developed a detailed database on technical specifications, operating conditions, and combustion and emission performance useful to benchmark your boiler.

Previous results have shown that, for a 1000 t/d kraft mill, a 1% increase in boiler throughput increases profit by $1 million per year in incremental pulp production, and that a reduction in water washes by 1–2 times per year increases profit by $0.3–1.5 million per year.
FPInnovations’ polysulphide technology, Paprilox™, is based on our discovery that the lime mud found in a typical mill’s causticizers is an extremely good catalyst for polysulphide generation. This discovery led us to develop a process that can be retrofitted into an existing pulp mill’s causticizing system, rather than requiring a complete new unit operation. The process has the benefits of low capital investment and simple operation.

With typical increases of 1.5% on wood, a payback period of 5 to 24 months is generally possible, depending on the mill’s production limitation (recovery boiler, digester, or pulp machine). In addition, increases in tensile strength from 5 to 17% relative to conventional kraft pulp can be realized. Paprilox™ is licensed to Noram Engineering and Constructors Ltd. Causticizing Control System is licensed to TEXO Consulting & Controls Inc.
Sensors and Control

Liquor analyzer

The lack of on-line sensors for key process variables and product quality attributes has hampered the development of process control strategies needed to reduce costs and increase process efficiency and product quality.

Our optically based Fourier transform near-infrared (FT-NIR) technology uses the unique spectral signature generated by the absorption of light through a process liquor to simultaneously determine the concentration of liquor chemical constituents. FITNIR Analyzers Inc. (http://fitnir.com/) is the exclusive global distributor of FITNIR Online and FITNIR Benchtop, which are based on this technology. To date, over 40 FT-NIR-based analyzer installations have been applied to continuous digesters, causticizing plants, recovery boilers, chlorine dioxide generators, and brownstock washers, driving process control strategies to optimize pulp mill operations.

FT-NIR Liquor Analyzer is licensed to FITNIR Analyzers Inc.

Causticizing plant control

Poor control of the causticizing process may lead to a host of operating problems including, but not limited to, increased energy consumption and chemical losses, reduced equipment capacity, low mud settling rates, free-lime in white liquor, increased digester and evaporator scaling, and low lime kiln thermal efficiency.

Our causticizing control system combines on-line liquor composition measurements (FT-NIR Liquor Analyzer) and model-based inferencing of lime quality to achieve accurate lime dosage control. Lime addition is determined by stoichiometry where the clarified green liquor flow and chemical composition, inferred lime quality, and white liquor causticity target are inputs. The lime quality estimator is based on a high-fidelity kinetic-dynamic model of the causticizing process. TEXO Consulting & Controls Inc. (http://www.texo-cc.com/) is the exclusive licensee of CAUST-X, which has 10 applications to date.

Causticizing Control System is licensed to TEXO Consulting & Controls Inc.
Long-term and online corrosion monitoring can identify changes in the process and how they relate to the corrosion of materials.

An unexpected shutdown at a mill can cost millions of dollars per day if a key component fails and requires repair. The cost of an unexpected shutdown is a function of lost revenue and the necessity for resources to be rushed to the site. There is a significant savings in annual maintenance and a revenue boost in the long run if a mill can operate 12 to 18 months between scheduled outages with confidence.

FPInnovations can help develop the confidence through the implementation and development of coupon and online corrosion monitoring. Our corrosion monitoring approach uses a coupon monitoring program where alloys are exposed to process conditions for a long period of time and the coupons are reclaimed and characterized. Online corrosion monitoring equipment is also used to relate corrosion as a function of regular or transient operating conditions. Consequently, corrosion data are not only monitored remotely from an online system, but data are also provided for the mill’s distributed control system (DCS).
Understanding why components fail and overcoming routine corrosion challenges are essential to long-term material reliability.

Regular and repeating failures of equipment in a process can result in significant costs over a short period of time. Components that are considered disposable can be replaced easily, but they still require time and effort to schedule and perform the repair. A mill that operates for 12 to 18 months may be able to eliminate these small repair tasks by performing failure analyses.

Our Corrosion Group can identify materials using X-ray fluorescence and can characterize samples of failed components using the group’s metallurgical and electrochemical laboratories and techniques, then perform further imaging and microscopy to determine a likely cause of corrosion and failure. We can then apply our knowledge and experience to develop long-term solutions using coupon monitoring or experimentation.
Short-term electrochemical experiments can identify corrosive elements in a simulated process stream.

Corrosion is an electrochemical reaction that causes material degradation and leads to failures. Our Corrosion Group is capable of performing experiments in mill-simulated aqueous conditions at temperatures as high as 200 °C. Electrochemical techniques have been accepted by ASTM as a method to study the corrosion phenomenon, and they have been utilized in numerous journal publications. Our electrochemical laboratory utilizes multiple autoclaves that are used to simulate industrial process conditions and to better understand the corrosion resistance of specific alloys.

Our Corrosion Group can also perform mechanical testing in addition to slow strain rate experiments within an autoclave. These capabilities are unique and are essential to understanding the corrosive nature of specific environments.

Our unique and state-of-the-art facilities are second to none.

Our facilities allow for experiments related to gaseous chemical, molten metal, and molten salt corrosion. The fume hood at FPInnovations includes both tube and muffle furnaces that can be used to simulate field conditions. Our state-of-the-art gas delivery system can deliver accurate gas mixtures and handle toxic elements safely.
Energy efficiency can be negatively affected by constant changes to configuration and operating process conditions, and the implementation of cogeneration and biorefining technologies. In addition, stringent environmental regulations and strong incentives to produce green power are putting pressure on reducing fossil fuel usage while increasing cogeneration capacity.

Our unique approach towards process integration allows substantially improving energy efficiency. The approach considers the changes in operating conditions and configuration of the process, process variability, fuel prices, steam cost, power contracts, and the complexity of the multiple system interactions that take place within the water, energy, and utility network. The end result is reduced production costs, increase productivity by identifying opportunities for short- and long-term energy savings, increased power production profitability, and improved mill sustainability from three perspectives: economic, energy, and environmental (reduction of water consumption and greenhouse gas emissions).

As part of the approach, we perform benchmarking (energy, water, and process operation) and develop a process and utilities simulation.

By applying this approach in several North American pulp and paper mills, we have been able to help each mill save $1-4 million per year.
Chemical Analysis & Microscopy

Identifying Contaminants
Characterizing Bioproducts

Our Chemical Analysis and Microscopy Group provides customized technical services, resolves process- and quality-related problems, supports the development of new products, and offers unbiased expertise for settling customer disputes.

We perform these services by drawing on our depth of expertise, and using specially designed analytical schemes and instrumental techniques, including FT-NIR spectroscopy, ion chromatography, inductively coupled plasma (ICP-OES), pyrolysis/GC/MS, field emission scanning electron microscopy (FESEM), X-ray (EDS) analysis, and light microscopy.

From basic testing to addressing complex issues, we have the knowledge and experience to deliver the highest value to our clients.

- Diagnosis of deposit, scaling, and contaminant problems
- Molecular weight distribution
- Characterization of products such as lignin, black liquor, cellulose nanocrystals, and bio-oils
- Analysis of additives and assessment of their impact
- Analysis of odours in end-use products
FPInnovations’ Pilot Paper Machine
Our in-house, unique pilot paper machine allows producers, equipment manufacturers, and chemical suppliers to test new products in real operating conditions. Our machine can produce paper, board, and tissue.

Mechanical Pulping Pilot Plant Facilities
We have both atmospheric and pressurized refiners as well as a chips impregnator. Pulp stock preparation can be simulated using our pressure screening and cleaning system and reject refining installation. We also provide specialized testing, including wood chips classification, wood species quality evaluation, and pulp linting propensity index.
FPInnovations is a world leader that specializes in the creation of scientific solutions in support of the global competitiveness of the forest industry. We are ideally positioned to innovate and deliver state-of-the-art solutions for every area of the sector.