Saving 1000 GWh/y through scientific discovery and the development of new technology

April 2009

Energy Reduction Research

OUR FIRST NEWSLETTER!

We are now more than two years into the five year $2.4M research program on "Electrical energy reduction in mechanical pulping" and we are launching a semi-annual newsletter as a means of communicating with our partners the research highlights, successes, progress and upcoming events.

The project is well underway. We have recruited our staff researchers and graduate students. Many of the PhD students have completed their courses and comprehensive exams and are beginning to make good progress in their research.

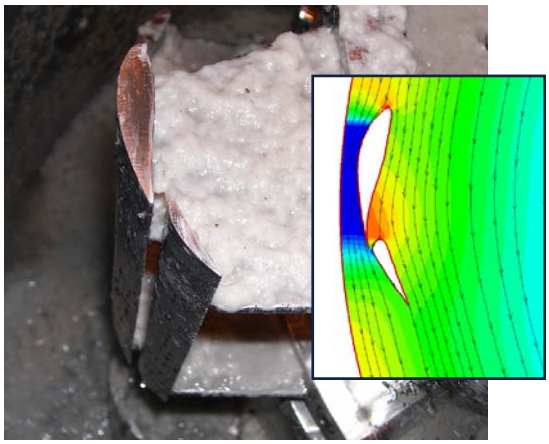
We have recently started to publish some of the research reports and papers generated as a result of this program. Hopefully you have received these in the last few months.

We are always looking for input into the program and rely on your involvement. This newsletter is a direct result of your input. Please contact any of the faculty at any time (contact information is on page 2).

ENERGY SAVING ROTOR WINS 2009 DOUGLAS ATACK AWARD

The Mechanical Pulping Committee awarded the paper entitled "High Performance Multi-Element Foil (MEF) Pulp Screen Rotor – Pilot and Mill Trials" by M. Hamelin, S. Delfel, J. Olson and C.F. Ollivier-Gooch the 2009 Douglas Atack Award for best paper presented at the Mechanical Pulping Session of the PAPTAC Annual Meeting in Montreal.

The new, UBC patented, AFT-MEF™ rotor was shown to provide a 43% energy reduction over typical OEM rotors in mill trials and up to 80% energy reduction over some of the rotors in BC. New rotor technology has the potential to save 15 GWh/yr in BC alone.



MEF Foil rotor in Catalyst Coquitlam De Ink mill trials and the CFD simulation (inset) showing pressure and flow streamlines.

NSERC ENHANCES FRACTIONATION AND CONTROL

An additional $168K in funding was received from NSERC to augment the control and fractionation projects. The funding will provide two additional Post Doctoral Fellows (PDFs) to work on the research over the next year.

The additional PDFs will work on two projects. A pulp screen fractiontion project will examine the impact of newly developed high performance pulp screen rotor and cylinders to effectively fractionate long and coarse pulp fibres for targetted refining. The ability to target the energy where it is need may be able to reduce energy consumption by 10%, with a potential 500 GWh/y savings in BC.

The second project will enhance the existing advanced TMP control project to integrate Dynamic Data Reconciliation (DDR) technology with a mechanical pulping plant multivariable optimizing controller and to develop process identification and control techniques suitable for this integration.

Energy Reduction Research

NSERC STRATEGIC PROJECT FOR ENERGY REDUCTION

Professors Olson and Martinez at the UBC Pulp and Paper Centre, in partnership with AFT, have been awarded a $350K NSERC Strategic Grant to support research on "Energy Reduction in Processing Pulp Suspensions".

The proposal is aimed at developing novel, energy efficient, technologies and processes through the application and understanding of methods to reduce the turbulent drag in fibre suspension flows. Fibre suspensions are known to exhibit the strange behavior of requiring less power to pump through pipes than water alone. This research aims to take advantage of this unusual behavior to design the next generation of energy efficient pulp processing equipment.

We will also investigate the synergistic effects of adding drag reducing polymers and wall contour modifications to fibre suspension flows with immediate application to pipe, hydrocyclone and pulp screen rotor design.

If successful, this research may lead to new technolgoy to dramatically reduce the energy conumed in all aspects of pulp processing and papermaking.

NEW PLATES SAVE ENERGY!

Mill trials at Catalyst Elk Falls have shown that reduced periphery refiner plates can reduce no-load energy by 36% or 171 kW per refiner without reducing pulp quality.

During the trial a reduced periphery, 55" refiner plate with bar height of 4.0 mm replaced a 58" refiner plate with a bar height of 5.2 mm. The reduced periphery plate had a similar tensile strength – specific energy response and had a larger freeness drop with specific energy than the 58" plate. The no-load power, measured at the maximum refiner gap, was shown to be 307 kW versus 478 kW for a savings 36% no-load energy reduction.

If this technology is implemented throughout BC it would result in a 1.36 MW reduction in power consumption in BC.

UBC-PPC BUILDS PILOT LC- REFINING FACILITY

AFT, FineBar, Aikawa and NSERC have partnered to build a state of the art LC refining facility in the UBC Pulp and Paper Centre. AFT / FineBar and Aikawa will donate the new LC refiner and plates, while NSERC will provide $142K in cash to purchase the ancilliary equipment.

The new facility will expand on the existing pulp loop in the pilot polant and should be operating before the end of the year.

RESEARCH PROGRESS

Overview

This proposed, multi-disciplinary research program aims to reduce electrical energy consumption in the mechanical pulping process by 1000 GWh/yr or 20% through scientific discovery and the development of new technology while maintaining or improving product quality and production. To accomplish this goal, we proposed a range of projects that span the risk-reward spectrum from incremental to transformative.

The program supports our shared vision that future mechanical pulp mills will transition to an increased reliance on energy efficient, low consistency (LC) refining and the reduction of high consistency mainline refining.

The program is composed of several projects that will combine theoretical, laboratory, pilot

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and mill scale experiments in the following strategic areas: Low consistency (LC) refining, latency removal, fibre fractionation, refiner control, novel mechanical pulping and mechanical strength and linting tendency of LC refined mechanical pulp.

1.1 Ultra-low intensity LC refining

Antti Luukkonen (PhD student)

This project aims to determine the energy savings potential of ultra-low intensity LC refining.

A new understanding of LC refining has been developed.

Two pilot LC refining trials have been completed at Andritz R&D laboratory in Springfield OH as well as a series of mill trials. These trials have demonstrated that specific energy and refiner gap are the two key variables in predicting pulp quality changes during refining. The trials have demonstrated that a minimum critical gap exists that if exceeded results in significant loss in tensile strength. In addition, we have developed a means to predict gap depending on refiner design and operation.

From this research we will be able to ensure that LC refiners are operated at or near the maximum energy transfer available for a given installation and minimize the energy consumed in the less efficient HC refining process.

Future trials will demonstrate the application of chemical pre-treatments, coupled with optimal LC refining to eliminate secondary refining, saving approximately 800 GWh/yr in British Columbia.

1.2 Chemical and biological treatments

David Kuan (Coop), 9 students (BCIT), Harry Chang (Researcher), Norm Weber (Arkema)

Objectives: To develop chemical and/or biological treatments that enhance the ability of LCR to be used as a process for reducing electrical energy consumption in refining.

Pilot LC refiner located at Andritz R&D laboratory in Springfield, OH.

Trials donated by Andritz.

Through bench scale simulation of low consistency refining, we have been able to identify and assess chemical treatments that show promise in reducing electrical energy consumption. It is estimated that alkaline peroxide treatment of coarse TMP, combined with low consistency refining, could reduce electrical energy requirements by up to 50%. We plan to test these findings at a pilot scale in the near future.

A report has been issued evaluating the chemical and biological treatments used in HC refining. A system has been developed to assess LC refining on a laboratory scale. This system is being used to screen potential chemical and enzyme treatments. Alkaline peroxide has proved to be the most promising treatment with potential electrical energy savings of 20 to 50% to a given tensile strength. The parameters affecting the efficacy of the alkaline peroxide treatment are being determined. TMP has been treated with two cellulases, two xylanases and ozone and the effects of these treatments on LCR and pulp properties are being analyzed.

During the next 12 months, the results of the enzyme and ozone treatements will be assessed, the mechanisms behind the energy savings with peroxide will be determined and energy savings achievable through treatment of coarse primary TMP prior to LCR will be investigated.

1.3 Minimizing no-load power

Stephane Lavoie (Summer student), Nina Rajabinasab (PhD student)

Objectives: To understand the flow field inside the refiner, to determine the effect of pulp suspension rheology and plate design and refiner operation on the no-load energy losses in LC refining.

No-load power for a range of plate geometry, rpm and flow rate using the UBC laboratory refiner was experimentally characterized. Mill trials were carried out at Catalyst Elk-Falls on three different plates. She is analyzing the laboratory refiner data, along with no-load power measurements made at Catalyst Crofton Elk Falls and the Andritz pilot refiner in Springfield OH. She has also begun a Computational Fluid Dynamic study of the LC refiner geometry to understand the mechanisms of viscous losses in the refiner. It is hoped that this new model will lead to a new tool for energy efficient LC refiner plate design.

1.4 Theoretical estimates of energy and intensity in LC refining of mechanical pulp

Eli Elahemir (PhD student)

Objectives: To derive a rigorous theoretical understanding how energy is used in mechanical pulping, with the ultimate aim of identifying precisely where and how energy might be reduced.

Progress to date: Recent work has focused on developing a force-based refining intensity for LC and HC refiners. Based on the Specific Edge Load (SEL), forces on bars per bar crossing per bar length have been estimated. Using estimates of fractional bar coverage of bars by fibre, forces on fibre mass were also estimated and found to compare favourably with recent measurents by researchers from the University of Victoria.

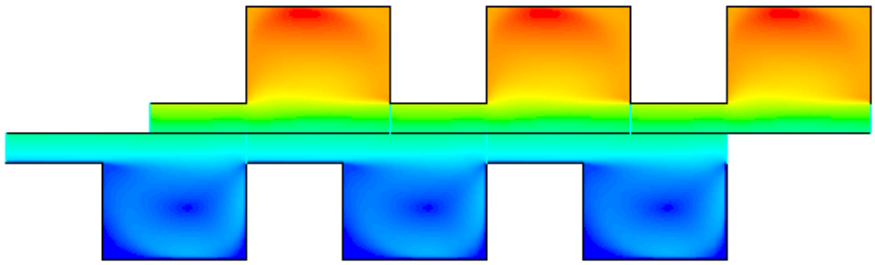
With further assumptions, forces on indivuidual fibre were estimated. Although approximate in magnitude, the analysis showed clear trends, one being a strong dendence of fibre force on both SEL and gap size. Given that SEL itself depends on gap size, this shows that forces on fibres increase dramatically with descreasing gap size. This finding offers an explanation for the findings of Murton et al for HC refiners, namely, that gap size corelates better with pulp properties than either energy-based refining intensity or residence time.

1.5 Optimal pumping efficiency in LC and MC treatments

Imad AbuYousef (MASc student)

Objectives: To design and build a pump test facility that accommodates the LC refiner loop, and to experimentally and theoretically determine the impact of pump design and operation on efficiency.

The pilot test facility is under construction and it is expected to be commisioned in the next 3 months. The design has been modified several times to accomodate a range of experiments. Pump efficiency will be experimentally



Computational Fluid Dynamic (CFD) simulation of an LC refiner plate.

Advanced Engineering tools are used to design plates with reduced no-load power!

determined for a range of speeds, impeller trims, pulp types, consistency and air bubble content. The impact of bubble content on the suction side of the pump and its impact on NPSH will also be determined. Finally, a rheological model of pulp suspension pumping efficiency will be developed that will enable improved design and operation of pulp pumping and pipe systems.

2 Latency removal

Jiyang Gao (PhD student)

Objectives: To optimize energy use in the recovery of the latent properties of mechanical pulp in the context of the complete fibre line.

The design for the laboratory tester is nearing completion and will be submitted for fabrication after Jiyang's comprehensive examination which is being held this April. Testing protocols and an experimental test procedure have been developed. A tentative kinetic model for latency removal has been proposed using available literature data, and will be confirmed and modified based on experimental measurements. The first pulp chosen for extensive characterization will come from a local mill, allowing for mill trials and linkage with mixing modelling later in the project. Another pulp (and mill) will be selected for extensive characterization as well. These data will allow protocols for rapid pulp assessment and characterization to be developed producing a widely applicable kinetic model and modelling capability.

3 Novel fibre fractionation

Ario Madani (PhD student)

Objectives: To develop a prototype device to effectively fractionate fibres based on fibre physical properties.

The UBC pump test facility to be used for Research and Education.

Pump donated by WestCan.

Tests have been performed using a 1D centrifuge and the calibration curves for the criteria of motion have been obtained. The results include the effect of different fluid properties, different particle densities and geometries. The particles used include spheres, cylinders and curved bars to simulate fibres curl. In the second stage, a high rpm centrifuge has been used to separate Rayon and Nylon fibres using the same principals. The future work would be completing the separation of Nylon and Rayon fibres in high rpm centrifuge and performing the tests on wood fibres.

4 Refiner control

Eranda Harinath (PhD student)

Objectives: To develop an advanced control system minimizing the energy consumption of mainline refiners together with third stage LC refiners, while maintaining or improving pulp quality variables.

A constrained MPC algorithm with a tailored quadratic programming solver has been

developed. This algorithm can be used in the regulatory layer of the advanced control system for fast computation. Development of a dynamic model for mainline refiners has started. Once Honeywell upgrades the current system, system identification will be performed for HC/LC refiners at Elk Falls.

Could shavings be the new low energy raw material for papermaking?

5 Novel mechanical pulping

Taegeun Kang (Post doctoral fellow)

Objectives: To develop a new, transformative technology for the energy efficient reducing of pulp wood into individual fibres suitable for high quality, lint-free mechanical printing papers.

In 2008, wood shavings (Quesnel River Pulp) were pretreated with alkaline peroxide and fed directly through LC refiner at UBC. LC refined wood shavings was required less energy to reach the same freeness and paper strength than HC refined wood chips, but the maximum paper strength of LC refined wood shavings were lower. Another advantage of LC refined wood shavings was found in higher light scattering coefficient and brightness of paper. In order to overcome the shorter fibre length of commercial wood shavings, a metal lathe was used to produce thinner wood shavings at UBC, and the fibre length of these shavings were longer than that of wood chips from the same logs. In 2009, pretreatments such as steam explosion and thermo-stable enzyme treatments will be separately applied to wood shavings before LC refining.

6 Mechanical strength and linting tendency of low consistency refined pulps

Pawel Trocki (MASc student)

Objectives: To assess the effect of LC refining on the mechanical strength and linting tendency of paper.

A literature review focusing on the effect of refining conditions on the strength and linting propensity of mechanical pulp papers is being conducted. A statistical design of experiments approach is being developed for this project.

PUBLICATIONS

Significant publications and reports from the sponsored research:

1. On site measurement of kraft pulp pump system efficiency, R. Kuhn and S. Green, Pulp and Paper Canada, 4:23, 2009.

2. Low consistency refining of wood shavings, T. Kang, G. Soong, J. Olson and M. Martinez, IMPC, Sweden, 2009.
3. Novel Fractionation Methods: Separation in a Viscoplastic Fluid, A. Madani, S. Storey, J.A. Olson, I.A. Frigaard J. Salmela, D.M. Martinez, 2009 Fundamental Research Symposium, Oxford, UK.
4. Review – The use of chemicals and enzymes to reduce energy consumption in refining. D. Vu and R. Beatson.

SCHOLARS AMONG US

Two of our graduate students received scholarships this year. Congratulations to Eranda Harinath who received an NSERC-Canada Graduate Scholarship, and to Imad AbuYousef who received a University Graduate Fellowship.

EVENTS

PAST EVENTS

PAPTAC Annual Meeting, Montreal, QC
February 3-5, 2009

Students presented 3 posters on their research. These posters were emailed out to all partners.

UPCOMING EVENTS

International Mechanical Pulping Conference, Sundsvall, Sweden, June 1-4, 2009

We will present two papers on our research. One examines the potential energy savings available by using shavings as a raw material and directly feeding them into LC refiners and the second paper presents what we learned from the pilot LC refining trials.

PACWEST Conference, Kamloops, BC
June 10-13, 2009

Three students will present posters on their work.

SPONSORS

The supporting organizations of this research are: AFT-Aikawa Group, Andritz, Arkema, BC Hydro, Canfor, Catalyst Paper, CEATI International, FPInnovations, Honeywell, Howe Sound Pulp and Paper Limited Partnership, NSERC, Ontario Power Authority, Quesnel River Pulp, the University of Toronto Pulp & Paper Centre and Westcan.

These organizations have representatives on our steering committee, receive early access to research results and are the first to trial new technologies and processes. Other companies interested in supporting our research can contact Prof. James Olson.

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