2006 Pulp Yield Symposium & Workshop
Marriott Marquis
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<td>Gopal C. Goyal, International Paper</td>
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<td><strong>The Yield Chain: The Role of Yield in Supply Chain Total Delivered Cost</strong></td>
<td>Frank McShane, Longview Fibre, Keynote Speaker; Daniel Wong, Longview Fibre, Keynote Speaker</td>
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<td><strong>Wood Supply Chain Efficiency and Fiber Cost: What Can We Do Better?</strong></td>
<td>Jacek M. Siry, University of Georgia; W. Dale Greene, University of Georgia; Thomas G. Harris, Jr., University of Georgia; Bob Izlar, University of Georgia</td>
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<td><strong>Optimizing the Value Chain to Improve Profitability</strong></td>
<td>Glenn Weigel, PAPRICAN, Speaker</td>
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<td><strong>Growing Kraft Pulp Yield from the Ground Up: Opportunities from Wood and Chip Quality Variability</strong></td>
<td>Paul A. Watson, PAPRICAN, Speaker</td>
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Measurements, Models and Simulation Tools for Optimal Fibre Utilization from Tree to Paper
Sven Olof Lundqvist, STFI, Speaker
Paper is basically a network of fibres, normally from wood. Fibres are processed and other components are added to produce engineered structures with different properties required. The original properties of the fibres in the wood normally have a large influence on the properties of the final product and on the processing needed to meet the quality requirements. Property variations of the wood raw material may account for as much as 30-40 % of the variations in the properties of the final product. With more suitable, more uniform and better-known raw material properties, it is less demanding to reach the requirements. The wood, chips, fibres and paper may be more precisely processed along the value chain and the use of materials, chemicals and energy may be reduced. It may also be possible to produce acceptable products from less suitable and lower cost wood and the mill and the company will benefit from improved competitiveness.

STFI-Packforsk has for many years performed research and development with the objective to improve product quality and production efficiency through more uniform and more suitable wood and fibre properties and to support better use of forest resource. In this work, it is necessary to apply a holistic perspective along the value chain from tree to paper. For this purpose, a number of capabilities have been built up:

• The Wood and Fibre Measurement Centre
• Databases on properties of trees, wood and fibres
• Models for predicting properties of raw materials
• Models for properties along the value chain
• Toolboxes for simulation

The Wood and Fibre Measurement Centre now includes several unique instruments for the measurement of important wood and fibre properties. One such unique equipment is the SilviScan instrument for efficient measurements on wood samples of radial variations from pith to bark of many wood and fibre properties, such as wood density, fibre width, fibre wall thickness, microfibril angle and wood stiffness. The SilviScan technology was developed in Australia at CSIRO, which has the other of the only two instruments existing in the world. Another unique technique has been developed for the characterization of not only fibres but also vessel elements in industrial pulps as well as in micro-pulps produced from annual rings or small radial sections of wood. This is now applied in various studies of hardwoods, such as within stem variations and differences between clones of aspen and eucalyptus.

Through compilation of forest data and data from analyses in the Measurement Centre, databases have been built with related information on properties of forest stands, trees, wood and fibres for various wood species and regions. Species studied are Norway spruce, Sitka spruce, Scots pine, Loblolly pine, poplar/aspen and eucalyptus. Studies have been performed in many European countries but also in Asia, South America and North America, where an investigation of Loblolly pine in southeast USA has been performed together with a paper company. From these databases, variations in wood and fibre properties are evaluated from industrial or forestry perspectives. Through use of proper sampling designs, models may be developed for the variations within and between trees and stands of different wood and fibre properties. Simulation toolboxes have been developed to interface models and different types of databases on forest and tree data to simulate the external sizes and shapes of stems as well as their internal property variations. These “virtual stem” are divided into logs and sawmill chips, which are then grouped into “wood sorts”, forming an assortment of raw materials available for sawmills, pulp and paper mills and energy production.

A very interesting application of these tools is use of forest inventory data for the building of “Regional Resource Databases” with information about very large numbers of stands and trees representing the resources in the acquisition area of a mill, as well as logs, chips, and fibres which can be made available for the mill from this resource. Through simulation of different selection and processing alternatives, the volumes, wood and fibre properties resulting from different strategies of wood utilization may be compared.

Typical properties simulated in this way are wood density, fibre length, fibre width and fibre wall thickness (averages and distributions). From these basic properties, “indicators” closer related to paper properties are calculated, for instance number of fibres per gram, crowding number (related to paper formation) and fibre collapsibility. When investigating difficulties or possibilities of a mill, the most important properties and indicators for the specific mill and products are selected and emphasized. Recently, a tool has been developed for simulation of fibre networks built up from fibres of different origin, for instance fibres described in a Regional Resource Database for the mill.

The current capabilities in the form of equipment, software and procedures for sampling, sample preparation, measurements, databases, modelling, simulation, evaluation and presentation of results have been successively developed and improved in research and contract work over a period of more than 10 years on many wood species with different partners. Based on these experiences, the procedures applied have been sharpened to high efficiency and, even if models are still improved and new functions added, the phase of less research and more application has been entered.
The prime task in this area of STFI-Packforsk is R&D for the pulp and paper industry, its suppliers and customers. The ambition is to contribute to reduced variations, improved product quality and more efficient production through better wood allocation from a mill perspective, plantation of trees with more suitable wood, fibres and vessel elements, more uniform and suitable fibres to the mill and specific solutions for mills and companies. The unique resources built up for studies of wood and fibres are, however, very useful also in fields like wood technology, forestry, tree improvement, genetics, etc. We are cooperating with researchers and companies all over the world. Further partnerships are now established with expertise in these fields. The tools already developed are applied and research is performed to improve the understanding of how properties of fibres influence properties of paper.

Silviculture and Genetic Impacts on Productivity of Loblolly Pine in the Southern United States

Steven E. McKeand, North Carolina State University, Speaker
H. L. Allen,

Deployment of improved loblolly pine (Pinus taeda L.) genotypes across the southern United States is standard silvicultural practice. Virtually every one of the 1.2 billion loblolly pine seedlings planted each year is the result of one of the tree improvement programs in the South (McKeand et al. 2003). Most of that planting is with open-pollinated (OP) families from first- and second-generation seed orchards. These OP families typically display remarkable rank stability for productivity and quality traits across a range of site characteristics, climates, and silvicultural systems. Open-pollinated families are genetically heterogeneous and appear to be well buffered to environmental extremes. Families that do well on one site usually will do well on all sites within a climatic zone with few exceptions. To date, management decisions have been fairly simple as to where to plant OP families and how to manage them in different silvicultural systems.

Intensive management of plantations of genetically improved loblolly pine in the southern United States is having a dramatic impact on forest productivity and financial benefits. Forest managers have recognized that intensive plantation silviculture is like agronomy; both the plant and the soil need to be actively managed to optimize production. When the best genetic material is planted and given the necessary resources to grow, mean annual increments of 20 m³ ha⁻¹ yr⁻¹ can be readily achieved on many sites (Allen et al. 2005). There are few other regions in the world where the use of integrated silvicultural systems that include the manipulation of site resources, management of stand density, management of pests, and use of genetically improved planting stock is having as positive an impact on plantation productivity. Today’s plantations are growing more than twice as fast as plantations of the previous rotation.

Most planted hectares are receiving some form of chemical and/or mechanical site preparation to reduce competing vegetation and improve soil conditions to ensure excellent survival and early growth of the planted pine. In addition, most plantations are also receiving at least one and sometimes up to four nutrient applications to ameliorate widespread nitrogen and phosphorus limitations. Thinning is now commonly practiced to increase the production of sawtimber in rotations that typically range from 22 to 28 years.

Foresters have recognized that the largest responses to resource manipulation such as nitrogen fertilization usually occur on poorer sites (Allen, unpublished data). An example is given in Figure 1 where the most responsive site to fertilization was the site with the poorer inherent volume growth (low volume growth on control plots). In contrast, genetic gains typically have the greatest impacts on the best sites (e.g. McKeand et al. 1997). The percentage increase of a good family vs. an average or poor family may be the same across sites with different productivities, but the absolute increase in volume is highest on the best sites (Figure 2). These 2 simple examples illustrate that productivity gains can only be optimized when tree improvement is an integral component of the silvicultural system for managing plantations, and when the forest manager understands where the greatest benefits arise from resource manipulation and/or genetic inputs.

Top Quality Sustainable Eucalyptus Plantations

G. D. S. P. Rezende, Aracruz Celulose S.A., Speaker
Ergilio Claudio-da-Silva, Jr., Aracruz Celulose S.A.

Starting to Lose It - Virtual and Real Wood Loss Before the Pulping Process

John R. Wood, Info-Wood Inc., Speaker
A Device and Rapid Method for Estimating the Screened Pulp Yield from Overthick Wood Chips Subjected to Compression Roll Treatment

Benjamin Levie, Weyerhaeuser Company, Speaker
Gevan R. Marrs, Weyerhaeuser Company

Mill data and laboratory cooks have demonstrated that screened pulp yield is increased by compression roll treatment of the overthick fraction from sawmill or chip mill produced wood chips. Compression treatment that is too harsh however can result in undesirable fiber damage; too gentle of treatment will not fissure the chips and give the expected yield increase. Traditional methods of chip size classification testing are incapable of discerning the degree or effectiveness of fissuring treatment of overthick chips because the overall chip size distribution doesn’t change measurably as it does in chips treated by a chip slicer or other size reduction process. A patented test device and test method is described that analyzes overthick chips directly for their water absorption rate characteristics, and this property has been found to correlate well with screened pulp yield. This method allows rapid and inexpensive testing of the effectiveness of treatment of fissured overthick chips, providing the information necessary to optimize initial compression roll settings and maintain good performance over time.

Chip Quality - The Good, The Bad, and The Money

Greg R. Stone, Longview Fibre Company, Speaker

Never before at Longview Fibre Co. has chip quality been passionately pursued by uniting intense sampling, statistical methods, and tremendous perseverance. Longview Fibre has implemented a new program designed to obtain uniformity across the mill’s entire wood chip supply. Suppliers are being educated and trained on an individual basis in an effort to optimize chip production at each source. Ultimately, savings in the wood basket are projected to be 12% due to increased chipper and digester yield.

Turning Chip Quality Data into Results

Gary A Cochran, International Paper, Speaker
Steven B. Jones, International Paper

International Paper Company operates an extensive integrated chip quality sampling program, possibly the world’s largest of its type. The program covers International Paper’s 20 US pulpmills and 23 sawmills, as well as approximately 400 independent suppliers, and is designed to improve the quality of fiber delivered to all of its paper mills. Although IP has emphasized improving chip quality for many years, the program in its current structure started in 2000 to align all of the facilities that had joined the IP during the last ten years. A focus since then has been on establishing a strong foundation by installing statistically valid chip collection procedures and utilizing consistent analysis techniques. Sampling and testing equipment have been installed in all locations and standard procedures have been implemented with the objective of which meeting or exceeding relevant industry standards. Wherever possible TAPPI approved test methods are utilized. This emphasis has been was critical in ensuring chip quality data are reliable so International Paper Company personnel can then take corrective or improvement action with confidence.

The presentation will provide a description of the procedures and processes the International Paper’s Chip Quality team go through to support both customers and suppliers. It will then outline some of the remaining challenges, then propose a program future state.

The Top Ten Factors in Kraft Pulp Yield

Martin MacLeod, , Speaker
Zap Cooking with New Liquors from BLG-Recovery System
Leelo Olm, STFI, Speaker
Disa Tormund, STFI
Niklas Berglin, STFI- Packforst AB

Pulp yield in Kraft-based processes such as Kraft and polysulfide cooking with and without AQ addition, can be improved considerably by using the ZAP cooking technique. ZAP means Zero effective Alkali in the Pre-treatment stage, i.e. pre-treatment with liquor containing mainly HS⁻, SnS2⁻ and/or AQ, but no OH⁻. In the most favourable case, ZAP-Kraft-AQ cooking, the yield improvement is approximately 4 % on wood compared to 1 % in the conventional Kraft-AQ process, at an AQ charge of 0.1 % on wood.

ZAP cooking requires a sulfur-rich and alkali free pre-treatment liquor. Black liquor gasification makes the separation of sulfur and sodium possible. However, the sulfur-rich liquor produced in a BLG recovery system contains also hydroxide and carbonate ions. The calculations of the compositions of the available liquors from BLG-system showed that with a good process design the hydroxide and carbonate concentrations in ZAP liquor would be sufficiently low to attain the desired yield improvement.

The laboratory cooking experiments clearly show that the final pH (25 °C) in the ZAP pre-treatment stage has a strong influence on the pulp yield. By addition of sulfuric acid to the ZAP stage, the pulp yield at a given kappa number can be improved significantly.

ZAP pulps require slightly more bleaching chemicals but are easier to beat reaching higher tensile index values. The optical properties are unchanged.

In this paper following aspects of ZAP cooking will be discussed: composition of ZAP liquor from BLG system, pulp yield, bleachability and strength properties of fully bleached pulps.

Impact of Cooking Conditions on the Hardwood Pulp Yield and Physical Strength
Nam H Shin, Andritz Inc., Speaker
Bertil C. Stromberg, Andritz Inc.

Two laboratory studies using multiple white liquor additions and multiple black liquor extractions were carried out to investigate the impact of cooking conditions on Eucalyptus pulp yield and physical strength. Results from the first study (alkali profiles at a constant cooking temperature) indicate that cellulose yield shows a good correlation with pulp yield and is significantly affected by alkali profiles. A higher alkali charge to the impregnation stage shows the most negative impact on cellulose yield. There is no significant difference in xylan yield between different alkali profiles. In addition, it was found that xylan content does not correlate with the pulp yield. The results from the second study indicates that cooking temperature does not affect the pulp yield and HexA content at a given kappa number but lower pulp viscosity is obtained from a higher temperature cook. The positive effect of higher H-factor at a higher cooking temperature on pulp yield, pulp viscosity, and HexA content is also reported.

The variation of cooking conditions does not affect brownstock tensile index, but do have an effect on bleached pulp tensile index. Both brownstock cellulose yield and pulp viscosity show a linear correlation with tensile index. However, brown pulp cellulose yield shows a better correlation than pulp viscosity. Xylan content of pulp does not show any effect on tensile index of either brownstock or the bleached pulp. In contrast to tensile index, both cellulose yield and pulp viscosity do not show any relationship with tear index. In addition, the bleached pulp tear index can be predicted by the brownstock tear index.

Key words: White liquor profile, brownstock, Xylan, Cellulose yield
Wood price is one of the dominant cost factors for a pulp mill, therefore, pulp yield has a major impact on the competitiveness of a mill. However, in order to optimize pulp yield, for example by changing operating conditions, introducing additives, and/or using different wooden raw materials, a mill must be able to monitor the pulp yield accurately. Traditionally, pulp yield is estimated based on wood usage and pulp sales data covering a period of 3-6 months to eliminate the dynamics of the mill operation. However, this approach can not be used to monitor yield changes properly due to the imprecision in both wood consumption and pulp stocks fluctuation. On the other hand, it is not conceivable to perform mill trials for such long periods to compare the pulp yield gains due to wood or process changes.

This presentation is divided in two parts. In the first part, the different pulp yield estimation methods available in the literature will reviewed, including direct and indirect methods. Particular attention will be given the a pulp yield measurement method based on a theoretical relationship between alkaline pulping yield and the mass fraction and degree of polymerization (DP) of cellulose in pulp by the authors. This relationship is derived from the cellulose mass balance and kinetics of the alkaline hydrolysis, peeling and stopping reactions of cellulose and has been successfully tested for cotton (as cellulose model) and some pure wood species for soda, soda-AQ, kraft, kraft-AQ, polysulfide and polysulfide-AQ pulping.

In the second part of this presentation, the advantages and the difficulties of using fast prediction methods for the pulp yield estimation, especially near infrared spectroscopy (NIRS), will be discussed. This topic will include the direct pulp yield prediction from wood NIR spectra and indirect pulp yield estimations, for example, by using this technique to estimate the chemical composition of both wood and pulp from NIR spectra or as a tool for fast estimation of the input parameters for the equation mentioned in the previous paragraph.

The wood cost dominates the production cost of alkaline pulp. Thus, it is highly desirable for a mill to increase pulp yield, for example by changing operating conditions or by adding additives like anthraquinone. We have developed a new pulp yield method, called the University of Maine Yield Prediction Method, which allows a mill to monitor pulp yield accurately. The method calculates the alkaline pulp yield based on the analysis of mill pulp samples and a theoretical "calibration" equation. The calibration equation relates the pulp yield to the mass fraction and degree of polymerization of cellulose in pulp. The University of Maine Yield Prediction Method is an extension of the so-called Y诚意 Method, and takes into account the cellulose loss due to the alkaline peeling reaction. The method is suitable for optimization and quantification of the pulp yield increase at the mill level. The quality control procedure for the University of Maine Yield Prediction Method will be described, and examples of pulp yield measurements at different mills before and after addition of anthraquinone will be described.
Using Paperican's Mannose Method to Measure Yield Gains at Kraft Pulp Mills
Richard M. Berry, PAPRICAN, Speaker

Accurately measuring pulp yield gains in kraft mills, particularly those with continuous digesters, is challenging. Chip-to-pulp inventory, liquor analyses, and “hanging basket” measurements (in batch digesters) have their places in assessing yield, but they also have limitations. Some of these limitations can be overcome by using methods that follow the changes in the carbohydrate concentrations of kraft pulps caused by changes in process chemistry. The methods that assess pulp yield using carbohydrate measurements potentially allow people in mills to take samples of pulp, make off-line measurements, and predict the yield with good accuracy.

Working with several mills running trials of modified pulping chemistries, we found that the Mannose Method (where the change in mannan concentration of the pulp is followed) works well for measuring changes in pulp yield. The cases include polysulphide-AQ, kraft-AQ, and a change between different modes of operations of modified kraft pulping.

Opportunities in the Screen Room
Brian J. Gallagher, P.E., GL&V USA Inc., Speaker
Anthony Herrington, Andritz

The Effect of Digester Kappa on the Bleachability and Yield of EMCC ™ Softwood Pulp
Peter W. Hart, MeadWestvaco Corporation, Speaker
Daniel Connell, EKA Chemicals Inc.

The purpose of this work is to determine the effect of brownstock kappa on the bleachability of softwood EMCC kraft pulp. We conducted a laboratory bleaching simulation of nine softwood pulp furnishes covering a range of kappa numbers from 12.5 to 33.5. All pulps except one were produced by lab simulation of EMCC pulping conducted by Evadale technical staff. One pulp was taken directly from the mill decker directly before entering the bleach plant. This pulp was used as a comparison with the lab produced pulps. The sequence simulated was XD0(EP)D1P, where X is the enzyme stage performed with xylanase.

We successfully modeled the response of screened yield to digester kappa based upon this work. The bleachability of the pulp was then modeled based upon the lab bleaching. From these models we are able to predict brightness, yield and final bleached viscosity based upon digester kappa and ClO2 charges in the D stages. We found that for final brightness targets below 88 % ISO the 35 kappa is most cost effective. However, as brightness targets are increased the optimum kappa for variable cost will shift lower. A 21 kappa is most cost effective at a 90 % ISO brightness target. The effects of recovery cycle solids loading and fiberline throughput were also explored. We conclude that a mill which is recovery boiler limited and desires higher fiberline production would be justified in running a digester kappa as high as 35 even at a high final brightness target.

Green Liquor Pretreatment with Thiocarbamide to Increase Yield
Lucian A. Lucia, North Carolina State University, Speaker

The process of green liquor (GL) impregnation of wood chips before a cook has been shown to provide significant chemical, energy, and pulp quality benefits. Remarkably, these benefits can be drastically amplified upon inclusion of an organic additive to the GL during the pretreatment. Thiocarbamide, when added at the front end of a GL impregnation, has been shown to improve chemical and energy savings by 30-50% over what is observed with neat GL, but in addition, it has provided significant yield benefits on a dry wood chip mass basis of up to 5%. This presentation will overview some of the benefits of GL/thiorcarbamide pulping with a focus on the yield benefits.

Session Chair
Patrick W. Ortiz, Longview Fibre Company
Much research over the past 25 years has shown that using polysulfide (PS) liquor instead of the white liquor normally used in kraft pulping results in increased cooking yields. Adding AQ to the digester increases that yield further, sometimes even synergistically. Gaining pulp yield has been the focus of PS research, and the perception in the industry is that is the only real economic benefit for implementing a PS/AQ cooking strategy. This presentation will look outside the box and show how we can use this new technology in another way -- lowering operating costs instead.

Today, with a relatively weak pulp market and mills often operating at lower-than-design capacity, it seems counter-intuitive to implement a system that is perceived only to increase production. Yet that is what we are recommending, although in today’s market we suggest the mill should focus on lowering operating costs first and when the market finally does become tight again, shift the operation into high gear and then produce more pulp. This can be done by simply installing both polysulfide and AQ systems and initially target for lower digester kappa number, without worrying about overloading the recovery boiler with more black liquor solids or having to compromise on lower pulp strength.

If your bleached softwood mill is operating at below its nominal capacity due to the poor market (e.g., it produces 32-kappa pulp today), this can be reduced to 25 kappa without any loss in pulp strength properties. Mills could do this on their own if it weren’t for the loss in yield that accompanies the lower kappa number. That is where cooking with PS/AQ comes into the picture. In fact, the typical PS concentration produced today along with some AQ can actually produce more yield than what is lost at the lower kappa number. In other words, the mill can save wood too. Note that the same argument can be made for hardwood pulps between kappa 20 and 15. But the real benefit comes with the lower kappa pulp requiring substantially less bleaching chemicals, meaning even lower operating costs. This strategy would also be very helpful for mills with over-loaded ClO2 plants. Plus there is a significant reduction in the AOX/COD/BOD/color load to the mill’s effluent treatment system.

What if it is a brown mill making linerboard or unbleached kraft paper? There are no bleaching savings to be made here. Again, looking out the top of the (corrugated) box, even without incremental capacity increases, there may be other benefits that a PS/AQ system would address. PS/AQ would be very economical for incremental capacity, but in poor market conditions capacity might already be excessive, so would there be any advantage to implementing PS/AQ? If asked why linerboard mills would like to lower their digester kappa number, one answer would be that the pulp will have a lighter color and less rejects to refine or handle. The negative aspect is that the yield loss would cost too much in wood. But with PS/AQ, yield would be retained despite lower kappa number. This strategy is especially elegant for linerboard mills that have already taken the penalty to cook to a lower kappa for its other benefits. By implementing PS/AQ, there will be a significant yield increase plus lower H factor (less steam) and lower alkali charge.

For mills that are fortunate to have a slight excess recovery boiler capacity, PS opens even more doors. They may already have been burning black liquor for other mills. With the recent and anticipated future increases in energy costs, they can use PS to decrease their own liquor generation, and increase the amount they burn for other mills. This saves this wood costs while maximizing the recovery boiler to generate steam from wood cooked at their neighboring mills. We will present other strategies that could also be used to increase the heat load in an underloaded boiler.

This presentation will explore these and other facets of implementing PS/AQ in bleached and unbleached kraft mills.
The Impact of AQ and AQ in Conjunction with a Penetrating Aid on Pulp Yield
Peter W. Hart, MeadWestvaco Corporation, Speaker
John C. Ransdell, MeadWestvaco Corporation

A statistical central composite experimental design with three variables at three levels was employed to determine the impact of both AQ and AQ in conjunction with a penetrating aid on pulp yield. The three factors (and their levels) selected for this experimental design were chemical additive (0.02%, 0.06%, 0.10%), H-factor (800, 1000, 1200) and alkali charge (16.5%, 19.25%, 22.0%). Other pulping parameters were held constant at the same levels as for the baseline cooks. The study employed well characterized hardwood chips and produced bleachable grade pulps at various kappa numbers. Both screened and unscreened yield were evaluated. Process economics were also considered.

In general, both additives produced substantial and statistically significant improvements in pulp yield. Less AQ was required when it was used in conjunction with a penetrating aid.

Green Liquor Pretreatment with Thiocarbamide to Increase Yield
Lucian A. Lucia, North Carolina State University, Speaker

Discussion topics:
*Measuring yields outside mills
*Measuring yields inside mills
*Complete fiber mass balances and supply chain modeling
*Best practices in chip making and chip screening
*Better trees/better forests for better yield?
*Digester additives - best opportunity to improve pulping yield?
*Digester systems and cooking techniques for optimal pulping
*Opportunities for yield enhancement in oxygen delignification and bleaching
*Minimizing non-fiber-producing contaminants
*Determining what's on a log truck or in a chip van
*Chip quality vs. chip value

Session Chair
Martin MacLeod