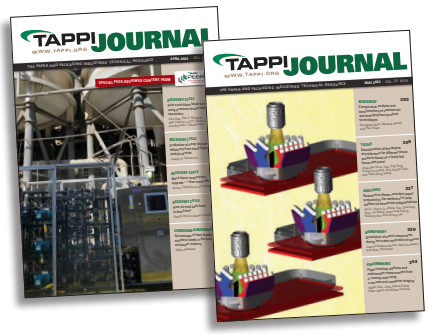
Summaries from *TAPPI Journal* April and May 2023



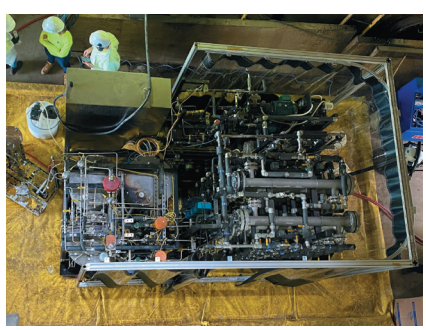
The papers summarized here are from *TAPPI Journal*'s April 2023 special issue with peer-reviewed research from the TAPPI PEERS Conference and the May 2023 issue. *TAPPI Journal* is an online, open access publication of relevant and timely peer-reviewed research. To receive *TAPPI Journal*, visit tappi.org/subscribe or search the archive of previously published papers at tappi.org/tj. Authors can submit research for publication in *TAPPI Journal* at tappi.org/tjsubmit. There is no fee to publish and copyright remains with the authors.

APRIL

RECOVERY CYCLE

Pilot scale black liquor concentration using pressure driven membrane separation

Sam Rae, Ella V. Richards, Max Kleiman-Lynch, Brent D. Keller, and Brandon I. Macdonald



Overhead view of membrane system for black liquor concentration at a deployment site.

Black liquor concentration using pressure driven membrane separation has long been proposed as a way to achieve energy savings and break production bottlenecks. To date, limitations in membrane performance and stability under black liquor process conditions have prevented those promises from being realized outside of tightly controlled laboratory settings.

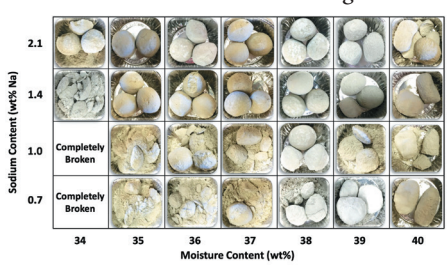
In this work, researchers describe the first successful pilot scale field deployments of a membrane system for black liquor concentration. Using a purpose-built system and commercial sized, spiral wound graphene oxide membrane elements, researchers logged nearly 6,000 hours of runtime across deployments to multiple mill sites. They demonstrate concentration of black liquor from 14 percent to more than 20 percent total solids, while generating permeate water comparable in quality to that of evaporator condensate and an 81 percent reduction in energy consumption relative to evaporation.

At a commercial scale, these results translate to US$2 million/year in net energy savings for a typical mill, as well as an opportunity to support production increases or mill expansions. These results represent a significant leap forward in the ability of membrane systems to deliver substantial value via black liquor concentration.

RECOVERY CYCLE

How do mud balls form in lime kilns?

Patrick Hinton-Barber and Honghi Tran



Effects of moisture and sodium contents on mud ball stability.

Mud ball formation in lime kilns has been a persistent problem in many kraft mills, particularly for older kilns that are equipped with chains. A systematic laboratory study was conducted to examine how mud balls are formed and the key factors that affect ball formation.

Results confirm the general mill experience that high moisture and high sodium contents in lime mud are the main contributing factors to ball formation. The high moisture content allows lime mud to agglomerate and grow to form balls, while the high sodium content helps the balls harden and retain their shape. A ball formation mechanism is proposed to explain how mud balls form and grow near the kiln feed end.

Understanding the mechanism and thresholds of moisture and sodium contents required to form hard mud balls can help mills develop viable operating strategies to alleviate the problem.

CORROSION & MATERIALS

Advantages of lean duplex stainless steels in the pulp and paper industry

Mikko Palosaari

Constructed in 2004, one of the first process tanks using lean duplex 1.4162/2101. It is at Stora Enso's mill in Imatra, Finland.

The performance of lean duplex stainless steels has been utilized by the pulp and paper industry since their introduction to the market almost 20 years ago. This group of stainless steels has exceptional performance in, for example, alkaline environments towards typical deterioration mechanisms, i.e., uniform corrosion and stress corrosion cracking.

The chemistry of the "lean" duplex steels is designed so that the content of volatile and expensive elements like nickel and molybdenum can be reduced to an absolute minimum without sacrificing technical performance. This reduces the raw material cost and most importantly provides predictability of the steel price. Thanks to a dual phase microstructure and high nitrogen content, lean duplex steels have at least two times higher strength compared to standard austenitic stainless steels. In pulp and paper construction, this enables lighter structures and less material to be used.

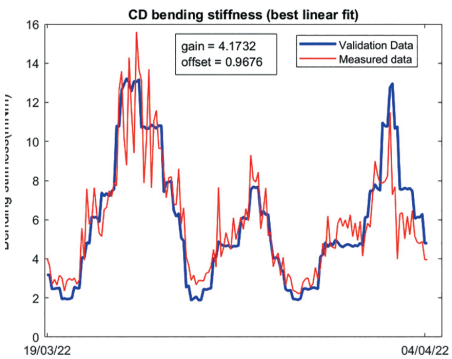
Today, lean duplex steels are widely available in various dimensions, from thin cold rolled sheets to thick hot rolled plates. Lean duplex steels are also fully recyclable after the decommissioning stage of the equipment, thereby contributing to the circular economy. They provide both technical advantages and cost predictability when used as construction material for typical pulp and paper process equipment.

MAY

PAPERMAKING

Paper bending stiffness and web tension measurement from a running web using a vacuum and computer imaging

Mikko Salo, Anna-Leena Erkkilä, Matti Vilkko, and Mikko Kanerva



Online measured CD-specific bending stiffness (mNm) with gain and offset vs. laboratory results of bending stiffness. The fluctuation in time from manufacture of different grades.

The authors introduce a novel method for measuring the bending stiffness of paper online during manufacturing. The method uses photometric stereo imaging to detect the shape of the deflection surface caused by a controllable pressure difference over the paper's surfaces. The hardware for the measurement is based on a combination of two existing sensors. The deflection and loads are tied together by the governing differential equation for the bending of an orthotropic elastic plate with selected simplifications. An approach to resolve material parameters and in-plane loads without knowledge of traditional boundary conditions is suggested.

The presented method was tested in a paper mill during manufacturing. For bending stiffnesses measured online, correlation coefficients 0.88 and 0.92 were obtained compared to state-of-the-art laboratory measurements. However, the results gained from a moving web are noisy and the data require correction of the slope and an offset. Several issues must be resolved before the method can be considered as an accurate measurement for industrial use, but the theoretical background, the performance of online implementation, and the results are promising.

This study introduces a proposed novel method for measuring paper bending stiffness. The study is related to the field of papermaking, as online strength measurements have been studied in the past, but not widely accepted for use by the industry.

BIOREFINERY

Dissolution of wood components during hot water extraction of spruce

Joanna Wojtasz-Mucha, Merima Hasani, and Hans Theliander

The purpose of this study was to investigate the autohydrolysis of softwood, which is the main chemical operation in both hot water extraction and steam explosion. Control of the process and monitoring its course were ensured by the careful choice of experimental setup and conditions: a milled spruce material was extracted in a small flow-through reactor to minimize degradation of the dissolved material and to enable analysis of the resulting liquors extracted at selected time points. The obtained liquid and solid fractions were analyzed for sugar composition and acetic acid concentration. The results showed that partially degraded hemicelluloses were extracted; hemicellulose side chains were cleaved off and detected as monomers, while deacetylation was limited. Chain scissions of cellulose were observed as a result of autohydrolysis.

This study focuses on understanding autohydrolysis and revealing the structural changes that occur in hemicelluloses and cellulose. This information could be used when designing and tuning pretreatment steps aimed at recovery of hemicelluloses prior to pulping.

TISSUE

Quantification of the degree of preference for different tissue products based on a hand-felt tissue test panel

Chao-Ben Gwo, Tser-Ying Teng, Ching-Ho Chang, Shih-Sheng Chen, and Yuan-Shing Perng

In this study, researchers successfully established a quantification model to determine the preference (PF) for different tissue products based on the results of a hand-felt tissue testing panel. The panel ascertained that products designed with four-ply tissues provided higher total tensile strength (TTS) and hand-felt surface softness (HSS) than did those of the three-ply, two-ply, and single-ply products.

When practically tested with a tissue softness analyzer (TSA), the four-ply tissue product had a softness (TSA-HF) advantage; however, in human panel tests, more than half of the participants could not be sure of the hand-felt bulk softness (HBS) of the four-ply tissue product. This was mainly because when using the four-ply tissue, the hand-held test pad gave an overall perception distinctly different from those of the hand-held two- or three-ply products, which also differed from the flattened state of test pieces used in the instrumental softness tests. Users could distinctly feel that a product was stronger (better TTS) and more comfortable (higher HSS). Thus, the fourply tissue product was accorded a higher preference.

The test method developed in this study can also be applied to other related industries that involve human perceptions or feelings. Based on the specific quality item, product adjustment and optimization could be carried out so that the products could gain the preference of specific consumer groups.

Other Research Appearing in *TAPPI Journal*'s April and May Issues

RECOVERY CYCLE (April)

Evaluation of soap recovery efficiency from black liquor—analytical tools

Joseph E. Bohannon

RECOVERY CYCLE (April)

Black liquor evaporators upgrade—How many effects?

James Cantrell and Jim Straka

BIOENERGY (May)

Comparative analysis and benchmarking of commercial and emerging fast pyrolysis technologies

Paul Stuart, Marzouk Benali, and Georgiana Bele

ADDITIVES (May)

Research on flame-retardant paper prepared by the method of in-pulp addition of ammonium polyphosphate

Yao Li, Kexin Liu, Zhiwei Yao, Guisheng Zhou, Yu Meng, Shancong Huang, Ruidong Pan, and Xinxing Xia