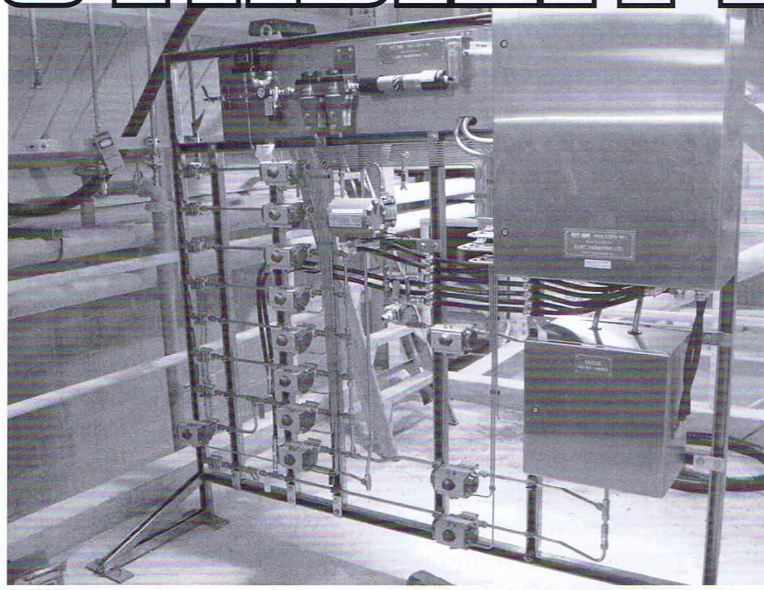
Seeking STABILITY

Canfor Pulp and Zellstoff Celgar share their experiences with recent process control upgrades. The investments have reduced the variability of several key inputs.

By Cindy Macdonald, editor

Zellstoff Celgar has implemented a number of process control upgrades that are contributing to more stable operation of the chemical recovery cycle and the digester. Located in Castlegar, B.C., Zellstoff Celgar is a single line kraft mill and producer of renewable power. The mill received significant upgrades in 1983 and 2012. It is currently producing 490,000 ADT of pulp and 521 GWh of power, with a goal of increasing pulp production to 540,000 by 2018.



Celgar's FITNIR Analyzer sampling skid. Photo courtesy FITNIR Analyzers Inc.

Start at the beginning: wood chip analysis

Use of the Cook-X control solution from Texo Consulting and Controls, together with the Chip Management System (CMS) developed by the Centre de Recherche Industrielle du Quebec (CRIQ) has allowed Zellstoff Celgar to stabilize digester operation. Most of the mill's variation in wood chip moisture and dry bulk density can now be attenuated.

The implementation of the new measurement and control scheme is described in a paper presented at PAPTAC's PacWest Conference in June 2013, *Improved Continuous Digester Controls using Wood Chip Analyzer at Zellstoff-Celgar*, by Joe Chircoski of Zellstoff Celgar, and Mario Leclerc and Laurier Morissette of Texo Consulting & Controls Inc.

The authors note that modern kraft mills measure almost all key inputs and variables for their process, yet wood chips are largely left unmeasured. In order to obtain an on-line, real-time dry bulk density measurement, they say, you need three different measurements: moisture, volume and mass. Measuring wood chip moisture in real time is challenging because it subjected to several different variables, including color changes and ambient weather.

Zellstoff Celgar chose to use CRIQ's Chip Management System to provide information for Texo's Cook-X technology. The authors explain that control algorithms were developed in a collaborative effort with Zellstoff Celgar's digester operation personnel.

"There was no need to resort to advanced process control (APC) tools such as model predictive control (MPC or any variant) or fuzzy logics to achieve improvement in digester control. The Cook-X technology is deployed under licence directly into the mill DCS, which is an ABB Bailey Infi90."

Chip volumetric measurements were installed on each conveyor near the discharge of each silo to help stabilize the desired wood chip recipe. A volume control at the chip silos has reduced variability on chip bin level by some 20%, the paper reports.

"The CMS information (temperature, moisture, mass) allows maximizing the flash steam usage, if available, to a maximum of 20,000 kg/hr. Since Zellstoff Celgar exports electric power, this is equivalent to 2.5 MW of extra green power produced from the displaced fresh steam."

The most noticeable benefit of the new control scheme, say the authors, is a 55% reduction in atmospheric venting of diluted non-condensable gases (DNCG).

One of the most important parameters for a hydraulic digester is the liquor-to-wood ratio. The ability to correctly adjust the liquor-to-wood ratio has largely attenuated changes in wood chip moisture imposed by the wood room operating schedule. The moisture level can change by up to 10% in 30-45 minutes at the time of wood room start-up, because of the processing of river logs.

The authors note that it has always been a struggle to maintain both impregnation and digester level, since both level controls are dynamically coupled. Using the CMS information, "a breakthrough was made that allows the level of the impregnation vessel to be maintained at target all the time." Residence time in the impregnation vessel is maximized.

Likewise, the new control system presents a way for the digester level to be maintained within range. Large variations of 10-15 kg/m^3 in dry bulk density can be dealt with within the digester.

Under the previous fixed chip meter operation, the authors explain, the maximum allowable production rate was curtailed to avoid excessive production rate when dry bulk density ran high, resulting in a kappa number range from 35 to more than 40.

Smoothing out the chemical recovery cycle

Since 2012, Zellstoff Celgar has been using a Fourier-Transform Near Infrared Spectrometer (FT-NIR) analyzer to measure the chemical constituents of various liquor streams in the recovery area of the mill. The mill also employs the Caust-X advanced process control system from Texo.

The use of these two tools to reduce variability in white liquor properties is discussed by Irene Coyle, and Shaun Russell of Zellstoff Celgar, and Vivek Rajbhandari, Mario Leclerc, and Laurier Morrissette, Texo Consulting and Controls Inc., in *Improving Smelt Dissolving Tank TTA Control at Zellstoff Celgar*. This paper was also presented at PacWest 2013.

Smelt dissolving tank process control is part of the Caust-X advanced process control solution from Texo. It aims to stabilize the raw green liquor TTA using a continuous TTA sensor and controller. A TTA saturation algorithm allows the process to run close to the saturation limit of RGL TTA strength.

The results benefit the mill, the paper explains, with a stable and increased white liquor strength at the re-causticizing process.

The existing controls at Zellstoff Celgar use nuclear density analyzers to provide measurements to the density controllers. The operator specifies the target density sepoint for the green liquor outflow, which modulates the weak wash flow into the smelt dissolving tank. To compensate for problems with measuring density, the operator has to make frequent adjustment to the density setpoint based on the TTA lab test.

A parallel TTA controller has been installed at Zellstoff Celgar. The system provided by FITNIR Analyzers provides periodic TTA measurements of the RGL sample analyzed using FT-NIR spectroscopy technology.

"The TTA soft sensor uses this periodic TTA measurement to update the TTA-density relationship model. The resulting TTA prediction from the soft sensor is robust and reliable and therefore stable RGL TTA control is achieved," the authors note.

Comparing RGL TTA before and after implementation of Texo's smelt dissolving tank control strategy, an average increase of approximately 2 gpl in raw green liquor TTA was observed. The authors say this was achieved due to the ability to run the smelt dissolving process close to the saturation limit for RGL TTA concentration.

Improved control and faster response

A more thorough look at Zellstoff Celgar's recovery control upgrades is provided in the paper *Improved Causticizing Control using FT-NIR Analyzer and Caust-X Controls at Celgar Pulp*, by Irene Coyle and Shaun Russell of Zellstoff Celgar, Thanh Trung of FITNIR Analyzers Inc., and Vivek Rajbhandari, Mario Leclerc, and Laurier Morrissette, Texo Consulting and Controls Inc. This paper was also presented at PacWest 2013.

Zellstoff Celgar is using a FT-NIR to provide information which is then used to control the green liquor TTA,in the dissolving tank and causticizing areas, and to control the white liquor (WL) causticizing efficiency (CE). The paper notes the following results since commissioning the system: an increase in CE, a reduction in the standard deviation of white liquor effective alkali, production of a more consistent cooking liquor, and faster response to changing mill requirements.

The installation of an on-line analyzer and advanced process control system in the chemical recovery cycle was seen as a way to reduce the risk of the recausticizing process becoming a bottleneck to production. The paper explains that Zellstoff Celgar asked FITNIR to implement a six-stream analyzer system to provide complete liquor composition determination as well as solids content.

The FT-NIR analyzer from FITNIR measures raw green liquor, weak wash, CGL, causticizer 1, causticizer 4 and WL.

The Castlegar mill also uses Caust-X, an advanced process control solution developed by Texo and FPInnovations.

Describing the results, the authors state there has been "a continual improvement in the WL EA with a large decrease in the standard deviation of the product strength. The CE standard deviation has also improved and CE increase with variability reduction by as much as 42%."

By improving the stability of the RGL at the dissolving tank, they explain, less variability is seen at the outlet of the green liquor clarifier feeding the slaker, and better control of the causticizing process was realized.

The CE improvements that Celgar has observed would have decreased carbonate dead load by 22 kg/t of pulp, the authors calculate. "Since $CaCO_3$ is the dominant dead load in the system and a serious contributor to scale in the digester system, this reduction in dead load will have a direct financial benefit."

The reduction in energy required to evaporate the water that is associated with the dead load could lead to further savings, the authors state.

They conclude that Celgar's use of on-line analysis of liquor compositions and advanced controls has achieved improvements in WL EA and CE, and a more stable recaust operation (40 to 50% less process variability). CE improved from 79 to 82%. They believe the combination of the FITNIR analyzer and Caust-X system will enable Zellstoff Celgar to move toward advanced process control of the wood-to-liquor ratio at the digester.

Brownstock wash control yields significant savings

Canfor Pulp's Northwood mill has achieved more stable and efficient brownstock washing as a result of replacing the existing control algorithm at with model predictive control. The experience was described at PacWest in a paper titled *Brownstock Washing Optimization Using Model Predictive Control*, by Aaron Shields, Dan Laing and Chris Roberts.

According to the authors, "the MPC system was found to be superior to a conventional control system, having much higher utilization, and yielding savings of about $700,000 per year."

The mill has two production lines manufacturing high-brightness NBSK pulp. Historically, the mill has been recovery limited, so the brownstock washing lines have generally been run to match the evaporator feed rate, the authors explain. A major recovery boiler rebuild in the summer of 2011 included maintenance on the evaporators, increasing their capacity. However, operators still tended to wash to the recovery limit, frequently resulting in very weak WBL.

As part of the controls upgrade, each production line added a refractometer to measure the solids content of liquor sent to the recovery area. These were calibrated in Baume.

The authors note that the overall project objective was to minimize the total cost of bleaching carryover, soda losses and WBL. It was decided to use solids concentration as the highest level of control. The group also decided to add wash ratio controllers as a middle level of control, to provided feedforward action during production rate changes and to act as limits on the outputs from the MPC.

They explain that goal setting in brownstock washing is complicated because some of the controlled and constrained variables may contradict each other. Also, it is necessary to keep tank levels in a reasonable range, but they can be allowed to vary within that range. In the Canfor case, these goals settings are handled using setpoint ranges and priorities.

Since diffuser washing efficiency is higher at lower production rates, an effort was made to maximize the extraction flows by running to a differential pressure constraint. The Canfor team found some success (a slight increase in total extraction flow), but the diffuser operation became much rougher and more prone to plugging. The authors comment that the constraint may have been set too high, at 80 kPa, when it should have been 70 to 75 kPa. "However, at this lower limit, there was little to be gained in extraction flow, so the maximum extraction flow setpoints were reduced to their previous limits."

A cost model was developed as part of the control project, and used to evaluate different operating conditions. For example, for the "B" mill, it was found that "for high production rates, the diffuser and decker washers became wash flow limited, and it was economic to bypass them with the excess liquor."

On the "B" mill, the control system achieved a 45% reduction in solids (Baume) variability. Calculating wash savings after the control system was implemented, the authors conclude the average annual savings for the "B" mill to be about $500,000. For the "A" mill, annual savings were calculated to be $200,000. The control system achieved 27% less variability in this situation.

One of the pitfalls of this MPC is that it was not fast enough during major process upsets to completely reject disturbances. External logic was added outside of the MPC on a few controlled variables, the authors explain. "Adding in external logic to prevent process upsets allowed operators to have confidence in the controls and encouraged long uptime for the strategy."

The paper concludes: "Through WBL solids control, the MPC has given the mill an excellent handle to optimize the washing efficiency. Running to a more stable and slightly lower weak black liquor strength is saving the mill roughly $500,000 on "B" mill and $200,000 on "A" mill, primarily by reducing bleaching costs and soda losses."

For these two mills, reducing variability in the process has a positive effect, felt all the way to the bottom line. **PPC**