On-line analysis of dissolved substances in deinking and papermaking applications

Methods of dissolved solids management include pH and purging control

By T.M. Garver, H. Yuan, K.H. Boegh, G.S. Hill and J. Allen

**Abstract:** Instrumentation to measure dissolved solids in white-water has been employed to understand the sources and effects of accumulating contaminants. On-line measurements employed include conductivity, UV absorbance and derived measures of total and organic dissolved solids. Production rates, bleaching and pressing conditions dominate the contributions to dissolved solids of TMP and dinked pulp. The effects of dissolved solids are related to drainage and colloid stability. Methods of dissolved solids management include pH and purging control.

The effects of the quantity and composition of dissolved and colloidal substances on the drainage and paper machine cleanliness are well known, and have recently been under intense scrutiny as mills move to improve efficiency and reduce water use [1-9]. Both laboratory experimentation and mill experience have yielded an understanding that lower dissolved solids and less variation in dissolved solids improve paper machine runnability. Problems with the accumulation of dissolved solids are related to the destabilization of the white-water system, which can result in deposits and difficulties in managing chemical-retention programs. Dissolved solids can also reduce drainage, leading to a wetter sheet to the dryer and decreased wet strength [6].

We developed an instrument for the measurement and characterization of dissolved solids in pulp and paper process streams [10,11]. This instrument uses UV absorbance and conductivity sensors to measure the total, inorganic and organic dissolved solids. The instrument has an internal controller that maintains the instrument zero, dissolved solids calibration, instrument diagnostics and communication to mill operating systems. With the results from on-line measurement of dissolved solids we have documented the reasons for the relationship between dissolved solids accumulation and poor runnability. The effect of dissolved solids on drainage is substantial, in part because dissolved solids can interfere with floculation [4,12]. In this paper we compare the measurement of dissolved solids with process variables that relate to production, drainage and floculation. Dissolved solids contributions from dinked pulp (DIP) are discussed with the objective of managing and minimizing the detrimental effects of dissolved and colloidal substances from deinking processes. Alternatives for controlling dissolved solids through pH control at pulp presses, counter-current control and purging strategies are presented in this paper.

**Dissolved Solids: Measurement**

We have used a patented combination of conductivity and UV measurements to measure total dissolved solids, organic dissolved solids, and inorganic dissolved solids. Once calibrated, these analyzers provide a robust and reasonably accurate measurement of dissolved solids over long periods of time. A detailed explanation of the measurement has appeared in previous publications [10,11]. Measurements are taken on a micro-filtered (0.05 micron cut-off) sample from a cross-flow membrane filter. The UV absorbance at 280 nm and conductivity of the sample are measured directly. Measurements of total and organic dissolved solids are calculated using a combination of UV and conductivity measurements.

Results presented in this paper are from the dissolved solids analyzers at the following locations: on the white-water recirculation on PM5 (Valmet Twin Wire former, newsprint) at Bowater
Thunder Bay, ON; on the white-water recirculation at Alberta Newsprint in Whitecourt, AB.; and at the clear pressate from the acid twin-wire press exiting the deinking plant at Bowater Thunder Bay, ON.

DISSOLVED SOLIDS: SOURCES

The generation and removal of dissolved and colloidal substances is central to pulp-bleaching and pulp processing. Even without the addition of a lignin-removing pulp-bleaching agent, mechanical pulp mills can generate 40 to 100 kg of dissolved solids per ton of pulp produced. The dissolved solids in a mechanical pulp newsprint operation are derived principally from wood with additional contributions from pulp bleaching agents or added retention or drainage aids. Soluble extractives, hemicellulose and lignin derived from wood dominate the contributions to the organic dissolved solids that are detected with UV absorbance [11]. Increases in TMP production to the paper machine area will increase the organic dissolved substances as measured by the UV absorbance, Fig. 1.

Sources of inorganic dissolved solids include pulp bleach and acids or bases introduced into the system to control pH. During periods of intense bleaching, pulp bleaching can drive the accumulation of inorganic salts in a white-water system. Figure 2 shows the increase in conductivity as a function of the amount of hydrosulphite bleach (Y) added during a fall heavy bleaching period. In general, production variation will increase or deplete the different fractions of dissolved solids relatively equally, while production changes such as increases in bleaching or changes in pulp furnish or pH will affect the relative composition of different amounts of dissolved substances.

DISSOLVED SOLIDS: ITS IMPORTANCE TO PAPERMAKING

Under normal situations when a fixed amount of water enters a mill, an increase in production will increase dissolved solids. Dissolved solids will continue to increase until the inputs are the same as the outputs. Paper machine operators previously have not been able to measure and observe the accumulation and depletion of dissolved solids in the paper mill water systems. The relationship between dissolved solids, the stability of the white-water and paper machine is provided in Fig. 3, which trends lost time due to wet end breaks with total dissolved solids in paper machine white-water. Normally, when dissolved solids are at a high level the system is in an unstable state. In this unstable supersaturated state, minor upsets due to changes in temperature, pH, fines level or furnish can lead to significant deposition or changes in drainage. Often one break leads to another, because the fresh water can upset the delicate balance by changing the temperature, pH or ionic strength. Under these conditions a series of breaks will follow a period of good runnability. The solution lies in maintaining dissolved solids below the unstable levels and in minimizing the change in the upsetting variable (temperature variation for example) during an upset or a break.

Typically, dissolved solids are both the cause and effect of paper machine runnability. During good production runs, the dissolved solids in the system increase because more pulp is coming forward and the water is reused more. During breaks the forward pulp flow and the dissolved solids with it are stopped while excess fresh water is brought in to move the broke. Orccoitoma et al have discussed the dynamics of white-water systems during web breaks including description of the effects of web breaks on white-water temperature [13]. During periods of breaks the water system becomes leaner. A straight regression of dissolved solids versus runnability may then yield a correlation between good runnability and an increase in dissolved solids.
solids. This is an effect of the good production and not the cause. Figure 4, the start of a period of good runnability, is labelled with a circle at the TDS level and the start of a series of wet-end breaks is labelled with a square. These periods of runnability were determined using an average number of breaks over 24 hours. Marking the start of periods of good or bad runnability helps distinguish the cause and effect related to dissolved solids. Good runnability starts with low dissolved solids, but causes an increase in dissolved solids.

Understanding the link between paper machine runnability and dissolved solids levels requires analysis of the importance of dissolved solids to drainage and deposition on the paper machine. To better understand the relationship between dissolved solids and drainage, dryer steam is taken as a proxy for sheet moisture content. Figure 5 shows that dryer steam or sheet moisture trend well with dissolved solids.

This is because dissolved solids have a substantial effect on flocculation and drainage. Li and Kwok reported that dryer steam is an important predictor of sheet breaks [14]. We have examined many other drainage-related variables including flocculation, formation, draw, and Uhle and nip water flows. All of these variables relate to dissolved solids and indicate that increased dissolved solids decrease flocculation and slow drainage. Dissolved hemicellulose and anionic substances can decrease the effectiveness of retention aids decreasing drainage rates [15], and increasing water retention value [16-18]. Laboratory measurements with a dynamic drainage jar confirm that increased dissolved solids decrease drainage rates. Fig. 6. Drainage rate variation is due largely to changes in flocculation, which, in turn, substantially affects paper formation [19].

Drainage affects draw, a manually set parameter indicating the difference in speeds between two sections of the paper machine. Draw is a measurement that tells how hard the sheet must be pulled during papermaking. The importance of draw in determining paper machine runnability has been reviewed by Pikulik [20]. Too much pull decreases paper strength, and also the sheet can be pulled apart. When the sheet is wetter the draw must be increased to compensate for the weight and the additional propensity of the sheet to stick to the paper machine. We have found that dissolved solids and draw trend together reasonably well. Management of dissolved solids is necessary for stable draws.

**Dissolved Solids: Management**

The sources and sinks for dissolved solids, and its effects, can be managed. Optimization of counter-current flow and purging programs fall into this category [3]. Recent interest in the application of process simulation and water pinch technology to optimize counter-current flow holds some promise for understanding and optimizing water flows [21,22]. In general, the best white-water management policy is to limit and control the sources of dissolved and colloidal solids. Independent or counter-current water circuits with washing and pressing
between pulping, bleaching and papermaking is a well-known route to improving the cleanliness of the white-water in the critical papermaking area. One simple water control method is to set purge rates proportional to production rates, Fig. 7.

This must be done with supervisory control from the white-water chest level to maintain necessary water levels. Many mills have water systems that were constructed piecemeal over many years, containing streams that do not run counter-current or go to the drain while still very lean in dissolved and colloidal substances. Ensuring that water going to drain contains high concentrations of dissolved solids is an important step in optimizing water use. On-line dissolved solids measurement provides a means to analyse the accumulation and depletion of dissolved solids with respect to process variables and source.

Typically, high-recycled pulp flows can result in higher inorganic dissolved and colloidal substances [7]. Inorganic dissolved solids from alkaline deinking operations can be rich in calcium and aluminium dissolved and colloidal substances that contribute to formation of sticky substances and secondary pitch that result in deposits on Uhle and flat boxes, press rolls and dryers. We identified the interaction of dissolved and colloidal substances and pitch as an important factor contributing to paper machine cleanliness and paper machine runnability. The incidence of secondary stickies from recycled components and pitch has been discussed by Carre et al [23].

Operational limits to the amount deinked pulp that may be used with TMP were set by papermakers because of the deposition and drainage problems related to running a furnish between 20% and 40% deinked pulp. In an effort to overcome these operational limits, acid loop equipment was installed for improved pulp washing and removal of troublesome cations from deinked pulp. In 2000, the Bowater Thunder Bay plant started up a new acid-washing loop at the end of the DIP processing. This improved washing resulted in substantially reduced deposition and necessary clean-ups on the paper machine, the ability to run higher amounts of recycled fibre in the DIP-TMP newsprint, and improved wet end related paper machine performance.

The Bowater Thunder Bay recycle plant is a two-loop, 500-tonne/day (t/d) deinking plant that uses 80% ONP and 20% magazine stock. In the recycle operation, the dissolved solids analyser measures the clear pressate from the acid twin-wire press (approximating the dissolved solids in the thick stock going forward). In one trial the pH at the acid press was decreased from 4.3 to 3.8, and then increased back to 4.3 before going up to pH 4.8. The response of the dissolved solids analyzer measurements of conductivity and UV absorbance are shown in Fig. 8. At low pH the amount of inorganic substances increases, and the amount of organic substances, as measured by the absorbance, decreases. As the pH increases the removal of organic dissolved solids is favoured over inorganic dissolved solids. We have found that the minimum removal of total dissolved solids is between pH 6 and 7.

During normal operation the production based proportional purge from both the acid and alkaline loops is pumped to a heat exchanger for heat recovery. Part of the water from the acid twin-wire press flows by gravity to the alkaline loop, Fig. 9 (top). During the trial the purge from the acid loop was pumped to the alkaline loop, thus increasing the purge from the alkaline loop (Fig. 9, lower). The purge from the acid to the alkaline loop was varied. This flow is compared to the TDS in the pressate from the acid twin-wire press in Fig. 10.

After normal operation until 12 noon, the acid purge pumped to alkaline loop was set to 5,000 litres/minute (Lpm), resulting in a drop in TDS from 1,400 mg/L to 900 mg/L. The plant was then down for seven hours before starting up at 3 a.m. with a lower purge rate of 3,000 Lpm from the acid loop to the alkaline loop. The TDS accumulated to 1,400 mg/L using this purge rate. When the purge rate was decreased to 2,000 Lpm, the TDS decreased slightly to 1,450 mg/L. This shows that by adjusting the flow rate of acid loop water to the alkaline loop — and hence adjusting the purge rate from the alkaline loop — the TDS of the pulp out of the acid loop can be controlled. Purging through the alkaline loop provides a method to recycle hardness producing calcium ions needed for the deinking operation.

**SUMMARY & CONCLUSIONS**

Increases in dissolved solids can cause both operational and quality issues for the papermaker.

Some of the operational issues related to dissolved solids include:

- Increases in dissolved solids decrease drainage rates, and increase steam consumption and paper machine draw.
- Dissolved solids and colloidal pitch lower surface tension, thereby decreasing wet strength.
- Dissolved anionic substances or “anionic trash” interfere with flocculation.

Beyond the production issues, quality issues related to dissolved solids include:

- Dissolved solids interfere with fibre bonding, leading to decreases in paper dry strength.
- Dissolved solids change paper formation by decreasing flocculation.
- The accumulation of dissolved solids can lead to debris in the
press section, doctoring problems and sheet holes.

- Accumulation of dissolved solids can decrease sheet brightness and increase reversion losses.

Management of dissolved solids can go in many directions, although the best practice is to keep dissolved and colloidal substances flowing in a counter-current direction. Measurements of dissolved solids can provide a means to improve counter-current flow and pulp pressing to reduce the accumulation of dissolved substances in the water. In addition, the effects of dissolved solids, especially those related to drainage, can be managed using other variables that can enhance drainage such as additional flocculant or increased system temperature.

**Literature**


**Résumé**: Des appareils de mesure des matières solides dissoutes dans l’eau blanche ont été employés pour comprendre les sources et les effets de l’accumulation des contaminants. Les mesures en ligne employées comprennent la conductivité et l’absorption dans les UV, ainsi que des mesures dérivées des matières solides totales et organiques dissoutes. Le taux de production, le blanchiment et les conditions de pressage sont les plus grands contributeurs des matières solides dans la PTM et la pâte désencrée. Les effets des matières solides dissoutes sont liés à l’égouttage et à la stabilité des matières colloïdales. Les modes de gestion des matières solides dissoutes comprennent notamment le pH et le contrôle de la purge.


**Keywords**: ON LINE MEASUREMENT, MEASURING INSTRUMENTS, CONTRARIES, ACCUMULATION, DEINKED STOCK, DIS-SOLVED SOLIDS, WHITE WATER.