



Vaisala K-PATENTS® SAFE DRIVE Process Refractometer PR-23-SD

For Brown Stock Total Dissolved Solids (TDS) Control and Optimization

BROWN STOCK WASHING

Brown stock washing (BSW) can be considered the key operation influencing the economics of the pulping process, as well as the environmental load of the mill. The purpose of brown stock washing is to remove both organic and inorganic soluble compounds from the pulp suspension (brown stock), while using the lowest possible amount of wash liquor or water.

Through optimization of the brown stock washing process and raising the black liquor solids content, mills gain immediate profits, cleaner and better quality pulp for bleaching, as well as optimized use of water, chemicals and energy.

EFFICIENCY OF WASHING PROCESS

The performance of the washing process has traditionally been controlled in two main ways: using wash loss and dilution factor (DF). Wash loss refers to the quantity of washable compounds in the pulp suspension that could have been removed by washing. The DF indicates the amount of water per ton of pulp added during washing, and which ultimately dilutes the black liquor.

Operators have found the washing process difficult to manage efficiently due to a lack of robust instruments that reliably measure wash loss in-line. For instance, conductivity is widely used for this purpose, even though it is based on the measurement of the ionic sodium species in the liquor (inorganic phase) and does not directly measure the organic phase, especially lignin and hemicellulose.

Other conventional methods also fail to measure the wash loss satisfactorily. Means of monitoring these variables, such as Chemical Oxygen Demand (COD) tests performed on the filtrate, only indicate organic compounds. Furthermore, off-line laboratory methods, such as standard dry solids analysis or COD analysis, have considerable time requirements, rendering them unsuitable for advance process control.

Total Dissolved Solids (TDS) has proven to be a reliable parameter for measuring washing efficiency, because it takes account of both the inorganic and organic fractions, thus all washable solids (real wash loss) are quantified. TDS can be measured in-line with a process refractometer that provides real-time wash performance information, while enabling a quick response to potential changes or disturbances in the process. The refractometer's output can also be calibrated to read COD.

Method	Advantages	Disadvantages
Total Dissolved Solids (TDS) using a process refractometer	<ul style="list-style-type: none"> • Suitable for measuring washing efficiency, because it accounts for both organic and inorganic fractions. • Can be installed directly in the pulp line. • Continuous in-line measurement enables a quick response to changes in the process. 	<ul style="list-style-type: none"> • Requires field calibration if the nature of the solid components (e.g. wood species) in the solution changes. However, calibration is performed easily using data from the laboratory. • Measures total dissolved components only, and cannot distinguish between different components present in a mixture.
Sodium, soda or saltcake loss.	<ul style="list-style-type: none"> • Measures the amount of sodium lost with the pulp, which needs to be replaced in the chemical recovery cycle. 	<ul style="list-style-type: none"> • Does not account for organic compounds, such as lignin. • Exact wash loss measurement is often complicated due to the addition of sodium compounds in the oxygen delignification stages. • Control is complex due to the constant recirculation of wash liquor, which alters the mass balances of the system.
Conductivity	<ul style="list-style-type: none"> • Provides a rough assessment and indication of the direction of process changes. 	<ul style="list-style-type: none"> • Does not quantify the organic fraction, which is typically 60-70 % of the dissolved solids, especially lignin. • Affected by the pH and temperature of the solution. Conductivity loses sensitivity at high concentrations. • Electrode fouling. • Interference from other ions. • Solution polarization. • Ion composition is different for cooking hardwood and softwood. • Does not provide an actual measurement of the wash loss, as the measurement is usually taken after dilution in the filtrate tank. • Time lag and delayed information.
Chemical Oxygen Demand (COD)	<ul style="list-style-type: none"> • Suitable for environmental reasons because it represents the organic fraction such as lignin, carbohydrates, methanol, and low molecular weight acids and extractives. • Independent of the chemicals added to the pulp. 	<ul style="list-style-type: none"> • Accounts only for the organic fraction in the stream (dissolved and suspended). • Time lag and delayed information. • Unsuitable for continuous monitoring. • Poor repeatability, especially at the low end of the range. • Affected by pH. • Many organic compounds present in the washing may increase the COD value, but only a few of these actually affect the bleaching process (e.g. methanol). • Test reagents generate hazardous waste.

APPLICATION

BETTER CONTROL OF TOTAL DISSOLVED SOLIDS (TDS) IN BROWN STOCK WASHING

When examining the overall economic relationship between operating cost and efficiency, the first considerations are maximizing the solids yield due to its heat value in the recovery boiler and minimizing the dilution factor to save steam in the evaporators. The next key factors are the cost of make-up chemicals for replacing sodium losses and the cost of effluent treatment. Other important considerations include evaporator efficiency limitations in many mills and bleach chemical consumption in bleachable grade mills.

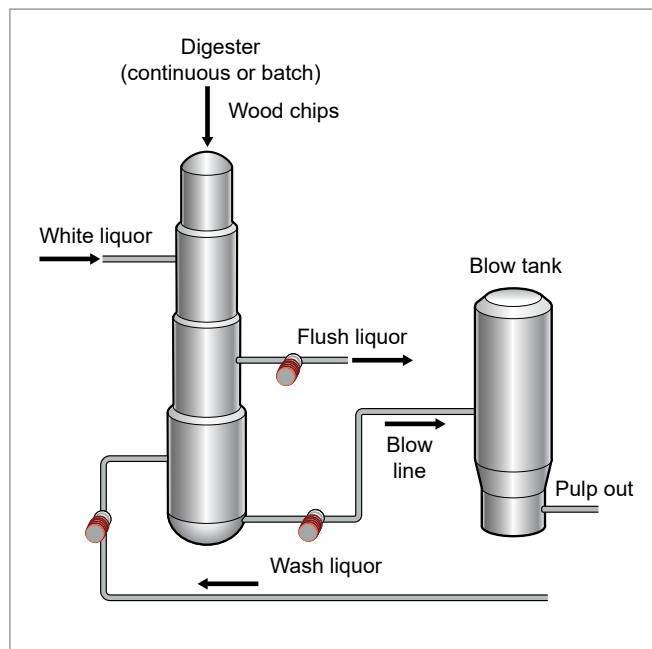
The development of the SAFE-DRIVE Process Refractometer PR-23-SD for the continuous measurement of dissolved solids content in a fiber suspension has made it possible to follow the performance of individual process steps continuously. TDS changes in the feed and outlet stock lines, as well as in incoming and outgoing filtrate lines, can be detected immediately.

Once a mill has the appropriate number of in-line total dissolved solids measurements, it can calculate and optimize its brown stock washing variables, such as the optimum Dilution Factor (DF), Displacement Ratio (DR), relative washing loss (1-Y), and the entire plant Efficiency Factor (E). This enables the implementation of upper level control in order to achieve the benefits of the full optimization of brown stock washing operations.

DIGESTER WASHING ZONE AND BLOW LINE

TDS measurement in the blow pulp suspension after the digester enables monitoring of the diffuser operation. Together with other measurements (e.g. filtrate and flush liquor) this provides the mill with the ability to control the performance of the washing zone in the digester. In addition, TDS measurement in the blow line allows the performance of the digester to be monitored, ensuring that it yields the correct concentration. The combination of these measurements facilitates continuous calculation of the mass balances of the digester.

DIGESTER



PULP FEED TO WASHERS

Accurate and real-time TDS measurement within the feed pulp allows a quick response to process changes and prevents disturbances from being carried over into subsequent washing stages. Process variables, such as the dilution factor, can be controlled in accordance with the properties of the inlet pulp, and mass balances can be continuously monitored.

WASHING STAGE

At this stage, in-line TDS measurements provide better control and help to determine the optimum dilution factor, right operation consistency and optimum concentration of solids in the stream to the recovery boiler. This prevents excess consumption of water in the washers, thus reducing the energy requirements of the evaporator and the need for make-up chemicals.

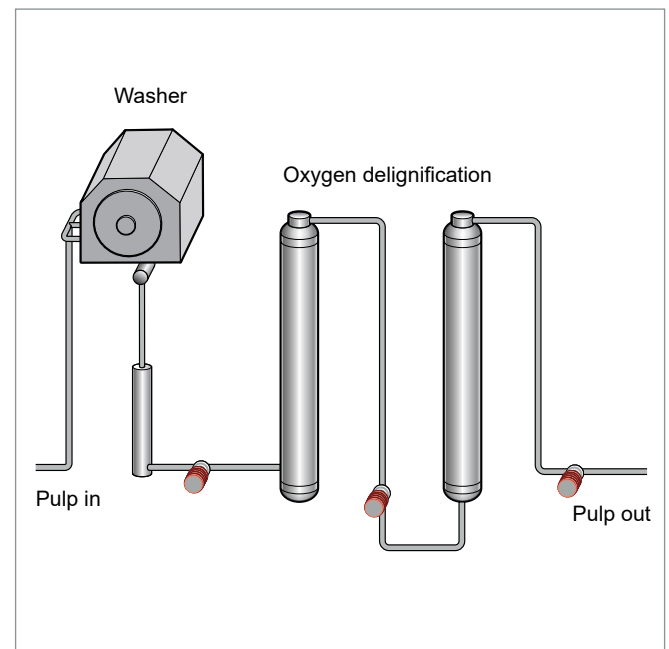
PULP TO OXYGEN DELIGNIFICATION (OD)

The cost and performance of the OD process can be optimized using in-line TDS measurements. Wash loss reduction in the inlet pulp to the reactors decreases the amount of alkali. Alkali is consumed in neutralization reactions of the organic acids. In addition, the temperature of the reactor can be optimized and the amount of oxygen decreased.

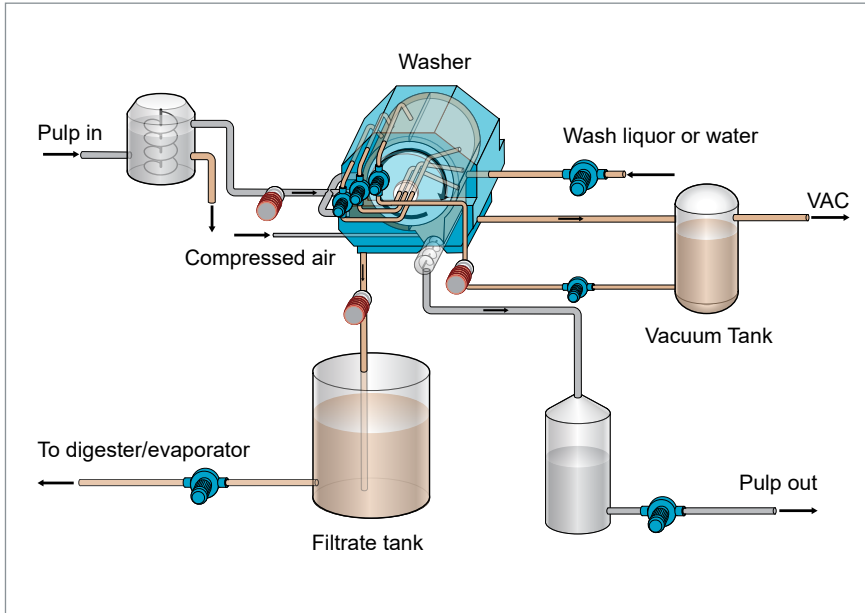
PULP DISCHARGE TO BLEACHING

Reliable continuous measurements of wash loss in the discharge pulp make it possible to control the success of the washing process. By minimizing the wash loss, the subsequent process steps can be optimized. Lower wash loss in the outlet pulp will improve its quality while also decreasing the amount of chemicals required in the bleaching stage. Reliable measurements improve environmental performance and can reduce effluent treatment costs.

OXYGEN DELIGNIFICATION



DD-WASHER



BENEFITS

- Continuous washing efficiency control
- Improved performance of oxygen delignification and bleaching
- Reduced consumption of additional reagents in the subsequent bleaching stages
- Improved pulp quality
- Less formation of harmful organic compounds in the bleaching stage, less load to effluent treatment
- Improved recovery of cooking chemicals (Na and S) and wood based dissolved organic materials
- Increased recovery boiler efficiency
- Optimized use of energy
- Enhanced mechanical performance of the washers, longer lifetime
- Improved process runnability
- Moderate initial investment; return on investment (ROI) is relatively fast, about 3-6 months

REFRACTIVE INDEX TECHNOLOGY

Our refractive index measurement technology has become an industry standard – it is widely used to measure black liquor dry solids and green liquor density in Kraft chemical recovery processes worldwide.

The technology addresses the critical factors required for measuring TDS in all types of brown stock washers and washing processes. Because of its patented design, measurements are not affected by suspended solids, bubbles or fibers, which make it possible to install the refractometers directly to the pulp or filtrate lines. Our refractometers are not influenced by vibration, temperature shocks or pressure peaks. Moreover, operation costs are low and the devices are maintenance-free.

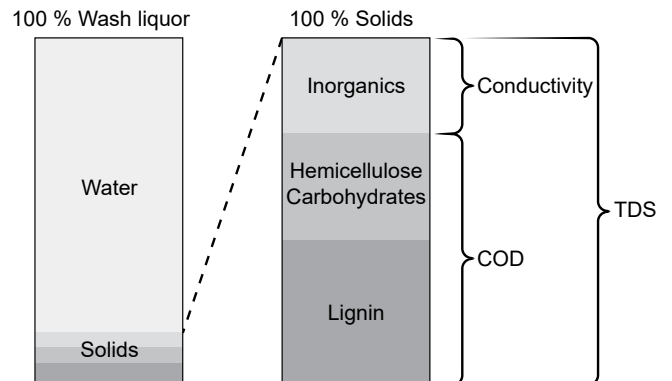
There are two types of SAFE-DRIVE Process Refractometer PR-23-SD systems specifically designed for reliability and easy installation directly in the process pipe line. The PR-23-SD comes factory calibrated for black liquor.

We can also provide a complete consultation service that begins with a pre-study and evaluation of the existing process, including potential bottlenecks. The service also offers recommendations on implementing total dissolved solids measurements for individual washing stages, and it provides guidance on connecting the technology to the existing process control system. The ultimate purpose of in-line measurements is to reveal the optimum changes required to achieve the greatest efficiency at each stage of the process.

PERFORMANCE FEATURES OF SAFE-DRIVE PROCESS REFRACTOMETER

- Indicates TDS in solution, see figure below
- Suitable for all concentrations
- Measures precise concentration of washable liquid substances
- Detects organic materials with a large molecular size, such as lignin
- Not influenced by COD caused by methanol
- In-line real-time measurement, immediate response time, suitable for control
- Mounted directly onto the pulp line
- Low operating costs, maintenance-free

MEASUREMENT OF SOLIDS CONTENT IN THE WASH LIQUOR



MOUNTING OPTIONS

FILTRATES AND WEAK BLACK LIQUOR



SAFE-DRIVE PROCESS
REFRACTOMETER PR-23-SD WITH
STEAM PRISM WASH

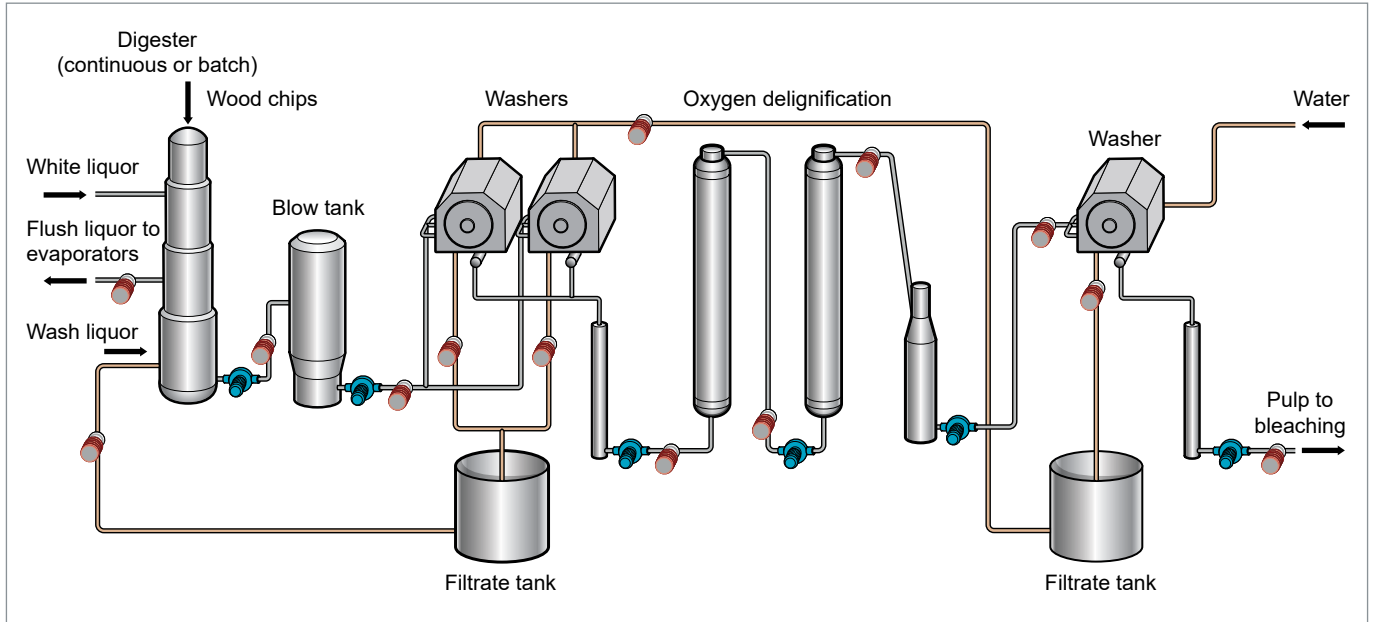
BLOW LINE AND PULP STOCK LINE



SAFE-DRIVE PROCESS
REFRACTOMETER PR-23-SD WITH
SPECIAL SAFE-DRIVE ISOLATION
VALVE AND PULP LINE INSTALLATION
PLATE SDI2-23-PL-SS

PRE-STUDY SERVICE

BROWN STOCK WASHING PROCESS



PRE-STUDY SERVICE FOR IN-LINE MEASUREMENT RECOMMENDATIONS

We provide brown stock washing pre-study service for all pulp mill customers to analyze the potential for washing efficiency improvement and to assist in the implementation of refractometers in this costly part of the pulping process. The service includes a 2-3 day on-site evaluation of the mill's current brown stock washing equipment and control practices, as well as the identification of potential areas for improvement. The customer receives an on-site consultation, report and recommendations from our application specialist.

Once our system is in operation, we will offer a comprehensive range of services covering technical support, maintenance and upgrades of the equipment, as well as continued training for site personnel throughout the product's lifetime. We provide training courses that can be delivered either at our premises or in the field at the customer's site. Training is also available through our local authorized representatives.

SCOPE OF THE PRE-STUDY

- Outlining of mill's current BSW, control practice and optimization areas
- Sampling in selected areas of the process, off-line measurements using the PR-33-AC refractometer and laboratory cuvette, and comparison with customer's laboratory
- Analysis and discussion of findings
- Simulating benefits
- Checking possible refractometer installation locations
- Field report with findings and recommendations for in-line solutions

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