Digester Control in the Kraft Process

BACKGROUND

The Kraft paper process is particularly efficient because it involves continuous recycling of raw materials. Wood chips are delignified by harsh chemicals (white liquor) to produce pulp and spent liquor (black liquor). The spent liquor is later regenerated to white liquor in the causticizer.

The most important physical parameter of pulp production is the Kappa number, which essentially indicates how well the chips have been cooked. Con-trolling the value of the Kappa number is difficult because the original wood chips may differ greatly in composition and moisture content. Measuring conductivity in the upper (or sometimes lower) recirculation zone of a continuous digester can provide control feedback and lower variability in the Kappa number of the product pulp.

PROCESS: CHEMISTRY OF PULP DIGESTION

A **continuous digester** has a constant charge of wood chips and a given flow rate of white liquor (basically NaOH and Na₂S). The digester fluid is heated to approximately 180° C (356° F) to accelerate the delignification reaction. The NaOH (caustic) is consumed by the acetic and lignin components in the wood to yield sulfates and carbonates:

Na₂S + NaOH + wood chips —>Na₂SO₄ + Na₂CO₃ + pulp (white liquor) (black liquor)

As residence time in the digester increases, the yield of pulp increases, but overcooking can degrade the strength of the pulp. The pulp is later separated from the black liquor and washed to reclaim the valuable chemicals.

The traditional method of controlling the Kappa number is to monitor the residual caustic in the black liquor and infer how much has reacted in the digester. A conductivity measurement at this location is thus correlated with an acceptable Kappa number range, and the feed rate of white liquor to the digester is adjusted to hold this conductivity value. Any monitoring system used in this service must withstand the hot, highly caustic liquid at pressures over 1700 kPa (246 psig). The black liquor/pulp mixture is a thick, viscous slurry that tends to coat and clog system piping, especially if allowed to cool. Automatic titrators have been designed for use under these conditions but are hard to maintain and require extractive ("grab") sampling. Grab samples may not reflect actual conditions because the time delay required for analysis allows other reactions to occur. The toroidal conductivity method is ideal for this kind of physical environment.

TOROIDAL CONDUCTIVITY

Rosemount Analytical recommends using toroidal conductivity to measure alkali concentration in black liquor because the sensors have proven rugged and reliable with a minimum of maintenance. Although conductivity is non-specific and all ionic species will interfere somewhat, the active components NaOH and Na₂S are the strongest contributors to the total. Other components are considerably lower in conductivity and any sudden increase in unreacted alkali concentration will be easily noticed. Conduc-tivity can be measured either at the product outlet or in the upper recirculation zone for rapid response to process changes. Figure 1 shows both of these locations.

Alkali concentrations are usually measured by wet chemical tests called ABC titrations. One test measures the sum of NaOH and Na₂S, which is called **Active Alkali**. Another test measures NaOH and one half the Na₂S, which is called **Effective Alkali**. These two quantities are related by the **sulfidity**, the percentage of alkali present in the sulfide form. Since sulfidity typically changes little in most processes, conductivity can by correlated to both Active or Effective Alkali with the addition of a constant sulfidity correction.





INSTALLATION OPTIONS

Rosemount Analytical has three separate sensor options for this application. The Model 242 flowthrough sensor is flanged and uses a PEEK or ceramic liner for maximum chemical resistance. The retractable Model 228 sensor has a unique lead screw design that allows safe retraction through a ball valve at up to 2030 kPa (295 psig).

The Model 226 Sensor, with its 4.75 cm (1.87 in.) bore, can be used when large solid particles are present and can also be adapted for flange mounting.

Compatible toroidal conductivity analyzers include the Model 5081-T and Xmt-T DC-powered HART and FOUNDATION Fieldbus analyzers, the Model 1056-21 analyzer, and the Model 54eC HART analyzer/controller. The Model 5081-T is housed in a robust explosion-proof enclosure that is especially suited to the harsh pulp mill environment. The Model 54eC is compatible with both toroidal and contacting conductivity sensors for optimum versatility in the field. Consult the appropriate Product Data Sheet for complete details.

INSTRUMENTATION

Model 5081-T Two-wire Conductivity Transmitter

- Automatic/Manual temperature compensation to ensure accurate monitoring and control.
- Hand-held Infrared Remote Control (IRC) link to activate all transmitter functions.
- · AMS compatible.

Model 228 Retractable Toroidal Conductivity Sensor

- Convenient isolation of sensor for cleaning or replacement.
- Easy insertion/retraction of sensor.
- · Flush ports on assembly chamber to allow sensor cleaning.

Model 226 Toroidal Conductivity Sensor

- Toroidal (inductive) principle of measurement greatly reduces sensor fouling problems.
- Chemically-resistant materials withstand the effect of highly corrosive solutions.
- · Large-bore design prevents plugging by solid particles.

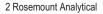
Model 54eC Conductivity Analyzer

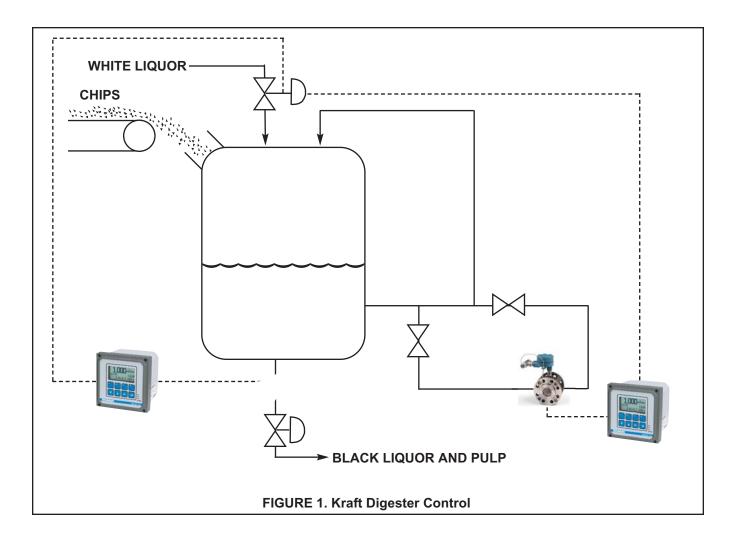
- Measures Conductivity, Resistivity, or Percent
 (%) Concentration.
- Uses either contacting or inductive sensors to meet most application requirements.
- · Optional TPC and PID control capability.
- Fully Descriptive Diagnostic Messages and easy-to-use interface spells out each operation in English, French, German, Italian, or Spanish.
- Two Independent Outputs for conductivity and temperature.
- Three alarms with Programmable Logic, plus one dedicated fault alarm.

Model 242 Flow-Through Toroidal Conductivity Sensor

- Now available in 4" pipe size.
- Toroidal measurement principle greatly reduces sensor fouling.
- Automatic temperature compensation with integral RTD.
- Externally-mounted toroids are protected from harsh processes.
- Modular design allows liner replacement without sensor replacement.









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Emerson Process Management

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