Conductivity Measurement in the Kraft Process

Process Overview

The kraft process is used to convert wood chips into a pulp that can be formed into paper products. The process was developed in the late nineteenth century and has become the dominant process for wood pulp production because of its efficiency at recycling the chemicals used to delignify the wood.

Wood chips are digested into wood pulp using a caustic mixture of sodium hydroxide (NaOH) and sodium sulfide (Na_2S), often referred to as "white liquor." This digestion process commonly takes place at 180 °C (356 °F). The spent chemicals, called "black liquor," are then separated from the pulp using a series of wash steps. The black liquor is purified in an evaporator and burned in a recovery furnace. The smelt from the recovery furnace is then dissolved in water and clarified to remove solids. The resulting mixture is called "green liquor." Lime is added to the green liquor in a device called a slaker that regenerates the active caustic (NaOH) from sodium carbonate (Na_2CO_3) by chemical reaction at a temperature near 100 °C (212 °F). This reaction is completed in large vessels called causticizers. The regenerated white liquor product is then clarified before being returned to the digester.

Within the white liquor recycle loop, there is often also a recycle process for the lime that is used to re-causticize the white liquor. The lime used in the slaker forms solid calcium carbonate. This calcium carbonate is then removed from the white liquor in the clarifier as "lime mud." Residual white liquor is washed out of the lime mud and used to dissolve the smelt. The washed lime mud is heated in a kiln to regenerate the lime for use in the slaker.

Conductivity Measurement

Alkali concentration is a key process parameter that must be monitored at several locations within the kraft process. Alkali concentration is monitored using conductivity sensors instead of pH sensors due to the high process temperatures and thick pulp. Electrical conductivity is an additive and non-specific property which means all acids, bases, and salts in the process stream will contribute to the total value.

In general, conductivity is related to alkali strength because each ingredient in the liquor has a characteristic contribution to the total alkali concentration. When conductivity is higher, more NaOH is present, and the liquor is "strong." When conductivity is lower, more Na_2CO_3 is present, and the liquor is "weak". Periodic measurements of alkali strength using chemical titrations are also made to check the on-line conductivity measurements.

The four main conductivity sensor applications in the kraft process are as follows:

1. Alkali concentration in the digester – The most important physical parameter of pulp production is the "Kappa number" which provides an indication of how thoroughly the wood chips have been digested. A Kappa number that is too high or too low is associated with lower quality pulp. Controlling the Kappa number is difficult because woods chips being fed to the process may vary in composition and moisture content. One way to reduce Kappa number variability is to control the amount of alkali fed to the digester. Conductivity provides a measure of white liquor alkali concentration. The volume of white liquor added to the digester can be tuned based on the alkali concentration to ensure a consistent total alkali charge. In addition, the alkali concentration in the black liquor leaving the digester can be used to infer the extent of the reaction that has taken place in the digester, allowing the Kappa number to be controlled by adjusting process parameters such as digester residence time.
2. Residual black liquor in pulp wash stages – The purpose of the wash steps after the digester is to separate the black liquor from the pulp. The efficiency of each wash step is monitored and controlled using conductivity to provide a measure of the residual alkali concentration in the pulp.
3. Alkali concentration in causticizer tanks – Conductivity sensors are used to measure alkali concentration in the causticizer tanks to control the lime feed rate. There must be enough lime for the causticizing reaction to occur, but unreacted lime is hard to separate from the white liquor.

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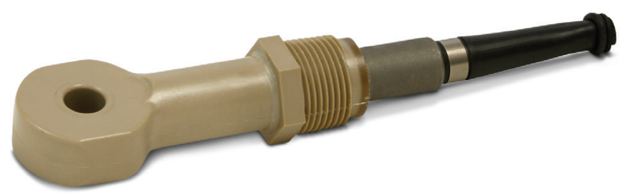
4. Green liquor alkali concentration – Conductivity sensors are used to monitor the residual alkali concentration in wash water from the lime mud washer. The feed rate of weak wash liquor to the smelt tank is regulated based on its alkali concentration to keep the density of the green liquor at the desired setpoint.

The Emerson Solution

Rosemount™ toroidal conductivity sensors are recommended for all the applications within the kraft process because they have proven to be rugged and reliable with minimum maintenance. Toroidal sensors provide much greater resistance to the effects of coating and corrosion than contacting conductivity sensors. This is crucial in the kraft process due to the pulp and lime solids present in the process as well as the corrosive nature of the liquor used to delignify the wood.

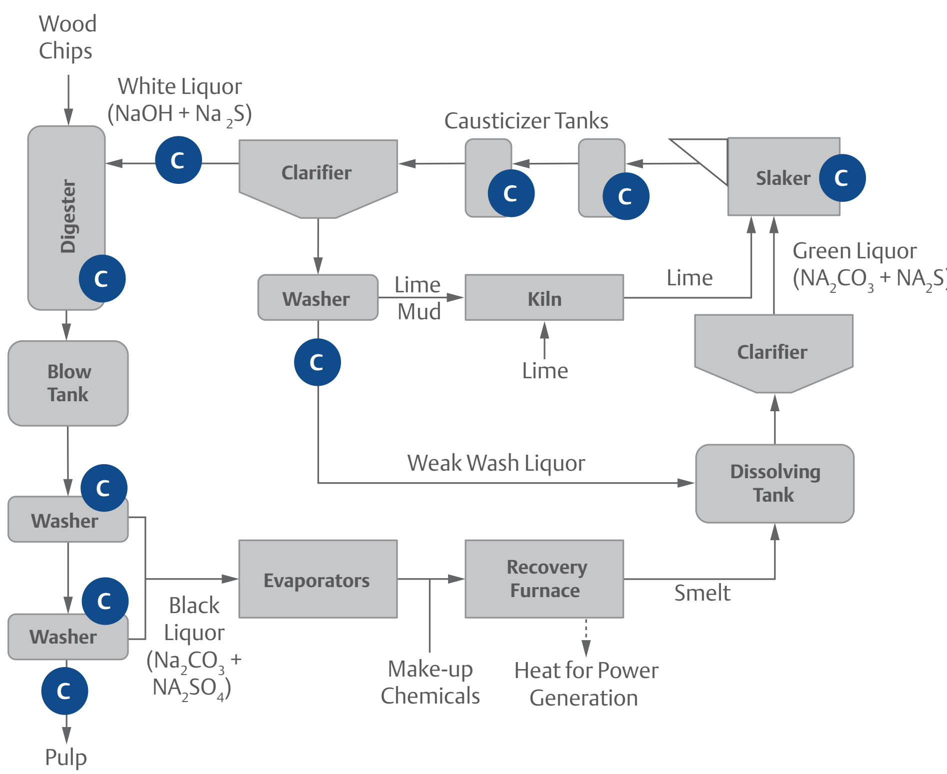
For most kraft process applications, the Rosemount 228 Toroidal Conductivity Sensor provides the necessary chemical and coating resistance. The 228 sensor has an optional retraction mounting assembly that is ideal for inline applications and installation in the side of the causticizer or clarifier tanks. For applications such as the slaker where there is a large loading of particulates, the large bore Rosemount 226 Toroidal Conductivity Sensor or 242 Flow Through Toroidal Conductivity Sensor may be preferred.

Rosemount toroidal conductivity sensors are compatible with all Rosemount liquid analysis transmitters including the Rosemount 5081 Explosion Proof Transmitter which features a rugged aluminum enclosure for the harshest industrial environments.



Rosemount™ 228 Toroidal Conductivity Sensor

Figure 1 - Kraft Process Diagram



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