KRAFT BLACK LIQUOR, GREEN LIQUOR, BROWN STOCK

Typical end products
Wood pulp, paper and board.

Chemical curve: Black liquor R.I. per Conc% by weight at Ref. Temp. of 20˚C

Introduction
Wood pulp for paper and board manufacturing can be produced with several different methods. These are chemical pulp, semi-chemical or chemi-mechanical (NSSC and CTMP), and thermo-mechanical pulp (TMP). Refractometer applications are in the chemical and semi-chemical pulp production processes.

The Kraft process converts wood into wood pulp, which consists of almost pure cellulose fibers. The process entails treating wood chips in alkaline cooking conditions, which break the bonds that link lignin to cellulose.

Application
Pulping process
Wood chips are fed into vessels called digesters that withstand high pressures. Some digesters operate in a batch manner and some in a continuous process, such as the Kamyr digester.

Wood chips are impregnated with cooking liquors. The cooking liquors consist of warm black liquor and white liquor. The warm black liquor is the spent cooking liquor from the blow tank. White liquor is a mixture of sodium hydroxide and sodium sulfide, which are produced in the recovery process.

In a continuous digester the materials are fed at a rate, which allows the pulping reaction to be completed by the time the materials exit the reactor. Typically, delignification requires several hours at a temperature of 130-180 °C (266-356 °F). Under these conditions lignin and some hemicellulose degrade, creating fragments, which are soluble in the basic liquid.

The solid pulp (about 50 % by weight based on the dry wood chips) is collected and washed. At this point, the pulp is in a suspension form of deep brown color and is known as brown stock. The combined liquids, known as black liquor, contain lignin fragments, carbohydrates from the breakdown of hemicellulose, sodium carbonate, sodium sulfate and other inorganic salts.
Fiber line and brown stock washing (BSW)

After cooking, the sulfate pulp passes through the blow line to the blow tank and then on to the washing stage.

During brown stock washing, the spent cooking liquors are separated from the cellulose fibers. Normally a pulp mill has 3-5 washing stages in a series. The pulp passes through further washing stages following oxygen delignification and after each bleaching stage. Several processes are involved: thickening/dilution, displacement and diffusion. The dilution factor is a measure of the actual amount of water used in the washing, compared with the theoretical amount required to displace the liquor from the thickened pulp. A lower dilution factor reduces energy consumption, while a higher dilution factor normally gives cleaner pulp. Thorough washing reduces the organic material in the pulp suspension, and consequently, the Chemical Oxygen Demand (COD).

In a modern mill, brown stock (cellulose fibers containing approximately 5 % residual lignin), produced by the pulping, is first washed to remove some of the dissolved organic material and then further delignified through the bleaching stages.

Recovery process

The excess black liquor comprises about 15 % solids and is concentrated in a multiple-effect evaporator. After the first effect, the black liquor’s concentration is raised to 20-30 % solids.

The weak black liquor is further evaporated to 60 % or even 80 % solids (heavy black liquor). This is then burned in the recovery boiler to recover the inorganic chemicals for reuse in the pulping process. The high solid content in the concentrated black liquor increases the energy and chemical efficiency of the recovery cycle. However, a higher viscosity may cause precipitation of solids, and may lead to plugging and fouling of the equipment.

The molten salts (smelt) from the recovery boiler are dissolved in process water, known as weak wash or weak white liquor. This process water is composed of all liquors used to wash lime mud and green liquor precipitates. It is kept in a weak wash storage tank. The resulting solution of sodium carbonate and sodium sulfide is known as green liquor. This liquid is mixed with calcium hydroxide to produce the white liquor used in the pulping process.

The recovery boiler also generates high pressure steam, which passes through steam turbine generators to produce electricity and to reduce the steam pressure for mill use. Therefore, a modern Kraft mill is self-sufficient for its electrical energy supply.

Instrumentation and installation

The K-Patents SAFE-DRIVE Process Refractometer PR-23-SD is used to measure in real-time the concentration of the liquors at various stages of the pulping process. The refractometer is mounted directly in the pipeline for continuous measurement of dry solids content of the liquors and the pulp suspension, thus reducing the need for sampling and laborious laboratory tests.

The SAFE-DRIVE refractometer helps to optimize the pulping process to obtain a high quality pulp, reduce energy consumption and environmental load and improve the economics of the mill.

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<thead>
<tr>
<th>Instrumentation</th>
<th>Description</th>
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<tr>
<td><img src="image1" alt="Refractometer" /></td>
<td>K-Patents SAFE-DRIVE Process Refractometer PR-23-SD for measuring black liquor dry solids and green liquor density or TTA in kraft chemical recovery process. K-Patents SAFE-DRIVE design allows for safe and easy insertion and retraction of the sensor under full operating pressure without having to shut down the process.</td>
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<tr>
<td><img src="image2" alt="DD-23 System" /></td>
<td>K-Patents Digital Divert Control System DD-23 for safe operation of kraft chemical recovery boiler. K-Patents DD-23 system complies strictly with all recommendations of BLRBAC. The DD-23 system includes two K-Patents SAFE-DRIVE Refractometer PR-23-SD sensors in the main black liquor line, and two Indicating transmitters and a Divert control unit in an integrated panel. Remote monitoring and event data logging via Ethernet.</td>
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Measurement range

Refractive Index (nD) 1.3200 – 1.5300, corresponding to 0-100 % by weight.