Gasification Edges Closer to Commercial Reality with Three New N.A. Mill Startups

G-P at Big Island, Va., Norampac in Trenton, Ont., and Weyerhaeuser at New Bern, N.C., are currently in or approaching startup of commercial-scale black liquor gasifiers

— By Ken Patrick, Editorial Director

During the past 75 or so years, chemical pulp mills around the world have been relying on Tomlinson recovery furnaces to process spent pulping liquors and produce by-product steam for process use and electrical cogeneration. Overall, the technology has served the industry well.

Although evolutionary developments have kept Tomlinson-anchored chemical recovery "islands" or loops performing more or less satisfactorily since the 1930s, problems inherent with an outdated, aging technology continue to nag mills and drag down overall pulp mill process efficiency. Among recovery boiler problems that seem to never go away is related to production bottlenecks in the pulp mill.

Many mills today operate at or near existing chemical recovery capacity, and over the years a growing number have become recovery boiler limited to the tune of 100 to 500 tpd of black liquor solids. Because the addition of recovery furnace capacity at these smaller incremental levels is not practical, such mills are faced with continuing to operate below maximum efficiency, curtailing production, or investing many millions of dollars ($60-$70 million) to install a new boiler.

Also many recovery furnaces around the world, especially in the U.S., are nearing or have surpassed their functional life spans, and not only are becoming progressively inefficient and cranky in their old age, but represent a potential explosion danger due to increasing metal fatigue, corrosion, stress cracking, etc. Clearly, mills face some critical capital spending decisions in the not-too-distant future.

Since the 1970s, the industry has been exploring alternative chemical recovery technologies to replace or augment the conventional Tomlinson boiler system. Among these has been black liquor gasification, which off-and-on during spotty trials and pilot studies in recent years has shown some interesting promise.

During the past couple months and into the fourth quarter of this year, a new round of commercial-scale (100–400 tpd black liquor solids) gasification units are in the process of starting up in the U.S., along with a smaller demonstration unit (20 mtpd of solids) at a Kappa Kraftliner mill in Sweden. One of these projects, a $66 million, 200-tpd black liquor solids gasifier due to startup later this month at Georgia-Pacific's Big Island, Va., semichemical containerboard mill, is a DOE funded project under AF&PA's Agenda 20/20 program.

Other projects recently in startup include black liquor gasifiers at Norampac's Trenton, Ont., containerboard mill (126-tpd black liquor solids) that went into operation in July, and Weyerhaeuser's redesigned/rebuilt unit (367-tpd black liquor solids) that started up at its New Bern, N.C., kraft mill in late June. The Big Island and Trenton gasifiers process spent soda based cooking liquors.

To explore the two basic technologies being used in these new projects, and to get some perspective on where black liquor gasification is today and where it might be in the next decade, PaperAge recently met with Barry Seidel, Technology Manager-Power & Recovery, BE&K Engineering Co., in Birmingham, Ala. The main points of this discussion are summarized below.

Emerging Technologies

From Seidel's perspective, wide-scale use of black liquor gasification by the paper industry as a whole is still at least a decade away, if not longer. "Right now, the industry is in a wait-and-see mode. The eyes of the industry are focused on the Big Island mill and will be

closely observing how the modified unit at New Bern handles kraft liquors in the longer term," he says.

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"But from what I've seen and heard recently, any new chemical recovery spending by the industry will be aimed at upgrading or buying new recover boilers. Other than the systems now starting up, no one is seriously looking at black liquor gasification right now. The technology available today is mainly usable in a hang-on, incremental capacity. But gasifier capacities today at 200–300 tpd of black liquor solids are nowhere near big enough to yet replace the 2.5–3.0 million lb/day capacity of existing recover boilers typically used in kraft mills," Seidel adds.

Although the industry's attention is still on the recovery boiler, "gasification will come," Seidel notes. "I think it will be more like 2010 or 2015 before mills begin buying and installing large capacity units to replace existing boilers. There is still a lot to do, but it will eventually happen," he believes.

One of the "keys" to success for gasifiers, Seidel continues, is to clean-up the syn-gas sufficiently for firing in a gas turbine. "A combined cycle gas turbine on the back end firing clean syn-gas from black liquor will potentially produce two to three time the electrical generation that can be attained with today's recovery boiler steam turbine combinations. Depending on the process used, dangerous smelt-water reactions can also be avoided, he points out.

Gasifiers being used in the current commercial scale mill operations can be classified into two basic types — low and high temperature, Seidel explains. Low-temperature units, such as those being used at the Norampac and Georgia-Pacific Big Island mills to process soda based spent cooking liquors, operate at 1,100°F–1,300°F, well below the melting point of inorganics, thus avoiding liquor smelt formation and associated smelt-water explosion hazards. Organics leave the low temperature gasifier as dry solids.

High temperature units generally operate in the 1,700°F–1,900°F range, and produce a molten smelt. Currently they are more effective with kraft liquors, and accordingly is the technology being used at Weyerhaeuser's New Bern mill. Both types of units provide a natural separation of sulfur from sodium, allowing pulping chemistry to be better optimized than with the current recovery boiler technology.

Manufacturing and Technology Conversion International (MTCI) of Baltimore, Md., has worked closely with DOE to develop its pulse-enhanced, indirectly-heated fluidized bed, steam reformer gasifier used at Norampac and Georgia-Pacific mills. The Big Island unit is designed to handle the mill's entire spent liquor feed, replacing two 50-year-old smelters that could not comply with new MACT II emissions standards.

The Chemrec AB (Sweden) system used at Weyerhaeuser's New Bern mill is an atmospheric, air-blown, entrained bed gasifier with a capacity of 367 tpd of black liquor solids. An earlier version of this system was operated at the mill for about three years before being shutdown in 2000 due to chloride assisted corrosion cracking of the stainless steel reactor vessel shell.

MTCI System at Big Island, Norampac

Before installing the Chemrec high temperature system at New Bern, in late 1996, Weyerhaeuser had run trials at the mill with the MTCI low temperature system. Following small scale (30 lb/hour solids capacity) testing in 1987, the MTCI gasifier was further developed and a 200 lb/hr unit was installed at the mill in 1995, running 500 hours and processing 2 tons/hour of kraft black liquor solids.

As shown in Figure 1, the MTCI steam reformer process is based on steam gasification of black liquor in an indirectly heated fluidized bed consisting of tube

bundles made of pulsed (vibrating) heater tail pipes. Seidel describes the pulse jets as operating similar to the old German V-2 rockets. The rapidly vibrating pulses provide excellent heat conduction into a bed of sodium carbonate crystals, which is fluidized by superheated steam. The superheated steam also serves as a reactant for processing organics in the liquor.

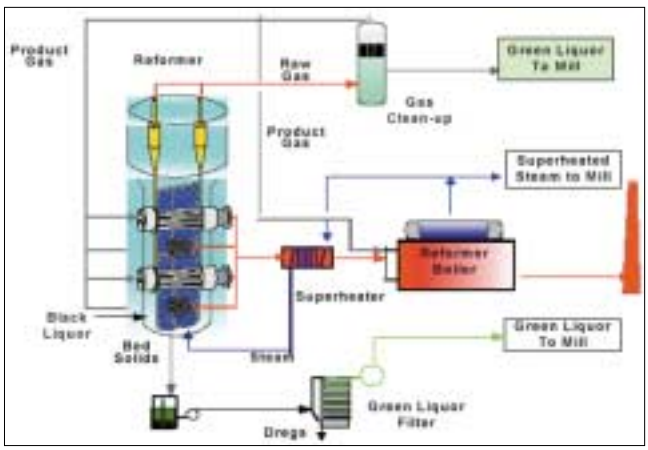

Figure 1. The MTCI process uses rapidly vibrating pulse jets to heat a bed of sodium carbonate crystals, which is fluidized by superheated steam. Black liquor is sprayed onto the bed, producing a hydrogen-rich syn-gas and a green liquor feed at temperatures well below the melting point of inorganic salts in the liquor, thus avoiding the dangers of a smelt-water explosion.

Black liquor is sprayed into the fluidized bed and coats the sodium carbonate particles, resulting in high rates of heating, pyrolysis, and steam reforming. The steam reacts endothermically with organic constituents of the liquor to produce a medium-Btu synthetic gas rich in hydrogen (approximately 65%) with a heating value of around 300 Btu/dscf.. Sodium sulfate in the liquor is reduced to sodium sulfide by reaction with carbon monoxide and hydrogen.

The sodium sulfide rapidly decomposes to hydrogen sulfide gas and sodium carbonate solids are formed. The product gas is then scrubbed with an alkali solution derived from the sodium carbonate bed solids to produce a green liquor. Bed temperature is generally maintained between 1,100°F and 1,150°F, well below the melting point of sodium and potassium slag, thus avoiding liquor smelt formation.

The 100-year-old Big Island mill produces some 750 tpd of semichemical pulp for the integrated manufacture of corrugating medium. It uses a no-sulfur based (sodium carbonate/sodium hydroxide) cooking chemistry. The gasification project is being conducted under the EPA's Project XL new technology program, which would allow the mill additional time to comply with emission standards, including the construction of a conventional recovery system, should the gasification approach not work.

Seidel notes that the 200-tpd black liquor solids unit at Big Island has two reformers and four pulse combustors. The system at Norampac is about half that size with only one reformer and two pulse combustors. The extremely low sulfur chemistry of both mills provides a lower risk environment for demonstrating the low temperature technology. The projected thermal efficiency is well above 70%, compared with 65% or less for conventional recovery boilers.

Chemrec System at New Bern Mill

The Chemrec system, depicted in Figure 2, utilizes a refractory-lined, entrained flow reactor that gasifies concentrated black liquor under reducing conditions. Black liquor is gasified by partial combustion. Preheated, compressed air is used to fluidize the bed and carry out the gasification reactions. The reactor bed is comprised of sodium carbonate and sodium sulfide particles formed during gasification.

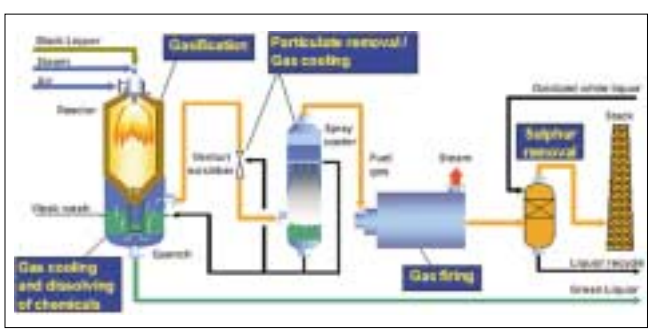

Figure 2. In the Chemrec high-temperature process, black liquor is quickly gasified in an entrained bed unit, producing a molten slag that is recovered as green liquor. The product syn-gas is cooled and cleaner and available as a low-Btu gas fro use in a mill's power boilers.

Black liquor at about 65% solids is heated indirectly and enters the reactor at the top through an atomizing nozzle that sprays it uniformly into the vessel. The gasifier is then run up to 1,700°F–1,900°F, which results in a molten smelt from the inorganic constituents in the liquor feed. Organics are converted to a low-Btu gas

containing carbon monoxide, methane, and hydrogen.

Both the gas and the molten salts travel to a quench dissolver where they are simultaneously separated and mixed directly with an aqueous cooling liquid, dropping the gas temperature to around 200°F. The smelt dissolves in the weak wash to form green liquor, which is pumped back to the dissolving tank. By design, the process naturally separates sodium carbonate from sodium sulfide, allowing two white liquor streams to be produced, each of differing sulfidity.

After leaving the gasifier, the syn-gas passes through particulate and cyclone cleaners to remove the sodium carbonate and sodium sulfide particles., which are returned to the gasifier bed. The cooled gas then enters a scrubber to remove the hydrogen sulfide, which is used to produce a high sulfidity white liquor stream. The low sulfidity white liquor stream is generated from the solids removed from the gasifier, which are subsequently mixed with the weak wash. Sulfur is recovered from the carbon monoxide and hydrogen syn-gas by absorption, and then the Claus process.

After being shutdown in 2000, the gasifier at New Bern was redesigned and fitted with a new type of alumina refractory liner and carbon steel shell that reportedly is not susceptible to chloride corrosion. The success of this redesign will not be known for at least several months.

The 367-tpd-solids unit at New Bern is being used in a hang-on, incremental capacity. The syn-gas is being burned in the mill's power boiler. ■