TJ SUMMARIES

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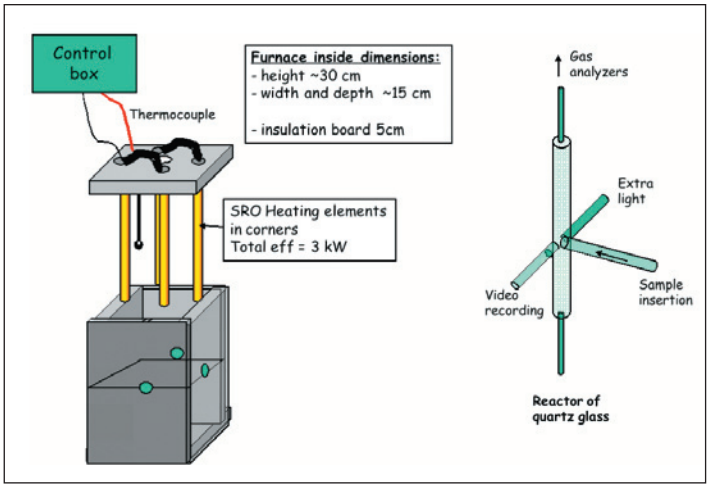
BIOFUEL

Co-firing black liquor and biomass in a laboratory single droplet reactor—effects on emissions and combustion characteristics

By Nikolai DeMartini, Esperanza Monedero, Patrik Yrjas, and Mikko Hupa

Mills having recovery boilers with excess capacity can potentially mix other biofuels into the black liquor to produce more electricity from biomass. This work is a laboratory study of the effect on combustion of mixing other biofuels with black liquor. The four fuels mixed with softwood black liquor were bark, wood chips, peat, and bio-sludge (which some mills already burn with black liquor).

Droplets of the mixed fuels were burned at 1100°C and 3% O_2 in a single particle reactor. Video and on-line gas analyzers for CO, CO_2, and NO were used to measure swelling, combustion times, carbon evolution ($CO+CO_2$), and NO formation tendency. Results from this preliminary study indicate that, from a combustion chemistry standpoint, there is potential to add biofuels to black liquor for combustion in a recovery boiler. The mixtures containing bark, wood, or bio-sludge appear to burn much like the original black liquor, but peat appears to significantly alter black liquor's combustion behavior at certain addition levels. In the future, the authors plan to study the impact of other variables and conditions. After that, the next technical step will address the mixing and spraying characteristics of various biomasses with high solids black liquor.



Quartz reactor used for single droplet combustion tests.

RECOVERY BOILER

In-furnace temperature and heat flux mapping in a kraft recovery boiler

By Anders Brink, Tor Laurén, Mikko Hupa, Ralf Koschack, and Christian Mueller

Gas temperatures, incident heat flux, and surface temperatures were measured in a large kraft recovery boiler. The measurements were a part of an extensive campaign planned and carried out to support validation of models based on computational fluid dynamics. The gas temperatures were measured with three different techniques: infrared (IR) pyrometer, suction pyrometer, and unshielded thermocouples. In addition to the temperature measurements, the radiative heat flux was measured in a number of locations in the boiler using a portable heat flux probe, and the surface temperatures inside the boiler were measured using a portable single-band IR camera.

The IR radiation pyrometer proved to be a versatile technique for measuring in the kraft recovery boiler. Since the technique is non-intrusive, the hostile environment inside the boiler is not a problem. The IR pyrometer is also able to detect fluctuation of the temperature where thermocouple-based techniques do not respond. The drawback of this technique is that no exact measurement point can be specified, since the IR pyrometer reading is the average of a line measurement.

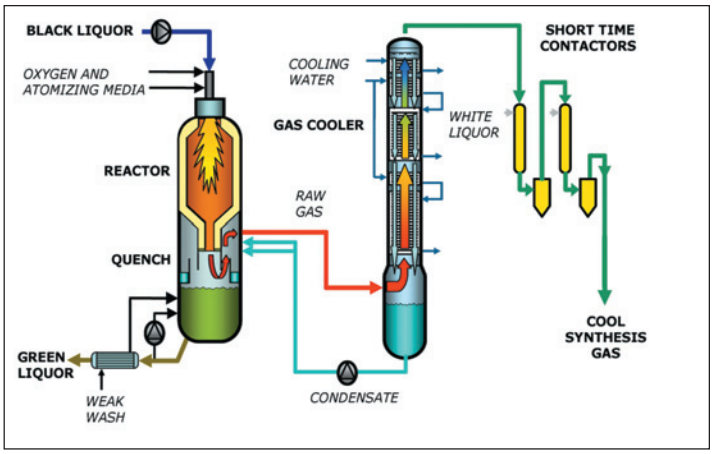
GASIFICATION

Experiments and mathematical models of black liquor gasification—influence of minor gas components on temperature, gas composition, and fixed carbon conversion

By Per Carlsson, Magnus Marklund, Erik Furusjö, Henrik Wiinikka, and Rikard Gebart

In this work, computational fluid dynamics (CFD) model predictions for a gasification reactor are compared to experimentally obtained data from an industrial pressurized black liquor gasification plant. The data consists of gas samples taken from the hot part of the gasification reactor using a water cooled sampling probe. During the experimental campaign, the oxygen-to-black liquor equivalence ratio (λ) was varied in three increments, which resulted in a change in reactor temperature and gas composition. The presented numerical study consists of CFD and thermodynamic equilibrium calculations in the considered λ-range using boundary conditions obtained from the experimental campaign. Specifically, the influence of methane concentration on the gas composition is evaluated using both CFD and thermodynamic equilibrium.

The results show that the main gas components (H_2, CO, CO_2) can be predicted within a relative error of 5% using CFD if the modeled release of H_2S and CH_4 are specified a priori. In addition, the calculations also show that the methane concentration has a large influence on the reactor outlet temperature and final carbon conversion.



Schematic drawing of the pressurized entrained high-temperature black liquor gasification (PEHT-BLG) process (image courtesy of Chemrec AB).

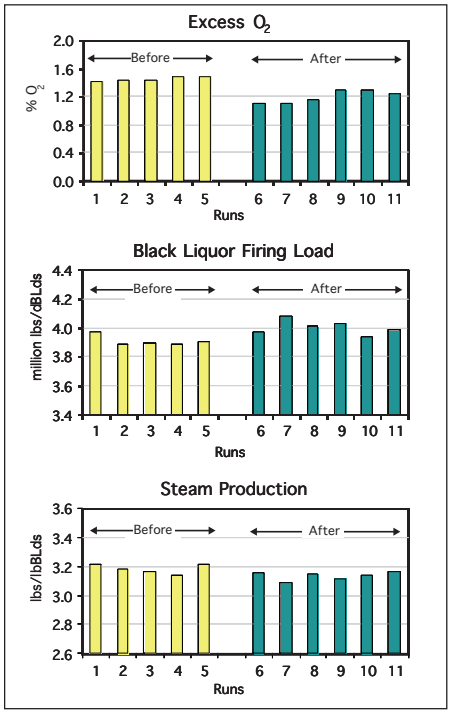
RECOVERY BOILER

Optimizing operation to increase recovery boiler throughput

By F. Donald McCabe, David Savoy, Chris Halcrow, and Honghi Tran

The recovery boiler at the Irving Pulp and Paper, Saint John, N.B., mill has been through several major retrofits to increase its original firing capacity of 1100 metric tons/day of black liquor dry solids to the present level of 1680 metric tons/day. Many problems have been encountered over the years, including tube corrosion and cracking, as well as plugging of flue gas passages, but they all have been overcome through operational changes and process optimization.

The latest challenge is to increase throughput without experiencing high total reduced sulfur (TRS) levels that would impact the environment and jeopardize compliance. An optimization program has been in place at the mill since December 2008 to further increase boiler production while maintaining environmental performance. The program, which automates liquor addition at full capacity according to targeted stack gas O_2 and TRS levels, enables the boiler to operate at lower stack gas O_2 targets and to achieve a 2%-3% increase in liquor throughput, while keeping TRS emissions under compliance. Mills that are recovery boiler limited may benefit from this approach for increasing throughput.



Excess O_2, black liquor firing load, and steam production during softwood runs before and after implementation of the Saint John mill's boiler O_2 trim program.