FOREST PRODUCTS

Project Fact Sheet

FUNDAMENTAL STUDY OF BLACK LIQUOR GASIFICATION KINETICS USING A PRESSURIZED ENTRAINED-FLOW REACTOR (PEFR)

BENEFITS

- Improvements in thermal efficiencies
- Reduction in energy consumption of >100 trillion Btus annually
- Twice the electricity output of atmospheric, gas-blown gasification
- Potential reduction in CO_2 emissions of 20 million tons/yr
- Lower capital costs than recovery boilers
- Improvements in pulping and other processes

APPLICATIONS

Recovery boilers in use in the pulp and industry are nearing the end of their useful lives. Adoption of oxygen-blown gasification technology in their place will generate significant energy and environmental benefits to mills.

Gasification Offers Industry the Potential To Become Energy Self-Sufficient Using Biomass Fuels

The aging recovery boilers of the pulp and paper industry will need replacing in the near future, and the industry has the opportunity to consider black liquor gasification technology in their place. Black liquor gasification offers pulp and paper mills the most efficient method for converting biomass energy to electric power, with thermal efficiencies of 74 percent compared to 64 percent in modern recovery boilers. Black liquor gasification also has environmental benefits, such as fewer CO_2 emissions and wastewater discharges, the potential for self-generation of power, and the potential for improved pulping operations.

Air-blown gasification technology, which operates at atmospheric pressure, is in place in mills in Sweden and the United States. This project will explore the feasibility of commercializing pressurized, oxygen-blown gasification using entrained-flow reactor technology. The design offers a number of advantages to the technology in use including lower capital costs, simpler gas cleanup, and greater electrical output when used in gas turbines. Moreover, the technology's greater thermal efficiency could potentially save more than 100 trillion Btus annually, and if mills replace their coal-fired power systems with gasifiers that self-generate power, CO_2 emissions could fall by 20 million tons/yr.

Figure 1. A milestone for IPST was the acquisition of a pressurized entrained flow reactor (PEFR) for black liquor and biomass gasification. Operating limits of 1500^{o}C, 1200 psi, and 10 sec residence time make it a unique addition to black liquor research capabilities.

PROJECT DESCRIPTION

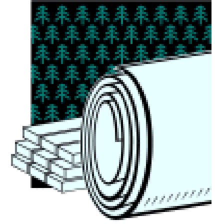
Goal: To evaluate the kinetics of gasification of kraft black liquor under laboratory conditions simulating pressurized, oxygen-blown gasification.

Kraft black liquor from both hardwoods and softwoods will be used in this study. Initial analysis of gases exiting the black liquor gasification reactor will be performed using Fourier Transform Infrared Spectrometry, and chemiluminescence. The next step will be a coupling of a pressurized, laminar-entrained-flow reactor (PEFR) and the National Renewable Energy Laboratory's Transportable Molecular-Beam Mass Spectrometer (TMBMS). This will be the first time that black liquor gasification kinetics will be studied in a laboratory/pilot scale high-temperature, high-pressure reactor using a spectrometer to analyze the synthetic gas. The last task will be to develop a kinetic model of the product gases.

The fate of trace components is of particular interest to researchers, especially of whether the nitrogen from the black liquor produces significant amounts of NO and NH_3 during gasification at high temperatures and high pressures.

PROGRESS & MILESTONES

- A PEFR was obtained by the Institute of Paper Science and Technology for use in this research.
- Preliminary experiments are underway with black liquor.
- Sequential tasks will be carried out to accomplish the following specific objectives:
  (1) Measure the effect of gasifier temperature, black liquor composition, particle size, and particle residence time on gas composition and fuel value, carbon conversion, distribution of sulfur between the condensed phase (Na_2S) and gas phase (H_2S and TRS compounds), NaOH formation in the condensed phase, and formation of trace species, including NH_3, HCl, and tars.
  (2) Develop kinetic models for pressurized, oxygen-blown gasification



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