



INDUSTRIAL TECHNOLOGIES PROGRAM

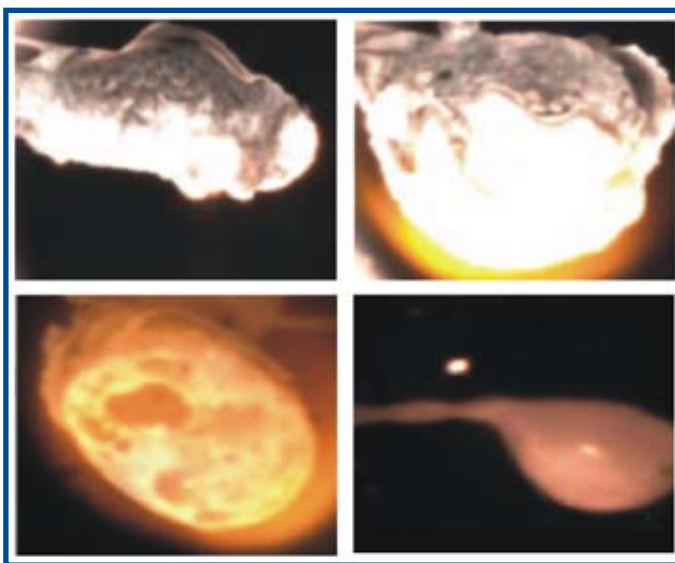
Optimization of Recovery Boiler Performance

Improved Boiler Efficiency Through Control of Combustion, Sulfur, and Alkali Chemistry

Black liquor recovery boiler energy and environmental performance depends strongly on the combustion characteristics of entrained black liquor solids. Recovery boiler combustion processes that have a strong impact on recovery boiler operation but lack sufficient characterization include: droplet/particle formation, drying, devolatilization, and elemental release rates; sulfur scavenging in the upper furnace; and sodium- and sulfur-dominated condensed-phase thermochemistry.

The current research effort completed a comprehensive model of black liquor drying, devolatilization, oxidation, and smelt formation. This single-particle model was validated using a series of novel experimental techniques that collected simultaneous surface and internal particle temperatures, particle shape and size, particle mass, and spatially resolved particle

surface temperature gradients all as functions of time during droplet combustion. Model predictions generally correspond with the data except that the seemingly random and highly aspherical shapes are not predictable, though if they are independently characterized the model accommodates their impact on particle combustion behavior. In addition, the thermochemistry of alkali salts relevant to deposit formation and sulfur scavenging has been developed in a quasi-chemical-based condensed-phase non-ideal equilibrium code. This code has been validated for binary systems with existing phase diagrams but there data are more difficult to find for higher order mixtures. This information will be used to develop a model that will help improve the design and operation of kraft recovery boilers, improve their energy efficiency, and to maximize their throughput and availability.



Black liquor combustion stages: drying (top left), devolatilization (top right), char burning (bottom left), and smelt oxidation (bottom right).



Benefits for Our Industry and Our Nation

- Improves recovery boiler efficiencies through better understanding of combustion processes
- Could reduce steam used for soot blowing up to 4 - 6%
- Could reduce flue gas temperature up to 17°C - 50°C (30°F - 90°F)

Applications in Our Nation's Industry

Optimizing the nation's fleet of recovery boilers to reduce soot blowing steam and flue gas temperature would save 38 - 58 trillion Btu/year (British thermal units per year).

Project Description

The main goals of this project are to develop a predictive single-particle model of recovery boiler performance based on fundamental physical and chemical characteristics of the combustion process in recovery boilers.

The research consists of experimental work to determine the mechanisms and rates of physical and chemical reactions during black liquor droplet combustion and modeling work to build a predictive integrated model that accurately predicts physical parameters under a range of conditions in the recovery boiler.

Pathways

The objectives of this project will be achieved through:

- Determining elemental and total mass release rates and yields for black liquor drying and devolatilization
- Developing a publicly available physical/chemical kinetic model of black liquor drop combustion, including new information on drying and devolatilization
- Determining mechanisms and rates of sulfur scavenging in recovery boilers
- Developing non-ideal, publicly available thermochemical model for alkali salts appropriate for recovery boilers
- Developing data and a one-dimensional model of a char bed in a recovery boiler

Progress and Milestones

- Conducted first new single-droplet experiments (Completed June 2003)
- Investigated the effect of temperature in the University of Maine char bed test facility (Completed June 2004)
- Formulated detailed model of laboratory char bed combustion (Completed June 2005)
- Completed modeling of laboratory char bed and deliver final algorithms of the rates of char bed combustion, alkali vaporization, and sulfur conversion reactions (Completed June 2005)

Commercialization

All software is intended for public use.

Project Partners

Brigham Young University
Provo, UT

University of Maine
Orono, ME

Babcock & Wilcox.
Barberton, OH

University of Utah
Salt Lake City, UT

Idaho National Laboratory
Idaho Fall, ID

Institute of Paper Science and Technology at
Georgia Tech
Atlanta, GA

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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