the ENERGY lab

PROJECT FACTS

Fuels

Development of Kinetics and Mathematical Models for High Pressure Gasification of Lignite-Switchgrass Blends

Background

Significant progress has been made in recent years in controlling emissions resulting from coal-fired electricity generation in the United States through the research, development, and deployment of innovative technologies such as gasification. Gasification is a process that converts solid feedstocks such as coal, biomass, or blends thereof, into synthesis gas (syngas), a mixture of carbon dioxide (CO_2), water (H_2O), carbon monoxide (CO), and hydrogen (H_2), which can subsequently be converted to power, fuels, or chemicals. Potential pollutants can be captured through this process and either safely disposed or converted to useful by-products.

The Department of Energy (DOE) is committed to supporting research focused on making use of the nation's coal and biomass resources to produce affordable power, fuels, and chemicals using methods that are less damaging to the environment than those presently available. The production of fuels and chemicals from feedstocks of coal-biomass mixtures can reduce overall greenhouse gas emissions. One area of research is the development and characterization of multiple coal-biomass mixtures which are transportable and storable and which can be co-fed directly into gasification systems. The National Energy Technology Laboratory (NETL) is partnering with the Georgia Tech Research Corporation (Georgia Tech) to develop kinetics and mathematical models for high-pressure gasification of lignite-switchgrass blends.

Project Description

The project team will test three blend compositions of lignite coal and switchgrass. Two different but complementary reactor configurations will be used in the test program: 1) a pressurized entrained flow reactor (PEFR) available at Georgia Tech and 2) a pressurized thermo-gravimetric analyzer (PTGA) available at the National Renewable Energy lab (NREL). The PEFR provides high heating rates and short contact times, thus mimicking the conditions encountered in a commercial gasifier. The chars generated in the PEFR will be characterized for porosity, BET surface area, morphology and composition, chemical reactivity, and reactivity using the PTGA under transport-limit free conditions. The PTGA studies undertaken at NREL will run concurrently with those at Georgia Tech. These studies will involve identification of gaseous species that evolve during transient pyrolysis at 600 °C, 800 °C, and 1000 °C and at three pressures: 5 bars, 10 bars, and 15 bars. Char gasification kinetics at

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PARTNERS

Southern Company[-National Renewable Energy Laboratory

PROJECT DURATION

Start Date
01/01/2011

End Date
03/31/2014

COST

Total Project Value
$1,565,399

DOE/Non-DOE Share
$1,101,814 / $463,585

conditions where the effect of CO and H_2 on char gasification rate will be quantified under transport-free conditions, and the catalytic role of inorganic species on char gasification kinetics will be studied.

Goals and Objectives

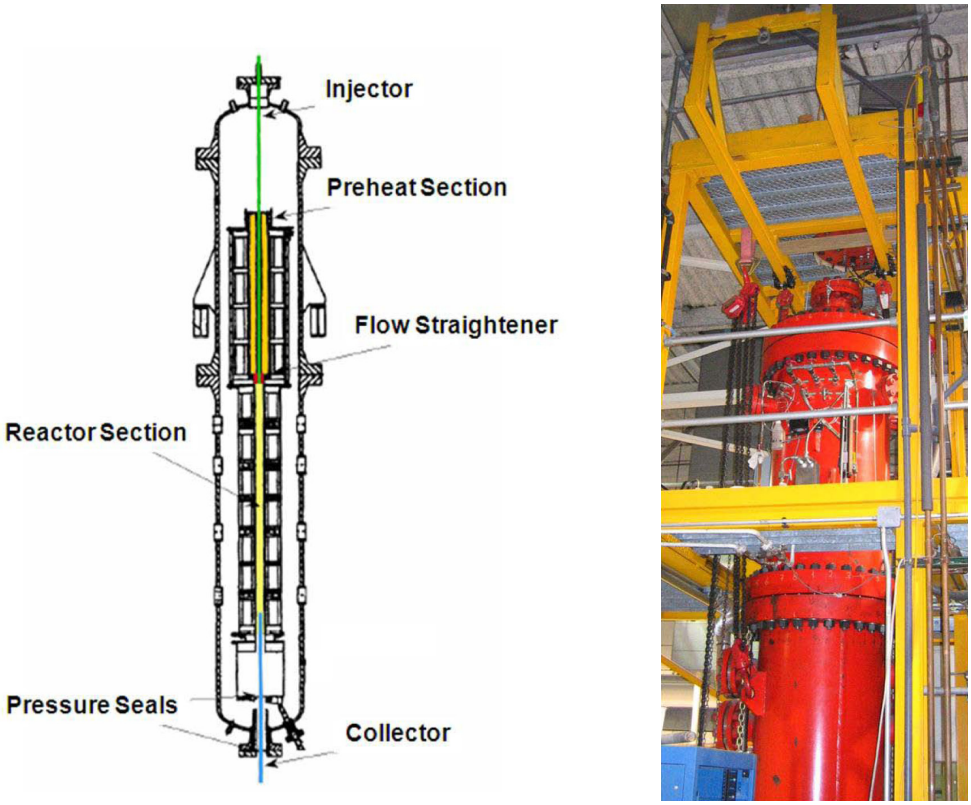
The objectives of the study are to (1) obtain experimental reactor data and develop kinetic rate expressions for pyrolysis and char gasification for lignite-switchgrass blends under conditions free from transport limitations; (2) develop a detailed understanding of the effect of pyrolysis conditions on the porous char structure and its gasification reactivity; (3) build mathematical models that combine true kinetic rate expressions with transport models for predicting gasification behavior for a broad range of pressures and temperatures; and (4) to investigate the physical and chemical parameters that might lead to synergistic effects in blending coal with biomass for gasification.

Accomplishments

The research team has acquired and initiated the processing and analysis of the lignites and switchgrass materials. The processing step includes size reduction by milling and sieving, and proximate and elemental composition (C, H, N, and O) analyses of the coals and switchgrass. PTGA pyrolysis of two different lignites (from North Dakota and Texas) was completed. Team members were trained in Scanning Electron Microscopy (SEM), nuclear magnetic resonance spectroscopy and inductively coupled plasma spectroscopy which will be used in the research for analyzing and characterizing the morphology and chemical composition of the chars and feed materials. Researchers were trained in the overall operation of the of the atmospheric PEFR and protocols and procedures were developed for collecting gas samples for subsequent quantitative gas chromatography analysis. Researchers also tested the PTGA set-up for char gasification.

Benefits

The research is aimed at making use of the nation's abundant coal and biomass resources to produce affordable power, fuels and chemicals in a safe and environmentally clean manner. In addition, the production of fuels and chemicals from gasification of coal-biomass blends as feedstocks has the added benefit of significantly offsetting the carbon derived from the fossil energy source, thereby reducing overall greenhouse gas emissions. This project, among others awarded by the DOE, will provide valuable data for improving our understanding of how to make coal/biomass gasifiers operate more efficiently. Specifically, this project will answer some critical questions that will enable kinetic and mathematical models to predict gasifier performance at a wide range of operating conditions. Better models will facilitate the engineering design of more efficient systems for using biomass feedstocks in combination with coal to produce electricity, chemicals, and other useful products.



Schematic and photo of the Pressurized Entrained Flow Reactor (PEFR) at Georgia Tech.
Source: PI (with permission)