the ENERGY lab

PROJECT FACTS

Fuels

Gasification Characteristics of Coal/Biomass Mixed Fuels

Background

Domestically abundant coal is a primary energy source and when mixed with optimum levels of biomass during the production of liquid fuels may have lower carbon footprints compared to petroleum fuel baselines. Coal and biomass mixtures are converted via gasification into synthesis gas (syngas), a mixture of predominantly carbon monoxide and hydrogen, which can be subsequently converted to liquid fuels by Fischer-Tropsch chemistry.

The Department of Energy (DOE) is supporting research focused on using coal and biomass to produce clean and affordable power, fuels and chemicals. The DOE's National Energy Technology Laboratory (NETL) is partnering with Leland Stanford Junior University (Stanford) to develop methods and models to predict conversion rates of the chars of coal/biomass mixtures in entrained flow gasifiers.

Project Description

The research team at Stanford is producing chars of a coal, a biomass and selected blends of the two in high temperature, reducing environments established in an entrained, laminar flow reactor and subjecting the chars to a series of tests in a thermogravimetric analyzer (TGA) in order to determine their reactivities to oxygen (O_2), carbon dioxide (CO_2) and steam (H_2O). Researchers use the data to determine chemical reaction mechanisms, with associated kinetic parameters, that describe the chemical reactivities of the chars. The reaction mechanisms are employed in direct numerical simulations of gasifying char particles in order to obtain the information needed to develop models that reflect the combined effects of chemical reaction and pore diffusion on overall particle mass loss rates.

The research team at Stanford is also developing a model to describe the variations in the mass specific surface areas of char particles as conversion progresses. The intrinsic chemical reactivities, the models that characterize mass transport limitations on conversion rates, and the mass specific surface area model will permit the development of a robust char-particle gasification model that is capable of accurately predicting mass loss rates, off-gas compositions and the sizes of pulverized char particles in specified gasification environments.

CONTACTS

Jenny Tennant
Gasification Systems Technology Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4830
jenny.tennant@netl.doe.gov

Arun Bose
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4467
arun.bose@netl.doe.gov

Reginald Mitchell
Principal Investigator
Stanford University
Building 520, Room 520C
Stanford, CA 94305-3032
415-725-2015
remitche@stanford.edu

PROJECT DURATION

Start Date
10/1/2010

End Date
09/30/2013

COST

Total Project Value
$ 571,979

DOE/Non-DOE Share
$ 457,583 / $ 114,396

Goal and Objectives

The overall objective of this project is to develop a model to predict conversion rates of the chars of coal/biomass mixtures under conditions relevant to a commercially-available coal gasification system configured to co-produce electric power and liquid fuels. Chars produced by devolatilizing pure pulverized Wyodak coal particles, pure pulverized corn stover particles, pure almond shells, and selected blends of these fuels are subjected to a matrix of tests in order to obtain data on mass loss rates as functions of gas temperature, pressure and composition as well as data on the evolution of mass specific surface area during char conversion. The data will be used to develop a char-particle gasification model that is capable of predicting particle mass loss rates, off-gas compositions and variations in particle sizes for char particles exposed to the types of high-temperature environments established in entrained flow gasifiers.

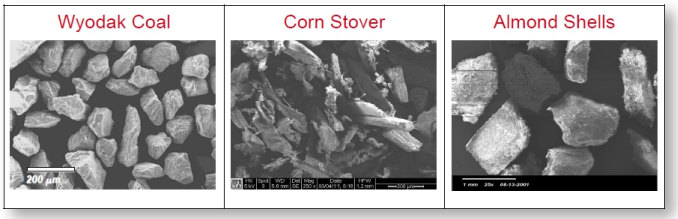

Figure 1. Materials that are being tested during this research project

Accomplishments

The research team has produced pure Wyodak coal chars, pure corn stover chars and mixed chars from coal/biomass mixtures by subjecting size-classified coal and biomass particles to a high-temperature, reducing environment in a laminar flow reactor. The research team measured the mass specific surface areas of the chars and developed a correlation that permits the determination of the initial mass specific surface areas of the mixed chars from the initial mass specific surface areas of the pure coal and biomass components, for mixed chars produced in reducing environments.

Char intrinsic chemical reactivities to O_2, CO_2 and H_2O have been measured via thermogravimetry and reaction mechanisms, with associated kinetic parameters for each pure char and for selected mixed chars, have been determined that accurately describe the char reactivities. Comparisons of calculations and measurements obtained in environments containing selected amounts of carbon monoxide (CO) and hydrogen (H_2) indicate that the reaction mechanisms developed accurately capture the inhibiting effects of H_2 and CO on char gasification rates.

The team has completed direct numerical simulations of char particles undergoing gasification under specified conditions, analyzed the results and developed models that account for the O_2, CO_2 and H_2O pore diffusion limitations on overall particle conversion rates that occur at high particle temperatures. This permits the development of a char-particle gasification model that is capable of predicting the mass loss rates, off-gas compositions and sizes of char particles as they are converted to syngas in entrained flow gasifiers co-fired with coal/biomass blends.

Benefits

Results from this project will enable further development of high-efficiency coal/biomass co-fired gasification plants for the production or coproduction of energy, fuels, and chemicals with low carbon foot prints. This technology will contribute to enabling a more efficient and environmentally sustainable use of coal, a domestic energy resource.

Figure 2. Pressurized thermogravimetric analyzer