PROJECT facts

Advanced Research

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U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

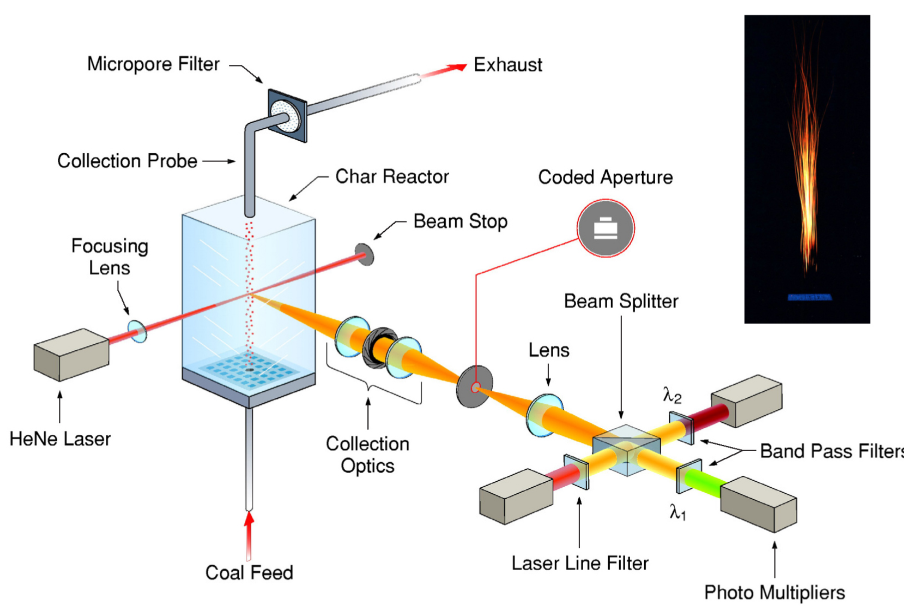
NETL

Quantitative Char Kinetics for Advanced Pulverized Coal Combustion

Description

Advanced pulverized coal combustion systems are being studied to produce a more compact, high-intensity combustion of coal that will reduce capital costs of the boiler and increase boiler efficiency. Two methods have emerged that may improve boiler efficiency: oxygen enrichment of air and firing coal in a mixture of oxygen and recycled flue gas (O_2-recycle combustion). Both methods receive elevated concentrations of oxygen in the main combustion zone, which leads to at least partial char combustion in regions of high O_2. In addition, the O_2-recycle combustion method entails combustion in a gas mixture dominated by carbon dioxide (CO_2), rather than nitrogen (N_2).

To adequately anticipate the effects of implementing these advanced combustion technologies on burner and boiler performance and emissions, accurate char kinetic rate expressions were determined for these unusual gas environments.



Schematic of the laminar entrained flow reactor and particle-sizing pyrometry diagnostic in the Char Combustion Laboratory (CCL). Inset photo: Coal particles burning within the reactor

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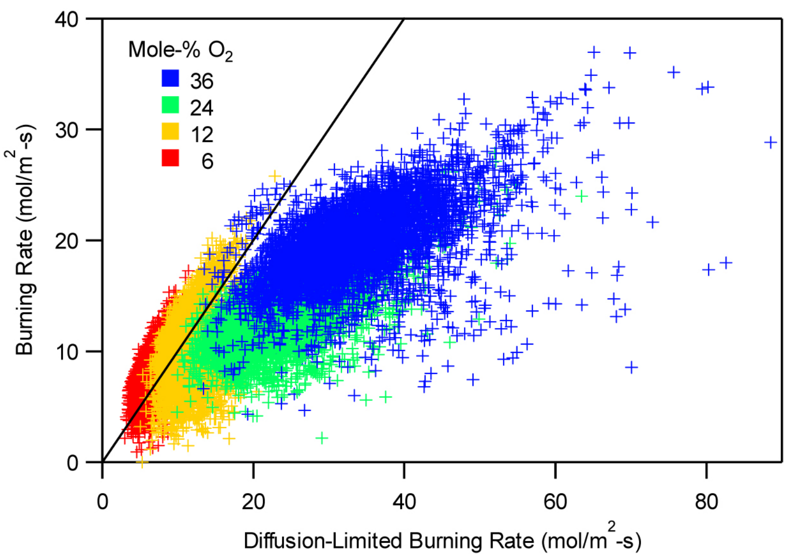
The object of this project was to use the single-particle two-color pyrometry diagnostic in Sandia's Char Combustion Laboratory (CCL) to derive quantitative char combustion kinetics for burning a typical bituminous and subbituminous coal in three environments: traditional, oxygen-enriched, and where carbon dioxide replaces nitrogen diluent. These kinetic expressions may be readily implemented into coal furnace computational fluid dynamics (CFD) models or other simpler approaches.

Accomplishments

Measurements of char particle temperature-size were collected by burning Pittsburgh seam hvA bituminous coal and Highvale subbituminous coal in gas environments that contained between 6–36% O_2 at temperatures ranging from 1,450–1,850 K. In contrast to expectations based on existing oxygen-depleted kinetic rates, char particle combustion became less diffusion-rate controlled as the oxygen content increased. A nonlinear regression technique has been developed for deriving the best-fit rate coefficients for applying an assumed kinetic rate expression to the data. This technique avoids biases traditionally introduced when a logarithmically linearized Arrhenius expression is applied to the data. The best-fit nth-order Arrhenius expression shows a low reaction order in oxygen for char combustion in oxygen-depleted environments, and a reaction order of ~ 0.5 for char combustion in oxygen-enriched environments. Preliminary analysis of data collected in CO_2-diluent environments indicates that CO_2 has a a negligible effect on the kinetic rate of char combustion.



Single-particle burning rates for Pittsburgh seam coal char compared to the calculated diffusion-limit burn rate, as a function of O_2 content in the bulk gas.

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PROJECT COST

$500,000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov