Technology

Thermal Science

Thermal Science Research Group

at the University of Mississippi

R&D Opportunity

The Chemical Engineering Department at the University of Mississippi is currently seeking a development partner to assist with technology for the clean burning of coal.

We envision that the partner would work with the Thermal Science Research Group (TSRG) to demonstrate the concept on pilot-scale boilers.

Introduction

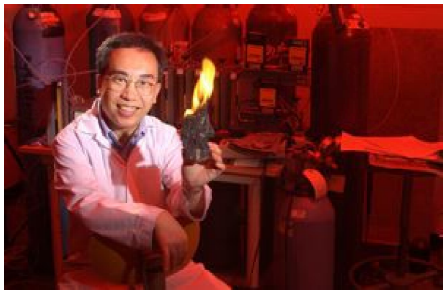
"Reburning" for the reduction of nitrogen oxide (NO) during coal combustion is a three-stage, in-furnace combustion technology whereby a small amount of reburning fuel is introduced above the primary flame where the majority of NO is chemically reduced to nitrogen. Reburning is attractive because it retrofits old boilers and enjoys a relatively low operation cost. Tests of reburning have demonstrated a 60% NO reduction floor.

With funding from the U.S. Department of Energy (DOE), the TSRG has been researching reburning with a bench-scale reaction unit, allowing for the elucidation of reburning mechanisms. A multi-functional, mixed fuel containing natural gas for NO reduction and lignite ash for reducing the reburning intermediate, hydrogen cyanide (HCN) has demonstrated remarkably high efficiency in reburning. Since the price of natural gas has increased and fluctuated significantly in the last five years, there is an incentive to find substitutes. An effective substitute for lignite ash is also desirable because of the large quantity required for the target HCN conversion. Several combinations of hydrocarbon substances and minerals have been chosen as the main reburning fuel and the HCN reducing agent in a reburning apparatus.

Results indicate that a wide range of mixed-fuels possess remarkably high overall NO reduction efficiency, up to 85% from the two-stage experiments at high reburning stoichiometric ratios, ranging from 0.90 to 0.95. The nitrogen speciation in both stages is very similar to natural gas. Both components are widely available waste materials.

An efficient HCN conversion catalyst has been identified. Only 60-200 metric tons of this catalyst is needed for a 172 MW bituminous coal-fired power plant, and it does not cause fouling or slagging problems in the coal-fired boilers. Both components of these substitutes are widely available at low costs. For fuels showing low overall NO reduction efficiencies, char-nitrogen conversion to NO in the burnout zone is a limiting factor.

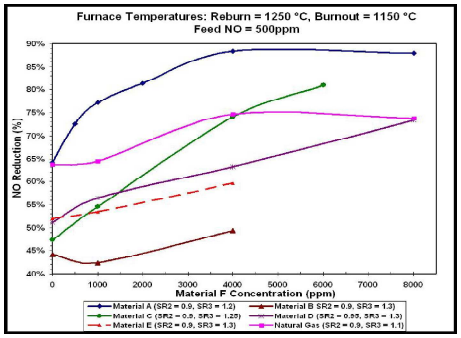
The University of Mississippi is currently applying for a patent for this technology.



Dr. Wei-Yin Chen in his Combustion Laboratory

Development Capabilities

The Thermal Science Research Group (TRSG) has the capability to investigate, design and develop various carbon transformation processes that lead to the efficient and environmentally acceptable utilization of carbon resources in the generation of energy and new chemical feed stocks. The TSRG is currently seeking partners to bring our current discoveries to the technology fast track by demonstrating the concepts on large-scale boilers. Moreover, we seek research collaborations that will provide synergies in the area of carbon utilization.



NO Reduction Efficiencies in Reburn with Different Binary Fuels

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Research Interest Areas

The primary areas of interest within the Thermal Science Research Group (TSRG) at the University of Mississippi are:

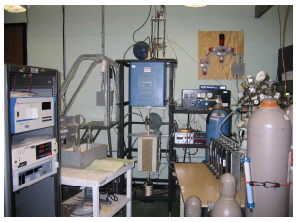
- the elucidation of nitrogen reaction pathways in reburning and burnout zones.
- the demonstration of discoveries on pilot-scale boilers.
- the minimization of the char nitrogen conversion to nitrogen oxide in flames.

Facilities and Resources

The facilities and resources available to the Thermal Science Research Group (TSRG) at the University of Mississippi are:

- 1,800 ft^2 combustion laboratory.
- Four (4) chemical reactors operated under different flow modules and solid-fuel injection techniques.
- Gas chromatography/mass spectrometer (GC/MS).
- Surface area and pore volume analyzer.
- Atomic Absorption Spectrophotometer.
- NO, NO_2, CO, CO_2, and N_2O analyzers.
- Specific ion detectors.

Char Oxidation Facility



Apparatus for NO Reduction

Funding

The Chemical Engineering Department at the University of Mississippi has received funding from the U.S. Department of Energy (DOE) and the National Science Foundation (NSF) to develop advanced clean coal combustion technology.

Additional Areas of Interest

With funding from the National Science Foundation (NSF), the TSRG is seeking to better understand the chemical reactions and physical transformation of young chars in flame environments, which constitutes a major gap in the combustion literature. Young char undergoes a complex network of reactions that include devolatilization, adsorption of oxidants, desorption of surface oxides, surface reactions, thermal annealing, interaction with CO, and mineral sintering.

In response to the urgent concerns of climate change and uncertainty in secured energy supply, TSRG is developing a technology-driven project for finding routes to mitigate the greenhouse effects and, in the mean time, reduce emissions of other pollutants for coal (and other) solid fuel-fired boilers. Critical review of current scientific evidence suggests that a better understanding of the CO_2 interactions with carbons (such as coals) in three distinct conditions could lead to a technological breakthrough that significantly mitigates the release of CO_2 and restores the carbon cycle. Two of the technologies also target simultaneous reductions in nitrogen oxide emissions and unburned carbon in ash from combustion.

Faculty and Staff

Dr. Wei-Yin Chen began his fossil fuel research just before the last energy crisis in the early 1970s, and has remained active in the field over the past three decades.

Between 1975 and 1990, he conducted a wide spectrum of research projects aimed at fossil-fuel utilizations. These subjects include coal pretreatment, coal pyrolysis, coal hydrogenation, coal liquefaction, coal combustion, and oil shale retorting.

Dr. Chen has secured over $2M of federal funds for his bench-scale research--essentially all of them awarded through stiff national competitions. He is currently writing two books; one on alternative energy and the other on the control of NO from coal-fired boilers.

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