R & D facts

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Integrated Removal of Pollutants From Fossil-Fueled Power Plants

The path to energy security for the United States will likely be paved with coal combustion. Electricity production from coal meets approximately half of current national requirements and the country has abundant coal resources – enough to last through the 23rd century. If coal burned cleanly, its use would not be in question today, but decades of study have shown that the by-products of coal combustion are sources of environmental degradation. EPA rules and regulations now mandate controls on sulfur and nitrogen oxides (contributors to acid rain) and mercury (a human health hazard). Carbon dioxide (CO_2), another significant by-product of coal combustion, has been increasing in the atmosphere since the dawn of industrialization, and studies over the past 10 years have linked these anthropogenic increases in CO_2 to climate change. NETL is investigating a cradle-to-grave strategy to control carbon dioxide and other by-products of fossil fuel energy production.

Oxy-fuel combustion of coal generates denitrified combustion gas comprising dominantly CO_2 and H_2O. The combustion gas is dried through repeated condensations and the remaining CO_2-rich fluid is compressed to a sequestration-ready supercritical mixture, in a gas clean-up operation known as integrated pollutant removal (IPR). Nitrogen oxides are reduced in oxy-fuel combustion. Mercury and sulfur compounds are captured with the CO_2 or removed as solids. The oxy-fuel / IPR technology may be retrofitted to an existing plant or incorporated into novel designs for new plants. In either case, these technologies are intended to enable fossil fuel utilization with ultra-low emissions.

Conducting experiments to determine oxy-fuel combustion gas response to desulfurization.

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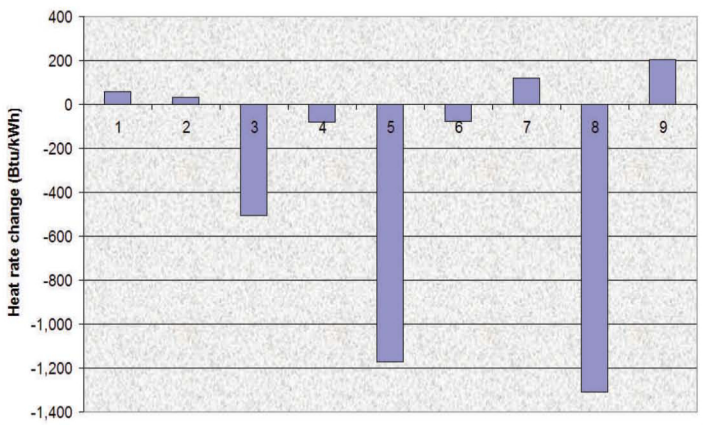


Partial results of GateCycle© modeling study; effect on heat rate of changes to oxy-fuel combustion parameters. All options are compared to a new-design advanced technology green field subcritical boiler.
Parameter changes are:

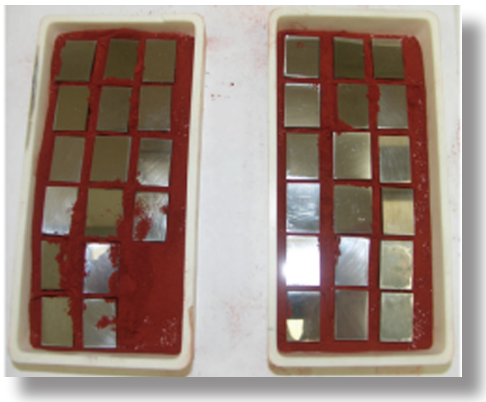
1. *Increased oxygen purity*
2. *No recycle of flue gas*
3. *Cooled recycled flue gas*
4. *Increased recycle rate*
5. *Cooled recycled gas at higher recycle rate*
6. *No heat recovery from compression*
7. *Reduced excess O2 fraction*
8. *Combined effect of negative changes*

NETL is examining oxy-fuel combustion with IPR gas clean-up on a systems level for both retrofit and new design plants. With the NETL Office of Systems, Analysis, and Planning (OSAP), various oxy-fuel and gas clean-up concepts are being applied to existing-plant and new-plant designs. Advanced techniques such as computational fluid dynamics and thermodynamic cycle modeling are being used to evaluate and compare the relative effects of the various concepts. NETL is also conducting experiments to address some of the challenges of the oxy-fuel and IPR systems. Current models of oxy-fuel plants recirculate a fraction of the combustion gas, and add high-purity oxygen to support combustion.

The altered combustion environment impacts combustion gas chemistry, temperatures, and heat transfer regimes, with implications for the materials used to build plants. The character of the combustion products and how they behave through the condensation / compression system is also not well defined.

NETL experimentation focuses on three areas:

- Corrosion studies of boiler alloys in low-nitrogen environments
- Heat transfer from an oxy-fuel flame to the power plant working fluid
- Behavior of denitrified combustion gas through the IPR system



Metallic coupons are arranged in a crucible in standard corrosion mixture (synthetic ash). To judge material performance, coupons are exposed for up to 1000 hours to hot gas mixtures simulating air or oxy-combustion gases.