PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental & Water Resources

11/2004

OXYGEN-ENHANCED COMBUSTION FOR NO_X CONTROL

PRIMARY PROJECT PARTNER

Praxair, Inc.
Tonawanda, NY
www.praxair.com

CONTACTS

Bruce W. Lani
Project Manager
National Energy Technology Laboratory
412-386-5819
bruce.lani@netl.doe.gov

Thomas J. Feeley, III
Technology Manager
National Energy Technology Laboratory
412-386-6134
thomas.feeley@netl.doe.gov

David Thompson
Praxair, Inc.
dave_thompson@praxair.com

WEBSITE

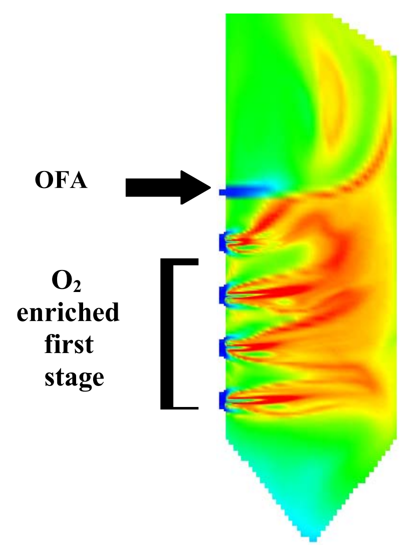
http://www.netl.doe.gov

Background

Enacted regulations pertaining to the NO_X SIP Call and potential future regulations in proposed legislation such as the President's Clear Skies Act or EPA's Clean Air Interstate Rule require power producers to seek the most cost effective methods to achieve compliance. In order to address present and anticipated NO_X emissions control legislation targeting the current fleet of U.S. coal-fired boilers, the Department of Energy's (DOE) Innovations for Existing Plants (IEP) Program develops advanced, low cost, NO_X control technologies. Managed by the DOE's National Energy Technology Laboratory (NETL), the IEP Program develops these technologies in order to keep coal a viable part of the national energy mix. Such technologies address issues of health, ground-level ozone, ambient fine particulates, visibility, eutrophication, climate change, as well as "acid rain" precursors.

As part of a NETL Cooperative Agreement, Praxair and its partners have developed an oxygen-enhanced combustion technology for controlling NO_X to levels below 0.15 lb/MMBtu and a novel oxygen separation process to reduce the cost of oxygen production. Conventional oxygen-fired combustion has been utilized in industrial glass melting furnaces to reduce NO_X emissions by as much as 80-90%. This novel technology replaces a small fraction of the combustion air. The result is a reduction in NO_X emissions from burning coal while improving combustion characteristics such as loss-on-ignition (LOI). In addressing the economic issues of oxygen production, Praxair is developing an Oxygen Transport Membrane (OTM) process that utilizes ceramic membranes with pressure as the driving force for separation of oxygen from air.

Oxygen with staged combustion



Objectives

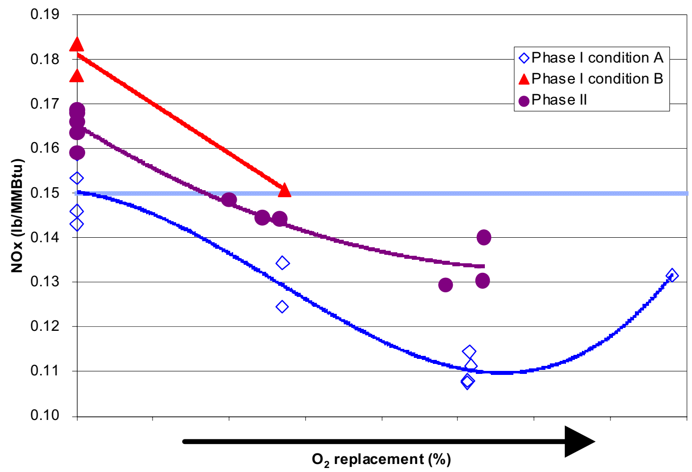
The objective of this project is to utilize pure oxygen at a feed rate of less than 10% of the stoichiometric requirement in demonstrating the use of oxygen-enhanced combustion in meeting environmental regulations requiring NO_X reductions to less than 0.15 lb/MMBtu for coal-fired boilers. Additionally, the OTM process is to produce significant quantities of oxygen from a multi-membrane reactor. In meeting these objectives, the anticipated levelized cost of the oxygen-enhanced combustion process will be at least 25% lower than that of the current state-of-the-art SCR installation.

Description

Praxair and its partners have developed a novel oxygen based technology that can reduce NO_X emissions from nitrogen containing fuels, including pulverized coal, while improving combustion characteristics such as LOI. This novel technology replaces a small fraction of the combustion air with oxygen. Conventional oxy-fuel knowledge would indicate that even this small replacement would have a beneficial impact on boiler performance independent of any reduction in NO_X.

Experimental work was performed using the Industrial Boiler Simulation Facility (ISBF) at ALSTOM Power Inc.'s Power Plant Laboratory. The experiments were designed to demonstrate that the concept of an oxygen-enhanced low NO_X combustion system could meet the emissions target of 0.15 lb/MMBtu with minimal impact on CO emissions and furnace performance. The ISBF is a water-cooled tunnel furnace designed to test burners up to 50 MMBtu/h in firing rate with time-temperature histories similar to PC fired boilers. The unit has two locations for separated overfire air (SOFA) injection. ALSTOM's commercial wall-fired low NO_X burner, an '*off the shelf*' RSFC burner, was used in these experiments. The burner was designed for a firing rate of 26 MMBtu/h and was typically fired at 24 MMBtu/h for these tests.

Results from ISBF Testin



In the first full-scale test campaign, denoted Phase I-A, Illinois No. 6 bituminous coal was used. Initial tests were performed to shake down the furnace and to obtain baseline NO_X data for this facility, burner, and coal combination. A series of experiments were then performed to explore the effect of oxygen addition on NO_X emissions. In the second test campaign, denoted Phase II, selected experiments were repeated with the Illinois No. 6 coal. An eastern bituminous coal, the Mingo Logan, was then used in Phase I-B to evaluate both the effect of a lower volatile coal and the effect of oxygen addition method. Data from the Illinois No. 6 experiments show that even when the baseline (air only) emissions are very low, oxygen addition can drive the NO_X emissions even further. The overall data further show that the reductions are relatively independent of the initial NO_X concentration. Data from the Mingo Logan experiments show that the concept works even with the lower volatile coal, and that the technique in injecting the oxygen has a large impact on NO_X reduction.

The membrane material element was tested in the single-tube high-pressure reactor at 900°C. The oxygen product purity was observed to be as high as 99.999% and remained above 98% for the duration of the test, which was >190 hours.

In addition to the reduction in NO_X, benefits can be achieved in the areas of reduced LOI and opacity, increased boiler efficiency, and reduced fan limits. Demonstrations at two utility boilers have proven these benefits of the technology while decreasing the NO_X emissions. Preliminary economic analysis indicates that cost savings of 40-50% can be realized when compared to SCR.

Typical Economics

**Based on 5 month operation*