Jupiter Oxygen – Oxy-Combustion and IPR

Project Title:

Jupiter Oxy-Combustion and Integrated Pollutant Removal Research and Development Test Facility

Technology Area:	**Technology Maturity:**
Oxy-Combustion	Pilot/Bench

Primary Project Goal:

Jupiter Oxygen will design, construct, and operate a 5-MWe, high flame temperature, oxy-combustion test facility with a 20-kWe integrated pollutant removal (IPR) bench-scale system to demonstrate carbon dioxide (CO_2) capture from an oxy-combustion process.

Technical Goals:

- Develop high flame temperature oxy-fuel burners.
- Collect data on burner performance and boiler heat transfer.
- Conduct a study of the ash and slagging characteristics of the process and its impact on boiler materials.
- Capture CO_2 and collect data on impurity removal using the Jupiter Oxygen combustion process along with IPR technology developed by NETL.

Technical Content:

There are two different approaches to oxy-combustion. Jupiter's approach is to use a high temperature flame that is minimally tempered with nitrogen, CO_2, or other inert gases (the only tempering occurs as a result of flue gas recycle that is used to motivate coal). High flame temperature oxy-combustion results in improved heat transfer in the boiler's radiant zone. Other oxy-combustion facilities use a low flame temperature approach which uses large amounts of CO_2 recycled through or at the burner to cool the flame to a temperature similar to air firing. The unique combination of the high-temperature approach coupled with the IPR system will allow the evaluation of the impact of using high- and low-temperature approaches and energy recovery on a variety of aspects of power plant operations.

Heating value, mineralogy, and trace element content of the coal will be determined using ASTM procedures, including proximate and ultimate analyses. This information will be used to determine the effect of the coal characteristics on oxy-combustion performance and the effectiveness of emissions capture. Other performance measurements for the test facility include water tube and web temperature, heat transfer rate, flue gas emissions (nitrogen oxides [NO_X], carbon monoxide [CO], CO_2, sulfur dioxide [SO_2], and trace metals), and loss on ignition (LOI) of the ash. The facility will incorporate the following approaches to conduct measurements:

- Flue gas species concentrations will be measured by Fourier Transform Infrared Spectroscopy (FTIR).
- Ash LOI will be measured by laboratory testing.
- Heat transfer in the radiant zone will be determined by spectral flame mapping, furnace gas temperature measurement (at the screen wall and boiler exit), temperature measurements of the flux through the boiler tubes, and optical measurements of the total radiant heat flux from the flame.
- Net heat output from the burner and heat absorbed by the boiler will be calculated based on combustion and steam side energy balances.
- Combustion side mass balances will be calculated by combining species measurements with mass flows.

- Corrosion monitoring probes will be used.
- Gas-phase and particulate-phase trace elements including mercury (Hg) by will be measured by samples from select runs.
- IPR contaminant removal will be measured by laboratory analyses and FTIR.

The IPR system was added to the pilot facility to remove pollutants from the oxy-combustion flue gas re-circulated stream. The current device is used to process 45 to 64 kg/hr (100 to 140 lb/hr) of flue gas from the facility. The IPR system will capture, separate, and produce a dry, supercritical stream of CO_2; a stream of captured pollutants; and a stream of condensed water from the flue gas. Figure 1 shows a representation of the IPR system that is integrated at a pilot-scale facility.

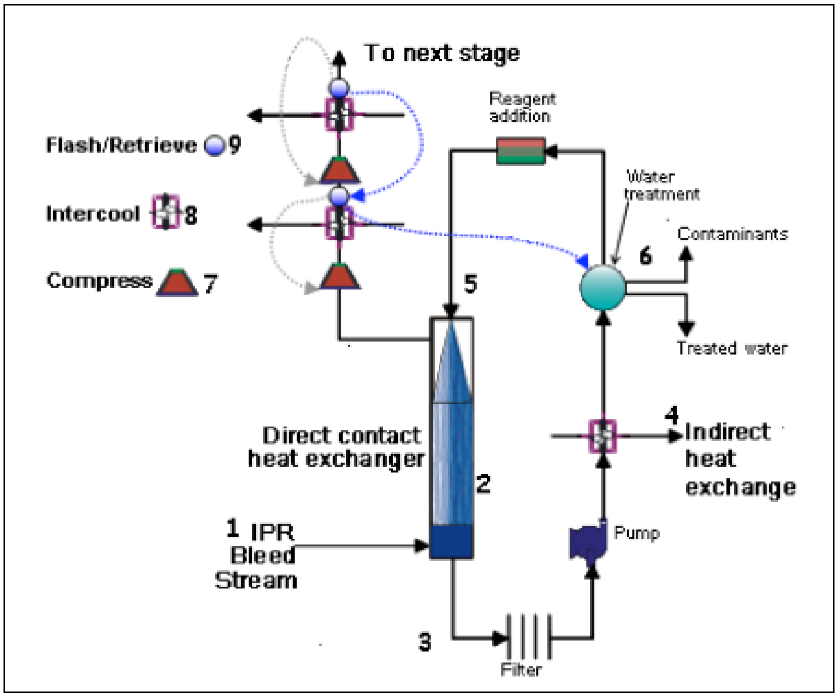

Figure 1: Representation of IPR System Integrated at a Pilot-Scale Facility

The generalized IPR process flow diagram is presented above: a flue gas bleed stream (1) enters the IPR system into a glass-pipe spray tower (2) in which sulfur oxide (SO_X) is removed by a spray stream (reagent addition) as the gas rises. The spray water and combustion condensed water (3) are cooled (4) and partially re-circulated back into the spray tower (5). The water that is not re-circulated back in to the spray tower is treated outside the IPR system (6). As the scrubbed gas leaves the tower, it enters a two-stage reciprocal compressor (7) and a water-cooled, counter flow heat exchanger (8). During the compression stage, separated water can be collected in the collection vessel (9).

Technology Advantages:

The higher flame temperature improves heat transfer in the radiant zone which increases boiler efficiency, lowers the quantity of flue gas, concentrates CO_2 in the flue gas, significantly reduces NO_X emissions and results in fuel savings. For retrofit applications, this technology maintains actual water wall and steam temperatures without altering the boiler design or size. For new construction this technology can use a smaller boiler, which provides the same thermal output as larger existing power plant boilers.

R&D Challenges:

High flame temperature oxy-combustion is still being tested at the pilot scale. Some issues that could arise include increased corrosion, fouling, and slag formation. A better understanding of the interaction of ash, SO_X, and slag on boiler materials is required.

Results To Date/Accomplishments:

- Retrofit and operated a 5-MWe equivalent oxy-coal combustion test facility and the ancillary systems.
- Performed a series of oxy-coal burner development tests which resulted in a modified first generation burner.
- Performed parametric studies with the modified first generation oxy-coal burner.
- Retrofit completed without major boiler modifications.
- No increased fouling and slagging indicated (study continues).
- No damage to boiler materials indicated (study continues).
- Measured performance and species streams in the IPR system.

Next Steps:

Further work with the 5-MWe equivalent oxy-coal combustion test facility and the ancillary support systems will include the following:

- Installation of a larger flue gas recycle blower to test at higher recirculation rates.
- Ramp up to the full 50 MMBtu/hr rating of the existing modified first generation burner.
- Develop a second generation high-temperature oxy-coal burner with the aid of CFD modeling.
- Develop an air-coal performance base line for the test facility.
- Conducting IPR system performance tests to optimize heat recovery and gas reactions.
- Complete slagging and fouling studies and boiler material corrosion studies.
- Conducting analysis for technical and economic scale up of the technologies.
- Developing data summaries from the studies.

Final test results will not be available until the September 2011 project completion date.

Available Reports/Technical Papers/Presentations:

S. Gerdemann, C. Summers , D. Oryshchyn , B. Patrick , T. Ochs, "Developments in Integrated Pollutant Removal for Low-Emission Oxy-Fuel Combustion."

Jupiter Oxycombustion and Integrated Pollutant Removal of the Existing Coal-Fired Power Generation Fleet – CO_2 Capture Technology for Existing Plants R&D Meeting – March 2009.

Results of initial operation of the Jupiter Oxygen Corporation oxyfuel 15 MW_{th} burner test facility – Paper presented at GHGT-9 Conference – November 2008.

The Jupiter Oxygen Boiler Test Facility: 3rd Generation – Poster presented at GHGT-9 Conference – November 2008.

Project Topical Report [PDF-58KB] (Aug 2009).

Project Status Update [PDF-28KB] (Jan 2009).

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FC26-06NT42811	

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