PROJECT facts

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

Innovations for Existing Plants

01/2009

RECOVERY OF WATER FROM BOILER FLUE GAS USING CONDENSING HEAT EXCHANGERS
PROMIS/PROJECT NO.: DE-NT0005648

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Background

As the United States' population grows and demand for electricity and water increases, power plants located in some parts of the country will find it increasingly difficult to obtain the large quantities of water needed to maintain operations. Most of the water used in a thermoelectric power plant is used for cooling, and the U.S. Department of Energy (DOE) has been focusing on possible techniques to reduce the amount of fresh water needed for cooling.

Many coal-fired power plants operate with stack temperatures in the 300 °F range to minimize fouling and corrosion problems due to sulfuric acid condensation and to provide a buoyancy force to assist in the transport of flue gas up the stack. However, there would be significant benefits to cooling the flue gas to temperatures below the water vapor and acid dew points, provided the acid corrosion problems can be over-come in a cost-effective way. With stack temperatures below the water vapor dew point, condensed water vapor would provide a source of water for use in power plant cooling; recovered latent and sensible heat from the flue gas could be used to reduce unit heat rate and thereby reduce carbon dioxide (CO_2) emissions; condensation of acid in a controlled manner would reduce the flue gas acid content and provide environmental, operational, and maintenance benefits; the reduced flue gas temperature would promote increased mercury removal; and the availability of low temperature flue gas with reduced acid and water vapor content would reduce the costs of capturing CO_2 at the back end of the boiler.

Description

The project will be a combination of pilot-scale tests, laboratory experiments, and heat exchanger design analyses and cost estimates. Pilot-scale tests will be performed using a slipstream of flue gas from a natural gas fired boiler with sulfur trioxide injection to determine the extent to which the addition of more surface area at the high temperature

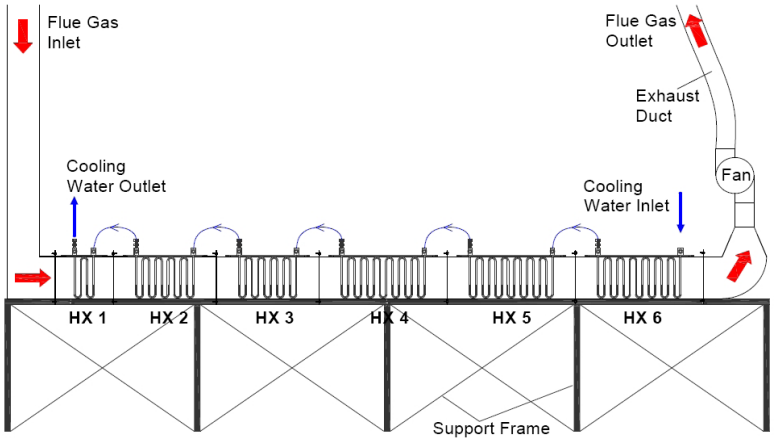

Diagram of Condensing Heat Exchanger Test Apparatus

PARTNERS

Southern Company

PERIOD OF PERFORMANCE

10/01/08 to 03/31/11

COST

Total Project Value
$1,187,301

DOE/Non-DOE Share
$920,484 / $ 266,817

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end of the condensing heat exchanger will make it possible to restrict sulfuric acid condensation to a narrow region well upstream of the region over which water vapor condensation occurs. Pilot-scale tests will also be performed using slip streams of flue gas from two coal-fired boilers to determine the effects of coal composition, inlet cooling water temperature, flue gas temperature, and cooling water flow rates and the amount of surface area in the high temperature end of the condensing heat exchanger on kinetics of sulfuric acid condensation, rates of flue gas water recovery and mercury capture, and composition of the condensate collected from the low temperature heat exchangers. Laboratory experiments will be performed to measure rates of acid corrosion of candidate tube materials for condensate acid concentrations and temperatures obtained in the field studies. Finally, condensed flue gas water treatment needs will be determined and condensing heat exchanger designs will be developed and their costs estimated for full-scale applications located both immediately downstream of an electrostatic precipitator (ESP) or baghouse and downstream of a wet sulfur dioxide (SO_2) scrubber.

Primary Project Goal

The primary project goal will be to recover water from coal-fired power plant flue gas using condensing heat exchangers.

Objectives

The proposed project will continue the development of condensing heat exchanger technology for coal-fired boilers which was started in Project DE-FC26-06NT42727.

In particular, it will:

- Conduct slip stream tests at two coal-fired units operated by Southern Company, one with high sulfur bituminous coal and a wet flue-gas desulfurization (FGD) scrubber and one with high-moisture, low rank coal. The tests will be conducted over a range of inlet cooling water temperatures with various amounts of surface area installed in the high temperature region to promote sulfuric acid capture.
- Develop cost effective solutions to reducing acid corrosion of heat exchanger tubes to acceptable levels. This will be done by:

  Developing improved means to restrict most of the sulfuric acid deposition to the high temperature region of the heat exchanger system.

  Determining typical concentrations of hydrochloric acid, nitric acid, and sulfuric acid in the low temperature condensed flue gas moisture.

  Determining corrosion rates of candidate heat exchanger tube materials for the different regions of the heat exchanger system as functions of acid concentration and temperature.
- Determine condensed flue gas water treatment needs.
- Develop condensing heat exchanger designs for full scale applications, both for installation immediately downstream of an ESP or baghouse and for installation downstream of a wet SO_2 scrubber, and estimate installed capital costs.
- Measure mercury capture efficiencies as functions of process conditions in power plant field tests.

Benefits

The successful development of cost-effective, corrosion-resistant condensing heat exchanger systems for use in pulverized coal-fired power plants will provide opportunities to recover moisture from boiler flue gas. Other benefits are to reduce acid and mercury emissions, provide opportunities to improve unit heat rate, and provide a technology that can be used to improve the effectiveness of post combustion carbon capture systems by removing water and reducing the flue gas temperature entering CO_2 scrubbers.