PROJECT facts

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

Environmental and Water Resources

11/2006

RECOVERY OF WATER FROM BOILER FLUE GAS

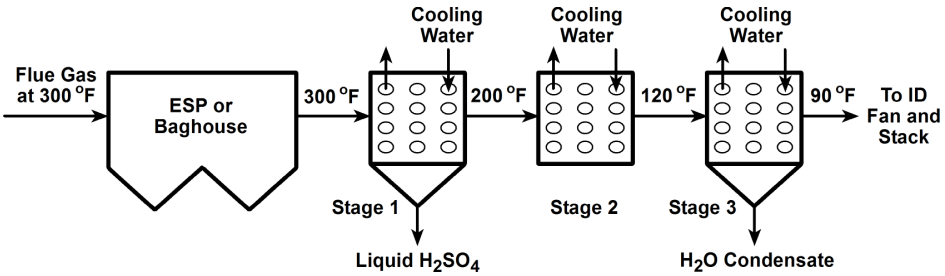
Background

Coal-fired power plants require large volumes of water for efficient operation, primarily for cooling purposes. Public concern over water use is increasing, particularly in water stressed areas of the country. Analyses conducted by the U.S. Department of Energy's National Energy Technology Laboratory predict significant increases in power plant freshwater consumption over the coming years, encouraging the development of technologies to reduce this water loss. Power plant freshwater consumption refers to the quantity of water withdrawn from a water body that is not returned to the source but is lost to evaporation, while water withdrawal refers to the total quantity of water removed from a water source.

The moisture in boiler flue gas comes from three sources: fuel moisture, water vapor formed from the oxidation of fuel hydrogen, and water vapor carried into the boiler with the combustion air. The amount of water vapor in flue gas depends heavily on coal rank. Sub-bituminous and lignite coals contain substantially more moisture than higher-rank coals such as bituminous and anthracite. At power plants firing low-rank coals, the availability of technology to extract moisture from flue gas could supply from 25 percent (for sub-bituminous Powder River Basin coal) to 37 percent (for lignite coal) of the plant's cooling tower makeup water requirements.

Primary Project Goal

The primary goal of this project is to develop a condensing heat exchanger to recover water vapor from flue gas at coal-fired power plants, and to evaluate the heat rate and emissions impacts of this technology at coal-fired power plants.



Multistage Heat Exchangers

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PERIOD OF PERFORMANCE

01/01/2006 to 06/30/2008

COST

Total Project Value
$691,888

DOE/Non-DOE Share
$550,307 / $141,581

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Objectives

The objective of this project is to develop new designs for condensing heat exchangers to recover water vapor from flue gas at coal-fired power plants. Specific objectives include the following:

- Perform pilot scale heat transfer experiments using oil- and coal-fired boiler flue gas to determine the extent to which the condensation processes for water and acid vapors can be made to occur separately in different heat transfer sections.
- Develop and test both smooth wall tube and compact fin-tube heat transfer bundle designs for condensation of water vapor.
- Perform boiler and turbine cycle analyses to determine potential heat rate gains from recovering sensible and latent heat from flue gas.

Accomplishments

A three-stage condensing heat exchanger system has been designed based on standard heat exchanger design procedures. The high-temperature section will reduce the flue gas temperature from inlet values in excess of 300 °F to an exit temperature of 200 °F. The intermediate heat exchanger stage, with inlet and exit flue gas temperatures of approximately 200 °F and 110 °F, will be used to remove additional sensible heat from the flue gas and serve as a buffer stage between the high-temperature and low-temperature sections. In the low-temperature section, temperatures will be lowered to below 90 °F, and water condensate will be extracted.

Once constructed, the condensing heat exchanger will be tested using flue gas slipstreams from an oil-fired boiler at Lehigh University and a coal-fired boiler at Alstom Power's research facility in Windsor, CT.

Benefits

The technology developed in this project will enable coal-fired power plants to produce freshwater from flue gas normally evaporated from the stack. This produced water can then be used for plant operations such as cooling tower or flue gas desulfurization make-up. By cooling the flue gas, an added benefit is the potential to remove vapor phase SO_3/H_2SO_4 and to utilize the rejected sensible and latent heat in the boiler or turbine cycle to improve boiler efficiency.

Planned Activities

The project will be a combination of laboratory and pilot scale experiments and computer simulations. Laboratory and pilot scale experiments will be conducted to determine the extent to which removal of acid vapors from flue gas and condensation of water vapor can be achieved in separate stages of the heat exchanger system. Additional experiments will be carried out to measure the heat transfer effectiveness of the fin-tube bundle designed for condensation of water vapor. Analyses of the boiler and turbine cycle will be carried out to estimate potential reductions in heat rate due to recovering sensible and latent heat from the flue gas.