the ENERGY lab

TECHNOLOGY TRANSFER

SUCCESS STORY

NETL's Thief Process for Mercury Removal Wins 2009 R&D 100 Award

Summary

On July 20, 2009, the editors of *R&D Magazine* announced the winners of the 47th Annual R&D 100 Awards. The awards recognize the 100 most technologically significant products introduced into the marketplace over the past year. These products, in the editors' view, "meet societal, scientific, or business challenges facing us today—and tomorrow." The NETL's Thief Process for removing mercury from flue gas was selected in the category of Environmental Science and enables the cleaner use of coal for electricity production.

The Thief Process cost-effectively removes mercury from flue gas. In this process, partially combusted coal from the furnace of a pulverized-coal power plant is extracted and then re-injected into the ductwork downstream of the air preheater to serve as a mercury sorbent. Testing at laboratory-, bench-, and pilot-scales has shown that the Thief sorbents have capacities for mercury capture from flue gas streams that are comparable to those of commercially available activated carbons. Because the Thief sorbents are significantly cheaper, the process holds great potential for reducing the cost of mercury removal from flue gas. NETL has licensed the Thief Process to Nalco Mobotec, Inc.

In addition to winning the 2009 R&D 100 Award, the process received the 2009 Excellence in Technology Transfer Award from the Federal Laboratory Consortium for Technology Transfer (FLC). Prior to winning national awards for technology transfer from the FLC, a regional award from the Mid-Atlantic Federal Laboratory Consortium Region in September 2008.

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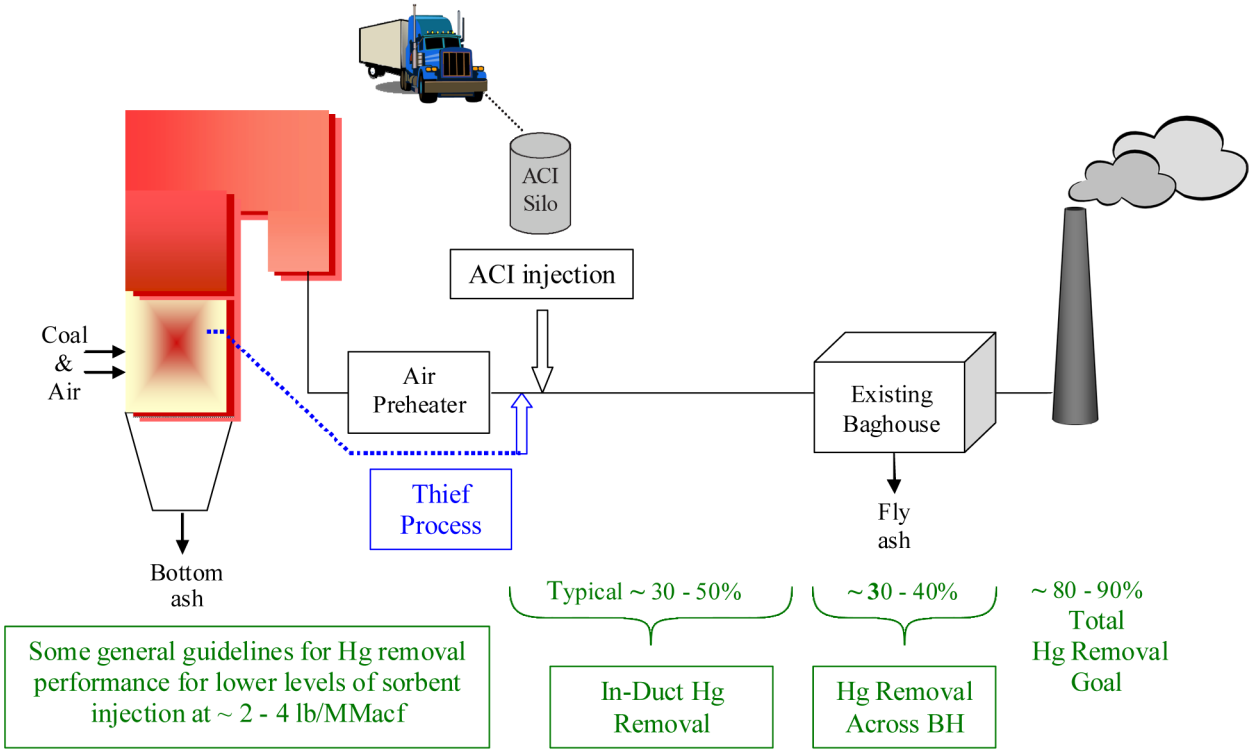
Description

NETL in-house researchers were actively involved in the Department of Energy's Innovations for Existing Plants Program, which was created to find means to extend the operational lives of existing power plants while meeting the ever more stringent emissions requirements. They had examined activated carbon and other adsorbents for the removal of mercury from flue gas, but realized the limitations of these technologies. Activated carbon soaks up many components of a flue gas stream, and so is not selective for mercury. Having other gases compete for the adsorption sites that are available for removing mercury was a major disadvantage because it increases the amount of carbon that must be used. The high cost of purchasing activated carbon from a manufacturer, having it transported to the utility site, and storing it there until needed was also a major drawback, which is projected to lead to higher electricity prices for consumers.

The NETL researchers saw an opportunity to eliminate these cost concerns by utilizing a raw material that was already available at the plant—coal. Raw coal dust is not an effective adsorbent because of its low porosity and surface area, but they speculated that partially burned coal in the boiler's combustion unit might be porous enough to have a large surface area for adsorption of mercury. Also, being only partially burned, it might still retain some chemical species on its surface that react with mercury and could possibly aid in the chemical adsorption of mercury, thus increasing its capture ability. In contrast, these chemical species are removed from the surface of activated carbon during its manufacture; activated carbon typically relies only on its higher surface area to physically adsorb mercury from a flue gas stream.

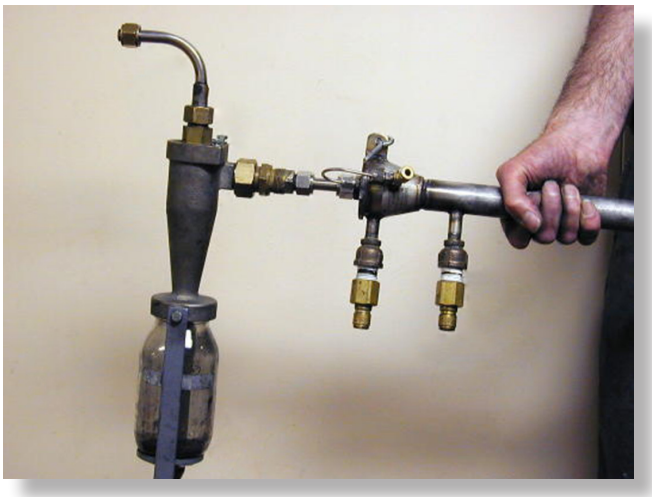


Schematic of the NETL Thief Process relative to the use of conventional activated carbon injection (ACI) in a coal-fired combustor.

Using NETL's 500,000 Btu/hr Combustion and Environmental Research Facility (CERF), which is a well-instrumented pulverized coal combustion system that simulates the firing found in a utility power plant, the researchers investigated the ability of partially combusted coal to remove mercury from the gas stream. Samples of two coal types (Pittsburgh #8 and Evergreen) were withdrawn from ports of the CERF, using a novel water-cooled probe with a cyclone separator to remove and concentrate the extracted powder. These extracted materials were then injected into the flue gas upstream of the baghouse at varying rates. For comparison, tests were also made with no adsorbent (baseline tests) and with two brands of commercial activated carbon. Additional tests at NETL were made on a larger 6 million Btu/hr pilot-scale pulverized coal-fired combustion system.

Picture of a "Thief" extracting partially burned coal through the wall of the pilot-scale combustor at NETL. The extraction probe is the black pipe jutting out from the combustor wall on the right into a small, silver cyclone separator, which has a collection container at the bottom.

Results indicated that partially combusted coal could be substituted for activated carbon with similar mercury removal abilities (> 90% across the system), but at a much lower cost. Based on these successful trials, Nalco Mobotec licensed the Thief Process from NETL in May 2005.



Close-up picture of the "Thief" apparatus used to extract partially-combusted coal from NETL's pilot-scale combustor.

Significance/Benefits

NETL has developed a product that is commercially available from Nalco Mobotec for application in removing mercury from flue gases in a large number of large coal-fired power plants across the U. S. and in other countries.

The Thief Process may help the vast electric utility industry meet stringent mercury reduction standards at a much reduced cost compared to prior state-of-the-art technologies. Estimates show that the cost of the mercury remediation via the Thief Process will be 0.21 mills/kW-hr versus 0.48 mills/kW-hr for the activated carbon injection method. For a 500 MW power plant, this amounts to a savings to the utility of $965,500 annually in levelized constant 2003 dollars.

The Department of Energy has recently estimated the cost for mercury control at $60,000 per pound of mercury removed. With twenty-six states having passed or considering mercury control legislation (typically requiring 90% removal of mercury), and the U.S. EPA reconsidering its national emission standard, it is likely that the domestic market for mercury emissions control at coal-fired power plants will shortly exceed 5 billion dollars annually. The potential domestic market for the Thief Process is conservatively estimated at 1 billion dollars per year.

Future benefits may include a safer, less toxic environment for human beings due to decreased levels of mercury in the air, water, and food supply. Coal-fired utility boilers are the largest anthropogenic emitters of mercury in the United States, accounting for approximately one third of the 150 tons of mercury emitted annually into the environment. The Thief Process's ability to prevent 90% of coal-derived flue gas mercury from reaching the atmosphere could greatly reduce anthropogenic emissions if the technology is widely adopted. The Thief Process allows for the removal of mercury from coal-derived flue gas at a minimal cost, protecting both the environment and economy. Reducing mercury emissions from coal-fired boilers is one step in making coal a cleaner fuel, thereby extending its useful lifetime for electricity generation. Experts estimate that the United States has enough coal resources to last another 250 years. The use of abundant domestic coal in a clean and environmentally responsible manner for the generation of electricity helps the security and economy of the United States.

Opportunities

Nalco Mobotec, as the exclusive licensee of the technology from DOE, is further developing and selling the Thief Process as a commercial product to supplement their line of pollution reduction technologies.