

PRE-COMBUSTION AND COMBUSTION TECHNOLOGY FOR CONTROL OF MERCURY EMISSIONS FROM COAL-FIRED BOILERS

Technology Overview

Mercury can be removed from coal and flue gas through pre-combustion, combustion, and post-combustion means. While each process and technology removes mercury by different methods, the end result from all removal processes is less mercury emitted into the air from coal-fired facilities. Pre-combustion and combustion mercury removal processes are not as widely recognized as post-combustion technologies but are showing significant results. Such processes include coal beneficiation, mercury oxidation additives, coal blending, and increasing unburned carbon in fly ash. Pre-combustion and combustion mercury removal processes can be an enhancement of or alternative to post-combustion controls.

Coal beneficiation upgrades low-rank coals that have high moisture content and low BTU value through the application of heat, and in one process pressure and heat, thereby reducing moisture content leading to a boost in BTU value of the coal. These pre-combustion processes have been shown to significantly reduce the mercury content of the coal feedstock, creating a solid fuel product that is more efficient and cleaner burning for coal-fired facilities.

Mercury oxidation additives can be applied directly to coal prior to combustion or injected into the system prior to the particulate control device. This process supplements the native halogen concentration (particularly in low rank coals), increases mercury oxidation and, when utilized with a suitable capture mechanism, can significantly improve the overall mercury capture of the existing air pollution control system. Potential capture mechanisms that can be utilized with mercury oxidation additives can include: unburned carbon and sorbent injection (including activated carbon) that is collected in downstream particulate removal devices, or Wet Flue Gas Desulfurization (WFGD) systems.

Blending low-rank coal and bituminous coal can also be an effective way to reduce mercury emissions. It has been determined that chlorine in coal assists mercury capture and low-rank coals have lower chlorine content compared to bituminous coal. By blending subbituminous and bituminous coals, chlorine content is boosted and mercury capture is enhanced.

Unburned carbon in fly ash acts very similar to activated carbon where mercury attaches to the surface of the carbon and then is captured in a downstream control device. Combustion conditions may be adjusted to raise the amount of unburned carbon to achieve desired mercury reduction.

Performance and Commercial Availability

These pre-combustion and combustion processes have demonstrated significant mercury reduction in a range of tests at coal-fired facilities. Coal beneficiation has been tested from the laboratory through full-scale power plant demonstrations. Results have indicated an average 70 percent mercury reduction comparing the mercury content of the feedstock coal to the beneficiated product while mercury removal in the 90 percent range has been achieved. The mercury content of the feedstock coal and other unique characteristics will impact the amount of mercury removed in the beneficiation process. Combustion and post-combustion controls may further reduce mercury emissions beyond the removal achieved through beneficiation.

Currently, one pre-combustion beneficiation process is commercially available and offered by KFx Inc. although there are several other companies that are in the development and testing phases. A 750,000 ton per year (tpy) K-Fuel™ production facility began initial operation in December 2005 near Gillette, Wyoming and initial permitting and engineering have begun for two additional production facilities that will produce a total of 12 million tpy of K-Fuel™.

Mercury oxidation additives have been tested in various power plant configurations with various coals. Mercury removal has been shown to range from below 50 percent to greater than 90 percent. The rank of coal and the existing air pollution control devices impact the amount of mercury removal achieved. The Energy and Environmental Research Center (EERC), URS, and EPRI are developing and testing various sorbent enhancement additives. ALSTOM has commercialized the KNX Coal Additive Technology for select applications and expects to expand the list during 2006.

Coal blending has been shown to increase mercury removal from nearly zero when only subbituminous coal is burned to approximately 80 percent when blended with small amounts of bituminous coal. As the amount of bituminous coal increases, the chlorine content of the blend increases, achieving improved mercury removal. The amount and types of mercury in the coals blended, chlorine content, and installed post-combustion control devices influence the amount of mercury reduced. The benefits of blending will also be impacted by the price of various coals in the market and the ability of a coal-fired facility to introduce new coals into its fuel mix.

Increasing the amount of unburned carbon in fly ash has been shown to boost mercury removal to above 80 percent. Combustion conditions need to be optimized in a way that balances the trade offs and benefits of increasing the amount of carbon in the fly ash and the amount of mercury reduced.

Typical Costs

The cost of beneficiated coal will be a factor of operating costs necessary to upgrade the coal, market demand for the product, and other factors. It is expected that beneficiated coal will compete in coal markets with coals of similar BTU, sulfur content, and other characteristics, and will be priced competitively with such comparable coals.

The cost to utilize mercury oxidation additives as part of an overall mercury control solution is strongly dependent on: a) the inherent (or baseline) mercury removal across the entire system; b) the active collection mechanism that will be applied and; c) the desired system mercury reduction that is required. For units that utilize unburned carbon or WFGD systems as the primary collection mechanism, the incremental cost of mercury removed is generally expected to be less than \$5,000 per pound of mercury removed. For units that utilize untreated, activated carbon, the cost of removal is generally expected to be higher but the actual figure will be strongly dependent upon whether the fly ash is resold, the sorbent injection rate, and the particulate removal configuration that is utilized. There are also applications that are fairly typical (example: units combusting PRB coal with dry flue gas desulfurization systems) where the cost of Hg removal is also expected to be less than \$5,000 per pound of mercury removed.

Coal blending costs are dependent upon the cost of the coals blended by a facility.

The cost associated with unburned carbon is a factor of increasing the amount of unburned carbon, making it unavailable for electricity production, versus the cost benefits associated with reducing mercury emissions. A facility may also determine that to maximize mercury removal benefits from unburned carbon that a fuel switch may be necessary, which may also influence cost.

Installation Basics

Installing or implementing any one or combination of these pre-combustion and combustion mercury control methods is relatively simple and efficient. Coal beneficiation processes are currently under development, with one process commercially available. Upgraded coal is available now to the coal-fired industry and supply of beneficiated coal will increase over the coming years. No shutdown period is necessary as a facility introduces this fuel to its system.

Mercury oxidation additives require an application system, depending on whether the sorbent additive is applied to the coal prior to combustion or injected into the flue gas. In the case where the additive is applied to the coal prior to combustion, the application system can be retrofitted while the boiler is on line and the entire retrofit can be completed in a matter of weeks. In either case, the time to retrofit is relatively short and costs are relatively inexpensive, as compared to the retrofit of a typical air pollution control (APC) system.

Implementing coal blending requires a coal-fired facility to make changes to their coal mix and coal supply contracts. There is a large and diverse supply of coals available for blending purposes.

Unburned carbon implementation may require changes to a facility's operating system to boost the amount of unburned carbon and, as stated above, a switch in fuel may also be implemented.

For Further Reference:

- KFx Inc., Howard Weil presentation, March 2006
- EERC and URS presentations to Subbituminous Energy Coalition (SEC), March 2006
- ADA-ES, American Coal Council presentation, March 2005
- ALSTOM Power, The KNX™ Coal Additive Technology A Simple Solution for Mercury Emissions Control, December 2005.
- EPA ORD Whitepaper, Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Any Update, February 2005.