SORBENT INJECTION TECHNOLOGY FOR CONTROL OF MERCURY EMISSIONS FROM COAL-FIRED BOILERS

Technology Overview

Injecting a sorbent such as powdered activated carbon (PAC) into the flue gas represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers. This technology has been used for the past two decades to control mercury from waste combustion gas streams in both the United States and Europe. The gas phase mercury in the flue gas contacts the sorbent and attaches to its surface. The sorbent with the mercury attached is then collected by the existing particulate control device, either an electrostatic precipitator (ESP) or fabric filter (FF) (Figure 1). This combined material consisting of 99 percent flyash and one percent sorbent is then either disposed of or beneficially used. This technology is ideally suited for retrofitting onto existing power plants for several reasons:

- Minimal capital cost of equipment (<$3/kW) due to the simplicity of the system.
- Can be retrofit with little or no downtime of the operating unit. Significantly shorter installation time compared to SCR and FGD technologies.
- Effective for bituminous, subbituminous and lignite coals.
- Can achieve 80 to 90 percent removal when used with a fabric filter and between 50 and 90 percent removal on an ESP, depending on configuration and coal.
- The sorbent injection technology can be integrated to enhance mercury capture with virtually every configuration of air pollution control equipment including ESPs, fabric filters, wet and dry scrubbers.

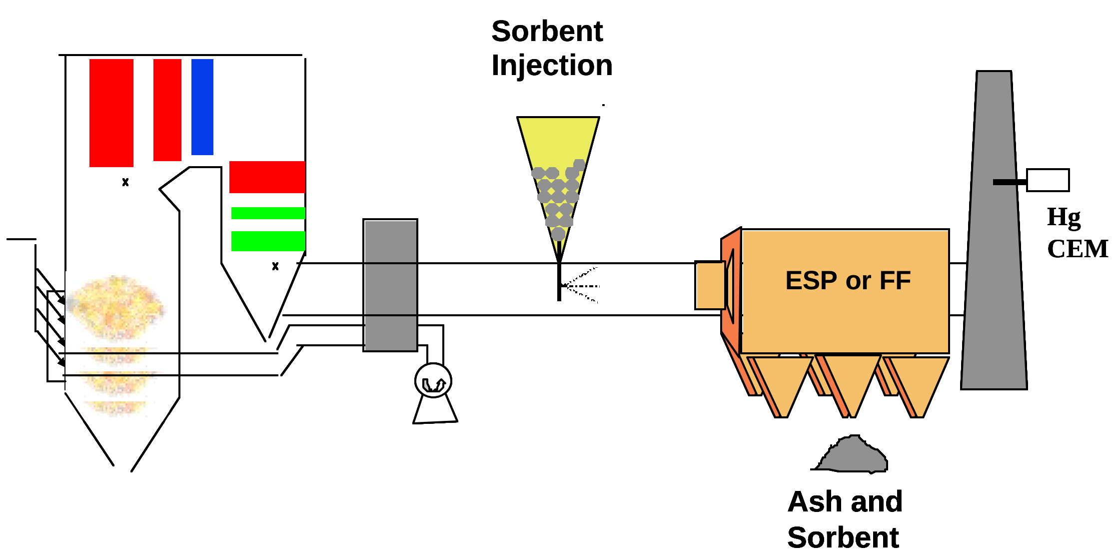

Figure 1. Schematic Diagram of Sorbent Injection Process

When the sorbent is injected into the flue gas it mixes with the gas and flows downstream. This provides an opportunity for the mercury in the gas to contact the sorbent to be removed; this is called "in flight" capture. The sorbent is then collected in the particulate control device where there is a second opportunity for sorbent to contact the mercury in the flue gas. The type of particulate control equipment is a key parameter defining both the amount of sorbent that is required and the ultimate limitation of the amount of mercury that can be removed.

In an ESP, the carbon is collected on plates that are spaced parallel to the gas flow. Although the residence time in the ESP can be several seconds long, there is a limited amount of contact between the gas and the collected particles because the gas can be as far as four inches from the plates. On the other hand, a fabric filter provides the ideal opportunity for good interaction between the gas and the sorbent as the gas makes intimate contact with the sorbent collected on the filter. Therefore, sites with fabric filters will achieve higher levels of mercury removal at lower levels of sorbent consumption. Currently, only 10 percent of the coal-fired power plants in the U.S. have fabric filters.

The most commonly used sorbent for mercury control has been activated carbon. For the past two decades, powdered activated carbon injection upstream of a fabric filter has been successfully used for removing mercury from flue gases from municipal and hazardous waste combustors. Activated carbon is a carbon-based material that has been "treated" to produce certain properties such as increased surface area, pore volume, and pore size. Activated carbon can be manufactured from a variety of sources, (e.g. lignite, peat, coal, wood, etc.). More commonly, steam is used for activation, which requires carbonization at high temperatures in an oxygen-lean environment. As some carbon atoms are vaporized, the desired highly porous activated carbon is produced. Commercially, activated carbons are available in a range of particle sizes, as well as other characteristics that are needed for a specific application.

The activated carbon is delivered through commercial sorbent injection equipment that consists of a bulk-storage silo to store the activated carbon and multiple blower/feeder trains to deliver the activated carbon to the injection point, as shown in Figure 2. PAC is delivered to the power plant in bulk pneumatic trucks and loaded into the silo, which is equipped with a bin vent bag filter. Using variable speed screw feeders, reagent is metered into eductors that provide the motive force to carry the reagent to the injection point. Blowers provide the conveying air. A PLC or DCS system is used to control system operation and adjust activated carbon injection rates. Hard piping carries the reagent from the feeders to distribution manifolds located on the inlet duct, feeding the injection probes.

Figure 2. Carbon Injection Storage Silo and Feeder Trains for 150 MW Unit.

Cost and Performance of Sorbent Injection Technology

Cost analyses by both EPA and DOE have shown that greater than 80 percent reduction in mercury emissions can be achieved at a cost ranging from $1-3 per MWh (mills/kWh). The higher costs are associated with 30 percent of the plants that currently sell their flyash. These plants will incur additional costs to either landfill their ash or add a fabric filter to capture the mercury sorbent separately from the flyash.

The costs for activated carbon injection consist of two components: 1) capital costs for the sorbent storage and injection equipment and 2) the operating costs associated with the expendable sorbent. The capital costs for the equipment are approximately one million dollars for all plants up to approximately 500 MWs. For larger power plants, a second silo may be required which will increase the capital costs by approximately 50 percent.

The operating costs depend upon the coal characteristics, type of existing air pollution control equipment at the plant, and the level of mercury capture required. This information is being made available as the result of over 30 full-scale demonstrations that have been performed with funding from DOE, EPRI, and directly from utilities. These tests have demonstrated the capabilities of the technology on a wide variety of plant configurations and have documented costs associated with application of sorbent injection. Figure 3 shows a summary of the level of performance and cost associated with different applications. This figure includes results that reflect the significant advancements in mercury control made in the past five years that have resulted in considerable reductions in costs to control mercury. For example new developments were demonstrated in 2004, where costs associated with the most difficult applications, i.e. Western coals, were reduced by a factor of four or more.

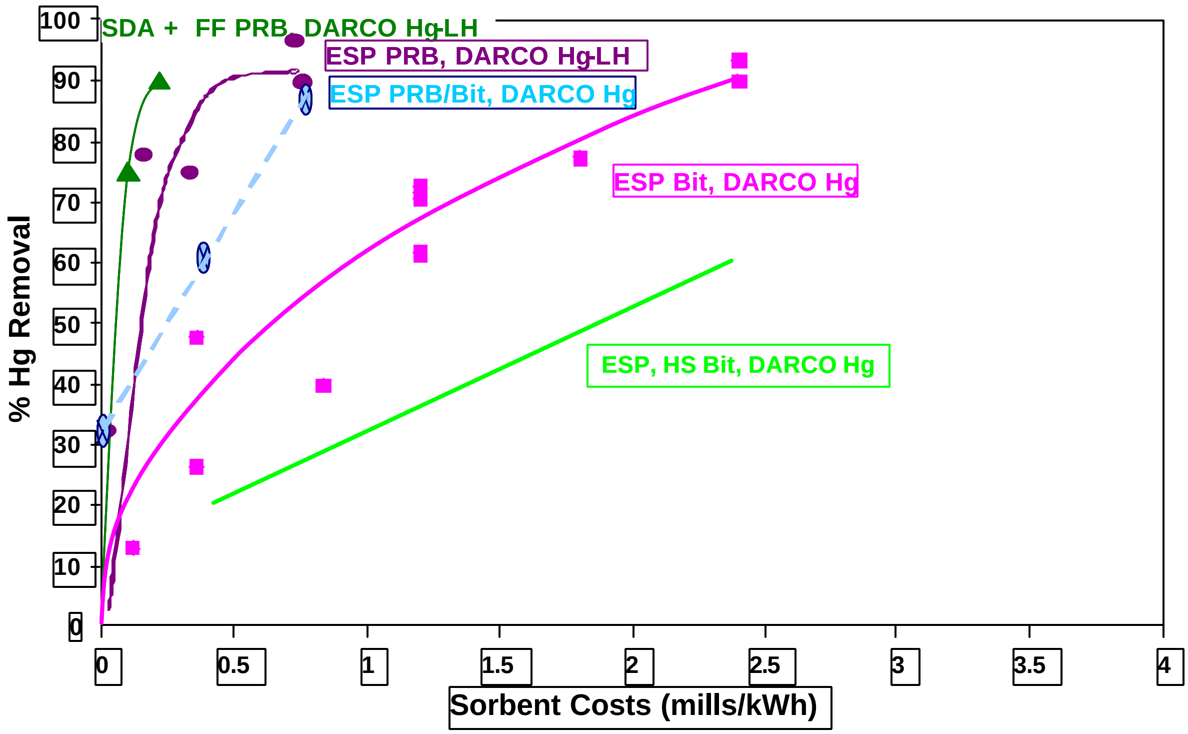

Figure 3 PAC Costs for Mercury Removal for Different Configurations and Coals.