THE MISSION AGAINST MERCURY

JOHN KNOTTS, WL GORE & ASSOCIATES, USA, AND KATHERINE GUENIOUI, KGES, UK, DEMYSTIFY THE MINAMATA CONVENTION, AND ITS IMPACT ON MERCURY EMISSIONS IN THE CEMENT INDUSTRY.

Introduction

This month will see the Minamata Convention enter into force. As a result, the parties that have ratified the convention will be legally bound by the obligations contained therein to reduce anthropogenic emissions and releases of mercury and mercury compounds. Though mercury emissions occur naturally in the environment, around one third of global mercury emissions are attributed to human activity; it has been suggested that the global cement industry is responsible for some 10% of all anthropogenic mercury emissions.[1]

Mercury is considered a global problem, both because it can travel huge distances, and because it is a persistent pollutant, i.e. it stays in the environment for a long time. There are two main ways that mercury poses a risk to people. The first is the high mercury levels found in fish: the toxin accumulates in people who eat a lot of seafood. Second, people that work in or live close to industrial

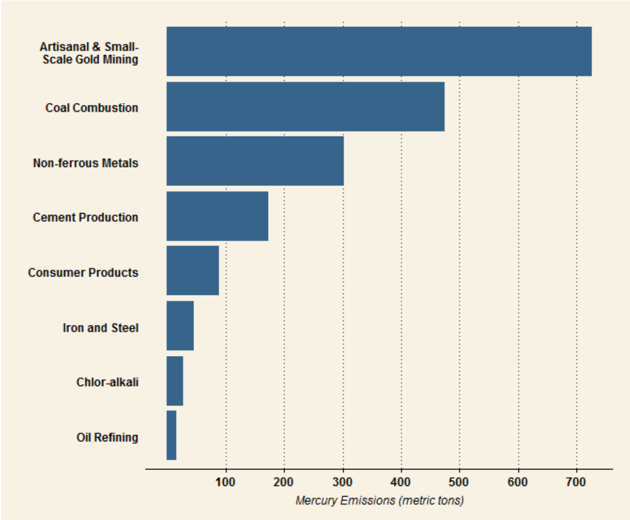

Figure 1. Annual mercury emissions by sector. Source: UNEP/Geovisualist.

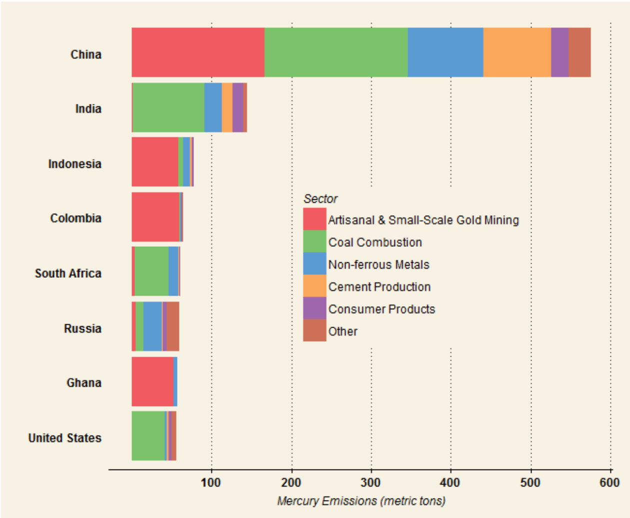

Figure 2. Annual mercury emissions by country and sector. Of these, China, Ghana, and the US have ratified the Minimata Convention; India, Indonesia, Colombia, South Africa, and Russia are signatories. Source: UNEP/Geovisualist and www.mercuryconvention.org.

plants emitting mercury are exposed to increased levels of mercury, which affects the nervous system and brain development, and poses a particular risk to developing foetuses and young children.

The Minamata Convention

The Minamata Convention is named after the city in Japan where 900 people were killed and more than 2000 made ill by mercury poisoning, when contaminated industrial waste was dumped into the bay in the mid-20th Century. The convention addresses the entire lifecycle of mercury, with measures including the phase out of mercury mines and of the use of mercury in products and processes, controls on emissions to air and releases to land and water, and greater regulation of artisanal and small-scale gold mining. Storage of mercury, disposal of waste containing mercury, and sites contaminated by mercury are also addressed.

The cement industry is subject to the obligations of the convention under Article 8, which covers controls on emissions of mercury. Technical guidelines on the best available techniques/best environmental practices (BAT/BEP) for industrial processes are currently being developed and will be adopted at the First Conference of the Parties in September. The draft guideline for the cement industry recommends, as a first measure, the "careful selection and control of all substances entering the kiln in order to reduce mercury input."[2] While this should be possible for fuels, it is not really realistic for existing cement plants to select their raw materials based on mercury content. Therefore, the additionally named measure of using "effective air pollution control devices" is of primary importance.

An alternative for mercury control

There are a number of possible air pollution control solutions that go some way to reducing mercury emissions, many of which have been implemented in countries where strict emissions legislation is already in place. With lessons learned from the coal-fired power industry, GORE has developed an alternative system that not only cuts mercury emissions, but also avoids many of the drawbacks or compromises of traditional techniques, such as dust shuttling and sorbent injection.

Developed in the US, the GORE Mercury Control System (GMCS) guarantees compliance with the strictest emissions limits and also offers minimal running costs, zero maintenance issues, and no operational concerns. Thanks to the unique design, the system has also done away with the need to buy, store, or dispose of reagents. Overall, once installed, there is really very little for the plant operators to actually think about; it is very much a 'plug and go' system.

The mercury control system

How does it work?

While sorbent injection systems work by injecting a sorbent into the flue gas stream, the GMCS pushes the gas past a specially-developed material called the sorbent polymer catalyst (SPC). This increases the exposure of the gas to the sorbent, which is embedded in the fluoropolymer composite material. The fabric was specially developed by GORE to capture both elemental and oxidised mercury, even in the wet gas stream. Its structure ensures a high capacity for mercury storage – measured in years, not hours – with no regeneration necessary. A co-benefit of the system is SO_2 polishing, thanks to a chemical reaction with the SPC that converts SO_2 to sulfuric acid, which is then expelled as condensate and washed away. Working together with a regular water wash, the sulfuric acid also helps to keep the modules free of pore-clogging contaminants.

The SPC is arranged in an open channel design and affixed in modules measuring approximately 2 ft. x 2 ft. x 1 ft. high. The gas flows through the system at velocities up to 18 ft/sec., giving the gas far greater contact time with the sorbent than in traditional injection systems. This, in addition to the fact that the system is designed to operate in the low-temperature gases downstream of a particulate collection system, where mercury capture rates are proven to be most efficient,[3] enables mercury reduction rates that are guaranteed to bring cement plants into compliance with the strictest emissions limits.

SPC modules can be stacked in parallel and in series, depending on gas volume and mercury reduction requirement, respectively. Figure 3 shows that the mercury sequestration and removal capabilities are scalable; the more modules installed, the greater the mercury reduction achieved.

The GMCS can be installed as a standalone system, but also works well when integrated into an existing wet scrubber above the mist eliminator. This is how the system was incorporated into the process at FirstEnergy's Fort Martin coal-fired power plant, the first full-scale installation in the US.

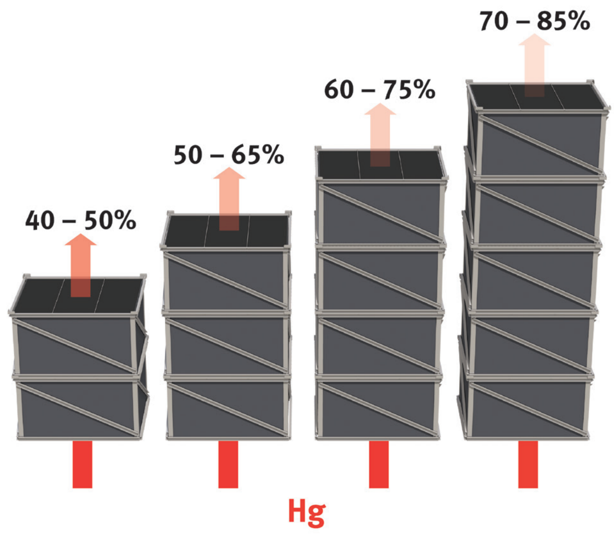

Figure 3. Example of mercury removal efficiencies in typical gas velocities of 8 – 16 ft/sec.

Figure 4. The arrangement of modules at the top of the FGD scrubber at Fort Martin.

Case study: Fort Martin power plant

Fort Martin is a two-unit coal-fired power plant situated in West Virginia, US. The two units were installed in 1967 and 1968, and generate a combined 1107 MW, using approximately 2.8 million tpy of coal. Both units have two electrostatic precipitators in series and a wet limestone forced oxidation scrubber with a wastewater treatment facility.

With the US Environmental Protection Agency's (EPA) Mercury Air Toxic Standards (MATS) regulations coming into play for the power generation industry in April 2015, FirstEnergy had put out a bid for mercury abatement solutions in 2012. The company was exploring various options, including activated carbon injection, duct sorbent injection, and mercury re-emission chemicals. The GORE Mercury Control System bid came via a contractor, and offered an alternate solution to meet FirstEnergy's requirements: a completely passive system with no ongoing reagent costs, guaranteed to meet MATS limits.

FirstEnergy evaluated the bids based on technical feasibility, capital cost, reagent cost, and operating and maintenance costs and, ultimately, the GMCS was selected as the best and most economical option. Installation on unit one was completed during a scheduled outage in Autumn 2014, with unit two following in Spring 2016.

The FGD scrubber systems on Fort Martin units one and two went into service in late 2009. Though it made sense for the GMCS to be installed inside the scrubber, there was not sufficient space in the existing layout and so it was necessary to redesign the scrubber internals. The mist eliminators, wash piping, and support trusses were removed to make way for a new shorter support truss with a more compact mist eliminator and wash system, so that the GMCS could be installed over the top. A new support truss was designed for the GORE modules and wash piping. The additional weight of the GMCS necessitated the installation of vertical supports on the outside of the vessel. These were installed before the unit outage, but the rest of the work had to be carried out within the scheduled outage period. It took 10 days to wash, install scaffolding, and remove the existing mist eliminators, wash piping, and support truss. The new mist eliminators, wash piping, and support truss, along with the GORE support truss, wash piping, and modules, were installed in just 5 weeks. External wash piping and valves were also installed during the outage. Finally, a coating contractor coated the inside of the scrubber vessel to protect the shell materials from sulfuric acid attack.

A second wash header was later added to unit one, bringing mercury emissions down to about 50 – 55% of compliance limits by removing particulate carryover from the SPC surface. This intermediary wash header was included as part of the design for the second unit.

"The beauty of the system is that now that it has been installed, it basically just sits there and does its thing," said Mark Scacia, Manager, Major Projects at Fort Martin. "We're not adding anything into our gas stream. We're not adding anything into our water stream. We don't have to take anything out in the wastewater stream. The operators virtually don't know it's there."

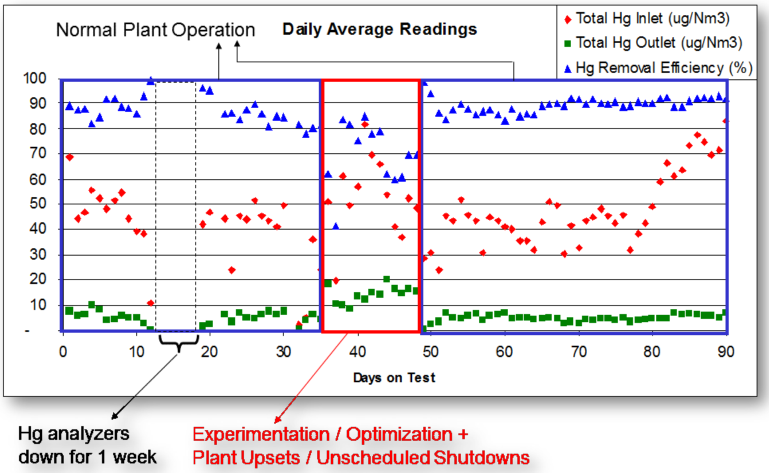

Figure 5. Data from a cement plant with a four-module stack over a 90-day period. It is evident that the mercury removal efficiency is generally above 80% and outlet emissions remain below 10 mg/Nm^3 without any adjustments to the system.

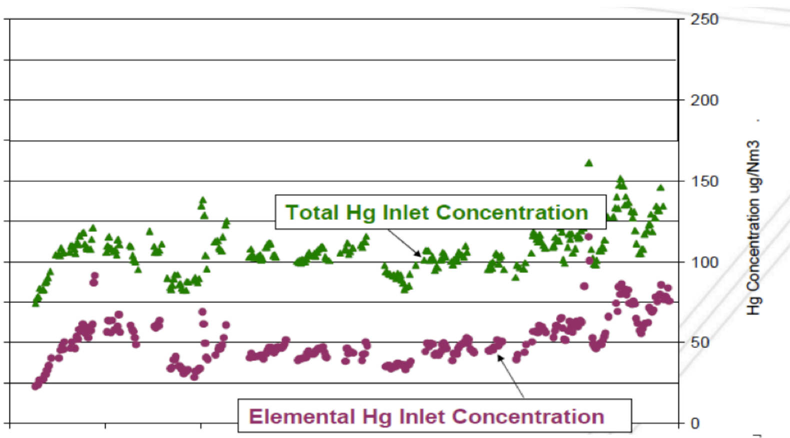

Figure 6. Cement plant mercury speciation analysis. While other technologies struggle to capture elemental mercury, the GMCS captures both oxidised and elemental mercury.

Application in the cement industry

Though the coal-fired power industry is a very different process to the cement industry, the process type is effectively irrelevant to the GMCS. The system is installed at the end of the line, and deals with air, gas, and mercury – not cement, coal, or steel. Given a low gas temperature and a velocity below 18 ft./sec, the GMCS will remove mercury regardless of the type of industrial process in which it is installed.

Working either in addition to, or instead of, carbon injection and dust shuttling, the GMCS provides consistent reduction efficiencies in both raw mill on and raw mill off operation. There are none of the contamination issues of the other technologies; the sorbent does not enter the process and the mercury is entirely sequestered in the SPC. There are no storage requirements and no question of where the captured mercury is likely to reappear; once it is sequestered in the SPC it is there to stay. Spent modules can be disposed of in a lined landfill with no fear of mercury leaching out into the environment. There are also the aforementioned benefits of low operating costs, no moving parts, and very simple operation.

To date, three pilot projects have been undertaken at cement plants in the US, with great success. Figure 5 shows data from a pilot plant installed for 90 days. For the most part, the mercury removal efficiency is over 80%. Mercury concentrations at the outlet are consistently maintained below the regulation limits without any adjustments to the system. Figure 6 shows a cement plant mercury speciation analysis, which demonstrates the significant concentration of elemental mercury. This is where the GMCS has a major advantage over other mercury abatement methods: thanks to the unique structure of the SPC and the prolonged exposure of the low-temperature gas stream to the modules, the GMCS captures both elemental and oxidised mercury with great efficiency.

Conclusion

Under the terms of the Minamata Convention, parties will be required to develop a national plan for industrial sources, including the use of BAT/BEP for new sources within 5 yr of the date of entry into force of the convention for that Party, and within 10 yr for existing sources, which are also obligated to control emissions within agreed limits. The BAT/BEP guidance will be adopted at the First Conference of the Parties, which is due to take place in September. At the time of writing there are 66 ratified parties to the convention and 128 signatories. The kind of stringent mercury regulations that have been seen in the US and Europe will be adopted by other countries, which will be seek out optimal air pollution control solutions.

The GMCS is a complete, low-maintenance system with minimal running costs, very little waste, and no reagents. It offers guaranteed compliance with the strictest emissions limits. It also provides SO_2 polishing as a co-benefit and can be tailored to reduce HCl levels.

Note

For more information, please contact the author via the editor.

References

1. 'Guidance for reducing and controlling emissions of mercury compounds in the cement industry', p. 2, www.wbcsdcement.org
2. http://www.mercuryconvention.org/Portals/11/documents/BAT-BEP%20draft%20guidance/Cement_clinker_production.pdf, p. 8.
3. http://www.mercuryconvention.org/Portals/11/documents/BAT-BEP%20draft%20guidance/Cementclinkerproduction.pdf, p. 30.