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IMPACT OF POTROOM WORK PRACTICES ON ROOFLINE FLUORIDE EMISSIONS AND WET SCRUBBER EFFICIENCY

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Abstract

Roofline wet scrubbers are employed at aluminum smelters to provide significant reduction in fluoride emissions from the potrooms. Roofline wet scrubbers are most useful at locations that have emission performance constraints owing to hooding efficiency limitations or pot technology issues that increase fluoride losses to the potroom. Unfortunately, roofline wet scrubbers are quite cost intensive to install, operate and maintain, which intensifies scrutiny regarding the value of these systems. This talk will present in-plant data showing real-time continuous monitoring of wet scrubber HF capture efficiency and the impact of work practices on the efficiency of the roof scrubbers for capturing gaseous fluoride from aluminum smelter potroom rooflines.

Introduction

Fluoride evolution, emission and transport are subjects of intense interest in the primary aluminum industry. During aluminum smelting, hydrogen fluoride is *evolved* from the electrolysis cells. The vast majority of this evolved gas is collected in massive hooding systems and ducted to gas treatment centers. A small fraction of this evolved gas escapes the hooding system and is released to the potroom. Fluoride *emissions* are any fugitive fluorides that escape from the pots or hooding system into the environment. These fluoride emissions present the potential for worker exposures or exceedances of operating permits. Wet scrubbers are the only commercially implemented technology for preventing potroom fugitive HF evolution from becoming HF emission.

During the aluminum smelting process, gaseous fluoride is evolved from the electrolysis reduction pots due to the reaction of bath with hydroxyls in feed alumina, ambient humidity, and other hydrogen sources.[1,2] The majority of this gaseous fluoride is collected in massive hooding systems and ducted to the dry scrubbers, where smelting grade alumina (SGA) is employed to chemically adsorb gaseous fluoride from the pot gases.[3,4] The gas collection efficiency achieved by pot ventilation systems can reach 99.5% during periods of no pot work. However, there is always a small fraction of gases that can escape from the hooding systems, emit to the potroom and finally release to the environment usually through the potroom roof-line. During periods of non work, fluoride emissions result from the cumulative impacts of total open gap areas in cell superstructures, pot ventilation flow balance, elevated pot temperatures and open areas in pot crust.[5] The primary contributors to potroom roofline fluoride emissions are during periods of active pot work, such as anode changes, tapping, oreing, and sampling, when the open hole areas exist in the pot crust and the ventilation system is compromised due to the removal of side panels.[6-10] Newer smelters have specialized ventilation systems to allow localized amplified suction to partially offset compromises in hooding efficiency due to panel removal.[11] Older smelters may not have localized elevated draft capability and or have lower overall effective ventilation rates. Potroom roofline wet scrubbers have been employed as countermeasures at locations that either did not have other commercially available options at the time of plant construction, or had emission performance constraints owing to hooding ventilation limitations or other technology issues that increase fluoride losses to the potroom.

The purpose of this work is to present real-time data regarding the HF capture performance of a roofline wet scrubber and to visually illustrate the temporal variability in fluoride capture efficiency observed owing to fluctuations in fugitive losses due to potroom operations.

Experimental

All testing shown in this study was acquired at the Alcoa Eastalco smelter in 2004. The Alcoa Eastalco smelter consisted of two potlines with 240 cells (side by side) per line and operated at 150 kA during time of this study. The smelter started operation in 1970 as a side work prebake and was converted to point feed technology in 1996. The Alcoa Eastalco smelter was curtailed in December 2005 and closed permanently in March 2010.

The wet scrubber system (Ceilcote) installed at Alcoa Eastalco was part of the original plant construction. This system consisted of 112 air collection and spray scrubber units located below the roof, along the centerline of the potrooms. Spray water pH was maintained ~ 10 using caustic. Captured fluoride was removed as CaF_2 by treating the spray water using $CaCl_2$.

Each potroom building consisted of two rows of pots with the main aisle in the center of the building. Each scrubber module treated an air stream pulled from each side of the potroom by an integral fan. The spatial distribution of the scrubber modules was such that the two inlets of each scrubber module were centered above four pots. In other words, each of the two inlets to a given scrubber module were located above and between two pots on each side of the room. The inlet air passed through a spray section, then through a demister and exited the roofline.

Figure 1 shows a picture of one of the roofline wet scrubber modules (at left) from inside the roofline. One of the two rectangular inlets is visible on the right side of Figure 1. The cylindrical spray section is visible on the left side of Figure 1. The exit ends of the roofline scrubber modules are shown in Figure 2. These exits could be accessed by walkways, as shown in Figure 2, to allow repairs or sampling.

Figure 1. Alcoa Eastalco Roofline wet scrubber module.

Figure 2. Roofline wet scrubber module exhausts.

Real time wet scrubber performance monitoring was performed by using a multiplexed fiber-optic based optical HF monitor to continuously measure HF concentrations in both inlet ducts and at the outlet from one scrubber module. This sampling strategy is illustrated in Figure 3. The potroom exhaust gases from each inlet duct were extracted to two separate, 2 meter long, Teflon® gas cells using dedicated sampling pumps. The light paths of two HF monitor transceiver/receiver heads were aligned with the long axis of the gas cells, allowing independent measurement of HF concentration in each inlet duct. A third transceiver/receiver head was applied to the roof vent of the wet scrubber module, aimed at a reflector at the opposite end of the 4-meter diameter vent. The real-time average concentration observed at the inlet ducts was considered as the inlet fluoride concentration of the wet scrubber module while that from the roof vent was assumed to represent the outlet of wet scrubber module. Accordingly, the real-time scrubbing efficiency can be obtained by comparing the HF concentrations observed before and after the wet-scrubber.

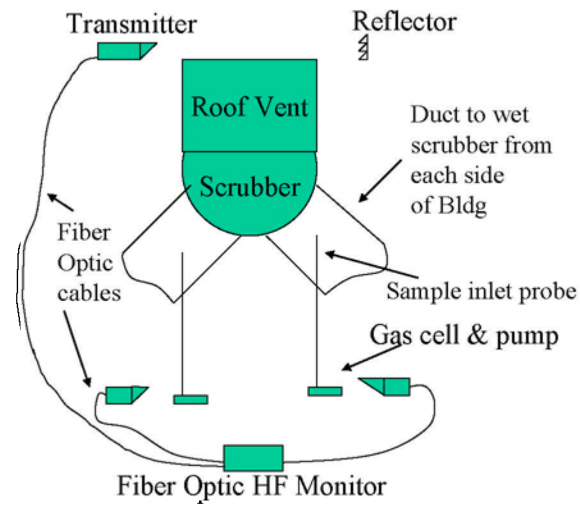

Figure 3. HF monitoring of wet scrubber module.

Results

Simultaneous 21.5 hour temporal HF concentration profiles observed at the inlets (blue and purple) and the exhaust (orange) of the B41 wet scrubber module are shown in Figure 4. The y-axis for the inlets is on the left, while the y-axis for the exhaust is at the right side of the graph shown in Figure 4. All data (and axes) shown in Figure 4 are referenced to the same unit-less scale. The temporal HF capture efficiency calculated for this same time period is shown in Figure 5.

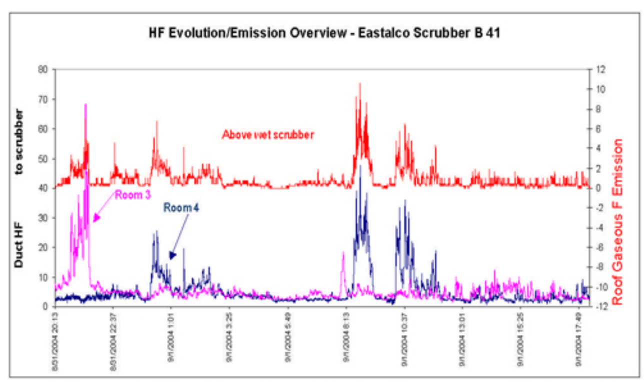

Figure 4. Wet Scrubber inlet/outlet temporal HF profile.

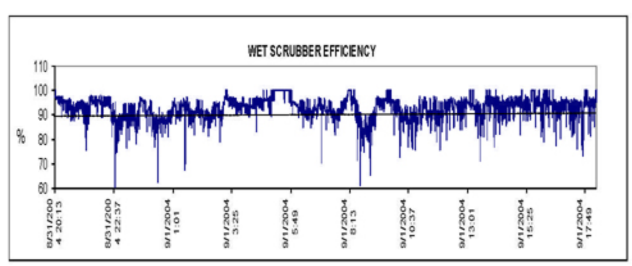

Figure 5. Wet Scrubber temporal HF capture efficiency.

Several observations are evident from the temporal HF concentration profiles shown in Figure 4 and 5.

1. Each of the two wet scrubber inlet HF concentration profiles independently reflect activity from their respective side of the pot room.
2. The exhaust HF concentration profile reflects an attenuated summation of the inlet HF profiles.
3. The instantaneous wet scrubber capture efficiency varied from 80-100% with short term excursions as low as 60%.
4. Wet scrubber HF capture efficiency is inversely correlated to inlet HF concentration.

The average HF wet scrubber efficiency observed over this period was 86%, consistent with sampling train exhaust stack sampling performed by Plant Lab personnel

Like alumina-based gas treatment systems, water based scrubbers that employ banks of spray nozzles rely on adsorption of HF during the transit time of potroom exhaust gas through the scrubber reaction zone. Several key levers for maximizing wet scrubber efficiency during periods of elevated HF evolution are:

1. Assure proper alignment and operation of spray nozzles.
2. Assure equivalent scrubber solution flow to all spray arms.
3. Visually inspect the scrubber modules to identify and repair any clogged spray nozzles.
4. Monitor spray solution pH and assure real-time control of caustic injection.

In addition to the wet scrubber control levers noted above, HF capture performance was further improved by limiting simultaneous open pot work to one cell within any given four cell area of the potrooms, thereby limiting the cumulative impact of each inlet on total HF load to any given wet scrubber module. This latter work practice modification is immediately implementable and offers negligible CAPEX or OPEX penalty.

Conclusion

This work presents real-time data regarding the HF capture performance of an aluminum smelter roofline wet scrubber and visually illustrates the temporal variability in fluoride capture efficiency observed owing to fluctuations in fugitive losses due to potroom operations. Wet scrubber HF capture performance was observed to correlate to inlet HF concentration in an inverse manner.

Several practical levers were identified for assuring >90% HF capture performance during all work potroom periods. These levers encompass opportunities from both the environmental (scrubber management) and potroom operations.

The number of active wet scrubbing systems employed for HF capture is slowly declining, owing to the OPEX of existing systems and alternative improvements for reducing losses from pots. The drive for further lowering of smelter emissions may start to bring back attention to the potroom roofs for engineering control options. Roofline wet scrubbers are the only commercially implemented option for direct treatment of potroom fluoride emissions.

Given the growing importance of SO_2 permit limits, the use of wet scrubbing at aluminum smelters may revive over coming years as a viable option for combined HF and SO_2 capture, owing to increasingly stringent environmental performance requirements and forward availability of low sulfur petroleum coke.

Acknowledgements

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