SIMPLE AND COST EFFECTIVE NESHAP COMPLIANCE

WILLIAM CIRO, CEMEX, USA, AND MELISSA SEWELL AND MARTIN DILLON, LHOIST NORTH AMERICA, USA, SHARE FIELD TEST AND MEASUREMENT RESULTS FROM A RECENT CEMEX FACILITY DEMONSTRATION TO SHOW THE BENEFITS OF USING ONE SORBENT FOR BOTH ACID GAS AND VAPOUR PHASE MERCURY CONTROL.

Introduction

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for Portland Cement (PC) facilities was promulgated by the US Environmental Protection Agency (US EPA) in September 2012. This regulation mandated that PC production facilities begin controlling these pollutants by September 2015 with the balance of PC sites having extensions until September 2016. To comply with this regulation, many facilities had to install emission controls for HCl and for vapour-phase Hg. The NESHAP regulation requires existing PC facilities to control HCl to below 3 ppmvd (parts per million, by volume, dry basis) at a reference oxygen (O_2) concentration of 7% as well as

Sorbent	Standard Hydrated Limes	FGT Grade Sorbacal® H	Sorbacal® SP	Sorbacal® SPS
Figure				
Typical Available $Ca(OH)_2$ - [%]	92 – 95	93	93	93
Typical Surface Area - [m²/g]	14 – 18	20	40	40
Typical Pore Volume - [cm³/g]	~0.07	0.08	0.20	0.20
Typical D_{50} - [microns]	5 – 7	5 – 7	8 – 12	8 – 12

Figure 1. Explanation of the various Lhoist hydrated lime sorbents and physical properties.

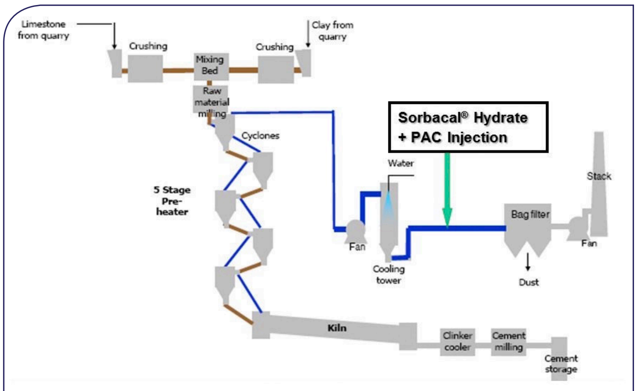

Figure 2. Typical cement facility layout showing DSI and ACI injection locations.

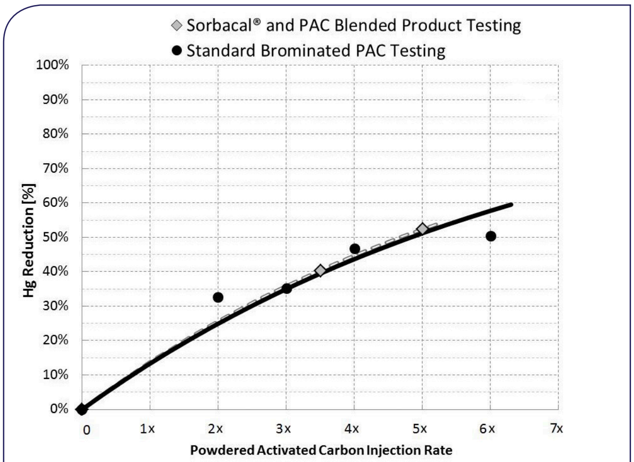

Figure 3. Blended product and PAC Hg removal performance curve.

control vapour-phase Hg emissions to less than 55 pounds of Hg per million short t of clinker produced (lb Hg/MM short t clinker). This article discusses trial results from a Cemex facility during which Lhoist North America provided sorbent as well as Fourier Transform Infrared (FTIR) measurements to investigate the feasibility of using Lhoist North America's blended sorbent consisting of enhanced hydrated lime sorbent, branded Sorbacal® SP in conjunction with a brominated powder activated carbon (PAC) sorbent.

Background

One of the most mature and lowest capital expenditure (CapEx) technologies for acid gas control and vapour-phase mercury reduction is typically considered to be Dry Sorbent Injection (DSI) and Activated Carbon Injection (ACI) respectively. Both Hg and acid gas control sorbents have proven effective in a multitude of industries (i.e. utility, waste incinerator, etc.) and have been used commercially in Europe and the United States for a broad array of control applications, in excess of 20 years. Trial results from the previous HCl test campaign with Cemex and Lhoist North America were detailed in a previous *World Cement* article.[1] DSI and ACI systems most often consist of either silo storage or bulk bag ('super sack') after which product is metered into a motive air stream and conveyed via dilute-phase into the process gas stream upstream of a particulate collection device. However, while often considered a low CapEx solution relative to other acid gas scrubbing technologies, the largest CapEx associated with DSI and ACI is the initial equipment procurement and installation. For applications where mercury control is either considered to be intermittent (i.e. for certain raw materials) or only needed for low injection rates, one way to be an even more CapEx friendly solution is if it were possible to use just one piece of injection equipment to inject both sorbents. Lhoist North America's blended product enables concurrent acid gas and Hg control using a single sorbent injection system (versus installing and maintain two nearly identical pieces of equipment) and inject the sorbents simultaneously as a pre-blended homogeneous product. For over a year, Lhoist North America has been domestically producing pre-blended Sorbacal® hydrated lime and PAC sorbents for this purpose. Lhoist North American can provide customised Sorbacal® SP and SPS blends with brominated PAC in either bag or bulk, in 5% by weight PAC blend increments up to 30%.

Development

The first generation of Sorbacal® sorbents, Lhoist's hydrated lime sorbents specifically developed for flue gas treatment, were developed in the 1980's. The advent of Sorbacal® A increased the surface area of above 10 – 20 (m²/g) as is the case with normal 'commodity grade' or standard hydrated lime. The higher surface area combined with a small particle size, gave the first generation of enhanced hydrated lime a significant performance boost compared to commodity grade products. During the acid removal reaction, the rate is understood to slow because the as the reaction products develop, such as calcium sulfate ($CaSO_4$), this forms a diffusion layer over the fresh unreacted $Ca(OH)_2$ material. More importantly, the reaction product $CaSO_4$ has a higher molar volume and gradually fills up sorbent pores. Lhoist learned that to improve the performance, increasing the surface area alone is not sufficient; and the pore volume must also be increased to improve gas-phase acid gas removal.

Extensive research performed by the Lhoist in the 1990's showed that both the acid gas capture capacity and the reactivity of hydrated lime were directly proportional to the pore volume. In contrast, the surface area was established to contribute to the acid gas removal efficiency to a lesser extent. This research led to the development of a second generation of sorbents with both a higher pore volume (more than 0.2 cm^3/g), which is almost three times greater than standard hydrated lime and twice the surface area (more than 40 m^2/g), and was designated this product as Sorbacal® SP. Furthermore, Lhoist also tuned the size of the micro and macro pores to improve their ability to capture and allow the acid gases to react. Numerous laboratory scale, pilot scale and commercial scale tests have demonstrated that the reactivity of Sorbacal® SP can be up to twice that of high quality commodity grade hydrated lime.

The third generation of enhanced hydrated lime sorbents, referred to as Sorbacal® SPS, combines the engineered pore structure of Sorbacal® SP with a chemical enhancement. This additive augments the sorbent's reactivity over that of Sorbacal® SP and greatly improves its reactivity with SO_2, it also increases its reactively with other common acids (HCl, SO_3, HF, etc). Figure 1 depicts the different hydrated lime products including a summary of the critical chemical and physical properties.

Test objectives and methodology

While Lhoist has been providing a blended product in Europe for over 20 years, Lhoist North America began producing a blended product to support recent US regulations to provide a solution for this market need. However, there were questions if the combined products would have the same acid gas and mercury capture efficacy as the sorbents do when injected independently and if they do perform differently – what are the associated product and balance of plant impacts? To address these concerns, Lhoist North America and Cemex determined a full-scale trial would be the best way to gather data to answer these questions. Since the host site had previously established the expected injection rates of Sorbacal® SP for HCl compliance, the next logical step was to determine how much PAC is required to achieve a vapour -phase Hg reduction of approximately 30% and an emission rate of less than 55 lb of Hg/MM short t of clinker production. Cemex supplied a demonstration-grade PAC injection skid as well as the temporary injection line into a nearby injection port to the permanent hydrate injection system. Mercury measurements for this study were made with the plant's existing Hg continuous emission monitoring system (Hg-CEMS). The plants installed Hg process CEMS were verified daily with the sites compliance Method 30B system.

Process configuration

A simplified process flow diagram of the Cemex host site is shown as Figure 2. Sorbacal® SP injection at this site is into a port approximately 50 ft upstream of the main baghouse.

Test results

Cemex personnel operated the demonstration ACI system and gathered Hg emission data from their existing stack Hg-CEMS. Emissions data from these tests were collected and used to develop a parametric performance curve. Based on the parametric performance results and stack Hg-CEMS Cemex determined how much brominated PAC was needed for approximately 30% vapour-phase mercury reduction. With the PAC injection rate established, Cemex and Lhoist North America were able to continue with a second phase of testing, using the appropriate blended product. Hg removal data from both test phases are presented in Figure 3. In Figure 3 the Hg data from the separate PAC injection test is presented as the black circles and has a solid black trend-line fit to the data set. The data from the blended product testing is shown by the grey colored diamonds and dashed grey line. As evidenced in Figure 3 the Hg removal data between the two data sets is nearly identical and suggests that the blending process as well as concurrent injection of these two products as a blended product did not impact the other sorbent's removal efficacy. Furthermore, the objective of 30% Hg removal was achieved with both products and provides Cemex another option for mercury compliance with a single product and with their existing hydrated lime injection system.

As the individual data points and best fit trend-lines in Figure 3 suggest, the two data sets have very good agreement with nearly identical removal characteristics which is also evidenced by the similarity between the slopes of the trend lines. Cemex has injected multiple bulk shipments of the blended product through their existing DSI feed equipment and have been able to do so without any issues or modification to their equipment. Lhoist North America's blended product continues to provide Cemex with 60% HCl removal required for NESHAP HCl compliance at the same product feed rate as those when injecting Sorbacal® SP alone. Additionally, Cemex has not experienced any balance of plant issues since they began using the blended product.

Summary

Cemex and Lhoist North America conducted a proof of concept field demonstration during which powder activated carbon was injected independently followed by injection of a blended product through an existing hydrated lime injection system. FTIR and Hg-CEMS measurements (w/ Method 30B checks) confirmed the blended product has the same Hg and HCl removal efficacy as the individual sorbents. The plant has not reported any balance of plant impacts from the sorbent change to a blended product. Cemex was able to achieve both their PC MACT vapour -phase Hg and HCl compliance goals with the blended product without the additional capital expense of having to install a separate ACI system or make changes to their existing hydrated lime DSI system.

References

1. HCl Control for MACT Compliance; William Ciro Ph.D, CEMEX; Melissa Sewell, Lhoist North America; World Cement, April 2014 pp. 50 – 53.