In-Duct Scrubber (IDS) – A Commercially Available Technology for Removal of Gaseous Pollutants from an Industrial Facility

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Abstract

Alcoa has conducted multi-year concept validation, pilot and full-scale demonstration studies to assess the technical feasibility of an energy efficient, horizontal gas-flow, co-current in-duct scrubber (IDS). More recently, Alcoa has completed a two year testing of the scrubber at its Lake Charles Carbon facility demonstrating an average SO_2 removal efficiency of 93 %, an average fluoride removal efficiency of 85 % and a total particulate removal efficiency > 55 %. Based on Lake Charles performance, IDS technology has been submitted for State MACT (Maximum Achievable Control Technology) permit replacing the age old electro-static precipitator at the facility. State MACT designation is expected during 4Q 2016. This paper will provide detail operational data from the performance validation testing at Lake Charles facility and will also touch upon the various scrubber blowdown management options that can be designed and commercially implemented at industrial facilities. IDS is targeted for worldwide commercialization in the area of small to medium size coal fired boilers, smelters, calciners and bake furnaces.

1. Introduction

Alcoa developed and patented an in-duct scrubber (IDS) technology that removes acid gases such as sulfur dioxide (SO_2) and particulate matter from flue gas, and is now installed for commercial operation at Alcoa's Lake Charles Carbon Plant in Louisiana. The technology, developed by the Alcoa Technical Center (ATC) is designed to remove greater than 90 % of the sulfur dioxide, over 80 % hydrogen fluoride and over 60 % fine particulates contained in the flue gas of smelters, anode baking furnaces, petroleum coke calciners and industrial boilers in the 50 - 120 MW/unit range.

Most smelters worldwide have been able to meet current SO_2 emission regulations without having a scrubber system in place. During the last ten years, SO_2 standards are becoming increasingly stringent in many parts of the world. In addition, the aluminum smelting industry is moving toward using petroleum coke with higher sulfur contents due to the reduced supply and higher cost of low-sulfur anode-grade petroleum coke. This results in increased SO_2 emissions from potrooms and anode bake plants at a time when emission limits are decreasing. To address these growing challenges, Alcoa's researchers developed this innovative horizontal co-current sodium based wet scrubbing technology, which has a smaller physical footprint, lower capital costs, and 30 – 40 % lower energy consumption. This is achieved by increased process and energy efficiencies for equal removal rates compared to conventional sodium or calcium based wet flue gas desulfurization (FGD) technologies. The system schematic is shown in Figure 1, which relates the simplicity of the system, e.g., no contactors or other mass transfer devices that consumes energy or contributes to scaling and increased maintenance.

2. Process Description

In the basic application a single bank of spray headers is installed in a horizontal duct after an optional pre-cooling spray (Figure 1). A clear alkaline sodium based scrubbing solution is introduced into the flue gas through the spray headers, further cooling the gas stream and neutralizing/removing the SO_2 from the flue gas stream. A large part of the reaction products, unused sorbent, and excess water fall to the bottom of the duct and drain into the recycle tank. Droplets remaining in the gas stream are removed by a mist eliminator in the duct from which the collected liquid also drains into the recycle tank. Additionally, the IDS can be operated in multiple regeneration modes. In one mode, caustic make-up is added to the recycle solution based on the pH in the Recycle Tank, which will ultimately render a sodium-sulfate laden waste stream. In another mode, blowdown from the recycle tank can regenerated with lime using a dual alkali chemistry process, thereby producing a gypsum byproduct (Figure 1). In the dual alkali mode the blowdown from the recycle tank is sent to a regeneration tank and mixed with fresh lime. The lime reacts with the sodium salts, regenerates sodium hydroxide (which is pumped back to the Recycle Tank) and produces calcium sulfate/sulfite. The addition of forced oxidation can convert the sulfite salts to sulfate and produce high quality gypsum that can be filtered and washed and potentially used as raw material for the cement or wallboard industry.

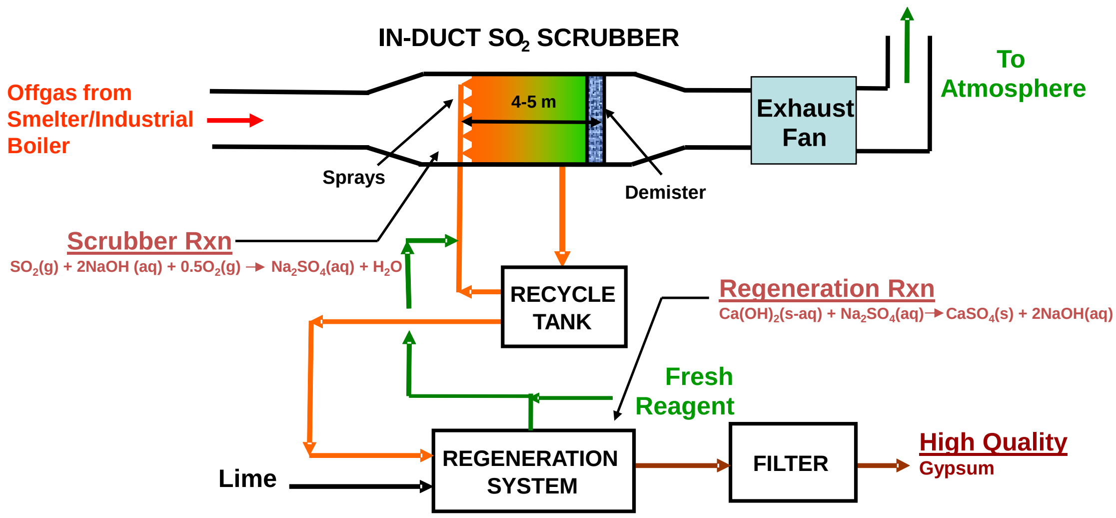

Figure 1. In-Duct Scrubber process diagram.

A 1/15th scale pilot IDS system is housed in the campus of the Alcoa Technical Center, the largest light metals research facility in the world. Another 1/15th scale unit was used for demonstration purposes at the Alcoa Massena smelter treating a slip stream of exhaust gases from the dry HF scrubber. Also, a 1/5th scale system is operated at test location in Canada. More recently, a full scale IDS system has been installed in Alcoa's Lake Charles Carbon plant and has been put to operation since April of 2014. This facility calcines green petroleum coke and then bakes carbon anodes that are send to smelters. Figure 2 shows the IDS unit that has been installed in Lake Charles, LA. Demonstration testing over an 18 month period has shown superior performance of the scrubber unit in treating acid gases, including SO_2 and HF, as well as organics and particulates.

3. Results

Figure 3 shows the test results from 2014 and demonstrates that the IDS system consistently performed with average SO_2 removal efficiencies in the 90 – 95 % range. Figure 4 shows the performance data from 2015. The scrubber continues to perform efficiently with SO_2 removal efficiencies between 92 – 98 %. In addition to the SO_2 removal, the scrubber has also been effective in removing HF as well as particulate matter 2.5 µm in size or less (PM 2.5) and particulate matter 10 µm in size or less (PM 10).

6. References

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