ASH QUALITY IMPROVEMENT–AMMONIA REMOVAL AND RECOVERY

New Technology Treats Ash Affected by Power Plant Actions to Address "Blue Plume"

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One challenge that impacts the ash industry is ammonium sulfate deposition in fly ash. Often, when power plants install pollution control devices, the contaminants removed end up in the fly ash. One example is control of NO_x using Selective Catalytic Reduction (SCR). Although very effective in controlling NO_x, the SCR catalyst also increases the conversion of SO_2 (sulfur dioxide) to SO_3 (sulfur trioxide). The SO_2 can be removed to a high degree in the "scrubber" (Flue Gas Desulfurization or FGD), but the scrubber is largely ineffective at removing SO_3. Water from the FGD and/or the atmosphere reacts with the SO_3 to form small quantities of acid mist. This acid mist is typically yellow-brown to grey-blue in color and makes the stack plume very visible and is often referred to as "blue plume."

Blue plume can be prevented in a number of ways. Arguably the most efficient is the injection of ammonia between the power plant air preheater and electrostatic precipitator (ESP). This removes SO_3 from the stack gas to a very high degree by converting it primarily to ammonium sulfate ($(NH_4)2SO_4$) which is captured in the ESP along with the fly ash. This typically results in levels of 1,000 to 3,500 ppm ammonia on the ash. Although ammonia is also used in the SCR and the ammonia "slip" (unreacted portion) from the SCR also makes ammonium sulfate, that use typically leaves only about 50 to 100 ppm on the ash. By far, the biggest contributor of ammonium sulfate on fly ash is the injection of ammonia to mitigate blue plume.

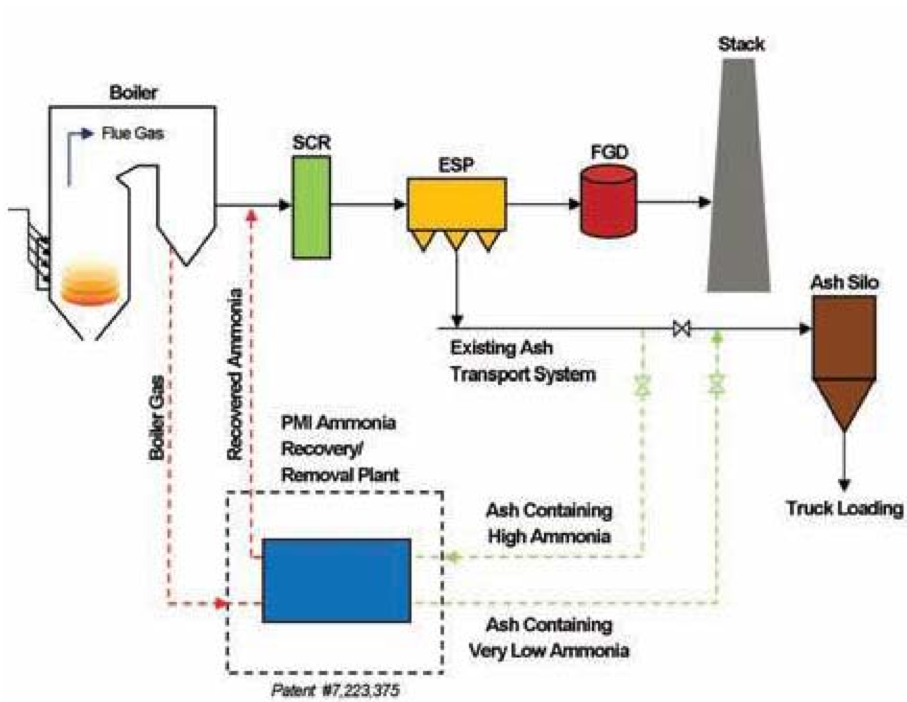

Figure 1. PMI Ammonia Recovery/Removal Plant tie-in. Ammonia removal and recovery systems are designed to integrate with existing power plant emissions control equipment.

PMI Ash Technologies, LLC is a technology development company specializing in coal combustion products and processes. We are also an operating company. We have invented and/or commercialized several technologies related to processing fly ash to make it more recyclable. Among the things that make us unique is that we have owned and operated processing plants as well as developed the technology that the plants were based upon. As a result, we have expertise in fine particle processing plant development, design and operation as well as the engineering subdisciplines that make them work. This includes combustion, thermal processing, powder handling, storage and transport and the associated machinery. One of the most recent development programs we have undertaken is the removal of the ammonium sulfate from ash and the recovery of the ammonia for reuse in the power plant.

Figure 2. PMI Ammonia Recovery/Removal Pilot Plant.

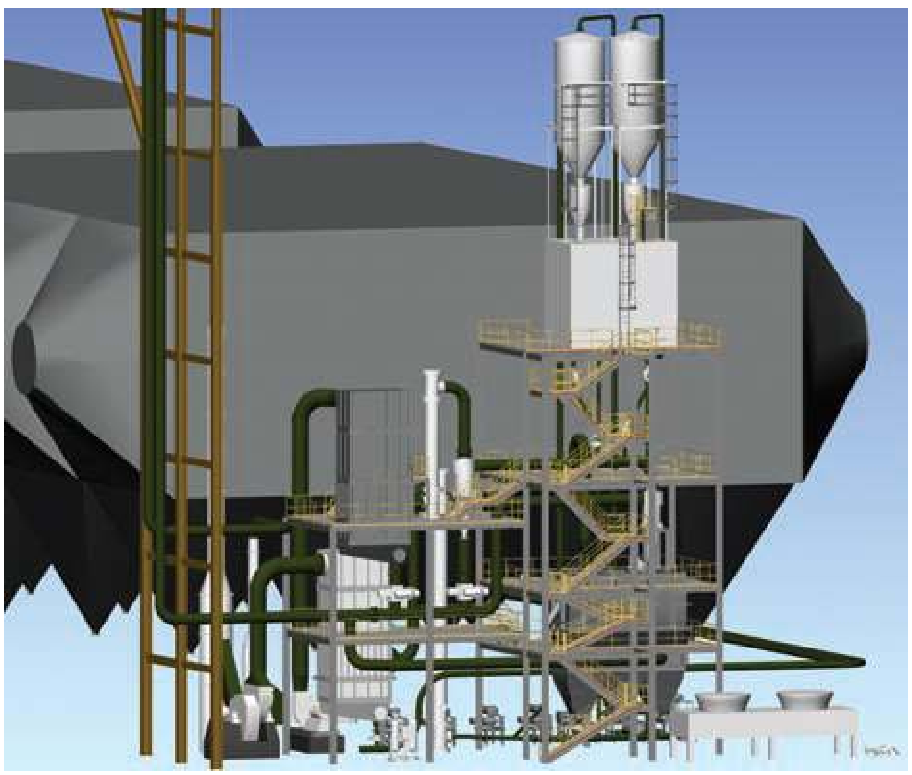

Figure 3. PMI Ammonia Recovery/Removal Commercial Plant.

There are various ways to remove the ammonium sulfate from the fly ash. For example, ammonium sulfate breaks down at elevated temperatures (to various compounds depending on the temperature). PMI's fly ash carbon reducing process, Carbon Burn-Out (CBO), is very effective at decomposing ammonium sulfate so that no ammonia exists (either in the ash or the exhaust gas) after CBO processing. However, some fly ash containing ammonia does not require carbon reduction – that is, it does not have the higher than specification loss on ignition (LOI) levels for which the CBO process was developed. For ash with the lower LOI, another process was needed.

PMI performed laboratory and bench scale pilot testing (which formed the basis for US Patent #7,223,375) that showed that the ammonium sulfate could be made to release the ammonia in gaseous form by exposing the ash to a suitable temperature for a suitable residence time. This thermal exposure greatly reduces the ammonia content of the fly ash while making a substantial part of the ammonia available for recovery and reuse. Notably, the heat required for the process can be provided by using a small amount of hot boiler gas (less than 1 percent) from the power plant boiler (see figure 1). After processing the fly ash, the boiler gas – now containing the recovered ammonia – can be reinjected into the boiler gas stream for reuse of the ammonia.

PMI advanced this invention into a scalable process that became the basis of a 1 TPH pilot plant (see figure 2). The fine particle fluid bed technology developed for the CBO process is an ideal method to provide the required residence time and is a key component in the ammonia removal/recovery process. However, it is not ideal for the initial heating of the fly ash to the desired temperature. For this, a proprietary, novel and efficient counterflow heat exchanger is used. The pilot plant confirmed the earlier data and process design, at a scale which allowed reasonable scale up to a commercial size. It also allowed optimization of the key temperature and residence time parameters. Finally, pilot plant stack gas testing was performed to confirm the composition of the gas being returned to the power plant.

Using data generated from the pilot plant, a preliminary design was developed to provide layout, interface and other technical data as well as a preliminary design level capital cost estimate for full scale commercial facility. A 750 megawatt power plant was assumed to be the "host" for the commercial ammonia reduction system preliminary design.

The commercial facility (see figure 3) will process a base load of 30 TPH of fly ash containing up to 3,500 ppm ammonia at the appropriate temperature and residence time to make a product ash containing well less than 75 ppm ammonia (see figure 4). This rate is somewhat more than the full load fly ash production for the 750 megawatt unit. The system also has a peak mode in which it will process up to 45 TPH (made possible by the ability of the system to achieve acceptable fly ash ammonia levels at a shorter residence time). The peak mode may be used to "catch up" in situations such as if the ammonia reduction system were off line for several hours while the power plant continued to make fly ash.

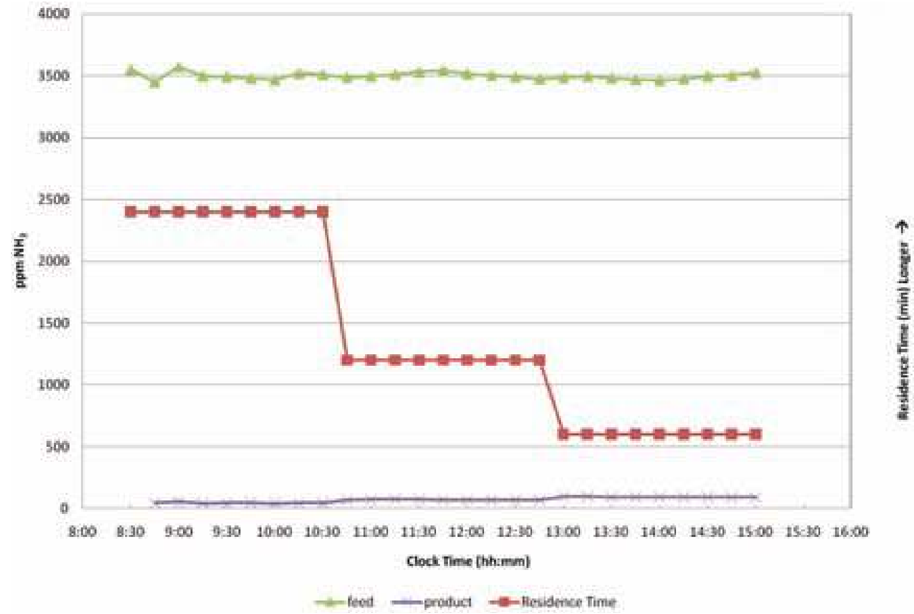

Figure 4: Typical Daily Chart of Pilot Plant Feed and Product Ammonia Content At Design Temperature while Decreasing Residence Time

The fly ash containing high ammonia levels, "the feed", is intercepted during transport from the ESP to the existing fly ash silo (see figure 1). After processing, the ash containing very low ammonia levels is transported, using the existing transport system, to the existing fly ash silo for loadout into tankers and transport to the market.

Heat supply to the ammonia reduction system is provided by ducts connected to different locations in the boiler back passes. This arrangement provides a gas stream at a relatively constant temperature even when the boiler is operating at reduced load. Most of the gas stream passes through a proprietary counterflow heat exchange setup and heats the ash (which is metered into the other end of the same system) to near the desired temperature in a few seconds. The remaining gas enters the fluid bed where the ash attains the design temperature and resides for the design residence time. The fluid bed exhaust gas (now containing much of the ammonia originally on the fly ash) joins the gas used for heat exchange and is routed back to the boiler just upstream of the SCR. The ammonia in this gas stream reduces the amount of new ammonia the power plant must purchase for use in the SCR.

The fly ash exiting the fluid bed has a very low ammonia content, but is still at bed temperature. A heat exchanger (very similar to the design proven in CBO plants for heat recovery) is used to cool the ash to a temperature acceptable for transport to the existing fly ash silo from which it is loaded into pneumatic tankers for transport to the concrete market.

In summary, utilizing ammonia for SO_3 control and the PMI technology solution to recover the ammonia and "clean-up" the ash is a win-win-win for the power plant, the ash market, and the environment. The power plant can utilize ammonia for very effective mitigation of "blue plume". The power plant most likely already has infrastructure for handling ammonia on site for its SCR. The market is assured a continued supply of fly ash with very low ammonia content to sell. Additionally, the environment is preserved by the recycling of fly ash and the well recognized reduction in CO_2 emissions from doing so. Ammonia is recovered from the ash for reuse which greatly reduces the need to manufacture alternatives from virgin feedstocks. ❖