Examples of Low Cost and High Benefit Improvements to a WTE Air Pollution Control System

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Abstract

The Miami-Dade 3,000 tpd Refused-Derived Fuel (RDF) facility is located in Miami-Dade County, FL and is operated by Montenay Power, a Veolia Environmental Services Company. A team composed of plant staff and outside experts underwent a thorough equipment-by-equipment review of the Air Pollution Control (APC) system and identified a series of low cost design and operational improvements to the lime slakers, the spray dryers and the baghouses. These improvements were implemented over the course of several months and resulted in a drop in lime consumption, in the economy of one and a half air compressor units, and in reduced APC related plant downtime and maintenance costs.

This paper describes several key improvement projects (including the upgrade of the spray nozzles, the change in slaking water quality and the fly ash fluidization project), detailing the initial problem, the chosen solution, the difficulties encountered during implementation and the achieved benefits.

Spray Dryer Absorber (SDA) Performance

The Miami-Dade 3,000 tpd Refuse-Derived-Fuel (RDF) Facility consist of four boilers, each with its own APC system. The flue gas is sprayed with a mixture consisting of slaked lime slurry for Sulfur Dioxide and Hydrogen Chloride removal, of dilution water to
cool the flue gas down to 315 °F and of activated carbon for Dioxin and Mercury abatement.

The lime slurry, dilution water and activated carbon are mixed in a small tank and pumped into dual fluid atomizing nozzles located at the top of the SDA vessel. The combined slurry flow is divided into four streams that feed four nozzle lances. The slurry is fed through a flexible hose into the center of a spray nozzle block with six spray nozzles located at the end of each lance (Figure 6). The air is fed into the same nozzle block and is divided into six streams that atomize the slurry mixture through the six nozzles.

The SDA spray nozzles were constantly plugging and required daily cleaning. This required a lot of physical labor to replace the plugged nozzle lance. The lance had to be isolated by shutting off the lime slurry and the air supply. Then two people were needed to lift the 12-ft long, eighty pound nozzle lance out of the well, replace it with a clean one and put the clean lance in service. Then, the plugged lance had to be taken to the ground level for cleaning (Figure 8). Because of difficulties with the elevator, the lances were regularly carried by two technicians up and down twelve flights of stairs. The cleaning consists of running a lime dissolving compound through the lance to remove the build up in the hose and pluggage in the nozzles. Some lances were so packed with sand and grits that they had to be physically taken apart to be cleaned.

The lime slurry is metered with a feedback signal from the outlet SO₂ to maintain the outlet SO₂ below the permit limits. The dilution water flow is controlled to maintain the SDA outlet temperature. The activated carbon is added at a fixed rate in accordance with Title V permit requirements.

The flow of the mixture of lime slurry, dilution water, and activated carbon is metered into the atomizing nozzles by using a variable speed pump.

The air flow is controlled by an algorithm that changes the feed pressure into the nozzle block as a function of the slurry mixture flow. The air flow into each lance is metered and displayed on the operator’s console.

Air Consumption

During the initial investigation, we noticed that the air flow transmitters were all maxed out and the flow indication had no meaning. Also, the two 2,200 scfm, 150 psig compressors originally supplied were insufficient to maintain the air pressure. The plant was running the spare compressor and had added a fourth one. Actually, all the compressors were needed, operating fully loaded just to maintain the minimum air pressure of 90 psig at the atomizing nozzles. This pressure often drops below the minimum pressure required whenever plant air was used. The plant was in the process of ordering a fifth compressor as a spare. During the failure of one compressor, an emergency rental compressor had to be brought on site to keep the plant operating at full load.

The first task was to determine where all the air was being used. Upon closer examination, we found that the flow meters (figure 7) had not been factory calibrated and thus there was no
documentation, only data sheets on the orifice size. The supplier of the flow devices was contacted and information to recalibrate the transmitters was generated. The flow transmitter ranges were adjusted to 350 SCFM instead of the 250 SCFM as suggested by the manufacturer. It was noticed that most of the transmitters were still pegging at this value, especially when there was no slurry flowing through the lance. This was about twice the amount of air consumption estimated by the Original Equipment Manufacturer (OEM) specification.

The nozzles were removed from a nozzle block and upon closer examination, it was noticed that they were made of Stainless Steel and had excessive wear (Figure 1). The first recommendation was to replace all the spray nozzles with OEM silicon carbide ones that would have a life span of one year instead of one week for the Stainless Steel nozzles. The first unit that was retrofitted with Ceramic Nozzles (Figure 2) showed very promising results immediately, with air flow staying in the 175 SCFM range continuously. The next units had to wait because the nozzles were out of stock and had to be back ordered.

We tried to increase the discharge pressure of the compressors and found out that the gear boxes on some of the compressors had been changed to give a higher flow capacity at a lower maximum pressure of 125 PSIG. The sequencer was limited to this new pressure to avoid overloading the compressors. Thus all the compressors running fully loaded were not capable of getting the maximum atomizing pressure recommended by the OEM. The gearing for two of the compressors was restored to obtain the higher operating pressure and realigned. The high pressure compressors would supply plant and atomizing air and the lower pressure units would supply the plant instrument air that did not require such a high pressure.

With all ceramic nozzles installed, the plant cancelled the purchase of a new compressor and has one spare compressor on standby and one compressor running loaded 50% of the time. This resulted in a saving of $150,000 in equipment purchase, $50,000 in installation costs, $80,000 in annual operating costs and $20,000 in annual maintenance costs.

Figure 1. Worn out and new stainless steel nozzles

Figure 2. Stainless steel and ceramic nozzles
Figure 3. Scale from precipitation of calcium carbonate found in nozzles.

Figure 4. View of debris found in slurry spray nozzles.

Figure 5. Close up of partially plugged nozzles.

Figure 6. View of the nozzles at the end of the spray lance.

Figure 7 View of air flow transmitter installed on one lance.

Figure 8. (Right) Lance cleaning area where 4 lances can be cleaned. (Left) Two Lances on the cart with their protective plastic pipe hoods to prevent breaking nozzles during ground transport.
Slaking Water and Purge Water Quality

With the problem of the air consumption under control, the next urgent problem to address was that of the constant plugging of the nozzles. The material caught in the strainers and in the nozzles was examined and was found to be multi-layered Calcium Carbonate scales (Figure 3), grits, and various debris (Figures 4 and 5). The slurry mixture pump which was changed from a positive displacement pump to a centrifugal pump was occasionally unable to supply the flow required by the process. The boiler load had to be reduced at times to avoid exceeding the permitted emission limits.

Calcium carbonate scale was forming in the SDA tank and in the supply lines. It was found that the dilution water and the line flushing water was recycled cooling tower blowdown water. This cooling tower blowdown water was not softened and contained large amounts of sulfates and carbon dioxide. The OEM equipment provided for softening this water malfunctioned from the beginning and was removed. The cooling tower blowdown water must be softened prior to coming in contact with lime slurry to avoid the formation of the calcium scale in the tank and piping. The frequency of acid cleaning the entire system (tanks and distribution lines) was increased from once a year to twice a year. The results were always very good following an acid cleaning. The softening of the dilution water was re-engineered and put back in operation.

Additionally, the lime consumption was very high. It was found that the slaking was also done with cooling tower blowdown water. This water has a very high sulfate content (1200 ppm) and is unsuitable for slaking. Chemco [3], the slaker manufacturer, recommended a maximum sulfate content of 300 mg/l.

P.S. Dwivedi [2] from Tata Chemicals states that waters containing 500mg/l of sulfite or sulfates are totally unsuitable for slaking. A study sponsored by EPRI [1] showed that slaking with sulfates in the water made the lime much less reactive, as much as 50% less reactive for certain limes. This lower reactivity results in increased lime consumption. The plant switched to low sulfates, soft water to increase the lime reactivity and reduced the lime consumption. The first change was to use readily-available city water, to be followed with clarified well water once the line is in place. This change in water quality decreased the lime consumption between 10% and 15%.

The flush water is taken from the dilution water tank and from the cooling tower blowdown header feeding the dilution water tank. Once the dilution water tank water is softened, the flush water lines connected to the cooling tower blowdown supply header will be re-routed to use softened water only. This requires increasing the size of the seal water pumps to accommodate this extra service.

Baghouse operation

The baghouse operating difficulties were reviewed in detail and the following observations were made:

1. The fly ash hoppers fill up during a cleaning cycle and the ash does not flow out, keeping a level in the hopper.
2. The ash removal system does not remove the ash fast enough causing the ash to sit in the hopper for a long period of time.

3. The ash then cools down, becomes sticky, and stops flowing.

The only method that works is removing the ash with a vacuum truck, sucking the ash with a hose through the thimbles. The hoppers with a very high level would then cause the bags to be filled with re-entrained ash as soon as the modules were put back in service.

The baghouse operating difficulties cause the ash to plug the bottom of the bags during the next cleaning cycle. The bottom portion of the bags fills with ash and become hard, much like a punching bag or a cigar. This then requires manually shaking each bag individually to empty them. The cleaning of the hoppers has become a major operational problem and costs thousands of dollars every month for vacuum truck services.

Several deficiencies were discovered. The original augers collecting the ash directly from two hoppers had very short half inch flights. Each screw feeder had a double dump valve at one end discharging the ash into a drag chain. This arrangement put the ash conveyors about 12 feet off the ground, making them difficult and time consuming to maintain.

The plant addressed these issues by increasing the flights from half inch pitch to three-fourth inch pitch and increasing the auger speed to 50 RPM. This required the motor size to be increased from 3 to 5 HP. The double dump valve was removed and the conveyors dropped down to discharge directly into the drag chain conveyor. A straight transition chute with a rotary valve was added to each hopper discharge.

These changes improved the operation, with a manageable situation of 5 to 7 hoppers out of 40 being plugged at any one time. However, the situation kept on deteriorating as the flight on the conveyors started to wear out and removal capacity decreased substantially. Eventually, the situation became intolerable with about half the hoppers plugged at any one time. Clearing and cleaning the hoppers has again become a huge operational issue. Additional clean out ports were installed on all the transition chutes but vacuum truck services are still the most effective means to clear the plugs and clean up.

Factors contributing to the ash problem

During the investigation, it was found that ash hopper heaters were out of service. These heaters were designed to keep the metal surface above the acid dew point of 250 °F. This lack of heating causes the ash to cool down on the hopper surfaces and to absorb moisture. The acids present in the flue gas condense on these colder surfaces and on the cold ash, and the very hygroscopic calcium chloride formed by the neutralization of the hydrogen chloride with the lime absorbs moisture from the flue gas and makes the ash very sticky and corrosive to the hopper surfaces.

Problems with the lime feed system result in prolonged operation with only cooling water to maintain the flue gas outlet temperature. This cooling water,
in the absence of a lime reagent, generates large amounts of acids and bisulfates when combined with the sulfur dioxide in the flue gas. These acids cause additional corrosion problems wherever cold spots are found inside the baghouse. Corrosion is found on the access doors and in areas around the access doors when door seals are damaged and leak. Corrosion is also found on cold spots around the reverse air fan doors and expansion joints that were not properly insulated. Evidence of corrosion is also found in heat sink areas caused by beam attachments to the baghouse casing.

The plant is in the process of replacing hopper heaters as necessary and modifying the hopper chutes. These will discharge through reconfigured rotary valves to increase the removal capacity. The screw conveyors will be modified; the flights will be increased to match the rotary valve output. It is expected that these modifications will improve the ash removal and keep hopper pluggage to a manageable minimum.

Summary

The problems identified include the use of non-OEM components, poor maintenance, a lack of commissioning, and a failure to understand the chemistry involved with RDF ash and SDA operation.

It is recommended that OEM design criteria be thoroughly understood by operators. Perform detailed engineering assessments of any proposed modifications. If a facility does not have in-house expertise, use the OEM or other expert as a partner in a long-term relationship for inspections, maintenance services, operator training, and documentation.

Remember that, while air pollution control equipment may not have many moving parts, it is still a complex system where each component plays a vital role. This includes instrument calibrations, mechanical alignments, heat balances, preventive maintenance, insulation, operator training (for they are an essential part of the system), and simple things like agitators and exhaust fans. The malfunction of any component, while it may not be an acute problem, will certainly lead to costly issues in the long run.

References:

