On-Line Carbon in Ash System at PPL Montour for Increasing Ash Sales

Todd Melick\(^1\), Larry LaBuz\(^2\), Matthew Paisley\(^2\)

\(^1\)PROMECON USA, Inc., 314 Collins Blvd., Orrville, OH 44667; \(^2\)PPL Generation, LLC Two North Ninth Street Allentown PA 18101

KEYWORDS: fly ash, unburned carbon, LOI, UBC, combustion by-products

ABSTRACT

The PPL Montour Station can sell fly ash below a specific carbon level for high value beneficial use applications. An on-line carbon in ash system was installed in October 2012 to provide the plant this critical information. This paper will present the carbon in ash technology and how it was applied at Montour.

INTRODUCTION

Coal fired boilers have various sources of thermal energy loss. The main sources are the dry gas loss as well as the unburned carbon (UBC) in the ash leaving the boiler. Reducing the excess air through the boiler decreases the dry gas loss, but at the same time this can increase the unburned carbon in ash. A complication is that the opportunity to sell the ash, and the price received can be based on the actual carbon level in the ash. With real time UBC values the plant operators can adjust parameters (excess air, mills in operation, classifier settings, etc.) that affect the UBC level obtained. But we must consider the complications of operating a plant and generating electricity can at times be a higher priority than the actual UBC value. So the ash marketer must be able to work with the ash produced and be flexible to respond to the available market. The real time UBC values at Montour will be available to the boiler operators, the ash handling personnel, and ash marketing group so that all can benefit and respond with this information.

CARBON IN ASH SYSTEM

PROMECON had installed a carbon in ash system for Separation Technologies at their processing facility located at PPL’s Brunner Island plant in 2007. This system is still operating on the two separation circuits. The ash facility receives the ash from the three boilers at this plant. The two UBC sensors are measuring the carbon content of the sellable ash coming off of the belt. In a concentrated ash stream each sensor can complete a measurement cycle approximately every 5 minutes.
The PROMECON UBC System consists of the measurement cabinet, the local control panel for each UBC sensor, and the UBC sensors. The measurement cabinet can control 4 to 8 UBC sensors. The remote UBC sensors can be up to 190 meters from the measurement cabinet. Located in the measurement cabinet are the microwave generator/receiver, a PLC, modem, power supplies, I/O, and touch panel operator interface. The local control panel provides breakers, operating lights, and the calibration button. The measurement cabinet is usually located in a fairly clean environment. A 4-20 ma signal, proportional to unburned carbon content, is generated in the measurement cabinet for each sensor and communicated to the plant control system. A telephone modem is also provided for remote communications with the system for monitoring its operation and for diagnostic and maintenance services.

The measurement method is microwave. It is based on the fact that the unburned carbon and the ash minerals have much different responses when subjected to microwave radiation. This fundamental difference in physical properties is utilized to measure the change in resonance frequency of a resonating device located in the measurement chamber. This change in resonance frequency is nearly linear with the change in unburned carbon content of the fly ash.

The UBC sensor consists of an auger that is turning slowly to compact the ash up into the measurement chamber. After the ash is consistently compacted the motor stops. The microwave signal is sent to the measurement chamber to record the frequency change. Then the motor reverses and a small amount of compressed air is injected into the measurement chamber to fluidize the ash. The end of the auger is open and the ash is ejected back to the hopper. Then the frequency is measured again to verify the measurement chamber is empty (empty frequency). That completes the measurement cycle and then it begins again.

Calibrating the system consists of taking an ash sample from the measurement chamber after the measurement is complete. A calibration button can be pushed on the local panel so the ash will not empty from the chamber for 30 minutes. This provides time for the manual removal of the ash sample. With the sample in hand the operator can push the calibration button to release the automatic cycle to begin. The sample is taken to the plant lab for analysis. On the initial calibration it is best to take 10-20 samples over the expected UBC range. After that, calibration should be checked every 3-6 months with 2 or 3 samples. With the lab results in hand the data is inserted into a spreadsheet to calculate the calibration curve.

Understanding the operation of boilers and ash handling systems is critical to applying an on-line UBC system. The most important features of any fly ash measurement system involve the approach to ash sampling and the subsequent analysis of that sample. Samples analyzed must be representative of the vast majority of ash leaving the boiler or the information generated will be misleading. In many on-line applications in the past, the measurement system draws ash samples from a very large flue gas duct. This approach only allows the coverage
of a small percentage of the cross sectional area (typically only a fraction of a square inch). Therefore, the coverage of the cross sectional area is minimal resulting in a non-representative sample of the ash flowing through the duct.

Figure 1 illustrates data collected and reported by GAI Consultants from three large flue gas ducts on a nominal 860 MWe, coal-fired utility boiler. The boiler is a supercritical, tangentially-fired unit with an LNCFS Level III low NOx firing system. It is a twin furnace design with three economizer ducts reporting to three air heaters. The data was collected in the down flow section of ductwork between the economizers and the air preheaters. A multi-point sampling grid was installed and isokinetic samples were collected over a wide range of operating conditions. This one data set is typical of numerous sets collected at various loads and boiler firing conditions and is simply included here to illustrate the maldistribution of fly ash as it flows with the flue gas exiting the boiler. There is simultaneous variation of both mass flow and unburned carbon composition of the ash. Even at constant load and firing conditions, the distribution changes due to fuel composition variations and changing furnace and convection pass cleanliness. Even larger variations occur as load changes and firing system adjustments are made.

It is clearly impossible to locate any ash sampling system, short of a complete duct array of sampling devices, which will collect a representative ash sample for all boiler operating conditions. This is simply not practical from either an economic or a plant operating and maintenance perspective.

![Figure 1: Typical fly ash UBC maldistribution in boiler flue gas ducts](image)

A more practical approach is to collect samples at a location where the vast majority of the ash has already been collected - namely the first collection field of the electrostatic precipitator or fabric filter. This location has been selected by many power stations as being most representative when compared to the ash finally delivered to the ash storage silo. Collecting samples exactly at this location provides the power station with two major advantages:
a) The measurement is representative of the ash being produced.
b) The values measured can be compared with laboratory measurements made on the identical sample, which leaves little room for “interpreting” the accuracy of the instrument measurement.

Figure 2 is a graphical illustration of the two sampling approaches in a typical power station. The conventional flue gas sampling approach is able to address only a minute amount of the fly ash while the bulk sampling approach addresses a much larger proportion. Although the composition of the ash will indeed vary in the second, third, and additional precipitator collection fields, the quantity is such that there is typically only a small difference in the composition of a mass weighted composite sample from all the fields compared to the composition of the first field alone. If that is a concern, additional sampling locations can be selected from a larger number of hoppers. A single instrument can report UBC content from 8 different sampling locations.

**Ash quality certification:**

Not representative  →  representative

![Diagram of sampling locations](image)

Figure 2: Comparison of sampling locations

**MONTOUR PLANT DESCRIPTION**

The Montour Steam Electric Station (SES), located approximately one mile northeast of Washingtonville, PA, burns about 3.5 million tons of coal each year, producing nearly 250,000 tons of fly ash and 70,000 tons of bottom ash. All of the coal ash produced at Montour is beneficially used. Fly ash is used as a pozzolan in
ready-mix concrete and concrete block, as a raw feed for cement manufacturing and as backfill or grout in mine reclamation projects. Bottom ash is used for anti-skid, septic sand for elevated sand mounds and construction aggregate.

PPL desires to increase the amount of fly ash that is beneficially used in encapsulated products, such as ready-mix concrete. However, this use is limited to ash with an LOI less than 6% per ASTM C-618 and state DOT specifications. The LOI of Montour fly ash typically ranges between 4 and 7%. The existing system has auto samplers installed in transfer piping just prior to the fly ash silos which are used to obtain an ash sample. After an analysis is performed and the ash is found to be acceptable, the plant ash equipment operator is notified to make the proper changes to capture the ash in one of two 4,000 ton storage silos. The existing system poses many challenges in obtaining large quantities of acceptable ash. A significant quantity of acceptable ash has already been conveyed before the sample results are obtained and operational changes can be made to capture the ash. Also, unless a technician is on-site and available to do the testing, the ash must be diverted from the sales silo to prevent collection of high LOI ash.

The Montour power plant has two coal-fired units each with about 768 megawatts of generating capacity. The boilers fire bituminous coal and are tangentially fired. For each boiler there are two parallel gas passes with parallel electrostatic precipitators (ESP). Each precipitator has eight hoppers wide and three fields deep, for a total of 48 hoppers. Each boiler has five air heater hoppers and five economizer hoppers. The dry vacuum system pulls the ash through 8" or 10" pipes. The 58 hoppers are emptied approximately twice per 12-hour shift. Mechanical exhausters pull the ash into two filter/separators located on top of a transfer tank. Below each filter/sePARATOR is a small transfer hopper. A valve on top of the transfer hopper opens until a high level switch closes the valve (approximately 90 seconds). Then the valve on the bottom of the hopper opens to empty the ash into the larger transfer tank (approximately 60 seconds). The filter/separator and transfer hopper are shown in Figure 3. The transfer tank is at atmospheric pressure with a bin vent filter located on top. Below the transfer tank are four Nuva feeders and the pressure blowers transport the ash in 12" pipes a long distance to two storage silos located outside the main plant area in a separate ash handling facility. There are a total of three 12" transport pipes from the two transfer tanks to the two silos. This provides the ability to perform maintenance on one pipe with the other two in operation. At the ash handling facility the ash can be diverted to either silo. One silo is dedicated to storing saleable ash. To change the ash diverter valve at the silo requires an ash operator to drive outside the main plant area to the ash handling facility and push a button near the silo. The complete dry ash conveying system as described is shown in Figure 4.
Figure 3 Filter/Separator Transfer Hopper

Figure 4 Dry Ash Conveying System
Locating the ash sensors in some of the first field ESP hoppers would provide more real time information to the boiler operators. But there are 16 first field hoppers. Also with only emptying hoppers twice a shift the UBC sensor would need to be located high in the hopper to continue receiving fresh ash. The ash concentration can be low higher in the hopper, so it can be difficult to locate the sensor where it will fill often. To prevent erosion the sensors should not be located in the high velocity transfer pipes. Locating the sensors near the bottom of the small transfer hopper (shown in Figure 5) offered several advantages:

- High quantity of ash when the ash system was operating
- Correlation of the UBC value to it’s origin (first, second, or third field ESP hopper, air heater hoppers, economizer hoppers)
- Adequate advance warning before the ash reached the silo diverter valve
- Mechanical installation access and protection from the weather

The new unburned carbon analyzer will provide real time data (as shown in Figure 6) which plant personnel can obtain and immediately make the appropriate
operational changes to capture the acceptable ash. This is especially useful with the better ash being available on evenings and weekends when the units may be operating at a reduced load. This project will make it possible to capture acceptable ash anytime the plant is in operation.

Figure 6 Montour Data
**MONTOUR STARTUP**

Two issues surfaced outside the normal startup procedures. The first was the high vacuum at the sensor location and the second was a method to permit secure communication with the measurement cabinet outside the plant.

During startup it was discovered that the transfer hopper where the UBC sensors are located operate at a vacuum of 12 in. Hg (0.4 atmosphere) when the upper valve is open. The UBC sensors have never operated in this high of a vacuum before. Sealing against pressure is more typical. The measurement chamber is exposed to both the high vacuum and atmospheric pressure. If ambient air is sucking through small openings into the measurement chamber, it makes it very difficult for the chamber to fill. The infiltrating air blows out the ash. The sensors were removed and every effort was taken to seal every possible leak.

PPL plans to award PROMECON a LTSA (Long term service agreement) for system maintenance, inspection, and calibration checks. PROMECON can remotely access the analog modem in the measurement cabinet through a secure VPN (Virtual Private Network) to download data, adjust the calibration curve, and perform diagnostics. Every complete measurement is communicated to the plant DCS via a 4-20ma signal. The ash marketing group and the PPL ash group can remotely access and monitor this information from the DCS data management system through a secure VPN.

**SUMMARY**

While all of the coal ash produced at PPL’s Montour station is beneficially used, PPL desires to increase the amount of fly ash that is used in encapsulated applications. Use as cement replacement in concrete has the highest value, but requires an LOI which Montour does not always produce. The PROMECON UBC System installed at PPL’s Montour plant allows real-time monitoring of fly ash LOI and permits PPL to maximize quantities of ash collected for sale in ready-mix concrete applications.
Figure 7 Startup Data