Carbon Burn-Out
An Update on Commercial Applications

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Introduction

Fly ash from pulverized coal plants can be a valuable mineral admixture in concrete provided it meets quality criteria such as size consist and low carbon and ammonia content consistently. Meeting all of these parameters reliably is an expanding challenge in an increasingly complex world. Ash quality problems lead directly to increased disposal, which is beginning to look even more ominous from an environmental/regulatory perspective.

Application of low-NOx burners in past years as a result of Clean Air Act requirements drove residual carbon levels in fly ash higher. To the extent that the ash was already marginal in meeting customer demands for low LOI, cleanup of that ash was needed to maintain, and even improve, the market for that ash and avoidance of disposal.

In addition, ammonia injection is used in some cases to enhance electrostatic precipitator performance, and is being applied widely in Selective Catalytic Reduction (SCR) and Selective Non-Catalytic (SNCR) Flue Gas Treatment Systems to meet more stringent NOx standards than can be met solely with low NOx burners. Ammonia contamination resulting from such systems further exacerbates the situation, and removal of ammonia is needed for any ash containing more than about 50-100 PPM (current range of limits being considered) if it is to be used in concrete applications.

Progress Materials, Inc. (PMI); a subsidiary of Progress Energy Corporation (which also owns Florida Power and Carolina Power and Light) has long recognized the benefits of using combustion technology to transform high-carbon fly ash into a marketable product. PMI developed a proprietary technology and patented process called Carbon Burn-Out (CBO) to not only accomplish carbon reduction, but also recover the energy associated with this carbon to improve the overall power plant efficiency of the host ash

source. As a side benefit, and without modification to the CBO, any ammonia on the ash is reduced to non-detectable levels.

South Carolina Electric and Gas CBO

The first full-scale application of CBO went into commercial service at the Wateree Station of South Carolina Electric and Gas in January 1999. Wateree is a two-unit, 772 MW plant located southeast of Columbia, SC. Design basis of the CBO installation is to process 180,000 tpy of ash with an average of 12.5% LOI.

A summary overview of that installation follows:

CBO plant with Wateree stack in background

Referring to the above photo, the Fluid Bed Combustor is within the tower at right-center. The heat exchanger is the inverted "U" in the center, and the product ash/flue gas separation takes place in the tower at left-center. FD and ID fans are behind the heat exchanger, as is the condensate pump and piping system. The CBO Control Room is just off the right border.

The CBO site at Wateree Station was selected for offering minimal duct runs while maintaining open access to all existing power plant systems. The ash product storage and load-out system is about 400 feet behind the photographer.

The CBO Fluid Bed Combustor (FBC) was designed and fabricated by DB Riley, using PMI's process design parameters. The combustor is a refractory-lined steel box divided into two cells to allow precise process control. The bed consists of only fly ash. For ease of maintenance, nearly all penetrations are through the roof. A start-up burner, fired by No. 2 oil, is in the air plenum below the bed. This burner is ramped down and then shut off once the bed reaches the residual carbon auto-ignition temperature of about 860^{o} F.

CBO fluid bed temperature is precisely and automatically controlled by a 'recycle' system metering cooled product ash back to the FBC, where the returning product ash acts as a thermal load. The rate at which this ash is metered into the FBC is determined by the temperature profile in the fluid bed at any point in time -- increasing temperatures signal for more cool ash, declining temperatures signal for less. Pilot plant work first demonstrated this to be a very effective temperature control technique. It has the added benefit of 'smoothing out' minor variations in ash product LOI. In addition, an Exhaust Gas Recirculation (EGR) system has been added since initial operations commenced and provides significant additional control, especially for enhancing turndown capability.

Environmental permitting for the Wateree CBO project proved quite straightforward. There is no solid or liquid waste stream from the CBO process -- all incoming high-carbon ash exits as a combination of product ash and flue gas. Wateree's heat rate is materially improved, resulting in less coal combusted for a given amount of electricity produced. Therefore overall site emissions are the same or less. Fly ash disposal at Wateree is minimized.

CBO Experience to Date:

Over 19,000 tons per month of premium fly ash have been sold from the Wateree CBO. Feed ash LOI to the CBO has ranged from 6.5 to 18%, averaging ~10-11%, while product ash has consistently averaged 2.5%, as targeted, and performed exceptionally well in the marketplace. It should be noted that product LOI can be lowered to a target of 2% or less if desired. However, experience with product performance on CBO ash yields most acceptable results at the current target.

Recovery of heat from CBO Wateree and application back to the turbine cycle in the power plant has functioned fully as designed.

Two people per shift perform CBO plant operations, including quality control on the product ash being shipped.

The Wateree CBO fly ash has the same superior air entraining characteristics demonstrated by the bench model and pilot plant product ash, even at slightly higher LOI than observed in the preliminary testing. Hardened concrete testing confirms the good strength-producing characteristics expected of Class F fly ash. There is no significant correlation between LOI and the concrete strength results obtained to date.

The Wateree CBO fly ash product is finer in particle size than the high-carbon feed ash, and is very similar to the fineness of low carbon fly ash produced by the Wateree units before Low NO_x burners. The CBO product fly ash shows no signs of agglomeration or other detrimental properties. The fly ash has performed very well in the concrete marketplace and is viewed as a premium product.

Santee Cooper CBO

Santee Cooper's Winyah Generating Station will be the site of the next CBO, slated to be in service in 2002. Winyah consists of four – 280 MW units located near Georgetown, South Carolina. Design basis for the CBO is to process 210,000 tons of fly ash per year, approximately 170,000 of which will come from Winyah. The remainder, approximately 70,000 tons, will come from Santee Cooper's Grainger station, which has two – 88 MW units. Combined LOI of the feed ash is expected to be 16%.

Among the design enhancements to be incorporated are improved feed ash blending facilities, elimination of above-bed burners (which were found to be unnecessary) and an integrated fluid bed rather than two separate cells. Also, we have designed an improved air distribution plate seal system, and eliminated "double dump" valves used to control ash flow to the exhaust duct for transport to the cyclone collector/baghouse. All of these improvements favor an even more economical means of using this technology.

Future Implications

Further reductions in NO_x emission limits will require wide application of either Selective Catalytic Reduction (SCR) or Selective Non-Catalytic Reduction (SNCR) technology. Both are known to deposit ammonia onto the fly ash. Even at relatively low levels, ammonia-on-ash presents significant marketing problems and perhaps occupational health and safety issues as well.

Progress Materials conducted a CBO pilot plant test program on over 25 tons of high-carbon fly ash containing several hundred parts per million of ammonia. This work demonstrated that, even without process flow changes, product ash from the Carbon Burn-Out fluid bed is both low-carbon and ammonia-free. Long residence times (particles average about 45 minutes in the fluid bed) together with average temperatures in the 1350° F range promote those reductions.

Summary

- Carbon Burn-Out has proven effective and efficient in producing a consistent, very high quality fly ash
- The Wateree CBO plant has demonstrated ability to produce a consistent 2.5% LOI product from a range of feedstock carbon contents and sources
- The CBO process flow was successfully enhanced so as to provide a much greater operating range than originally designed
- Plant storage and loadout features significantly enhance market flexibility
- Heat recovery back to the power plant functions fully as designed
- CBO product ash quality meets or exceeds applicable specifications and the concrete market's requirements
- The Winyah CBO plant will go into service in 2002, incorporating several design improvements from "lessons learned" at Wateree
- Ammonia-on-ash is a now major concern. Carbon Burn-Out produces ammonia-free fly ash