CARBON BURN-OUT™ – A COMMERCIALLY PROVEN SOLUTION for FLY ASH WOES

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ABSTRACT

Carbon Burn-Out™ (CBO) combusts residual carbon in fly ash, producing a very consistent, low carbon, high-quality pozzolan. The process is continuous and is fueled solely by the residual carbon. Heat is recovered and sent back to the power plant that originally produced the high-carbon fly ash, significantly improving the power plant efficiency. Any ammonia contamination of the fly ash created by flue gas conditioning or by the addition of Selective Catalytic Reduction (SCR) or Selective Non-Catalytic Reduction (SNCR) technology for NOx control is effectively eliminated without additional equipment or chemicals.

Progress Materials, Inc. developed this technology with support from EPRI and EPRI members. A one-TPH CBO pilot plant was constructed and continues to test a wide variety of ash sources. Data gathered at this plant during test programs provides design parameters for full-scale CBO plants. Extensive concrete testing has been and continues to be undertaken in order to demonstrate the superior characteristics of very low-carbon Class F fly ash from Carbon Burn-Out. Consistently good air entrainment performance is also favored, perhaps due to preferential combustion of "char" type carbon rather than "graphitic", and corresponding surface area differences.

Commercial application of CBO began at the Wateree Station of South Carolina Electric and Gas (SCE&G), which was placed into service in early 1999 to process 180,000 tons per year of raw fly ash. This CBO is owned by SCE&G and operated by The SEFA Group (SEFA), and has achieved a production rate in excess of 200,000 tons of high quality fly ash per year.

A second unit, capable of processing 210,000 tons per year, was constructed at the Winyah Station of Santee Cooper, and was placed into commercial operation in the 3rd quarter of 2002. This CBO is owned and operated by SEFA, who also market the ash.

Early interest in this technology was primarily centered on applications where fly ash carbon was either high or increasing due to low NOx burner conversions to a level that would render the material un-marketable as a pozzolan. Avoided disposal, loss of marketability due to high carbon and the value of heat recovery were the key drivers.

These remain as the key drivers today, although an additional factor is becoming a significant issue: ammonia contamination of ash by either SCR or SNCR technology. EPA's actions to further reduce NOx emissions from coal-fired boilers are accelerating the application of this technology, which may be required for as many as 600 units nationwide. CBO is effective at removing ammonia residue from contaminated ash with no changes to the basic process.

This paper presents information about the operational experience of the Wateree Carbon Burn-Out plant and the design and operation of the Winyah Carbon Burn-Out plant, including design enhancements.

Introduction

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

Application of low-NOx burners in recent years as a result of Clean Air Act requirements have driven 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 is now needed to maintain, and even improve, the market for that ash and avoidance of disposal.

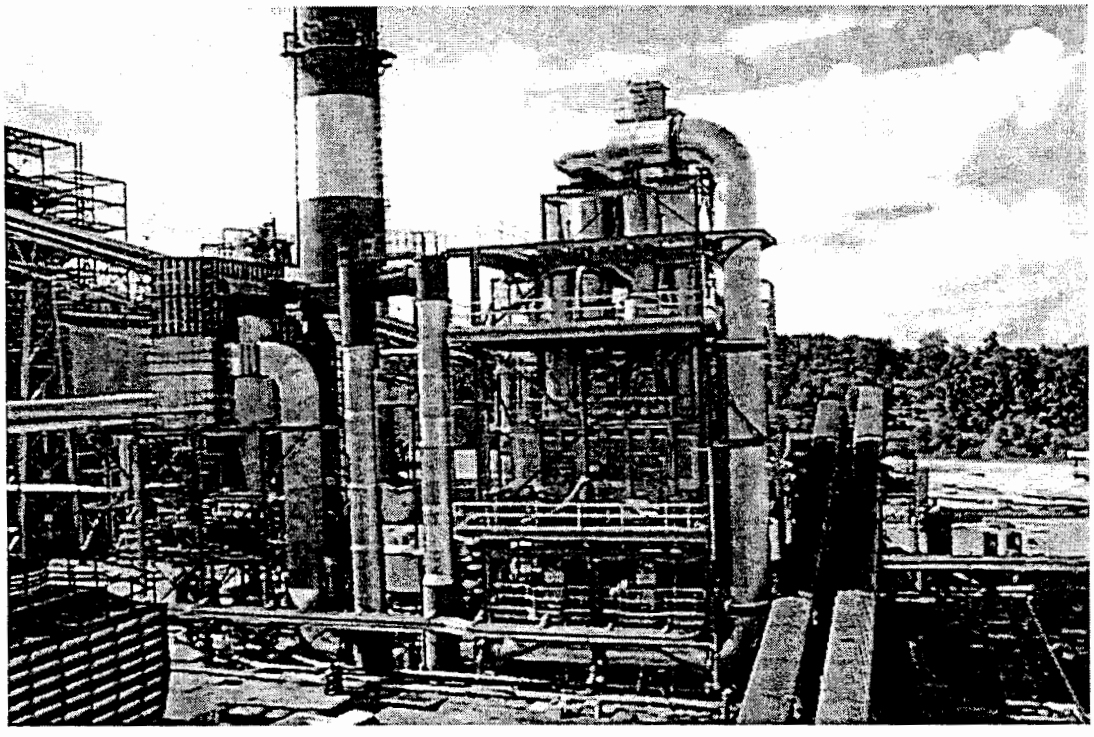
In addition, ammonia injection is used in some cases to enhance electrostatic precipitator performance, and is being applied widely in Selective Catalytic Reduction (SCR) and Selective Non-Catalytic (SNCR) Flue Gas Treatment Systems to meet more stringent NOx standards than can be met solely with low 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 if it is to be used in concrete applications.

Progress Materials, Inc. (PMI); a subsidiary of Progress Energy Corporation 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 raw feed 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 beyond 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 others, using PMI's process design parameters. The combustor is a refractory-lined steel box divided into two cells. 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 ductwork 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° F.

CBO fluid bed temperature is precisely and automatically controlled by a "recycle" system which meters 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. 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 (heat returned to plant is roughly equivalent to 19,000 tons of coal per year). Therefore overall site emissions are the same or less. Fly ash disposal at Wateree is minimized.

CBO Experience to Date:

Over 18,000 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 around 10.6%, 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. There is no technical driving force toward lower LOI.

Recovery of heat from CBO Wateree and application back to the turbine cycle in the power plant has functioned 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. In addition, SEFA reports that the product ash has lived up to their high expectations. Ash has been processed from multiple sources imported to Wateree without problems.

The Wateree CBO fly ash product is finer in particle size than the high-carbon feed ash, and is finer than the 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.

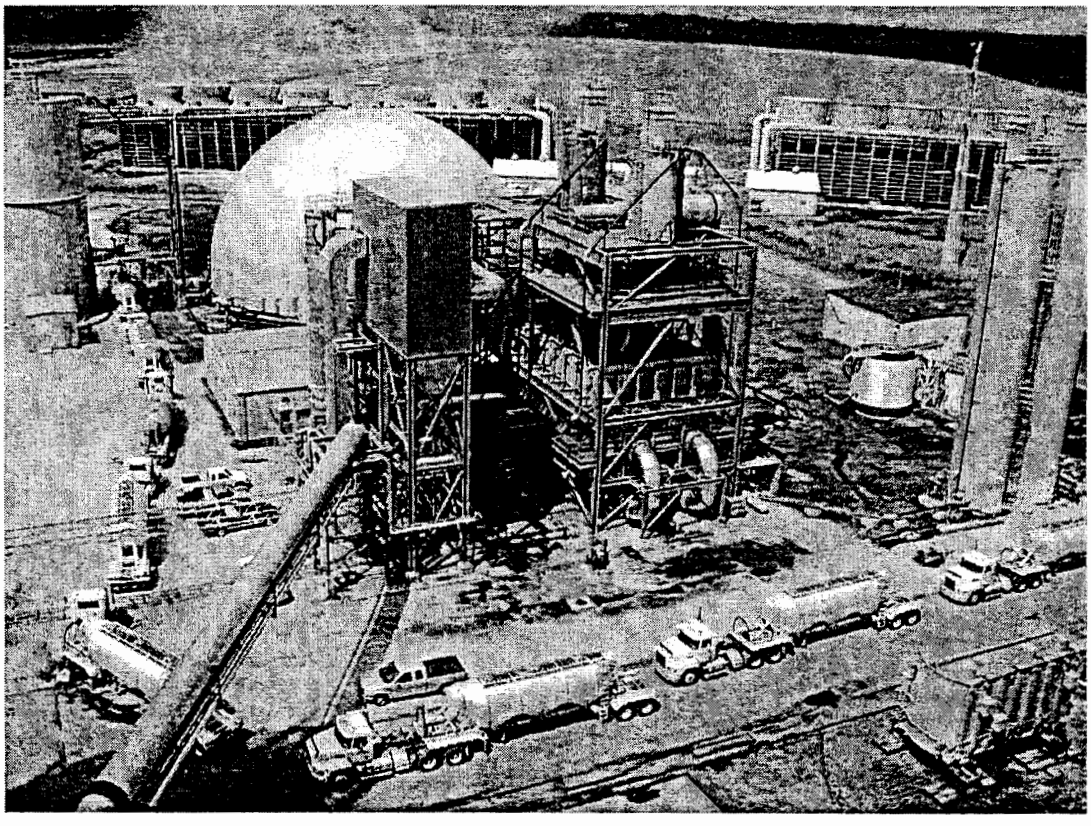
Second Unit Design Enhancements – Winyah CBO

Santee Cooper's Winyah Station is the site of the second commercial CBO, placed in service in September 2002. It is designed to process 210,000 tons per year of raw feed having an LOI of 16%. Among the design enhancements incorporated were improved feed ash blending facilities, elimination of above-bed burners (which were found to be unnecessary) and a single cell 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. Finally, we have replaced a similar arrangement of valving for return of the high carbon ash to the bed from the hot cyclones, using dip tubes that extend into the fluidized bed. Overall height has been reduced. The entry points for hot cyclone return and recycle ash for bed temperature control have been rearranged to provide for improved temperature distribution. All of these improvements favor an even more economical means of using this technology.

SEFA, the CBO operator and ash marketer at Wateree, is the owner of the Winyah CBO facility in addition to operator and ash marketer.

A photo of that installation follows:



Future Implications

Further reductions in NO_x emission limits may well require the 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 high-carbon fly ashes containing between fifty and 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 and Winyah CBO plants have 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 as designed
- CBO product ash quality meets or exceeds applicable specifications and the concrete market's requirements
- Ammonia-on-ash is a now major concern. Carbon Burn-Out produces ammonia-free fly ash without any change to the process.