Successful Fly Ash Beneficiation at Carolina Power & Light's Roxboro Station

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Electric utilities operating coal-fired power plants must dispose of the resulting ash by-products in landfills or find beneficial uses for the materials. By partnering with an independent company, a utility can minimize its resources devoted to this problem. In turn, a full service coal ash by-product company can optimize the value realized from beneficial uses while reducing or eliminating disposal costs. To accomplish this, Carolina Power and Light has partnered with ProAsh LLC to manage the utilization and disposal of coal ash from the CP&L Roxboro and Mayo generating stations.

The Problem

In response to Phase II of the Clean Air Act of 1990, U.S. electric utilities operating coal-fired power plants are currently installing low NO_x equipment to meet new air emissions requirements. As these plants begin to operate under the lower NO_x requirements, more carbon typically remains in the fly ash, often exceeding the maximum allowable carbon content of 6% for use in concrete.

The percentage of unburned carbon present in fly ash is most often measured by the loss-on-ignition process (LOI). Low NO_x burners generally produce higher, more variable-LOI fly ash. Factors that determine the variability of LOI include boiler load, burner design, the efficiency of pulverizers, and operating characteristics of classifiers. The resulting high-LOI fly ash must be disposed in landfills or used in low value, non-concrete applications. For utilities that have become accustomed to marketing the majority of their combustion by-products, land filling fly ash is a highly undesirable alternative.

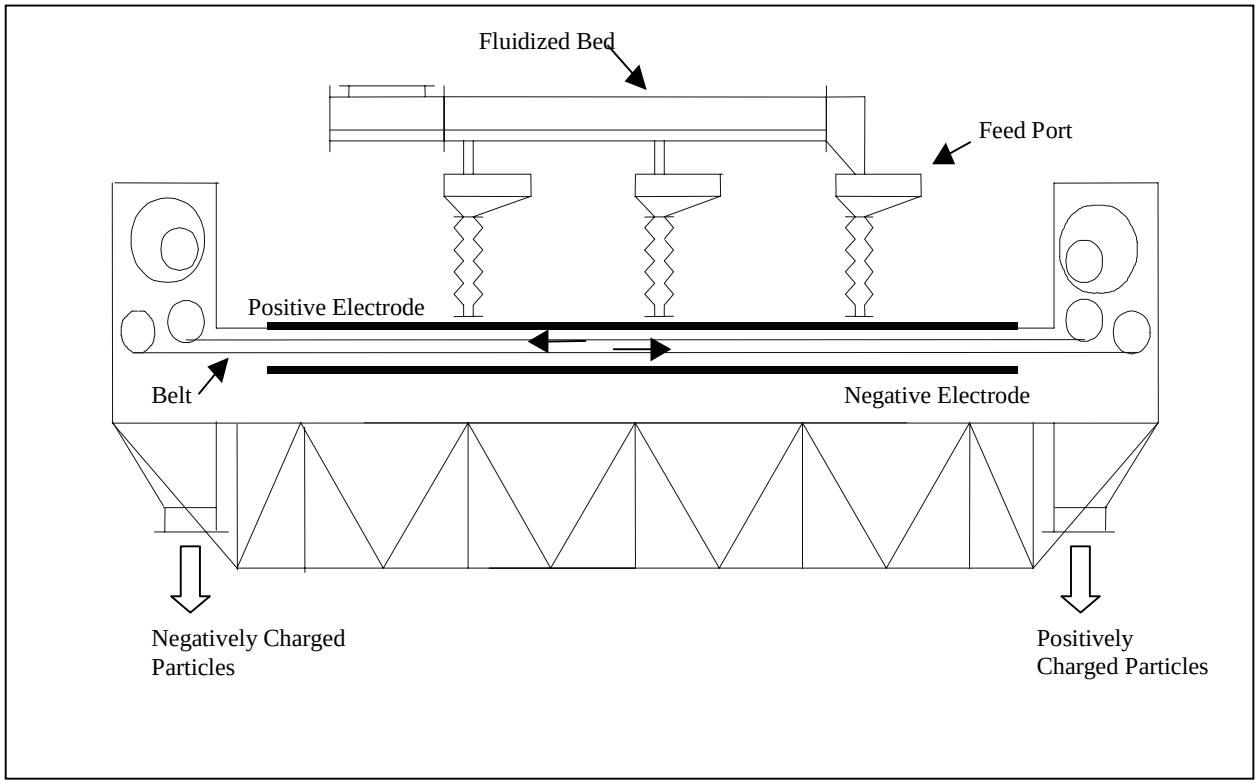
The Solution

Carolina Power & Light (CP&L) anticipated that they would face similar problems after the installation of low-NO_x burners in 1997. With a goal in mind to maximize the value of coal-combustion by-products from its facilities, CP&L began exploring different beneficiation technologies in 1996. After evaluating various technologies including carbon-burnout and froth flotation, CP&L selected a triboelectric separation process developed by Separation Technologies, Inc. (STI). This process was chosen as the most viable technology available based on its long-term performance in New England and proven flexibility in processing variable LOI fly ash.

In September 1997, ProAsh LLC, a partnership between Separation Technologies and Roanoke Cement Company (RCC), installed the first separator at the Roxboro Plant. ProAsh LLC owns and operates the separation facility and is under contract to manage all fly ash and bottom ash disposal from the plant. STI operates the processing facility; Roanoke Cement Company markets and sells

processed ash from the facility under the brand name *ProAsh*©. ProAsh LLC subcontracts operation of the on-site landfill to Trans Ash.

The physical operation of the STI separator has been described previously in other publications.[1,2] A schematic illustrating the basic components of the STI separator is shown below. The separator is relatively compact; the standard machine footprint is approximately 25 feet by 4 feet and can be housed under a silo or in a small building.



Project Capital

ProAsh LLC invested the majority of capital for the construction of the beneficiation facility. The first separator installed in September 1997 at a cost of $3 million has the capacity to beneficiate 200,000 tons of fly ash per year. In June 1998, an additional $2 million was invested in a second separator doubling the capacity of the facility to over 400,000 tons annually. This expansion was necessary to meet the increasing demand for processed ash in the region.

The ProAsh LLC separation facility produces fly ash to a self-imposed specification of 2% ± 0.5% LOI (full range). This specification was set by ProAsh LLC after establishing the relationship between LOI content and air-entrainment in concrete. ProAsh LLC determined that a 2% ash from the Roxboro facility would provide the best performance and economic advantages to ready mix customers. In addition to consistent air entrainment in concrete, control of slump, water/cement ratio, finishability, set time, and strength development are more uniform batch-to-batch.

The processed, low LOI fly ash (*ProAsh*©) is supplied to ready mix operations in Virginia, North Carolina, and South Carolina. Fly ash is utilized extensively in this geographic area to mitigate alkali silica reaction in concrete due to the use of reactive aggregate and unavailability of low alkali cement. Commercial operations have succeeded in meeting the desired quality control with the LOI of processed ash being extremely consistent at Roxboro. The average LOI of all shipments has been 1.95% with a standard deviation of 0.25 % for the history of the project.

Due to the consistent LOI of the processed ash, customers have reported almost complete elimination of air entraining problems previously encountered with variable LOI fly ash.[3] By eliminating costs and delays associated with air entrainment problems, ready mix concrete operations have increased productivity while reducing costs.

Other Applications for Ash

While ProAsh LLC utilizes fly ash beneficiation as the platform for managing the fly ash at the CP&L plants, the implementation of other ash applications is also an important part of managing by-products. In a joint effort with CP&L, ProAsh LLC is presently negotiating with companies seeking to use fly ash and bottom ash in concrete block and pipe, light weight aggregate, structural fill, soil stabilization and other applications. Through close coordination of these contracts and an economic understanding of each process, ProAsh LLC can optimize the value recovered from CP&L by-products.

Utilization of Unburned Carbon (UBC)

In addition to the production of a controlled-LOI fly ash for use in ready-mixed concrete, ProAsh LLC recovers an ash stream enriched in carbon. Presently, considerable research is being conducted throughout the industry to identify high-value uses for unburned carbon (UBC) recovered from fly ash.

Use of the recovered carbon as an adsorbent analogous to activated carbon is frequently discussed.[4,5] However, the characteristics of the UBC differ drastically from activated carbons accepted in the filtration industry. While the surface area of activated carbons typically range between 500–3000 m^2/gm primarily as micropore structures, fly ash carbons seldom exceed 10 m^2/gm with the large majority of the surface area associated with macropores and mesopores. The leachability of minerals trapped within the carbon structures will also limit the use of the fly ash carbon for water treatment.

UBC recovered by processes requiring floatation reagents may be deactivated by the adsorption of those reagents. This situation will require further treatment to remove the reagents. While some specific and limited absorbent applications for UBC may be of interest, extensive use of UBC as an absorbent will require development of cost-effective activation processes.

Fly ash has been tested as filler for plastics.[6] For use as high-grade filler, particle size distribution, particle shape, surface chemistry, color, electrical conductivity, and other properties are critical. Based on STI's analysis of various ashes, high volume utilization of fly ash as plastic filler is not practical.

Application of UBC as an adsorbent of mercury from utility flue gases may have merit. Since the UBC can be recovered in large quantities and used at the plant site and thus avoid transportation costs, the economics of this application may be favorable.

Fuel Value of Recovered Carbon

The reburning of high-LOI fly ash in utility boilers is a relatively simple method of utilizing UBC. Furthermore, recovery of the residual energy contained in the high-carbon fly ash increases the value of the beneficiation process directly to the power plant operation in the form of reduced fuel costs.

New England Power (NEP) and Salem Harbor Station demonstrated the combustibility of high carbon ash from the STI process and its use as a fuel in 1995.[7] To access the combustion properties of high-carbon ash, drop-tube furnace combustion tests and full-scale field trials injecting ash into a commercial boiler were conducted. Trials at the Salem Harbor station have proven the viability of burning the high-carbon ash as a supplemental fuel. Burnout efficiencies were greater than 85% and flame shape and stability were unaffected. Particle and gas emissions and opacity all remained acceptable. Based on the success of these reburn trials, STI and New England Power installed a permanent system for burning the high-carbon fly ash and began commercial operations in July 1997.

CP&L Tests

In August, 1996, CP&L submitted a proposal and subsequently received a matching grant of $7,500 from the North Carolina Division of Pollution Prevention and Educational Assistance (DPPEA) Challenge Grant program[8]. The scope of work proposed included the installation of beneficiation technology with a goal of reducing fly ash sent to the landfill. The final report concluded that ash disposal could be reduced by 400,000 tons/year by 1) selling processed ash into the ready-mixed concrete market, and 2) reburning the high-LOI ash produced by the separators in the utility boilers.

As part of the emissions testing required by DPPEA, CP&L conducted a series of "test" burns using high-LOI ash produced by the ProAsh LLC facility. CP&L obtained permits to reburn a mixture of coal and high-LOI ash in Units 1, 2, and 3. The permit required particulate emission tests (PETs) within 90 days of the first firing of the carbon-rich fly ash in the boilers.

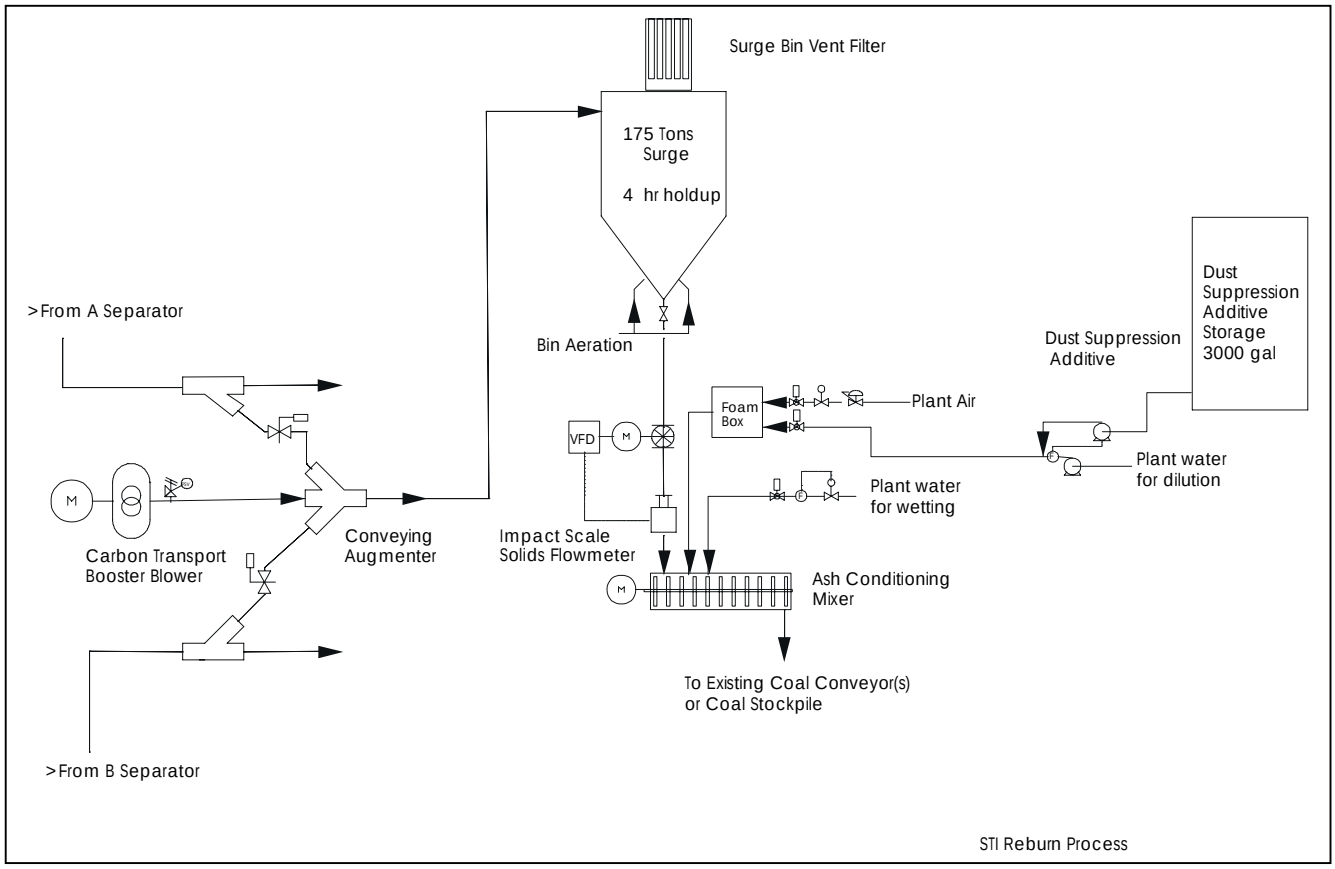
Wet conditioned high-carbon fly ash was placed on the coal conveyer using a portable conveyor with a variable speed belt. The portable conveyor was calibrated and then used to achieve a coal/ash ratio of 9.5%. The conditioned, high-LOI ash contained 25% moisture to control dusting. A 23% LOI ash with an estimated heating value of 2000 Btu/lb and a 12,000 Btu/lb coal was used for the tests. Since completion of the test burn, low-NO_x burners have been installed on Unit 3. As a result, the high-LOI ash from the ProAsh LLC facility has been as high as 45% LOI. The heating value of this ash is about 6000 BTU/lb.

During the test period, over 800 tons of high-LOI ash was added to six different mills at the plant. The tests showed that the energy from the high-carbon fly ash was recovered. A significant change could not be detected in steam-side performance heatrate (9322 vs. 9323). Air emissions and precipitator performance was not impacted during the tests.

Fuel Savings

Assuming 400,000 tons of ash were processed at an average LOI of 15%, ProAsh LLC could produce enough high-LOI ash to displace approximately 60,000 tons of coal (400,000 x 15%). Additional savings for the utility could be realized from avoided disposal costs.

STI has designed a carbon-reburn system for the Roxboro Plant. The system will convey high-LOI ash from the storage silo to a 175-ton surge bin. The ash will be conditioned with a dust suppression additive and then placed on the coal conveyor. A simplified flow diagram is shown below.



Conclusions

Management of coal ash by-products from electrical generation stations requires an excellent understanding of the materials and coordination of demand for beneficial uses to optimize utilization and minimize disposal costs. CP&L has greatly improved the management of their ash by-products through the efforts of ProAsh LLC and its use of the STI beneficiation process to maximize the value of fly ash.

High LOI ash from the STI process has been successfully reburned at CP&L's Roxboro Station without negative effects on boiler efficiency, precipitator performance, or air emissions. A full-scale system to reburn high-LOI ash at Roxboro Station is in the planning stages.

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