20 Years of Commercial Experience in Dry Triboelectrostatic Beneficiation of Fly Ash

F. Hrach, S. Gasiorowski, H.Guicherd

ST Equipment and Technologies LLC (STET), 101 Hampton Avenue, Needham MA 02494 USA

CONFERENCE: Vietbuild Ho Chi Minh City – June 2015

KEYWORDS: Triboelectrostatic, Beneficiation, Dry Fly Ash, Carbon Separation

ABSTRACT

STET Triboelectrostatic separation has been used for the commercial beneficiation of coal combustion fly ash to produce a low carbon product for use as a cement replacement in concrete for nearly twenty years. With 18 separators in 12 coal-fired power plants across the world, ST Equipment and Technology LLC's (STET) patented electrostatic separator has been used to produce over 15 Million tonnes of low carbon product.

To date, commercial beneficiation of fly ash has been performed exclusively on dry "run of station" ash. STET's electrostatic beneficiation technology reduces the carbon content of coal fly ash, producing a consistent, low carbon ash for use as a substitute for cement. Fly ash with carbon levels up to 25% have been used to produce ash with a controlled carbon level of 2 ± 0.5%. A carbon rich product is simultaneously produced to recover the fuel value of the carbon.

INTRODUCTION

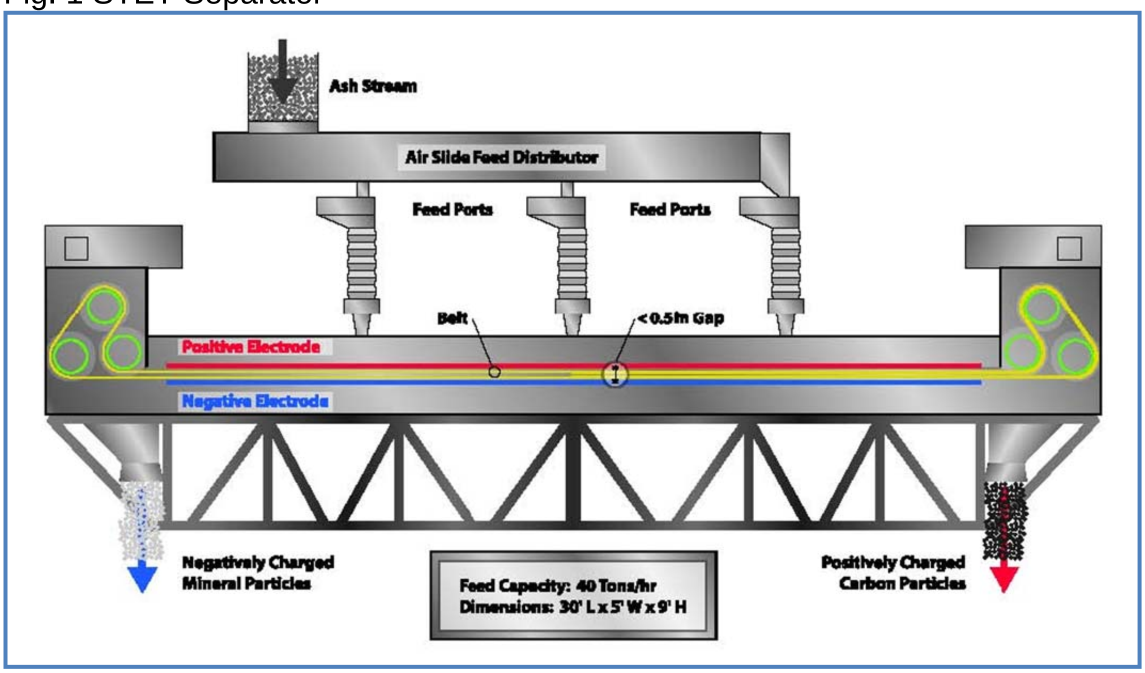
The American Coal Ash Association (ACAA) annual survey of production and use of coal fly ash reports that between 1966 and 2011, over 2.3 billion short tons of fly ash have been produced by coal-fired utility boilers.[1] Of this amount approximately 625 million tons have been beneficially used, mostly for cement and concrete production. However, the remaining 1.7+ billion tons are primarily found in landfills or filled ponded impoundments. While utilization rates for freshly generated fly ash have increased considerably over recent years, with current rates near 45%, approximately 40 million tons of fly ash continue to be disposed of annually. While utilization rates in Europe have been much higher than in the US, considerable volumes of fly ash have also been stored in landfills and impoundments in some European countries.

An excessive amount of unburned carbon in fly ash is the most common problem. The American Association of State Highway and Transportation Officials (AASHTO) and European Standards (EN 450 Category A) require that the amount of unburned carbon in fly ash, measured by loss on ignition (LOI) not exceed 5% by weight. However, starting in the mid-1990's, installation of mandated NOx control equipment at coal-fired power plants increased the carbon (LOI) content of much of the previously marketable fly ash. Further requirements to reduce NOx and other power plant emissions have resulted in the contamination of fly ash with ammonia. As a consequence, while understanding of the benefits of using fly ash in concrete continues to increase, the availability of suitable quality fly ash is decreasing. Processes to economically beneficiate off-quality fly ash are thus also of increasing interest to the power and concrete industries. STET has pioneered such processes for both carbon and ammonia removal from fly ash.

TECHNOLOGY OVERVIEW – FLY ASH CARBON SEPARATION

In the STET carbon separator (Figure 1), material is fed into the thin gap between two parallel planar electrodes. The particles are triboelectrically charged by interparticle contact. The positively charged carbon and the negatively charged mineral (in freshly generated ash that has not been wetted and dried) are attracted to opposite electrodes. The particles are then swept up by a continuous moving belt and conveyed in opposite directions. The belt moves the particles adjacent to each electrode toward opposite ends of the separator. The high belt speed also enables very high throughputs, up to 36 tonnes per hour on a single separator. The small gap, high voltage field, counter current flow, vigorous particle-particle agitation and self-cleaning action of the belt on the electrodes are the critical features of the STET separator. By controlling various process parameters, such as belt speed, feed point, and feed rate, the STET process produces low LOI fly ash at carbon contents of less than 1.5 to 4.5% from feed fly ashes ranging in LOI from 4% to over 25%.

Fig. 1 STET Separator



The separator design is relatively simple and compact. A machine designed to process 36 tonnes per hour is approximately 9 m (30 ft.) long, 1.5 m (5 ft.) wide, and 2.75 m (9 ft.) high. The belt and associated rollers are the only moving parts. The electrodes are stationary and composed of an appropriately durable material. The belt is made of non-conductive plastic. The separator's power consumption is about 1 kilowatt-hour per tonne of material processed with most of the power consumed by two motors driving the belt.

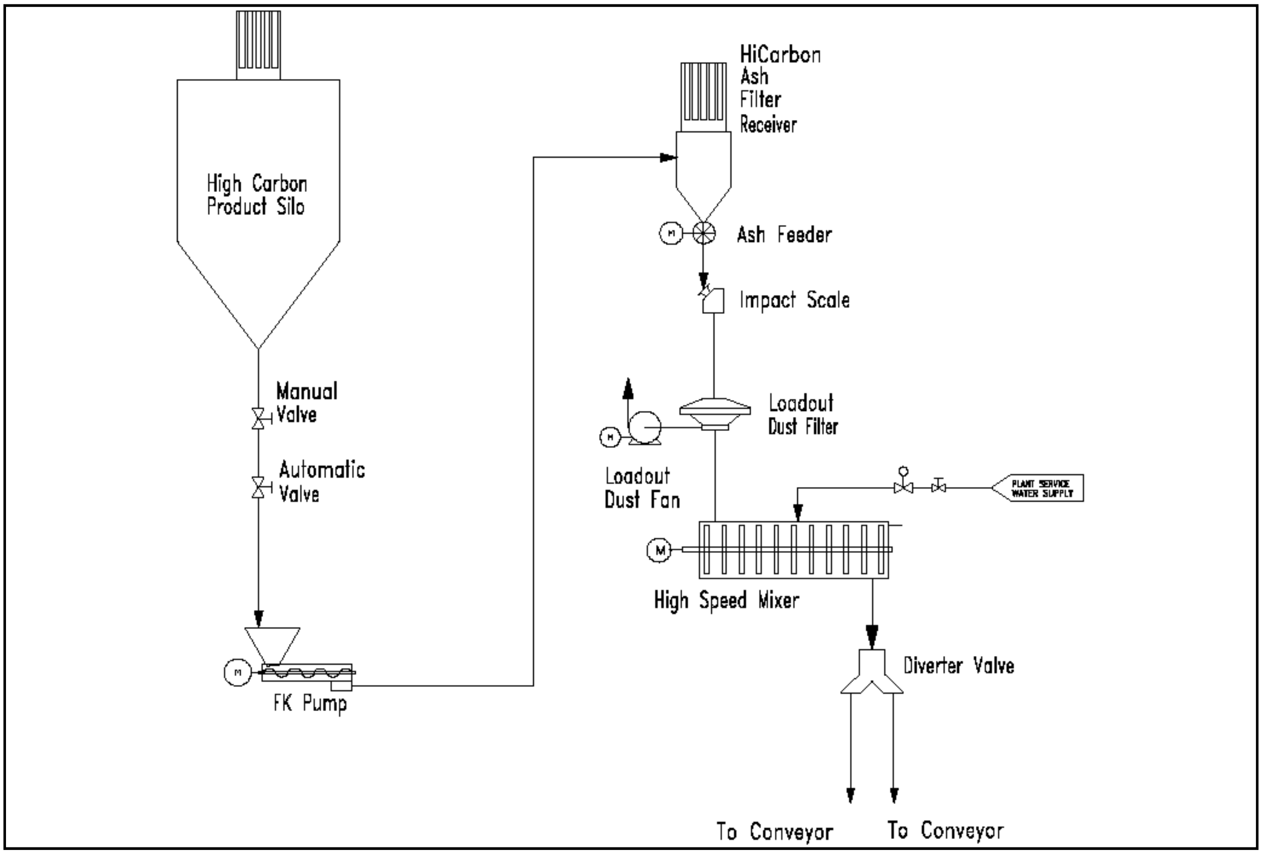
The process is entirely dry, requires no additional materials other than the fly ash and produces no waste water or air emissions. The recovered materials consist of fly ash reduced in carbon content to levels suitable for use as a pozzolanic admixture in concrete, and a high carbon fraction useful as fuel. Utilization of both product streams provides a 100% solution to fly ash disposal problems.

RECOVERED FUEL VALUE OF HIGH-CARBON FLY ASH

In addition to the low carbon product for use in concrete, brand named ProAsh®, the STET separation process also recovers otherwise wasted unburned carbon in the form of carbon-rich fly ash, branded EcoTherm™. EcoTherm™ has significant fuel value and can easily be returned to the electric power plant using the STET EcoTherm™ Return system to reduce the coal use at the plant. When EcoTherm™ is burned in the utility boiler, the energy from combustion is converted to high pressure / high temperature steam and then to electricity at the same efficiency as coal, typically 35%. The conversion of the recovered thermal energy to electricity in ST Equipment and Technology LLC EcoTherm™ Return system is two to three times higher than that of the competitive technology where the energy is recovered as low-grade heat in the form of hot water which is circulated to the boiler feed water system. EcoTherm™ is also used as a source of silica and alumina in cement kilns, displacing the more expensive raw materials, such as shale or bauxite, which are used in cement production. Utilizing the high carbon EcoTherm™ ash either at a power plant or a cement kiln, maximizes the energy recovery from the delivered coal, reducing the need to mine and transport additional fuel to the facilities.

STET's Talen Energy Brandon Shores, SMEPA R.D. Morrow, NBP Belledune, RWEnpower Didcot, EDF Energy West Burton, and RWEnpower Aberthaw fly ash plants, all include EcoTherm™ Return systems. The essential components of the system are presented in Figure 2.

Fig. 2 EcoTherm™ Return system



STET ASH PROCESING FACILITIES

Controlled low LOI fly ash is produced with STET's technology at twelve power stations throughout the U.S., Canada, the U.K., Poland, and Republic of Korea. ProAsh® fly ash has been approved for use by over twenty state highway authorities, as well as many other specification agencies. ProAsh® has also been certified under Canadian Standards Association and EN 450:2005 quality standards in Europe. Ash processing facilities using STET technology are listed in Table 1.

Table 1. STET Commercial Operations

Utility / Power Station	Location	Start of Commercial operations	Facility Details
Duke Energy – Roxboro Station	North Carolina USA	Sept. 1997	2 Separators
Talen Energy - Brandon Shores Station	Maryland USA	April 1999	2 Separators 35,000 ton storage dome. Ecotherm™ Return 2008
ScotAsh (Lafarge / Scottish Power Joint Venture) - Longannet Station	Scotland UK	Oct. 2002	1 Separator
Jacksonville Electric Authority - St. John's River Power Park, FL	Florida USA	May 2003	2 Separators Coal/Petcoke blends Ammonia Removal
South Mississippi Electric Power Authority R.D. Morrow Station	Mississippi USA	Jan. 2005	1 Separator Ecotherm™ Return
New Brunswick Power Company Belledune Station	New Brunswick, Canada	April 2005	1 Separator Coal/Petcoke Blends Ecotherm™ Return
RWE npower Didcot Station	England UK	August 2005	1 Separator Ecotherm™ Return
Talen Energy Brunner Island Station	Pennsylvania USA	December 2006	2 Separators 40,000 Ton storage dome
Tampa Electric Co. Big Bend Station	Florida USA	April 2008	3 Separators, double pass 25,000 Ton storage dome Ammonia Removal
RWE npower Aberthaw Station (Lafarge Cement UK)	Wales UK	September 2008	1 Separator Ammonia Removal Ecotherm™ Return
EDF Energy West Burton Station (Lafarge Cement UK, Cemex)	England UK	October 2008	1 Separator Ecotherm™ Return
ZGP (Lafarge Cement Poland / Ciech Janikosoda JV)	Poland	March 2010	1 Separator
Korea South-East Power Yeongheung Units 5&6	South Korea	September 2014	1 Separator Ecotherm™ Return
Lafarge Cement Poland Warsaw	Poland	2016	1 Separator

CONCLUSIONS

Maximizing the utilization of fly ash as a cement substitute in concrete production substantially reduces the carbon dioxide emissions associated with construction activity. However, pollution control systems implemented by the coal-fired power stations have resulted in a reduction of available fly ash meeting concrete-grade specifications. Further degradation of fly ash quality is expected due to further reductions in allowable gas emissions. In order to avoid loss of this valuable resource of material for concrete production as well as reduction of greenhouse gas emissions associated with concrete construction, processes for restoring the quality of the fly ash in an economic and environmentally viable way are needed.

The beneficiation of fly ash with STET processes further increases the supply of this important material. The STET beneficiation processes continue to be the most extensively applied methods to upgrade otherwise unusable fly ash to high value materials for cement replacement in concrete. Eighteen SETT carbon separators are currently in place with over 100 machine-years of operation.

ProAsh® has found wide acceptance in the concrete industry as a premium fly ash requiring far less monitoring of air entrainment requirements due to less LOI variability than other ashes. Returning the high-carbon concentrate from the STET process to the boiler at a power plant allows recovery of the recovered carbon fuel value at an efficiency similar to coal. STET offers economical means to recover ash for high value use that would otherwise be landfilled. Electrostatic carbon separation and Ecotherm™ return to the boiler provide a modular solution to a utility's fly ash needs. These processes can be implemented in phases, or as a single project.

REFERENCES

[1] American Coal Ash Coal Combustion products and Use Statistics: http://www.acaa-usa.org/Publications/Production-Use-Reports.