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Three Processes for Increasing Consumption and Value of High Carbon Fly Ash

In response to increased demand by coal-fired utilities to market ash products to increase profit at a time when ash quality, in terms of increases unburned carbon content, is on the decline, Pittsburgh Mineral & Environmental Technology (PMET), a technology development company serving the mining, metals, and electric power industries, has developed three (3) novel processes for commercial utilization of coal combustion ash that permit up to 100% recycling of ash and eliminate, or drastically reduce, the need for landfill disposal. These processes include:

- a method of converting fly ash and bottom ash into environmentally-sound bricks, blocks, and shaped building products.
- a process for the physical separation of carbon from fly ash that yields a saleable ash product having a carbon content of less than 3% LOI,
- a process that the carbon-rich, fly ash beneficiation by-product into saleable ash having an LOI of less than 3% and a saleable carbon with a 70-80% LOI that is suitable for use as absorbent carbon, metallurgical-grade carbon, or as a fuel supplement.

Production of Shaped Building Products

The PMET process for manufacturing bricks, blocks, and shaped building products from coal combustion fly and bottom ashes produces materials that are resistant to weathering and have mechanical properties equivalent to those of fired clay bricks. The technology is environmentally favorable in that it reduces the amount of ash requiring disposal and the amount of energy needed to produce these materials is considerably less than that required to manufacture conventional brick. The manufacturing process can also be adjusted to regional market demand to maximize profitability by the variability of the shapes (brick, block, architectural forms, etc) that can be produced from a single production line. PMET has demonstrated the effectiveness of its technology through extensive laboratory testing that was concluded with a successful commercial scale demonstration. Ash materials utilized in the development contained carbon contents as high as 15% LOI. Typical test results from PMET's brick products are presented in the table below.

PMET Typical Brick Performance Measures

Test	Test Result	ASTM Method
Compressive Strength (Average of 5)	6,000 psi - 10,000 psi	C62-92
Modulus of Rupture (Average of 5)	1,000 - 1,500 psi	C62-92
Water Absorption 24 hour soak 5 hour boil	 11.7% 12.2%	C62-92
Permeability	Pass (7/16" sample)	C1167-96
Freeze/Thaw	Pass	C62-92

PMET Fly Ash Beneficiation Process

The PMET Fly Ash Beneficiation Process, which is applicable for both dry and wet separation, is capable of reducing the carbon content of many fly ash products to less than 3%. Laboratory, pilot, and near commercial-scale testing confirm that the fly ash beneficiation process is both technically and economically viable as a means of consistently producing low carbon ash products from most ash-producing facilities. Testing performed at rates up to 0.5 tons per hour have shown that the process efficiently and effectively reduced the carbon content of fly ash to< 3% LOI in most individual ash samples tested. The carbon removal efficiency is a function of the ratio of the weight of usable product to the weight of reject material and can be varied as required to achieve the targeted carbon content in the ash. Results of tests performed on individual ash samples provided by one or more plants from each of five power generation systems are presented below.

PMET Fly Ash Beneficiation Process Results

System/ Plant	Raw Ash LOI (wt%)		Product Proportion (% of Feed)	Product LOI (wt%)		By-product Proportion (% of Feed)	By-product LOI (wt%)
A	6.0		90	2.7		10	30.3
B	4.2		80	2.7		20	9.6
C	10.2		62	2.4		38	23.1
D	4.1		80	2.9		20	7.0
E	5.4		87	3.1		13	9.0

The by-product resulting from the process is an ideal feed for the PMET Carbon Recovery Process described in the following section. It may also be utilized as a fuel/silica additive in cement kilns.

The development of this technology is complete. All equipment components required for a full-scale commercial production plant are proven and immediately available for purchase from equipment vendors. As the methodology of the PMET Fly Ash Beneficiation Process is the subject of a pending patent application, process details are considered proprietary and disclosable only under a standard confidentiality agreement.

The PMET Carbon Recovery Process

The removal of carbon from fly ash products by the PMET Fly Ash Beneficiation Process produces both a low-carbon fly ash suitable for use as a concrete additive and a byproduct stream containing a significant quantity of unburned carbon. Coupling this separation process with PMET's proprietary Carbon Recovery Process further improves the economics of fly ash beneficiation and reuse by converting the high-carbon by-product from the beneficiation process into:

- a high-grade carbon product with a carbon content of 70-80% LOI, and
- low-carbon fly ash (< 3% LOI) suitable for use as a concrete additive.

Utilizing the PMET Carbon Recovery Process to treat a carbon-rich by-product resulting from the treatment of commercial fly ash using PMET's Beneficiation Process yielded the following results:

PMET Carbon Recovery Process Results

	Weight Distribution (%)	**Carbon Content by LOI Analysis (wt %)**	**Carbon Distribution (%)**
Carbon By-product - Feed	100.00	36.86	100%
Ash Product	45.60	2.04	2.5%
Carbon Concentrate	54.40	66.05	97.5%

Although it is possible to utilize the Carbon Recovery Process to process fly ash that has not undergone the Stage 1 separation, there are several advantages to the combined approach, including:

- equipment size and energy consumption are dramatically decreased by removal of the majority of the fly ash during the beneficiation process, and
- improvement in upgrading efficiency by enabling the carbon particles to concentrate more freely without interference by a voluminous ash fraction.

Investigations by PMET and others have shown that unburned carbon of this type can be used in several applications including:

- an absorbent carbon product characterized by moderate demand and high value,
- a metallurgical grade carbon reagent characterized by high demand and, high value, and
- a supplemental fuel material characterized by large demand and low value.

Regardless of which eventual market, or combination of markets, are realized, the combined use of PMET's Fly Ash Beneficiation and Carbon Recovery Processes has the potential of completely eliminating landfill disposal and converting an operating cost into significant added income. At the present time, the methodology of the PMET Carbon Recovery Process is considered to be proprietary and is disclosed only under terms of confidentiality.