Total Solutions in Particle Characterization

APPLICATION NOTE

Use of Electric Power Generation By-Products in Wallboard, Cement and Plastics

Philip E. Plantz, PhD

Application Note

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Provided By:

Microtrac, Inc.

Particle Size Measuring Instrumentation

Coal represents a major contributor to the production of electric power. It also provides coke for production of steel, gasified coal for production of carbon monoxide and hydrogen to produce Tylenol and NutraSweet, and coal tar for light oils and ammonia. The large amount of coal used for power generation produces by-products that are deemed deleterious: sulfur dioxide contributes to production of acid rain; nitrogen oxides contribute to acid rain, ozone, and smog; particulates contribute to production of smog; CO_2 is believed by some scientists to contribute to global warming. The Clean Air Act of 1970 advanced a beginning to reduce the quantities of these substances emitted to the environment. Subsequent acts placed further requirements to reduce environmental exposure to acid rain (1990) or to adopt Clean-Coal Technology (2005). This paper provides a short outline of some of the advances and positive actions taken by the electric power companies to comply with these acts by using by-products of coal burning for electric power...

Gypsum Production

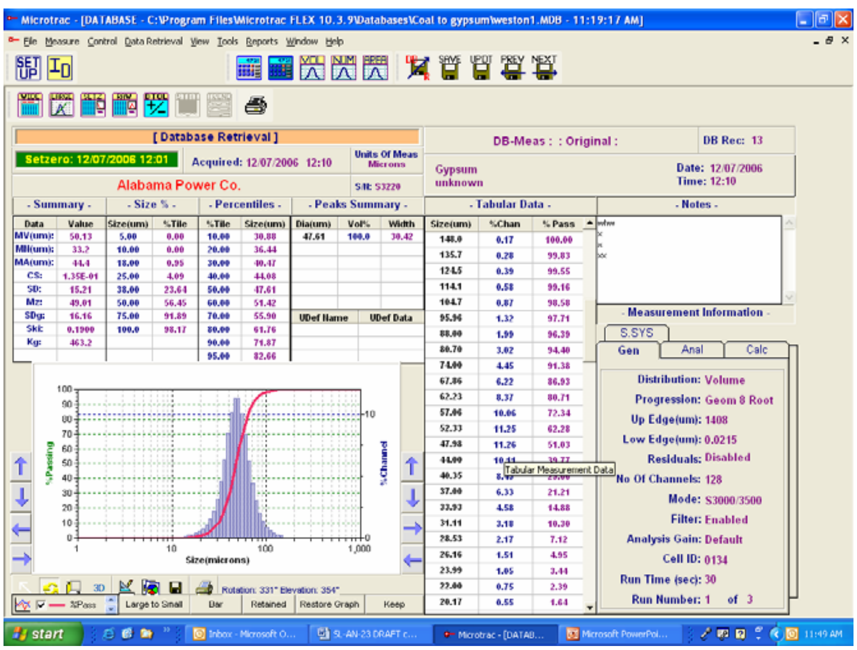
Coal burning produces many substances such as sulfur dioxide, nitrogen oxides, particulate and carbon dioxide. Electric power companies have reduced the emission of these substances considerably during the last 20 to 30 years. The adoption of Clean Coal Technology has been beneficial to controlling emissions. Devices known as “scrubbers” have been used successfully since 1980 to remove sulfur by a process known as flue-gas de-sulfurization. Since 1980 USA emission of SO_2 has been reduced by about 40%. In this use of wet or dry scrubbers, sulfur dioxide is flowed past dry or slurried limestone or lime to react to form calcium sulfate where up to 90% of the emission is eliminated. At the same time a useful product (gypsum) is produced by converting SO_2 gas to $CaSO_4$. Typically a wet-flue system is used due to its low operating costs, high reliability and efficient removal of SO_2. The converted SO_2 is collected at the bottom of the scrubber as a solid or slurry. It is also collected by bag-houses or electrostatic precipitators.

The chemical reaction occurring to remove the gas is shown below.

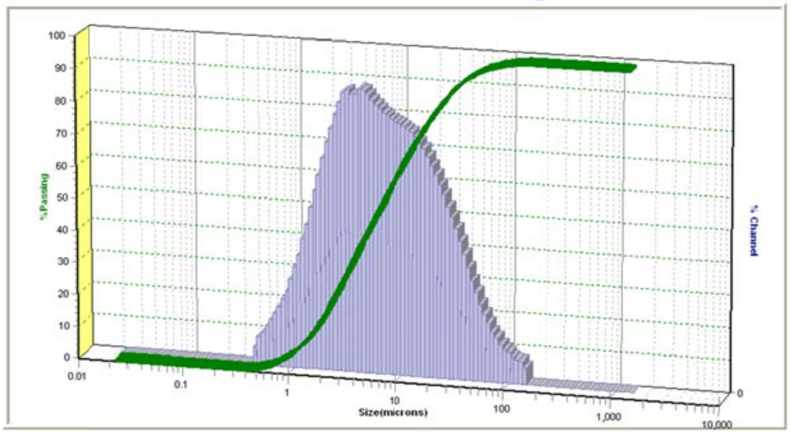
$CaCO_3 + SO_2 + ½ H_2O \rightarrow (CaSO_3 \bullet ½ H_2O)_s + CO_2$
Limestone gypsite

$Ca(OH)_2 + SO_2 \rightarrow (CaSO_3 \bullet ½ H_2O)_s + ½ H_2O$
Lime gypsite

Scrubber sludge contains a compound known as gypsite, but it also contains a number of impurities such as $CaSO_4 \bullet ½ H_2O$ and $CaCO_3$. The process can be of two types where natural conditions cause oxidation of the gypsite to gypsum ($CaSO_4$) or forced oxidation can be used. Forced oxidation results in nearly 100% conversion of gypsite to gypsum (named synthetic gypsum). Gypsum is the primary component of wallboard so the scrubbing activity provides a means for producing gypsum in addition to the time-tested mining method. Impurities in the synthetic gypsum affect hardening rate of wallboard so it must be purified prior to use, but the purified product has found wide acceptance due to its cost effectiveness.



Pre-reacted Limestone Measured Using Microtrac S3500



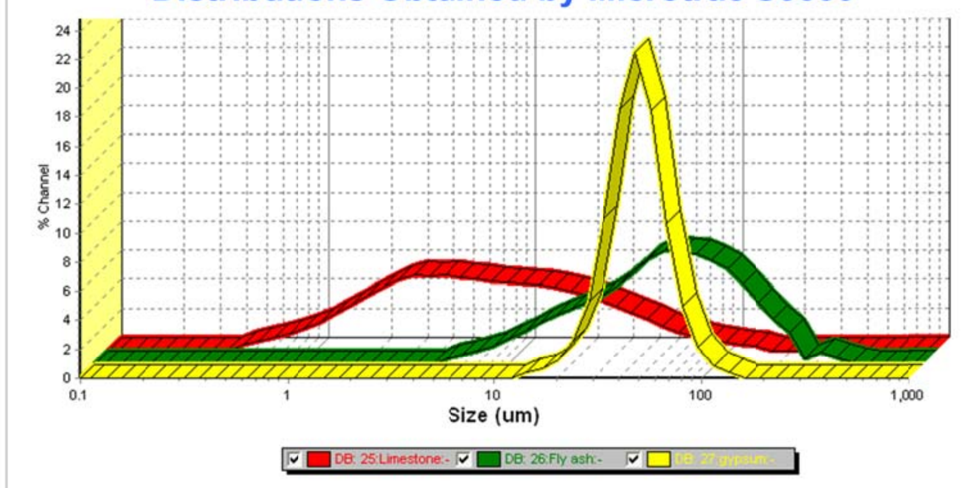
<u>By-products Used in Portland Cement</u>

Synthetic gypsum along with bottom ash and fly ash from bag houses or electric precipitators has also found use in cement where the material is added to clinker or final cement product. Over 420,000 tons of power plant scrubber products are used annually in cement production. Fly ash decreases permeability and increase long term strength, while gypsum is used in the finish mills of Portland cement. Thus two by-products normally sent to land-fills are used. Cement kiln dust (by-product of cement manufacture) is mixed with synthetic gypsum to produce a powder to be added to finish mills. Combining the materials thus reduces environmental stress by reducing emissions as well as reducing land-fill use.

<u>Plastic Filler Substitution with Coal-Burning By-Products</u>

A final example of using by-products of electric power generation is the addition of fly-ash as filler to plastics. Plastic fillers enhance properties of plastics to improve performance and reduce costs. Due to its chemical and physical properties, fly-ash is considered a mineral such as alumina, kaolin, talc and mica, which are used as fillers. However, flyash has a particle size distribution that contains too much particulate above approximately 5 microns. Thus, flyash must be treated to reduce the presence of coarse particles before it can be used. A typical Microtrac particle size distribution is shown for fly-ash.

Comparison Plot of Limestone, Gypsum and Fly Ash Distributions Obtained by Microtrac S3500



Sample Preparation and Measurement.

Note that the sample particles are slightly soluble in water. Usually our lab receives sample as a dried "cake" which results from processing. It can further be dried to produce a powder form which results in agglomerates that require some extra time for final dispersion using ultrasonic energy.

Recirculator carrier fluid: 99% Isopropyl Alcohol, Refractive Index: 1.38
Particle Refractive Index: 1.53
Particle Shape: Irregular

Transfer well mixed powder sample to 60ml of IPA contained in a 100 ml beaker. Evaluate the sample by microscope to determine the presence of agglomerates. If agglomerates are present, treat the slurry of IPA and powder with 10 seconds ultrasonic energy if powder is from a cake or 60 seconds of ultrasonic energy if the cake has been dried. Its best to check the preparation by microscopy to be sure that particle agglomerates are completely dispersed. Once the sample is dispersed, stir the beaker preparation with an overhead stirrer. While the prep is stirring, remove portions of the dispersion using a pipette and transfer the portion to the recirculator containing IPA. Repeat transfer of portions until loading is acceptable.

Microtrac S3500 Particle Size Analyzers are used in over 20 of the largest and most modern electric power plants where coal is used as a fuel source and Clean Coal Technology is being practiced. New processes are being developed to reduce environmental stress of all power plant emissions. Laser particle size measurement by Microtrac instruments will be ready to assist these developments.

The photo below shows the wet/dry sampling system on which any solvent can be used for fluid suspension analysis, as well as dry powder analysis using the analytical-friendly Turbotrac Dry Feeder. Microtrac instruments are considered to be the easiest to use while providing high quality, research grade measurements using laser light scattering. Nanosize plastic fillers can be measured using Nanotrac instruments where measurements can be made of slurries without dilution.

References:

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