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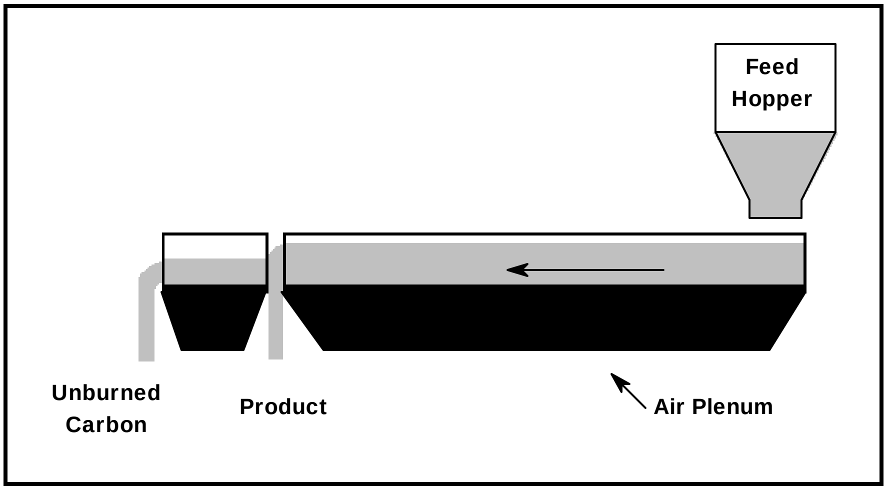
FLUIDIZED BED SEPARATOR BEING DEVELOPED TO REMOVE UNBURNED CARBON FROM FLY ASH

Problems of high levels of unburned carbon (or LOI) in fly ash are becoming increasingly common in pulverized coal boilers, particularly those with low NO_x burners. There is wide spread interest within the utility industry in the development of ways of utilizing fly ash as an alternative to ash disposal. But, for most high-volume uses of fly ash, it is necessary to limit the fly ash carbon content to levels of about four percent. The Energy Research Center has been developing a new method for processing fly ash to reduce its unburned carbon content and make it more suitable for reuse. This approach to fly ash beneficiation utilizes a bubbling fluidized bed gravity separator, operating at room temperature.

When a gas, such as air, flows upward through a container filled with particles, some of the gas flows through the bed in the form of voids of gas or bubbles if the gas flow rate is high enough. As the bubbles move upward through the bed, they cause agitation and motion of the solid particles and circulation of bed material in the vertical direction. This leads to transport of low density particles to the top of the bed and high density particles to the region of the distributor at the bottom of the bed. In the case of fly ash, the relatively low density carbon particles segregate towards the top of the bed, permitting a separation between the unburned carbon and the inert portion of the fly ash.



Unburned carbon is removed from the fly ash in a long horizontal fluidized bed. The material is separated into carbon-rich and carbon-lean streams at the discharge end.

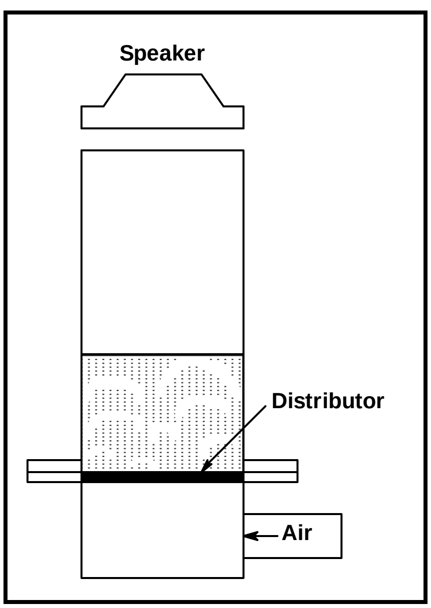
In order to apply the fluidized bed approach to fly ash, it is necessary to achieve the proper bubbling conditions. Fly ash particles are relatively fine, with mean particle diameters typically less than 15 to 20 microns. Particles in this size range normally do not fluidize well. As a result of interparticle forces, they tend to cluster together causing unsteady slugging or spouting instead of steady bubbling.

To solve this problem, the ERC project team is using a new technique for fluidizing fine particles in which a high intensity acoustic field is used. The energy of the sound waves disrupts the interparticle forces, permitting active bubbling and thus allowing the carbon particles to separate from the rest of the fly ash.

To determine the effect of the sound waves on the behavior of the fluidized bed, the Lehigh investigators performed experiments using a six inch diameter fluidized bed operating in the batch mode. Samples of fly ash were sieved, with the plus 325 mesh fraction added to the bed, fluidized with room temperature air, and the air and sound then abruptly shut off. The fly ash was then removed from the bed vessel, layer by layer, and analyzed for LOI. The results showed the strong segregation patterns which result from fluidizing the material. The degree of stratification which occurs depends heavily on the size distribution of the fly ash, the distribution of carbon by size, and the bed operating conditions. The overall percent reduction in carbon also depends on product recovery rate.

For continuous operation, the process relies on the use of an inclined fluidized bed similar to a long, nearly horizontal, table. The fly ash is added at one end and fluidizing air passes upward through the distributor as the fly ash flows along the surface of the bed. As the ash flows along the length of the bed, segregation occurs with the dense fraction settling downward towards the distributor and the carbon rising to the top of the bed. At the discharge end, the material is separated into carbon-rich and carbon-lean streams.

Fly ash has a wide size distribution and in order to achieve good separation of carbon, in some cases, it will be necessary to first separate the fly ash into two parts by size. A complete fly ash beneficiation system would then consist of a particle size separator, along with fluidized beds, for the removal of the low density unburned carbon. The system would initially classify the fly ash by size, separating it into coarse and fine components. Each of these streams would then go to a fluidized bed for processing to remove unburned carbon.



Sketch of fluidized bed illustrating arrangement of acoustic speaker.

In a typical case, the system would be installed at a power plant between the precipitator and ash silo. In the case of a 500 MW power plant burning coal with ten percent ash, 25 tons per hour of fly ash is produced at full load conditions. If this were processed in the fluidized bed system, two fluidized beds, each four feet wide by about twenty feet long, would be sufficient for handling the ash.

According to Edward Levy, the project director, "In preliminary laboratory trials we have achieved fifty percent reduction in LOI with about sixty percent mass recovery. We are in the midst of studies to optimize process operation and, thus, we expect to see some improvement in the LOI reduction rate. If the goal is to achieve a fly ash with a LOI of four percent or less, we expect the process will be able to handle fly ashes with LOI's of up to eight to ten percent."

There are significant financial incentives to developing cost-effective techniques for handling fly ash. U.S. electric utilities currently spend about one billion dollars annually to dispose of most of the seventy-five million tons of ash removed from their pulverized coal burning plants.

The fly ash beneficiation project is funded by the Pennsylvania Energy Development Authority, GPU Generating Company, Potomac Electric Power Company, and Lehigh University. The project team includes Edward Levy, Director of the Energy Research Center, John Salmento, Toru Masaki and Carlos Herrera, graduate students in Mechanical Engineering, and Asher Ayalon, a Visiting Research Engineer.

The objectives of the project are to determine the technical feasibility of using the fluidized bed approach for fly ash beneficiation and to determine equipment and operating costs. Working with CQ, Inc., a firm that specializes in coal cleaning and handling, the ERC has developed designs of both commercial and pilot scale fly ash beneficiation systems. Cost studies performed by CQ, Inc. show the technology is capable of processing the fly ash with a cost of less than $3.00 per ton of clean product.

According to Levy, "Based on the results we've obtained so far, we feel this approach for removing carbon from fly ash has very good commercial potential. The next obvious step in the process development is the construction and testing of a pilot scale facility at a pulverized coal power plant. This will enable us to determine how well the system performs under field conditions, with normal day-to-day variations in fly ash properties. We will be able to test out and refine our system design, identify instrumentation and control needs and determine required levels of manpower for operations and maintenance." •

RESEARCHERS' PROFILES

Dr. Edward K. Levy is a professor of mechanical engineer and mechanics at Lehigh University and Director of the University's Energy Research Center. Dr. Levy has a B.S. degree from the University of Maryland and M.S. and Sc.D. degrees from the Massachusetts Institute of Technology, all in mechanical engineering. His research deals with the thermal aspects of power generation and energy conservation, with an emphasis on emission control and performance of electric power generation equipment.

Dr. Nenad Sarunac, senior research engineer at the Energy Research Center, has a B.S. degree in mechanical engineering; a M.S.

RESEARCHERS' PROFILES
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degree in electrical engineering from the University of Zagreb in Zagreb, (former) Yugoslavia; and a Ph.D. degree in mechanical engineering from Lehigh University. A specialist in modeling and computer analysis of thermal-fluid systems, Dr. Sarunac has worked extensively in development and testing of on-line heat rate measurement methods.

Mr. John Salmento is a Ph.D. candidate in mechanical engineering and mechanics. He has a B.S. degree in mechanical engineering and engineering and public policy and a Master of Engineering degree from Carnegie Mellon University. His research deals with the flow characteristics of a bubbling fluidized bed.