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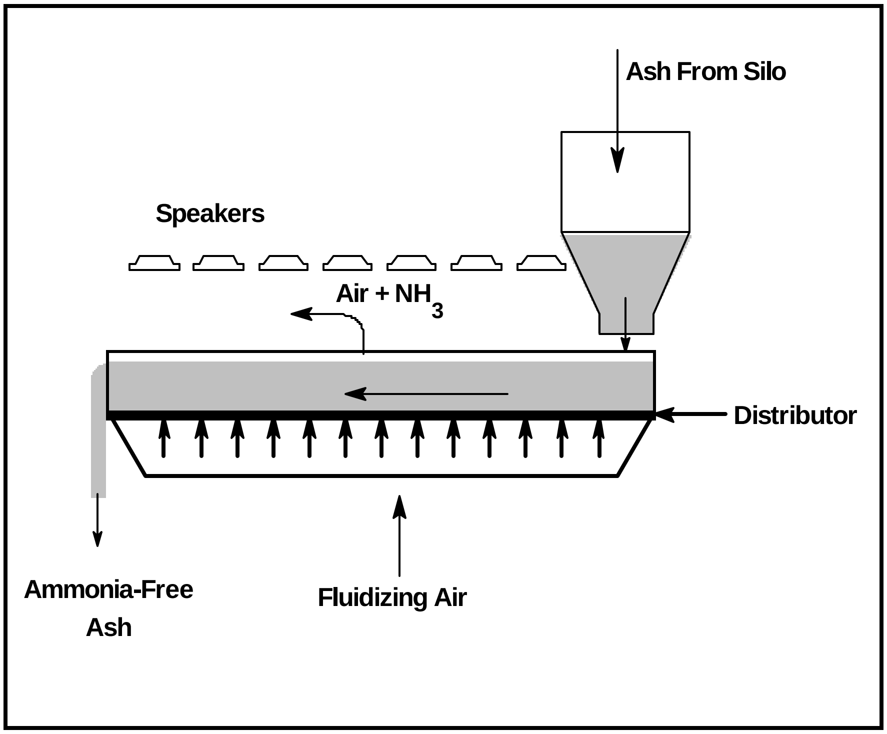
REMOVING AMMONIA FROM FLY ASH

Contamination of fly ash with ammonia presently occurs at several U.S. coal-fired units. This type of contamination will become much more common with widespread use of the Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR) processes for NO_x control. With these technologies, ammonia is injected into the boiler. Invariably, some ammonia reaches the stack as part of the flue gas and some is adsorbed onto the fly ash. There is concern the presence of ammonia on the ash will adversely affect ash utilization. In response to this, researchers at the Energy Research Center are developing a process for the removal of ammonia from fly ash at the power plant.

The Center's ammonia removal process makes use of a bubbling fluidized bed. The ammonia laden ash is fed to the bed and is heated to temperatures required to drive the ammonia from the ash. Fluidized beds are widely used in industry because when operated with the right range of conditions, they exhibit excellent heat transfer, solids mixing and gas contacting characteristics. In a bubbling fluidized bed, the particles are supported by a gas distributor. At sufficiently high gas velocities, bubbles of gas are formed at the distributor, and these rise vertically through the particle bed, creating turbulent-like motion and very good solids mixing.

According to Ed Levy, "Previous tests with fly ash in a fluidized bed in our laboratory showed that because of the very fine size distribution of fly ash particles, the particles tend to be attracted to one another. This leads to a clustering of particles in the bed, which makes it difficult to achieve stable fluidization with active bubbling. Since the ammonia removal process requires vigorous and consistent bubbling, the process described in this paper makes use of acoustics to agitate the fly ash. A loud speaker, positioned at the top of the bed, creates high intensity sound waves. These disrupt the interparticle forces and promote active bubbling."



Sketch of inclined fluidized bed for continuous processing of fly ash.

Using this approach, experiments on ammonia removal were carried out in a six-inch diameter bed, fluidized with air. Electric resistance heaters submerged in the bed were used to heat the ash. Thermocouples in the bed measured the ash temperature at several locations. As the ash temperature increased, samples of ash were removed periodically and these were subsequently analyzed for ammonium content.

Three different ashes were tested. These had initial ammonium concentrations ranging from 500 to 1,000 ppm. The test results showed that ammonia release began in the 300-400°F range and the ammonium content was reduced to less than 10 percent of the initial ammonium level when the ash was heated to bed temperatures of 650-750°F. The ammonia removed from the ash was carried from the bed with the fluidizing gas.

Levy adds, "Our experiments demonstrated that ammonia can be removed from dry ash by heating the ash in a bubbling fluidized bed with the assistance of acoustics to promote bubbling fluidization. These experiments were performed in a small laboratory scale batch bed. In this case, cold ash was loaded into the fluidized bed vessel. The ash was fluidized and heated until most of the ammonium was gone. However, a full-scale commercial process will need to operate continuously and we propose to accomplish steady operation using an inclined fluidized bed. An inclined bed resembles a long, nearly horizontal table. Dry ash is fed to the bed at one end and is heated as the ash flows along the surface of the distributor. Ammonia-free ash is removed at the far end of the bed. We believe the inclined bubbling fluidized bed is the ideal type of reactor for this application. It is of simple construction, it has no moving parts, and it permits continuous operation. Finally, because of extremely low fluidizing air velocities, energy requirements for heating and the cost of solids air separation can be kept to a minimum."

Levy and his students carried out design calculations for a system processing 25 tons per hour of ash. They assumed the ash enters the bed directly from ESP ash hoppers at 250°F. It was further assumed that the ash was heated using electrical resistance heaters immersed directly in the bed. Busbar electricity costs were taken to be 4 cents per kWh. For these conditions, the energy costs for ash heating were calculated to be $2.14 per ton of ash. If desired, energy types other than electricity can be used for ash heating. For example, a hot gas produced by natural gas combustion can be circulated through tubes immersed in the bed to heat the ash to the required temperature.

The off-gas from the fluidized bed consists of hot air with small concentrations of ammonia, SO_2 and entrained ash particles. In some applications, it will be possible to inject the off-gas into the furnace where the ammonia will provide small amounts of NO_x reduction through SNCR reactions. In other applications, an ammonia scrubber or a fabric filter and ammonia scrubber will be needed for cleaning the off-gas prior to discharge to the atmosphere. In this case, however, the flow rate of gas to be treated will be quite small.

Levy concludes, "Our results demonstrate the potential for using a heated fluidized bed to remove ammonia from fly ash. We are in the process of building a laboratory scale facility for demonstrating continuous processing of the ash in an inclined fluidized bed. Once we have done this, the process will be ready for scale-up testing at a power plant." €

RESEARCHERS' PROFILES

- Dr. Richard Conn is a Senior Research Scientist with a Ph.D. degree in Fuel Science. He is a specialist in ash slagging and fouling.
- Dr. Nenad Sarunac has a Ph.D. in Mechanical Engineering and is a Principal Research Scientist with the ERC. His research focuses on power plant heat rate improvement and emissions control.
- Dr. Edward Levy has a Ph.D. in Mechanical Engineering and is Professor of Mechanical Engineering and Mechanics and Director of the Energy Research Center.