# AMMONIA REMOVAL FROM FLY ASH USING AN ACOUSTICALLY ENHANCED FLUIDIZED BED

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## INTRODUCTION

In meeting the reduced levels of $NO_x$ emissions which are required under EPA regulations, many coal-fired units will be equipped with either selective non-catalytic or selective catalytic reduction technologies. Both of these techniques make use of either ammonia or urea-based reagents and, in both cases, some ammonia reaches the stack as part of the flue gas and some is adsorbed onto the fly ash. This paper deals with the development of a dry process to remove ammonia from fly ash. The process involves use of a fluidized bed in which ash is fluidized with air and heated to decompose the ammonium compounds. Fly ash is typically difficult to fluidize because of the small size of the particles, and to solve this problem, acoustic excitation of the bed is used to promote active bubbling and improve the fluidization characteristics of the ash.

Laboratory experiments were performed in a batch fluidized bed on fly ashes heavily contaminated with ammonium. Data are presented on the bed process conditions required to accomplish removal of the ammonium. For commercial scale operation, the process will need to operate continuously, and the paper also describes the use of an inclined fluidized bed to accomplish continuous steady operation.

## EXPERIMENTS ON AMMONIA REMOVAL

The ammonia removal process requires vigorous and consistent bubbling, and to achieve this, the process described in this paper makes use of acoustics to promote active bubbling of the fly ash. The experiments on ammonia removal were performed in a 6" diameter bed, fluidized with air. Electric resistance heaters, submerged in the bed, were used to heat the ash and a loud speaker was positioned at the top of the bed. Thermocouples in the bed measured ash temperature at several locations. As the ash temperature increased, samples of ash were periodically removed and these were subsequently analyzed for ammonium content.

Three different ashes were tested with initial ammonia concentrations in the 700 to 850 ppm range (Ash A), 600 to 1100 ppm (Ash B) and approximately 500 ppm for Ash C. The results show sharp reductions in ammonia content began at temperatures of 500°F, with 80 percent ammonia removal in the 650 to 700°F range and 90 percent ammonia removal occurring between 700 and 750°F.

## CONTINUOUS OPERATION

The bed used in the experiments described above is a small, laboratory-scale batch bed. However, a full-scale commercial process will need to operate continuously, and we propose to accomplish steady operation using an inclined fluidized bed. In the case of the inclined bed, 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, with no moving parts. 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.

Design calculations were performed for a system processing 25 tons/hr of ash. It was assumed the ash is heated using electrical resistance heaters immersed in the bed. The ash heating costs vary with the cost of electric generation and ash feed temperature. At 4¢/kWh, the energy costs for ash heating range from $2.14/ton to $3.05/ton, for ash feed temperatures from 275 to 70°F. 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 will consist of hot air, with small concentrations of ammonia, $SO_2$ and entrained ash particles. In some applications, an ammonia scrubber, or a fabric filter and ammonia scrubber, may 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. The fluidizing velocities are less than 0.05 ft/s for this design and the flow rate of fluidizing air will be of the order of 200 to 300 scfm.

## CONCLUSIONS

These results demonstrate the potential for using a heated fluidized bed to remove ammonia from fly ash. The authors are in the process of building a laboratory scale facility for demonstrating continuous processing of the ash in an inclined fluidized bed.

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