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Granular Filtration in a Fluidized Bed

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Successful development of advanced coal-fired power conversion systems often require reliable and efficient cleanup devices which can remove particulate and gaseous pollutants from high-temperature high-pressure gas streams. A novel filtration concept for particulate cleanup has been developed at the Morgantown Energy Technology Center (METC) of the U. S. Department of Energy. The filtration system consists of a fine metal screen filter immersed in a fluidized bed of granular material. As the gas stream passes through the fluidized bed, a layer of the bed granular material is entrained and deposited at the screen surface. This material provides a natural granular filter to separate fine particles from the gas stream passing through the bed. Since the filtering media is the granular material supplied by the fluidized bed, the filter is not subjected to blinding like candle filters. Because only the in-flowing gas, not fine particle cohesive forces, maintains the granular layer at the screen surface, once the thickness and permeability of the granular layer is stabilized, it remains unchange as long as the in-flowing gas flow rate remains constant. The weight of the particles and the turbulent nature of the fluidized bed limits the thickness of the granular layer on the filter leading to a self-cleaning attribute of the filter. Batch mode filtration performance of the filter was first reported at the Ninth Annual Coal-Fueled Heat Engines, Advanced Pressurized Fluidized-Bed Combustion, and Gas Stream Cleanup Systems Contractors Review Meeting. This poster paper presents work since then on a continuous filtration system.

The continuous filtration testing system consisted of a filter, a two-dimensional fluidized-bed, a continuous powder feeder, a laser-based in-line particle counting, sizing, and velocimeter (PCSV), and a continuous solids feeding/bed material withdrawal system. The two dimensional, transparent fluidized-bed allowed clear observation of the general fluidized state of the granular material and the conditions under which fines are captured by the granular layer. A series of experiments were conducted over various ranges of operating conditions with two different bed materials: a 30x270 mesh acrylic powder with particle density of 1.1 gm/cc and a 40x270 mesh Millwood sand which has particle density of 2.5 gm/cc. During the experiments, fine sand (less than 100 micron) was fed continuously to the bed through the powder feeder at a constant rate of 3.8 gm/min (0.5 lb/hr). Bed material and captured fine particles were withdrawn continuously through an overflow tube. In order to maintain a constant bed level, makeup bed material was also fed continuously through a non-mechanical valve to the bottom of the fluidized bed. Performance of this granular filtration system was measured by the PCSV at downstream of the filter.
High filtration performance was measured when lower density powder was used as bed material. Collection efficiencies over 99% were obtained with this bed material in a continuous flow mode. Low filtration performance was experienced with heavier bed material. The low filtration performance with this material may be attributed to the failure of maintaining a sufficiently thick granular layer at the screen filter surface. Filtration performance as a function of particle size distribution and the pressure drop across the granular filter will also be discussed in this poster paper.