Energy Products of Idaho

Flue Gas Desulfurization In Fluidized Bed Boilers Firing Paper Sludge

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By

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Fluidized bed combustor/boiler systems have become the technology-of-choice to convert paper sludge and deinking sludge into usable energy. One of the many recognized advantages of this technology is the ability to achieve very low gaseous emissions levels. Residence time, turbulence, and intimate contact of fuel to bed material/sorbent, combine to create a near ideal environment for complete and clean combustion and for capturing sulfur compounds contained in the sludge fuel.

Sulfur dioxide (SO_2) is a priority gaseous pollutant generated when sulfur in the waste material is thermally oxidized, or combusted ($S + O_2 \rightarrow SO_2$). In paper sludges, sulfur is often present because it is a component of the chip softening and coagulation chemicals and is therefore a residual in the waste sludge material. At high temperatures, calcium is very reactive with SO_2 compounds and is often employed to reduce sulfur dioxide emissions. In a typical reaction, calcium oxide combines with sulfur dioxide in the presence of oxygen, at high temperatures, to produce gypsum ($2CaO + 2SO_2 + O_2 \rightarrow 2CaSO_4$). The resulting product (gypsum) is an inert solid collected in the ash handling system. The ash product from the overall process has a variety of beneficial uses including cement additives, soil additives and landfill cover.

Often, paper sludges and deinking sludges contain considerable concentrations of calcium. This fuel-bound calcium is effective in reducing the sulfur dioxide emissions in a fluidized bed combustion system. For sludges that do not have sufficient quantities of retained calcium, the addition of calcium compounds is required to reach the regulated sulfur dioxide emissions limits. Energy Products of Idaho (EPI) conducted substantial pilot plant and full scale production testing to determine the effect of various calcium compounds, at various operating conditions, on sulfur capture and sulfur emissions abatement.

Calcium is available in many compounds and physical forms. Some of the more readily available compounds are limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) and quicklime (CaO). All of these compounds can be used as effective sorbents, at various operating levels, in a fluidized bed combustion system.

Limestone and dolomite must be calcined in order to be efficient sulfur sorbents. Effective calcination begins in the 1500˚F range. This makes this low cost material a reasonable selection for fuels that allow an operating bed temperature of 1500˚F or higher. Unfortunately, the low heating values of paper and deinking sludges prevent bed temperatures from reaching the 1500˚F to 1600˚F range. Bed temperatures are more typically in the 1350˚F range. Laboratory and field testing of local deposits of these two minerals show the following results:

	Operating Bed Temperature	Reactivity (lbs. of mineral/lb. of sulfur adsorbed)
Limestone	1350˚F (732˚C)	non-reactive
	1600˚F (871˚C)	12.8/1
Dolomite	1350˚F	41.0/1
	1600˚F	18.0/1

Depending upon the elemental composition of the sorbent and the porosity of the matrix, different reactivity is possible. However, if bed temperatures are maintained in the 1350 to 1400˚F range, calcination of these mineral sorbents will be poor and reactivity will be low.

EPI's testing confirms that quicklime (CaO) when intimately mixed with wet fuel is a very effective sorbent for SO_2 capture at lower operating bed temperatures (less than 1500˚F). Quicklime is produced in high temperature lime kilns specifically designed for the calcination of limestone. Although it costs two and one half to three times more than limestone, it is many times more reactive at lower temperatures. Laboratory and field testing reveal the following:

	Operating Bed Temperature	Reactivity (lbs. of mineral/lb. of sulfur adsorbed)
Quicklime	1350˚F (732˚C)	9.6/1
	1600˚F (871˚C)	5.0/1

Testing in an EPI fluidized bed firing paper and deinking sludges showed results of better than 96% sulfur abatement utilizing quicklime in a powder form mixed with the wet fuel and combusted at temperatures in the 1400˚F range. Clearly, this alternative is more economically attractive than add-on flue gas desulfurization equipment involving large, expensive and maintenance intensive equipment.