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CFD Modeling for Mercury Control Technology

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Compliance with the Clean Air Mercury Rule will require implementation of dedicated mercury control solutions at a significant portion of the U.S. coal-fired utility fleet. Activated Carbon Injection (ACI) upstream of a particulate control device (ESP or baghouse) remains one of the most promising near-term mercury control technologies. The DOE/NETL field testing program has advanced the understanding of mercury control by ACI, but a persistent need remains to develop predictive models that may improve the understanding and practical implementation of this technology.

This presentation describes the development of an advanced model of in-flight mercury capture based on Computational Fluid Dynamics (CFD). The model makes detailed predictions of the in-duct spatial distribution and residence time of sorbent, as well as predictions of mercury capture efficiency for particular sorbent flow rates and injection grid configurations. Hence, CFD enables cost efficient optimization of sorbent injection systems for mercury control to a degree that would otherwise be impractical both for new and existing plants. In this way, modeling tools may directly address the main cost component of operating an ACI system – the sorbent expense. A typical 300 MW system is expected to require between $1 and $2 million of sorbent per year, and so even modest reductions (say 10-20%) in necessary sorbent feed injection rates will quickly make any optimization effort very worthwhile.

There are few existing models of mercury capture, and these typically make gross assumptions of plug gas flow, zero velocity slip between particle and gas phase, and uniform sorbent dispersion. All of these assumptions are overcome with the current model, which is based on first principles and includes mass transfer processes occurring at multiple scales, ranging from the large-scale transport in the duct to transport within the porous structure of a sorbent particle. In principle any single one of these processes could limit the overall capture of mercury. For example, capture may be severely limited in situations where the dispersion of sorbent is poor, or where adsorption rates are low because of relatively high temperatures.

Application examples taken from the DOE/NETL field test program were considered. The sites considered include Brayton Point, Meramec, Monroe, and Yates. Some general lessons learned concerning the impact of turbulence and flow stratification on dispersion and capture will be presented.