SAFL Seminar Series

Wednesday, Oct. 14, 2009, 3:30pm

St. Anthony Falls Laboratory ~ Auditorium

Modeling and simulation of mass transfer in multiphase flows: Mercury, coal, and virtual sorbent beds

Dr. Sean Garrick

Associate Professor

Department of Mechanical Engineering

University of Minnesota

On March 15, 2005, the U.S. Environmental Protection Agency issued the Clean Air Mercury Rule to permanently cap and reduce mercury emissions from coal-fired power plants. Activated carbon injection (ACI) is the most mature and most tested approach to controlling mercury emissions from CFPPs. During ACI, powdered activated carbon is injected into the highly turbulent flue gas where it adsorbs gas-phase mercury. The virtual sorbent bed (VSB) is a relatively new concept (for filters) that has the potential to become a cost-effective means to clean up effluent species. VSBs remove mercury vapor from flue gas by facilitating condensation on micron-sized carbon particles. Subsequently, the carbon particles are removed within an electrostatic precipitator. However, the VSB technology is in an early stage of development and not yet ready for industrial applications. The effects of particle entrainment (and subsequent dynamics) and fluid-particle interactions on the removal of the effluent species is a complex one. For example, in the presence of such gas-particle slip, higher rates of gas-particle mass transfer are possible by convection. Yet, because the particles remain entrained within the flowing gas, they effectively present none of the fluid pressure drop of a fixed sorbent bed. Understanding these and other phenomena is key for the successful technological development and adoption of VSBs. The mixing of the mercury vapor and activated carbon particles — often under turbulent conditions — is key to achieving high mercury capture in VSBs. However, the gas-to-particle mass transfer process under turbulent conditions is not very well understood. Additionally, there is little data available from full-scale tests. Numerical simulations of condensation mass transfer in turbulent particle-laden flows can aid in the design and performance optimization of VSBs by elucidating the underlying particle and fluid dynamics under a variety of flow and particle parameters. Professor Garrick is developing numerical tool that simulate gas-particle mass transfer in turbulent flows. The aim is to elucidate the underlying dynamics and obtain a better understanding of the gas-particle mass transfer process in VSBs. The approach is comprised of three parts: the description of the fluid dynamics (via direct numerical simulation and large eddy simulation), the particle motion within the fluid, and condensation of mercury onto the particle surface. Funding for this work is provided by the National Science Foundation.

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