Infrared Particle Cloud Temperature Fluctuations in the Superheater Pendant Region of Utility Boilers

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Accurate knowledge of turbulent particle cloud temperature fluctuations in the superheater pendant region is critical in coal-fired utility boilers not only for understanding the interactions between turbulence and radiative heat transfer, but also to control ash deposit slagging and fouling on superheater tubes. This paper presents a model to theoretically predict the particle cloud temperature fluctuation structures. Particle volume fraction fluctuations in the downstream of superheater pendants were numerically investigated. The continuous gas phase was simulated using large eddy simulations with the discrete particle phase simulated using the Lagrangian approach. A mushroom shaped particle distribution was predicted while the particle volume fraction varied periodically in the two-color pyrometer imaged diagnostic volume. Theoretical analysis of the particle cloud temperature fluctuations gave a periodic fluctuation frequency of 42 Hz which was twice vortex shedding frequency of the gas-particle flow around the cylindrical superheater tube. The fluctuation amplitude in the pendant region was 50 K higher than at other measurement locations. Theoretical predictions of the infrared particle temperature power spectra and the fluctuation amplitude agree well with experimental data in the literature. The preferred periodic frequency in the power spectra and the high fluctuation amplitude are due to the vortex shedding of the flue gas flow around the superheater pendants in coal-fired utility boilers.