Measurements and Modeling of the Spectral Radiative Properties of SiO_2 Particle Beds

Chuyang Chen [S], Chiyu Yang, Devesh Ranjan, Peter Loutzenhiser and Zhuomin Zhang [C]
George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, U.S.A.
zhuomin.zhang@me.gatech.edu

Attenuation and scattering of light through a homogeneous medium can be captured using absorption and scattering coefficients and scattering phase function(s). These properties are directly integrable into the radiative transfer equation with appropriate boundary conditions to accurately predict radiative transport within the medium. Simple geometries (*e.g.*, slab) in conjunction with net radiation method simplify the calculation process while providing predictive modeling results. These methods are less accurate when modeling porous media (*e.g.*, a particle bed) where air gaps are present. Large deviations from the models are potentially due to heterogeneous media and the geometric configurations. The goal of this work is to experimentally measure the radiative properties of particle beds of SiO_2 particles and to investigate the effects of multiple reflection, particle size, and particle density by employing accurate radiative heat transfer models. The particle diameters range from 10 to 325 µm, and experimentation is performed over wavelengths of 0.4 to 15 µm, which is also modeled with geometric optics. A Monte Carlo ray-tracing (MCRT) model of a particle bed is developed and compared with experimental measurements. The measurements have shown an enhancement of reflection by particle bed in the light transmitting region and an increase in absorptance in the light absorbing region. These enhancements are attributed to the multiple reflections within the particle bed from adjacent particles, which significantly increases the scattering phenomena. As a result, the measured radiative properties are significantly different from the prediction by net radiation method. The MCRT predictions justify the observation and provide detailed information concerning spectral variations. The influence of particle size and particle density (volume fraction) will be quantified to further address the scattering effect. This work facilitates an understanding of the impact of key parameters on the radiative properties of the particle bed and will benefit various practical applications.