High-Temperature Emittance of Bauxite and SiO_2 Particle Beds

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Solar thermal energy storage using particles as storage media provides a clean and sustainable path towards transitioning from fossil fuels to concentrated solar power (CSP). On-sun heating of particles is accomplished in falling particle receivers by employing cascading granular flows of falling particles that are directly exposed to concentrated solar irradiation. Accurately determining the particle emittance is critically important for modeling radiative transfer in particle receivers. In this work, the temperature-dependent spectral emittances of bauxite and SiO_2 particles are investigated. This is impactful for accurately analyzing the radiative heat transfer in falling particle receivers where particle-to-particle and particle-to-wall interactions significantly impact the boundary conditions. The particle emittances are measured with an in-house high-temperature emissometer, which uses a Fourier-transform infrared spectrometer to perform direct measurements of the spectral emittance over wavelengths of 2 to 16 micrometer. The particle beds are heated up to 700 °C to capture the operating conditions found in CSP applications. The spectral emittance of different bauxite and SiO_2 particle sizes are measured to investigate size dependency. These results are compared to measured spectral emittances at ambient temperatures determined from the reflectance measurement by encasing particles in a windowed sample holder. A broadband peak of near-unity spectral emittance in the mid-infrared region was observed for the bauxite particles at both ambient and elevated temperatures, indicating the spectral emittance was not a strong function of temperature. A strong temperature dependency is observed in the mid-infrared region for SiO_2 particles. The results from this work provide important information and guidance for radiative heat transfer modeling of granular flow for falling particle receivers.