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Multi-Scale Simulation Of Biomass Gasification In Fluidized Beds

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Extended Abstract

Fluidized beds are widely used as energy-intensive chemical reactors for biomass gasification, involving high particle concentration, complex gas-particle/particle-particle interactions, intricate chemical reactions, and significant heat and mass transfer [1]. However, due to the harsh operating conditions of fluidized bed gasifiers, the physical and thermochemical characteristics of dense gas-solid reactive flow inside the reactor remain poorly understood. To address this issue, we have developed a multi-scale numerical strategy that integrates the computational fluid dynamics-discrete element method (CFD-DEM), coarse-grained method (CGM), and multiphase particle-in-cell (MP-PIC) with complex thermochemical sub-models [2-4]. The integrated models were validated using experimental data, demonstrating their reasonable accuracy.

The CFD-DEM model enables the high-fidelity simulation of lab-scale bubbling fluidized bed gasifiers, providing detailed information on particle residence time, heat transfer contribution, carbon conversion ratio, and other crucial parameters. In contrast, the CGM and MP-PIC models facilitate the high-efficiency simulation of pilot-scale and industrial-scale circulating fluidized bed gasifiers, offering in-depth insights into vital in-furnace phenomena such as cluster evolution, size-/density-induced segregation, gas pollutant formation, and so on. Our multi-scale simulation approach is expected to provide valuable information for optimizing the design and process of biomass gasification in fluidized beds and promoting the efficient utilization of renewable energy resources.

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