Euler-Euler simulation of waste plastic gasification in a fluidized bed with kinetic model

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Abstract
Thermo-chemical recycling, particularly gasification, has emerged as a promising alternative for treating plastic waste. This approach offers flexibility in processing unsorted and uncleaned feedstock and produces smaller, more stable molecular components. Among the various reactor configurations, the fluidized bed reactor is the most widely adopted for plastic waste gasification due to its high efficiency in mass and energy transfer. However the complex transport mechanisms within this multiphase flow system have not been understood well, and few numerical studies considered the detailed chemical kinetics into the analysis. Therefore, to advance the understanding of plastic gasification mechanisms, this study aims to develop a computational fluid dynamics (CFD) model to simulate the process. The model facilitates the analysis of flow behavior and feedstock conversion characteristics during gasification, thereby providing valuable insights for the design and optimization of industrial gasifier operating parameters.
The large number of particles and diverse plastic components, coupled with the hundreds of reactions occurring during gasification, necessitate a computationally intensive approach. To address this, the Euler–Euler CFD model was adopted to simulate the complex 3D hydrodynamic phenomena. The Multiphase Operator Splitting algorithm was used to integrate detailed descriptions of chemical reactions. This approach enables the coupling of first-principles-based kinetic mechanisms with the long timescales characteristic of industrial reactors. The gasification of polyethylene in a fluidized bed was first simulated to validate the model. The gas-phase kinetics were not considered, during the temperature rise, polyethylene decomposed into its dimer and monomer, with the monomer subsequently evaporating within the gasifier. In the future work, the gas-phase kinetics will be considered into the model.