Monte Carlo Radiative Heat Transfer Analysis of a Methane Flow Laden with Carbon Particles

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The transient behavior of a two phase medium initially composed of gaseous methane and argon, laden with solid carbon particles and exposed to concentrated solar radiative energy is investigated by means of a numerical simulation. Effects being accounted for comprise, additionally to radiative heat transfer, convective heat transfer at the phases' interface, one dimensional convective mass and energy transfer, and chemical kinetics. For the simulation of radiative heat transfer, the Pathlength Monte Carlo method is applied and optical properties of both phases are considered. The influences of different operational parameters, namely particle diameter, solid phase volume fraction, methane concentration, and incoming radiation flux intensity and direction are discussed.
A comparison with experimental results obtained running the methane cracking process with different carbon particle types in a 5 kW prototype reactor at ETH's high flux solar simulator is carried out.