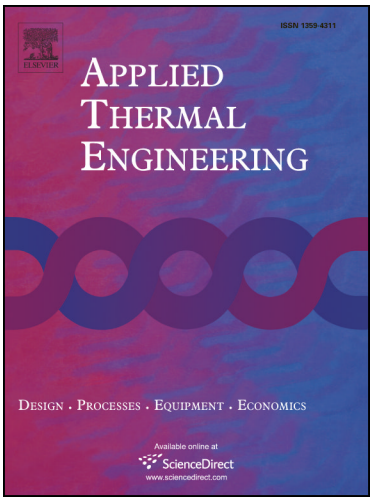

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A. Salmasi, M. Shams, V. Chernoray

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Simulation of sub-bituminous coal hydrodynamics and thermochemical conversion during devolatilization process in a fluidized bed

A. Salmasi[1], M. Shams[2*], V. Chernoray[3]

[1] PhD, Faculty of Mechanical Engineering, K.N. Toosi University of Technology, Tehran, Iran

[2]Associate Professor, Faculty of Mechanical Engineering, K.N. Toosi University of Technology, Tehran, Iran

[3]Associate Professor, Department of Applied Mechanics, Chalmers University of Technology, Gothenburg, Sweden

*shams@kntu.ac.ir, +989123596236

Abstract

The majority of the numerical studies conducted on the thermochemical conversion of solid fuels in a fluidized bed have ignored the bed materials inside the bed and just considered the effect of hot air passing the fuel particle. In this study, a sub-bituminous coal particle hydrodynamics during the devolatilization process is modeled inside a 2D fluidized bed in two different cases. In the first case, the energy exchange of inert phase with the fuel particle is included in the simulation and, in the second case, it is ignored. The coal particle's motion is modeled including the drag force from the bed and the heat and the mass transfer are also simulated during the devolatilization process while the fuel particle is heated up using the chemical percolation devolatilization model. The simulation successfully predicted the motion of the particle inside the bed as well as the temperature increase and volatile release from the particle during the simulation time. The mass loss and temperature history of the fuel particle resulting from the simulation show good agreement with the experimental results. The simulation also indicates that inert particles have a great effect on the heat transfer coefficient inside the bed and ignoring them will cause a difference in the devolatilization time, and this difference will also increase significantly with the increase of the fuel particle's diameter.

Keywords: Devolatilization, Fluidized bed, Volatile, Eulerian-Eulerian-Lagrangian

1. Introduction

For the last few decades, fluidized bed technology has been widely used in combustion applications for energy production. Compared to other industrial methods, fluidized bed combustion has numerous advantages, including higher thermal and combustion efficiency, reduction of nitrogen oxides' formation and, consequently, air pollution and enabling the combustion of different low-grade coals [1]. As a sequence, fluidized bed combustion is widely used for obtaining energy from different types of fuels.

When a fuel particle is introduced to a fluidized bed, it undergoes a number of distinct processes collectively called thermochemical conversion. Drying is the first process to be commenced which can even start below the boiling point of water due to water vapor diffusion from the particle, and this process will increase rapidly once the boiling point is reached. The next process is the devolatilization referring to a rapid thermal decomposition at which the particle decomposes into light gases, tars and a highly carbonaceous solid called char. The amount of each component developed during this stage depends on the composition