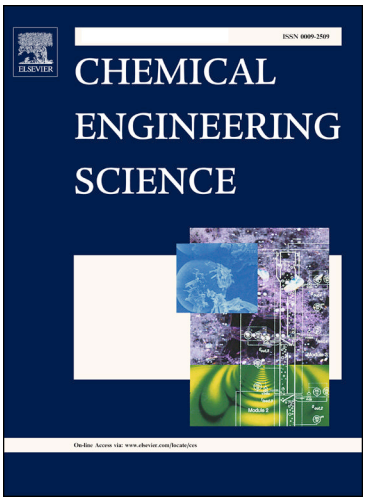

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Mehdi Baniasadi, Maryam baniasadi, Bernhard Peters

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Coupled CFD-DEM with Heat and Mass transfer to Investigate the Melting of a Granular Packed Bed

Mehdi Baniasadi, Maryam baniasadi, Bernhard Peters

University of Luxembourg, Faculty of Science, Technology and Communication, Campus Kirchberg, 6, rue Coudenhove-Kalergi, L-1359, Luxembourg

Abstract

The eXtended Discrete Element Method (XDEM) platform which is a Coupled Eulerian-Lagrangian framework with heat and mass transfer, is extended for melting of granular packed beds. In this method, the fluid is simulated by computational fluid dynamics (CFD) and the soft-sphere discrete element approach (DEM) is used for the particle system. A four-way coupling accounts for solid-liquid interaction via drag and buoyancy forces and the collisions between the particles and the walls. The contact forces between the particles and wall-particle contacts have been calculated by the hertz-mindlin model. The particles heat up, melt and shrink due to heat and mass exchange, and the temperature distributions inside the particles are described. In order to validate the method, melting of a single ice particle and of a packed bed of ice in flowing water have been carried out. Very good agreement between the simulation and experiment has been achieved. The effects of the temperature and velocity of flowing water on melting rate are also discussed.

Keywords: XDEM, CFD-DEM, Melting, heat/mass transfer, packed bed

1. Introduction

The complex liquid-solid two-phase flow with melting process are found in various natural and industrial processes such as electric arc furnaces, vitrification processes, thermal energy storage and the motion of an ice jam in a river. The modeling of this kind of phenomenon has been of interest in recent years particularly by using numerical methods. Generally, mathematical models used to predict multiphase flows including solid particles are mainly based on two methods: Eulerian-Eulerian and Lagrangian-Eulerian.