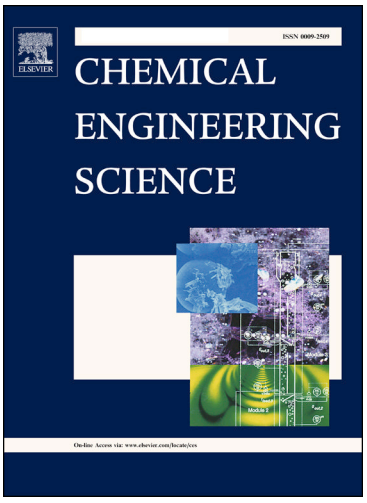

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Effect of mass diffusion upon the thermal-diffusive behavior of a dry vibrated granular bed

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Abstract

We report the results of an experimental study on the thermal-diffusion mechanisms of particles with fluctuant motion in a dry granular system. Granular beds with different intensities of particle self-diffusion were produced by exerting vertical vibration-driving forces of different strengths. The effective thermal diffusivity, α_e, was determined by solving the inverse transient heat conduction problem. The self-diffusion coefficient in the vertical direction, D_{yy}, was calculated to describe the diffusive motions of the particles in the bed. The dimensionless Lewis number, *Le*, was calculated to investigate the relationship between mass diffusion and thermal diffusion. First, we demonstrated that mass diffusion increased the thermal-diffusive behavior of the dry granular system. Second, we identified a positive linear correlation with the specific slope $S_{\alpha d}$ between α_e and D_{yy}. In particular, the value of $S_{\alpha d}$ represents a characteristic of the granular system related to the relationship between thermal diffusivity and the mass diffusivity; this means that *Le* may approach the value of $S_{\alpha d}$ if the intensity of particle self-diffusion in the bed is sufficiently strong.

Keywords: Particle self-diffusion, Effective thermal diffusivity, Vibrated granular bed, Lewis number

1. Introduction

Heat transfer in granular systems is encountered in many engineering applications, for example, in porous media and food processing, as well as in geophysical contexts. The heat-transport mechanism in a granular system is more complex than transport through a pure solid material because of the effect of interstitial fluid in the voids between the particles. A number of studies have investigated the effective conductivity of a stagnant dry granular system [1, 2, 3, 4, 5, 6, 7]. For granular systems with high solid-to-interstitial-air conductivity ratios, the heat-transfer mechanisms

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