Onset of natural convection induced by bottom-up transient mass diffusion in porous media

Abstract

The theory of convection induced by transient mass diffusion in porous media is advanced and verified by computational fluid dynamics (CFD) simulation. A theory of the onset of buoyancy convection and a new transient Rayleigh number were derived. 2D time-dependent simulations were conducted for bottom–up diffusion of methane gas in a porous medium pre-saturated with air. Sand particles with diameter ranged from 0.003 to 0.006 m were used as the porous media. The average maximum transient Rayleigh number for the onset of convection in the simulations was found to be 29.7, which was quite close to the theoretical value of 27.1. The critical times, critical depths of gas penetration and wavelengths were predicted accurately. It was found that the mass transfer may be driven by simultaneous diffusion and buoyancy convection after the onset. The rate of mass transfer for the convection phase was over three times that of pure diffusion.

Keyword: Transient Rayleigh number; Convection; Onset times; Porous media