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Coupled heat and mass transfer in porous media with biological and chemical reactions.*

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Abstract

Heat and mass diffusion in self–heating porous media with turbulent air convection is analyzed in this paper. A sequential procedure based on three different mathematical models build on non–linear unsteady coupled partial differential equation is used to describe thermal explotions in compost piles. A $\kappa - \varepsilon$ turbulent air model describes the forced convection around the pile. Arrhenius type source terms are used to assess the biological and chemical effects inside the porous material. Inside the pile, water flow and air diffusion through unsaturated porous media is considered. When the water flow is included, a third source term allows to incorporate the energy balance due to the phase change of water. Time evolution for tempertaure and oxygen concentration is calculated from the coupled energy / mass transfer partial differential equations. The system of governing equations is solved with the finite volume method (FVM) developed by Patankar. A first–order discretization is used to calculate the source, transient and diffusion terms. Convective terms are calculated with the fifth power law as the interpolation function. The SIMPLE algorithm (Semi–Implicit Method for Pressure Linked Equations) is used to calculate, pressure, velocity, temperature in the turbulent air flow around the self–heating porous media. Three computational programs, one for each mathematical model, written in Fortran language, are used to calculated the dependent variables. A suitable combination of the TDMA with the Gauss–Seidel method is implemented as an iterative solver. The solution procedure is applied to describe fluid dynamics, heat and mass transfer processes in two industrial applications: a compost pile and a bio–drying reactor.

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