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Analytical solution for the coupled heat and mass transfer formulation of one-dimensional drying kinetics

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Abstract

In this investigation the analytical solution for the coupled heat and mass transfer problem applied to the drying kinetics of thin layer slabs is presented. The coupling of the conservations laws are boundary based, while the inner matrix formulation is decoupled. The water driving mechanisms are assumed to be liquid capillarity in the inner matrix and convective evaporation on the interface. A number of physically possible boundary conditions are described, being the analytical solution obtained for two commonly encountered cases in foodstuff drying experiments. Two distinct drying stages are derived as a result of the formulation of the problem. The first one is characterized for the influence of the convective coefficient as well as the ambient relative humidity. The second one is controlled by the internal effective diffusivity. In the first part of this study, the solutions have been obtained in pure theoretical grounds. The second part deals with the model validation by application to experimental data found elsewhere.

Keywords: Drying kinetics, analytical solution, Fourier series,
Chilton-Colburn analogy

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