Modeling Deep-Bed Grain Drying Using COMSOL Multiphysics®

J.G. Pieters[1], R. ElGamal[1], F. Ronsse[1]

[1]Faculty of Bioscience Engineering, Department of Biosystems Engineering, Ghent, Belgium

Abstract

Grain drying is a simultaneous heat and moisture transfer problem. The modeling of such a problem is of significance in understanding and controlling the drying process. The main goal of this study was to predict the heat and mass transfer processes during deep-bed rice drying. To achieve this, firstly, a coupled CFD and diffusion model was developed to investigate the heat and mass transfer for thin-layer drying of rice. The transfer coefficients were computed simultaneously with the external flow field and the internal diffusive field of the grain. Then, CFD simulations were carried out to analyze the external flow and temperature fields at steady-state for a control volume of a stationary rice bed. The model was used to predict the volumetric heat and mass transfer coefficients in a rice bed, and correlations were developed for the volumetric heat and mass transfer coefficients as a function of drying air flow rate.

Finally, the thin-layer model was extended to volumetric heat and mass transfer in a deep-bed of rice using the volumetric heat and mass transfer coefficients. All mathematical models were solved using the COMSOL Multiphysics® simulation program v4.3, which uses the finite element method to solve the model equations. The model was used to predict the temperature of the air and grains, the air humidity and the grain moisture content at different locations of the dryer during the drying process. The theoretical prediction of moisture and temperature profiles inside a deep-bed of rice was verified using experimental data from literature. After validation of the model, the effects of velocity, temperature and humidity of the drying air on the drying behavior of rice were analyzed.

Figure 1 shows steady-state temperature distribution of the rice kernels surface.

Reference

Aregba, A.W. and Nadeau, J.-P. (2007). Comparison of two non-equilibrium models for static grain deep-bed drying by numerical simulations. Journal of Food Engineering 78, 1174-1187.

Figures used in the abstract

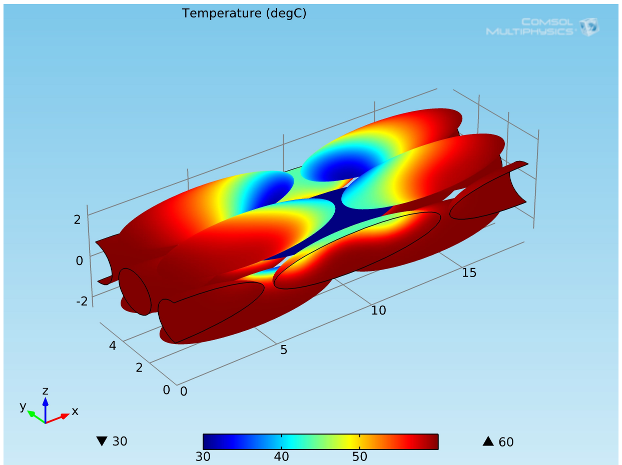

Figure 1: Steady-state temperature distribution on the rice kernels surface.