MATHEMATICAL MODELING OF HEAT AND MASS TRANSFER IN A ROTARY KILN

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The rotary kiln is widely used in the field of civil, metallurgical and chemical industries as a unit operation in chemical engineering especially for drying, reacting, mixing, granulating and heating of granular materials. According to the reasons mentioned above, examining the heat transfer phenomena in order to improve the modeling tools and to understand the dynamics of heat and mass transport in rotary kilns is crucial. The main objective of this research is to compare the results of the proposed 1D heat transport model with numerical simulations of mass transport in a direct-heat rotary kiln at laboratory scale. Another objective is to investigate the effect of individual parameters on the formation of an active particle surface in buoyancy, which enables efficient heat transport.
The studied rotary kiln is a low-angle cylinder with a length of 0.5 meter and a diameter of 0.108 meter with regularly arranged lifters on the inside. The heat is transported into the rotary kiln by hot air at the inlet. The load in the rotary kiln consists of spherical particles with 1 millimeter diameter. The rotary kiln rotation speed is 21.5 rpm. For each simulation, 20 rotations were performed. The Discrete Element Method implemented in an open-source code LIGGGHTS was used for simulations. Data post-processing was performed in Matlab.
Efficient heat transfer is made possible primarily by the large number of particles in the buoyancy, which are heated by the warm air blowing in. To begin with, the number of lifters and their geometry was found to be a key parameter controlling the amount of particles in the gaseous regime. Furthermore a zone is created into which the particles cannot reach. This phenomenon is due to the dynamics of particle transport, as the particles are not maintained in the active phase and move rapidly towards the load due to gravity. In conclusion, the effect of this zone is negative, as hot air flows through it without resistance, preventing the system from heating effectively.

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