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Influence of Self-Compaction on the Airflow Resistance of Grain Bulks

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Abstract

Aeration practices have been widely employed to force conditioned air through in-storage grain bulks to guarantee quality preservation and safe storage. Despite the attention given in the last decades as a principal grain management technique, many obstacles have been encountered in reducing the deteriorative effects of high moisture content and temperature throughout the in-storage bulk. This was attributed to the misestimation of the resistance of stored grains to the airflow, which led to deficiencies in bulk aeration. This resistance is complex and strongly dependent on airflow and grain properties. In this study, the airflow resistance of wheat grains (Pioneer A DSV AG, 12.37 % w.b moisture content) during storage was investigated. A cylindrical, stationary bed (0.5 m diameter and 3.6 m height) was used as an experimental basis. A coherent set of airflow velocities ranging from 0.01 to 0.15 $m\,s^{-1}$ and storage times ranging from 1 to 236 h at four grain depth levels were applied accordingly. The relationship between pressure drop and velocity was assessed experimentally and modeled theoretically with an overall goodness of fit of $R^2 = 0.99$, RMSE = 25.7, and MAPE = 10.4. Results demonstrated an increase of the airflow resistance throughout the depth of the grain bulk and storage time. This behavior was ascribed to the self-compaction of the bulk material arising from the burden pressures imposed by the dead weight of the bulk. The self-compaction decreased the porosity significantly, increased the bulk density, enlarged the airflow resistance and consequently, considerably increased the pressure drop. Hence, extra power supplies for aeration are prerequisites to overcome the resistance caused by self-compaction. The spatial and temporal effects of self-compaction in stored grain bulks should be accommodated in the design and analysis of aeration systems.

Keywords: CAD, compaction, grain aeration, mathematical modelling, physical properties, wheat

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