Influence of self-compaction on the airflow resistance of grain bulks

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Introduction

- Aeration practices are widely employed to force air through the stored grain to reduce grain deterioration and prevent storage losses.
- Mis-estimation of airflow resistance contributes to uneven aeration and therefore to the formation of temperature and moisture pockets in the stored mass.
- The main objective of this study was to assess the influence of self-compaction on the airflow resistance of in-storage grain bulks.
- This work demonstrated that the airflow resistance increases temporally and spatially during the storage imposed by the bulk's dead weight.
- Extra air supply is a prerequisite for overcoming the excessive resistances arising from self-compaction.
- The self-compaction phenomenon in stored grain bulks should be accommodated in the design and analysis of aeration systems.

Material and Methods

- A cylindrical, stationary bed (0.5 m diameter and 3.6 m height) filled with wheat grains (Pioneer A DSV AG, 12.37 % w.b moisture content) was employed as an experimental basis (Fig. 1).
- A coherent set of airflow velocities (0.01 to 0.15 m·s$^{-1}$) and storage times (1 to 236 h) at grain depth levels (0 to 3.6 m) were applied.
- Semi-empirical mathematical modeling was used to predict the pressure drop-airflow velocity relationship.
- An increase of the airflow resistance throughout the depth of the grain bulk, storage time and velocity was observed (Fig. 2).
- During 236 h of storage, bulk porosity and density changed spatially and temporally due to the burden pressures imposed by the dead weight of the bulk (Fig. 3).

Mathematical Model

$$\Delta P = \sum \delta P$$

Fig. 1. Schematic CAD design of the experimental set up.

Results

- Li (1994) was found to be the best predictive model for pressure drop-airflow velocity relationship with an overall goodness of fit of $R^2=0.99$, RMSE=25.7, and MAPE=10.4.

$$\Delta P = 2 \left( \frac{k_1}{Re} + k_2 \right) \rho (1 - \varepsilon) \nu^2 \frac{1}{\varepsilon^3 d_e}$$

Fig. 2. Surface plot of pressure drop $P$ dependent on the storage time $t$, bed depth $D$ as well as airflow velocity $\nu$.

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Conclusions

- This work demonstrated that the airflow resistance increases temporally and spatially during the storage imposed by the bulk's dead weight.
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