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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.

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.

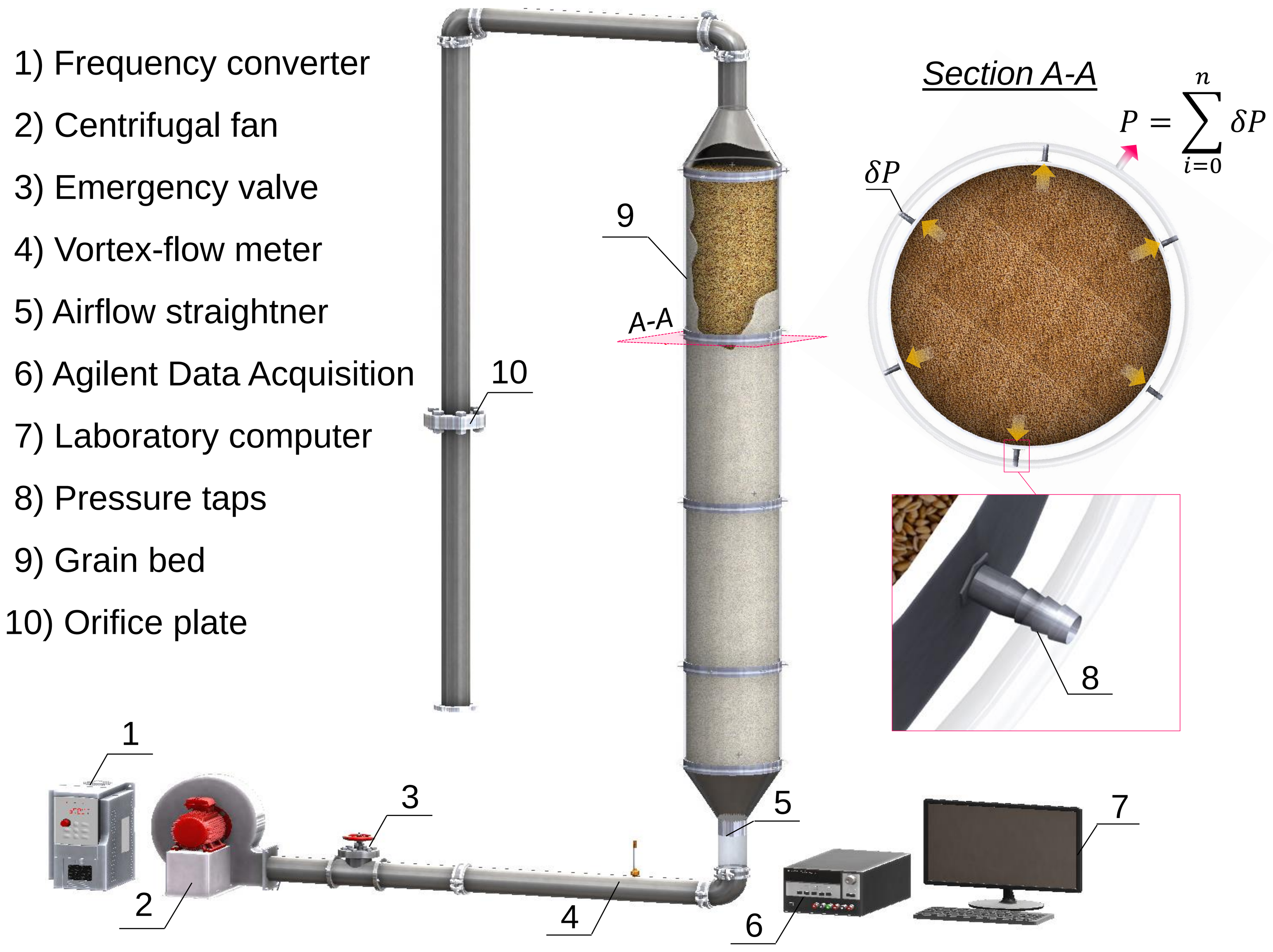

Fig. 1. Schematic CAD design of the experimental set up.

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.

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

ΔP is pressure drop (Pa), v is airflow velocity (m·s^{-1}), D is grain bulk depth (m), d_e is the equivalent diameter of particle (m), ρ is air density (kg·m^{-3}), ε is the bulk porosity (-), k_1, k_2 are empirical constants (-).

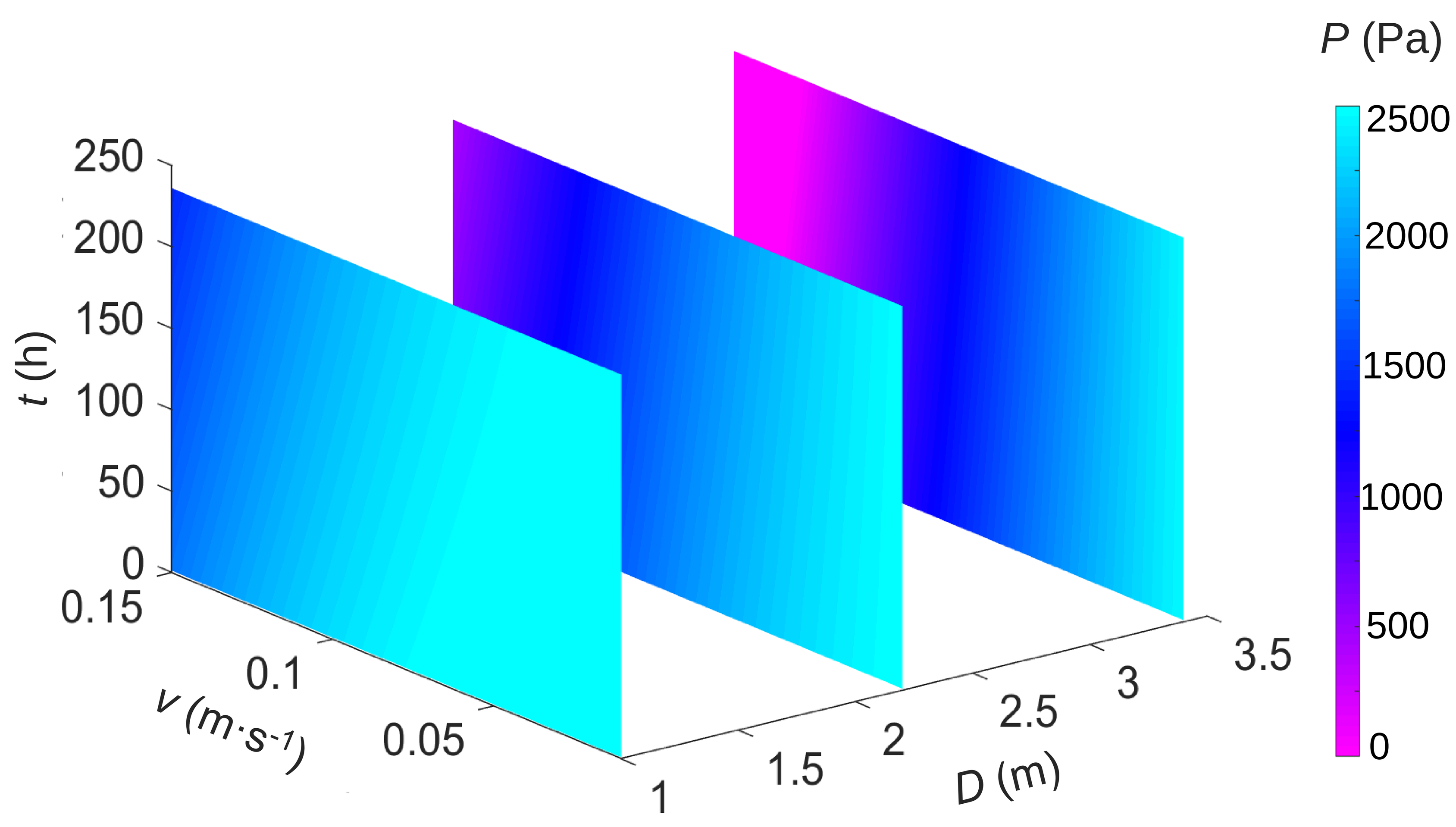

Fig. 2. Surface plot of pressure drop P dependent on the storage time t, bed depth D as well as airflow velocity v.

- 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).

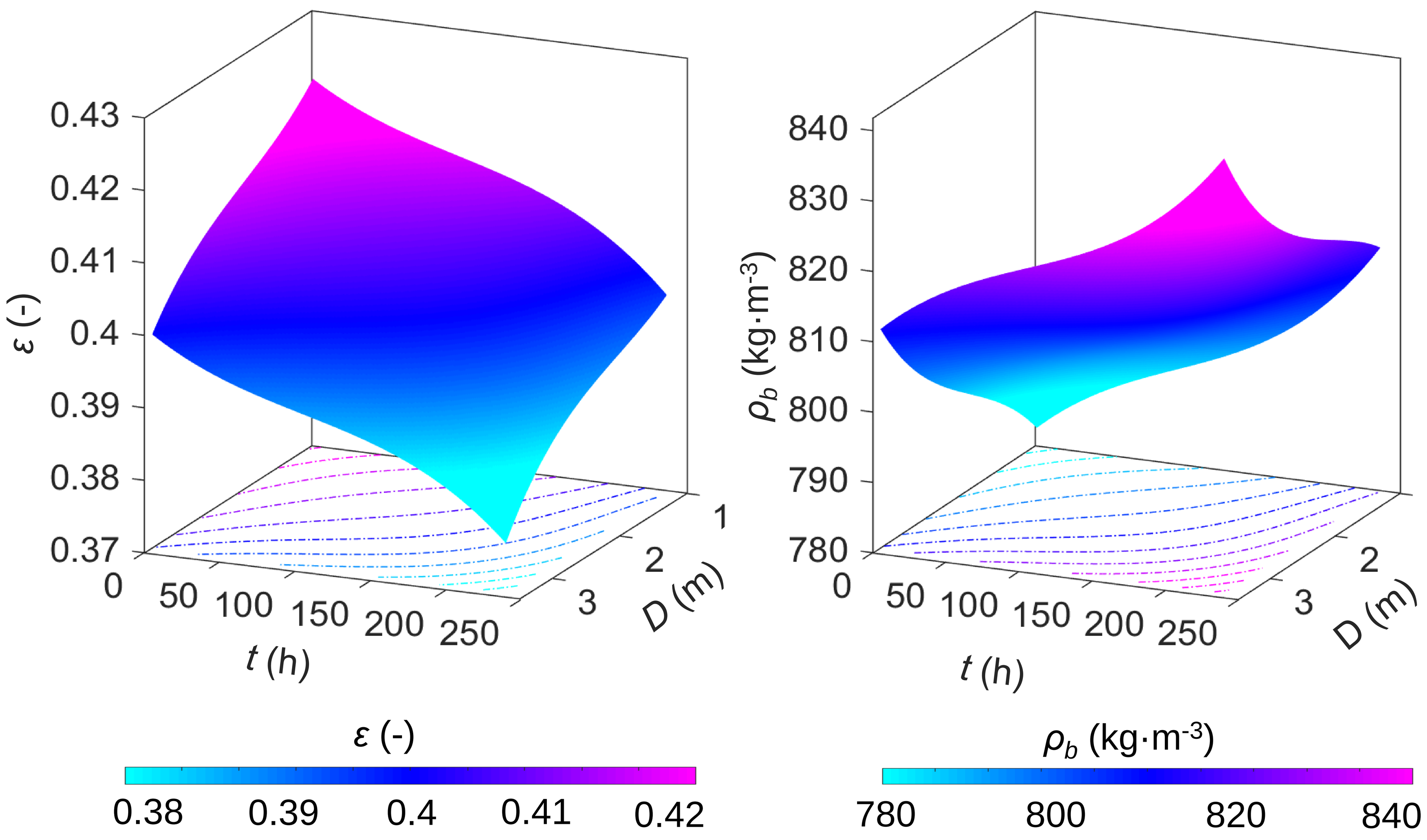

Fig. 3. Spatial and ephemeral changes of porosity ε and bulk density ρ_b influenced by self-compaction.

Conclusions

- 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.

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