Summary

Scaling is a widely used concept in engineering. It is mainly used to predict the outcome of full scale behaviour by performing experiments on a small scale model and convert the results to full scale. In the research into bulk solids properties and the interaction with equipment, scaling is not as well implemented as in other engineering fields. However, scaling is an effective and low cost concept for the design of bulk solids handling equipment and for the research into the behaviour of bulk solids materials. Therefore the main objective of this research is making an overview of the literature regarding scaling of bulk properties and equipment. The most important findings in the literature considering this subject together with relevant background information are discussed in this report.

Scaling of bulk material and equipment can be divided in two groups: scaling regarding physical experiments and scaling regarding computer simulations with the discrete element method (DEM). DEM is a numerical method based on a simple mathematical model, described by the laws of motion. Within these groups two kinds of models can be distinguished, small scale models and full scale models.

In experiments small scale models are mainly used, since experiments at full scale are expensive. The majority of the studies concerning small scale experiments resulted in empirical scaling laws. These are deduced from a series of experiments and describing the measurements in the investigated region. Extrapolation to full scale is necessary, however, in studies this is often not included. Scaling laws which are deduced from an analytical description of the process imply that also material properties should be scaled, causing problems in selecting the proper material.

Computer simulations with the discrete element method allow the use of full scale models. However, due to the proportionality between the number of particles and the computational time, the number of particles is the limiting factor. Therefore scaling in DEM simulation mainly concerns the up-scaling of the particles. Scaling laws for the up-scaling process can be deduced from the equations of motion used in DEM. The link between physical experiments and DEM simulation is made by the tests, like the shear test and the angle of repose test, which are used in the calibration and validation process of a DEM simulation.

Recommendations for further research concerning DEM simulations are to verify the used scaling laws, investigate the limited particle size with respect to equipment dimensions and to standardize the calibration and validation process. Concerning physical experiments, recommendation are to investigate the validity of the empirical scaling laws outside the investigated regions.