Executive Summary

BACKGROUND

In order to cope with the fluctuations in the volume and quality of an incoming bulk material flow, consumers will generally make use of storage systems which generally have three functions: buffering, composing & homogenizing. It is this homogenizing function which is the focus of this report. Homogenization of bulk material embodies the mixing of an incoming flow of material to minimize the deviations from the average chemical or physical properties in the outgoing flow. This is often achieved by depositing the material in layers in a storage system and reclaiming it at an angle with respect to these layers. With increasingly stringent environmental legislation, enclosed storage is seen to be applied more frequently. And for this reason other ways of storage have come up such as mammoth silos.

HOMOGENIZATION IN MAMMOTH SILOS

In 1994 a research project started at Delft University of Technology which resulted in a number of concepts for stacking and reclaiming bulk material in mammoth silos to improve the homogenizing characteristics. Although the concepts where patented, the extent of homogenization was not determined thus leaving the best method undecided.

Some ten years after this initial project additional research effort was made to extend and adapt the existing homogenizing theory for blending piles so that the geometry of the mammoth silos could be taken into account [1]. However, is was shown that no analytical solution could be acquired for the extended theory. For this reason numerical calculations were necessary to calculate the homogenizing efficiency and to determine the optimal silo setup. The goal of this study was therefore to develop a calculation tool to determine the homogenization efficiency of a mammoth silo configuration with varying input characteristics.

The assessment criteria of the homogenization effectiveness are the homogenizing efficiency (i.e. the reduction of the variance of the input signal) and the improvement of the auto covariance function (ACVF). This ACVF is regarded to improve when it reflects a higher dependency (one point being more dependent on previous ones). In addition to these criteria, Schott [1] defined the characteristic volume of a method (CVM) and process dynamics (PD) to be indicators of homogenization to some degree.

THE SIMULATION MODEL

As stipulated by Schott [1], to calculate the homogenization effect η_H of a specific method, the process can be subdivided into a geometric solution which defines the input to output function and a calculation of this output. Therefore, this subdivision is also made in the developed simulation model. The first part of the simulation focuses on solving the required volumetric distribution while the second part focuses on the transformation of input to output. In the initial development phase, the following assumptions were made:

1. the geometry of stack layers and reclaim slices is not dictated by the precondition of mutual equally volumes;
2. sample values are assigned to input parts instead of to stack layers;
3. the value of the material property of the input part is determined by its preceding sampling value (the continuous, user defined function is sampled);
4. volumetric contributions of input parts mix perfectly in the target stack layers;
5. volumetric contributions of stack layers mix perfectly in the target reclaim slice;
6. the value of the material property of the output part is determined by its preceding sampling value (the reclaim slices are sampled).

The first assumption was made for the sake of generality and in order to be true to reality which in turn led to the second and third assumption. To be able to compare the discrete signals, the output signal should have the same sample interval thus leading to the last assumption.

EVALUATION AND CONCLUSIONS

The developed simulation program was consequently validated with the aid of PD and predefined situations with known a homogenization effect. These criteria were used after the example of Schott so that cross-validation could be used. The model proved to be a good fit according to most of the criteria. However, the first assumption proved to be troublesome since mixing occurs in every 'signal processing step'. More specifically, the first assumption demands two sampling steps which cause sampling related homogenization effects in the process. To mitigate these effects the layer thickness and sample intervals can be taken to approach zero. However, this requires excessive processing time. Therefore, additional research is recommended into the geometric compilation of the stack layers and reclaim slices. To alleviate the possible predicaments, it is designed that the user of the simulation tool can access intermediate results. This way the data of the stacking-to-reclaiming step can be isolated from sampling related homogenization effects. Finally, it is noted that some of the issues addressed in the process could not be explored in detail since it was not within the scope of the study. The issues were mainly input signal related and were associated with sample size and required simulation runs. For this reason, additional research is required to determine the appropriate values for these parameters.