

Master Thesis Assignment: Mathematical Modeling and Numerical Simulation of Granular Flow Sticking to the Walls of an Externally Heated Rotating Cylindrical Pipe

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1 Introduction

Albemarle Corporation (see e.g. albemarle.com and wiki on albemarle) is an international company that manufactures specialty chemical products. At its factories in Amsterdam it produces catalysts for the petro-chemical industry.

2 Mathematical Modeling and Numerical Simulation

Zeolite is an important component in the production of catalysts at Albemarle. For its production an externally heated rotary kiln is used. Under particular circumstances the zeolite material tends to stick to the lateral walls of the kiln. This sticking prevents the continuous production process. The objective of this project is to optimize the production process of zeolite. One wishes to better understand the process of the material adhesion to the walls and seek ways to prevent it. The optimization process is expected to result in energy and material cost savings.

In a previous stage of the collaboration with Albemarle, master students of the TU Delft very successfully developed a one-dimensional model for the heat transfer along the axis of the kiln. The scope of this assignment is to include three-dimensional into the model effects of the zeolite material mixing and the hot air flow in the kiln. The aim is to obtain a better understanding of the attachment of material to the walls. The following aspects can be looked into:

- the motion of granular material in an inclined rotating cylinder. This motion can be decomposed into a mixing component in the plane perpendicular to the axis of the kiln and a transport component along the axis of the kiln;
- the absorption of heat by the granular material. The material is heated by a forced hot air flow through radiation and by contact with the hot walls of the kiln through conduction. Both effects will have to be taken into account;
- the change of physical properties of the granular material (density, rheology);
- the turbulent flow of air in the cylinder and the exchanged of moisture between the granular material and the air;
- the sticking of the material on the lateral surface of the wall;

3 References

- kiln description by Albermarle
- report by master students on zeolite kiln;
- book Boateng on rotary kilns;
- *Coupled CFD-DEM Modeling* by Norouzi