TECHNISCHE UNIVERSITÄT WIEN
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Caking mechanisms during production process

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Project Outline

- Part of a funded project
- One of the industrial partners wants to store urea in big silos after the production process
- Together with this partner we want to predict the compressive strength of the bulk material in a silo over time
- Today I will talk about caking due to process moisture (easy, because of the more or less homogeneous bulk)

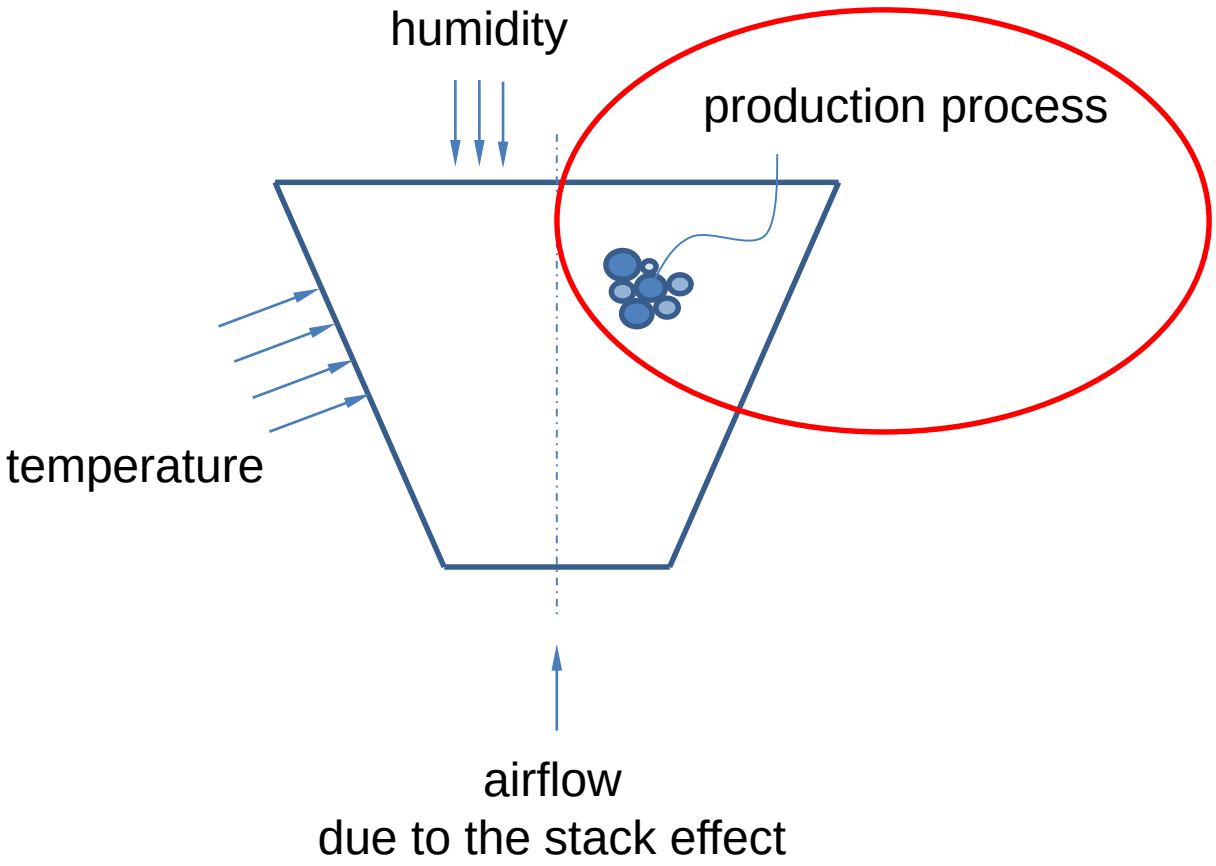
Overview

- Urea production process
- Measurements
- DEM Simulation
- Comparison
- Summary
- Further Research

caked urea cylinder

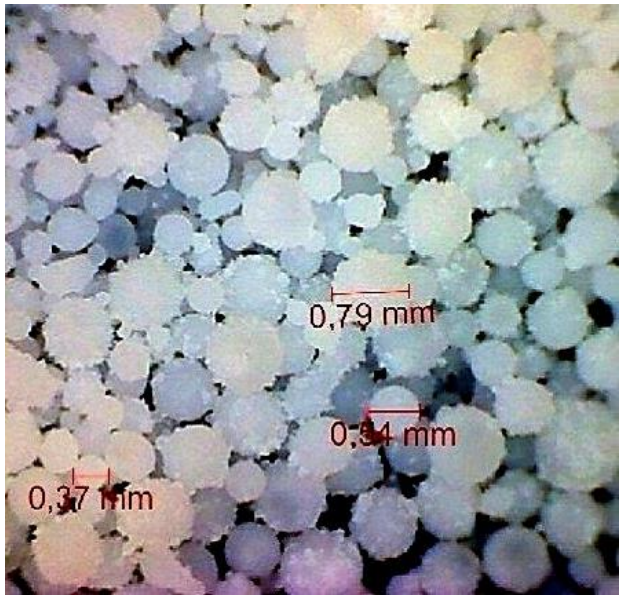
Urea production process

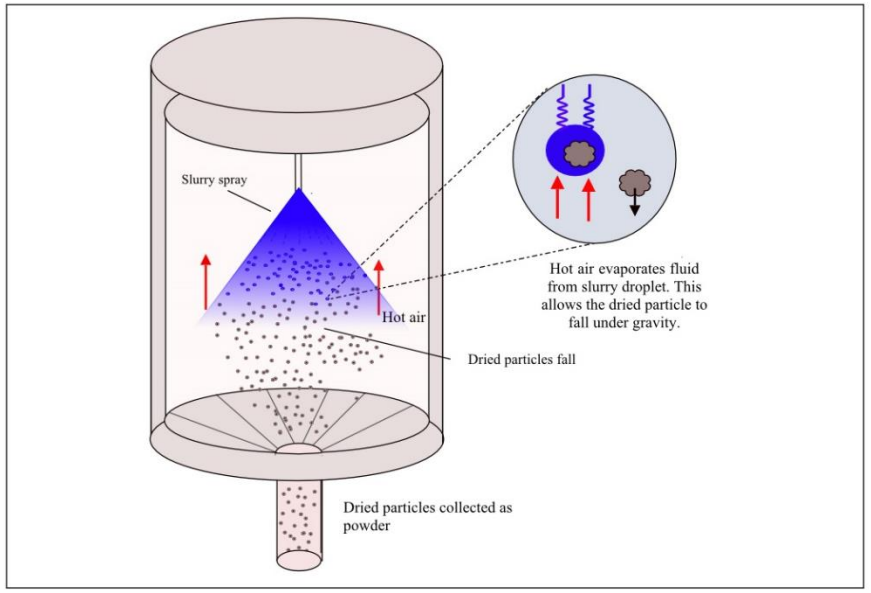
Influencing factors on caking



Urea production process

- Urea is produced from ammonia and carbon dioxide
- spray drying of the liquid urea solution
- more or less uniform particle size and moisture content
- no thermodynamic equilibrium when stored

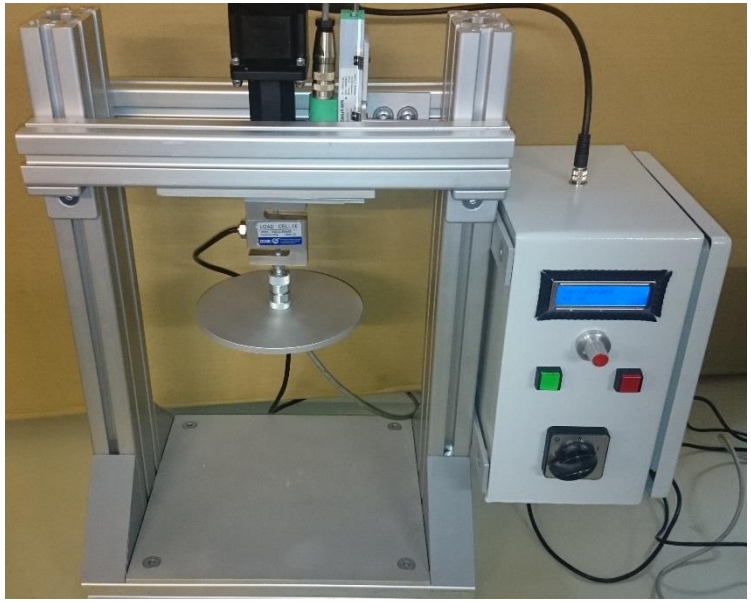




Measurements

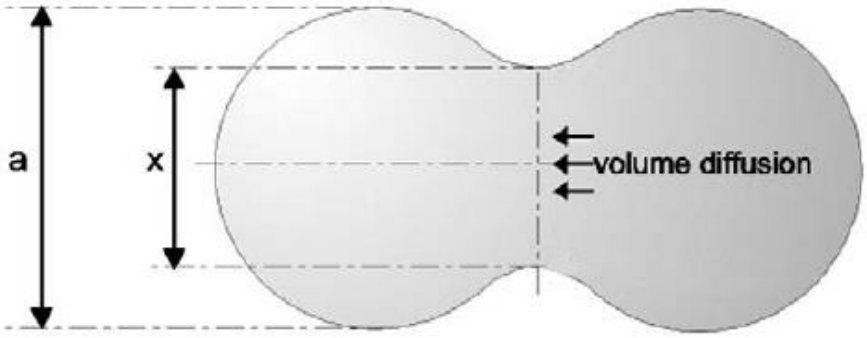
- Process moisture inside the particles

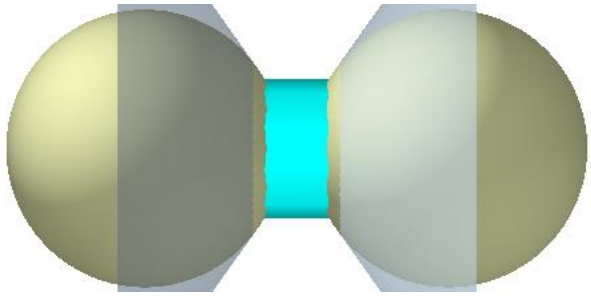
  → measurement on site is necessary
- mobile compression testing machine
- climate chamber to simulate the closed system of a silo



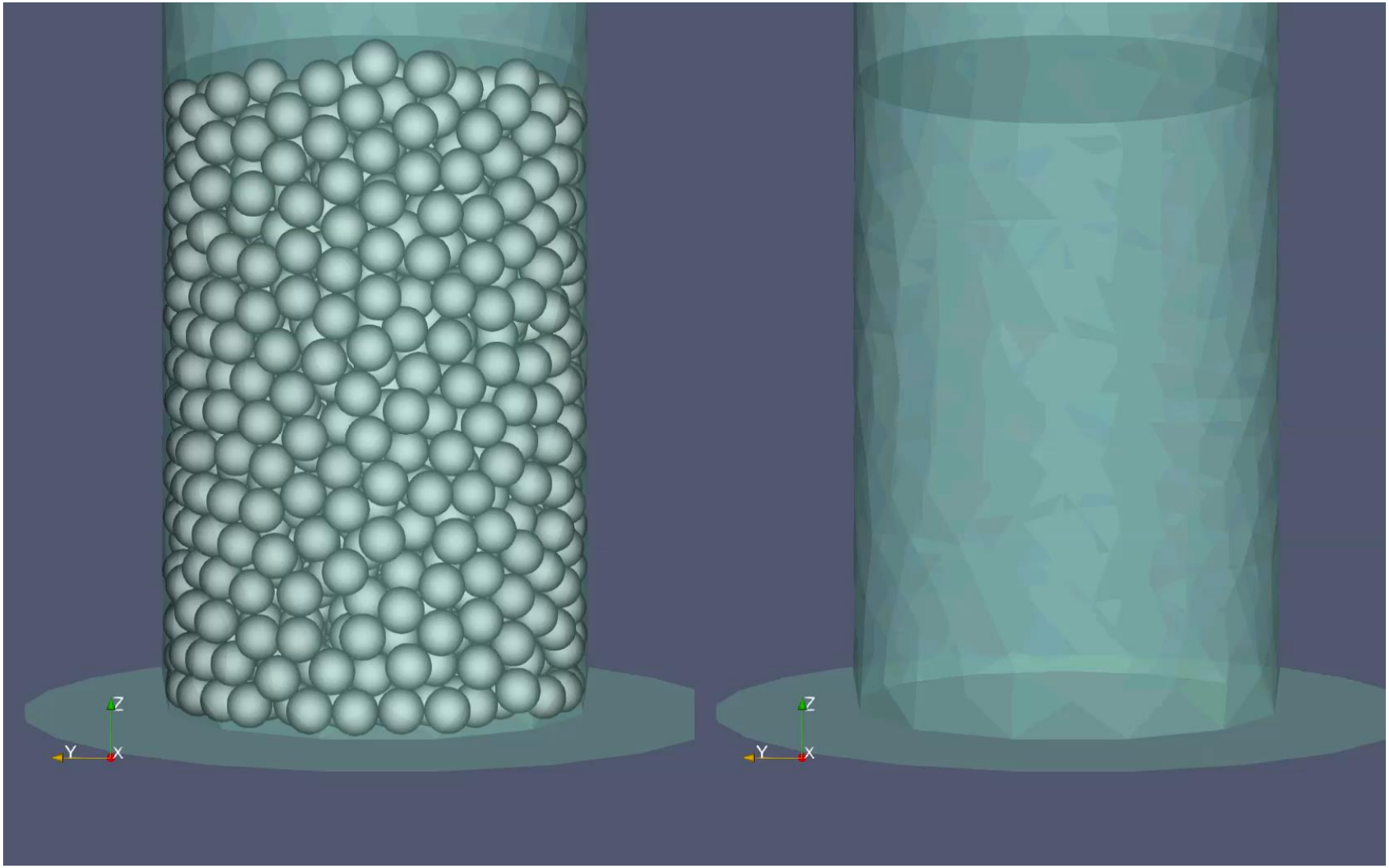
LIGGGHTS contact model with bonds

- normal und tangential stiffness of the bonds [N/m³]
- critical normal- und tangential stress in the bond [N/m²]
- diskradius of the bond
- maximum particle distance for the bond creation at a specified time

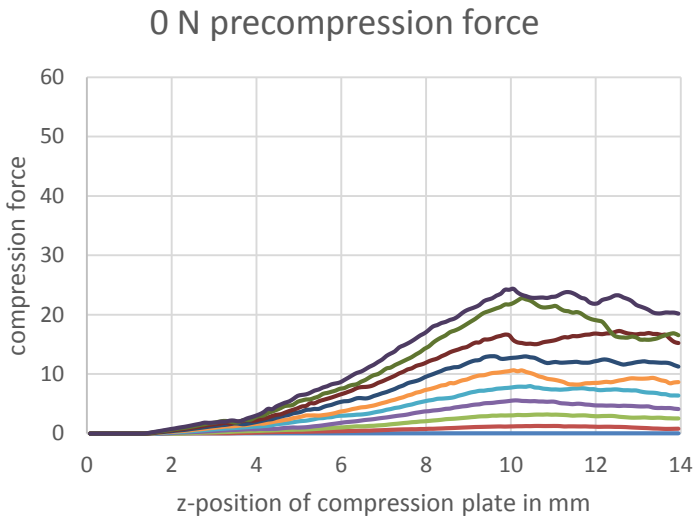


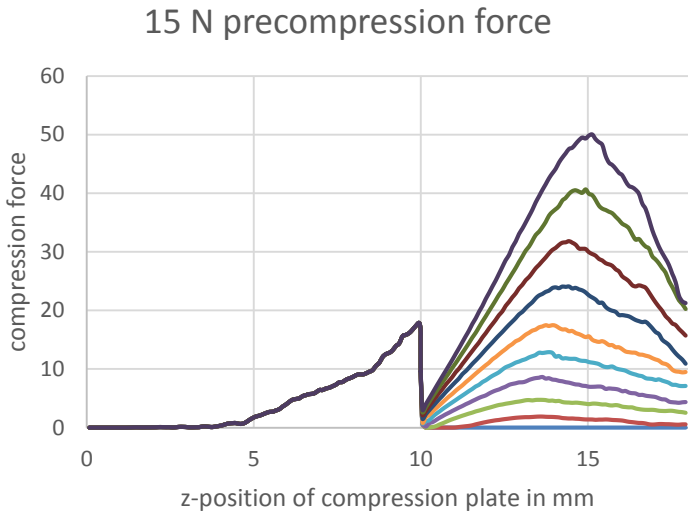


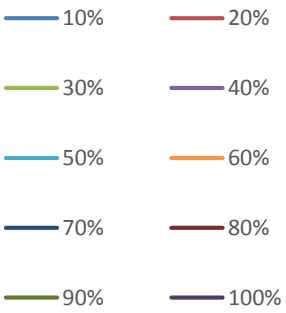
DEM Simulation

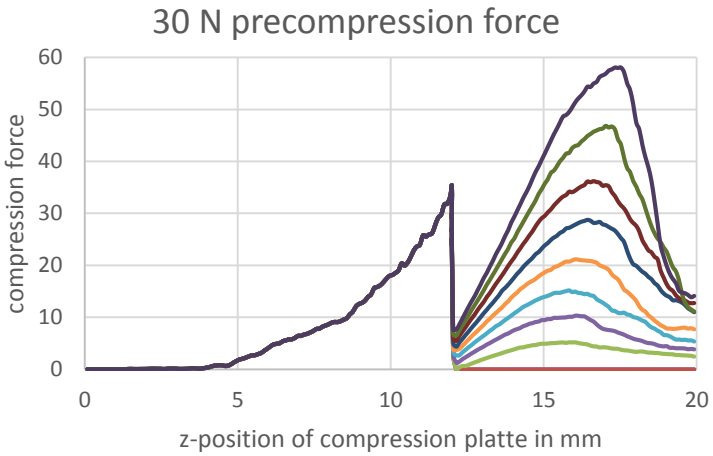


Results: force on the compression plate

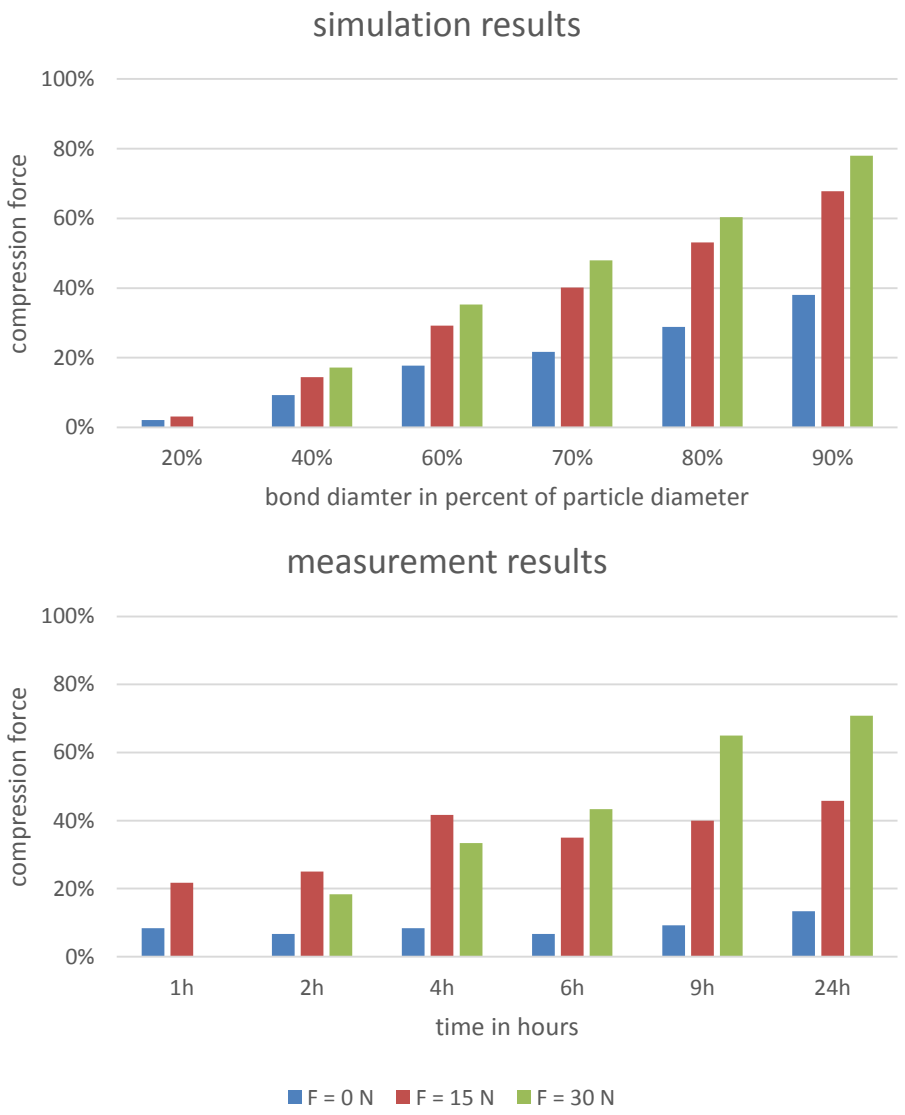








Comparison


simulation results
100%
80%
60%
40%
20%
0%
compression force
20%
40%
60%
70%
80%
90%
bond diamter in percent of particle diameter
measurement results
100%
80%
60%
40%
20%
0%
compression force
1h
2h
4h
6h
9h
24h
time in hours
F = 0 N
F = 15 N
F = 30 N

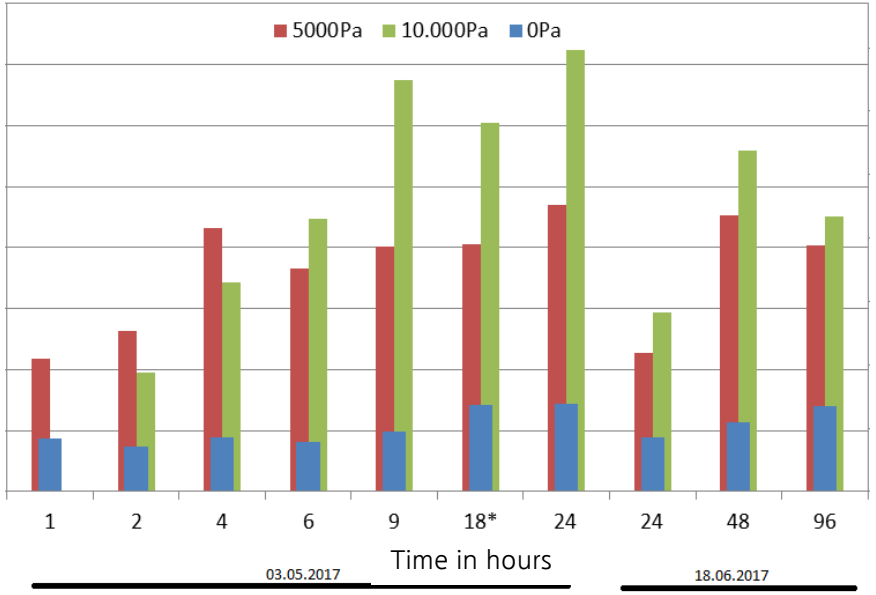
Summary

- Good qualitative accordance between simulation and measurement on first sight
- But:
  - Maximum value is reached depending on precompression force
  - Diskradius is not the same at every bond

  → improvement necessary

Further Research

- There is not the same bond radius over the hole domain
  → prediction of the actual bond radius by calculating the liquid bridge volume between two particles
- Further influencing factors (temperature, airflow,…)
- Product quality and process reliability



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Thank you for your attention!

CFDEM®project user meeting & workshop – Linz, Austria