FAST MEDIA-SCALE MULTI PASS SIMULATIONS USING GEO DICT

Dr. Stefan Rief, Dr. Jürgen Becker, Dr. Andreas Wiegmann

Fraunhofer-Institut
Techno- und Wirtschaftsmathematik,
Kaiserslautern

Dr. Martin J. Lehmann, Steffen Pfannkuch

MANN+HUMMEL GMBH, Ludwigsburg

FILTECH 2011

March 24, 2011
Wiesbaden, Germany

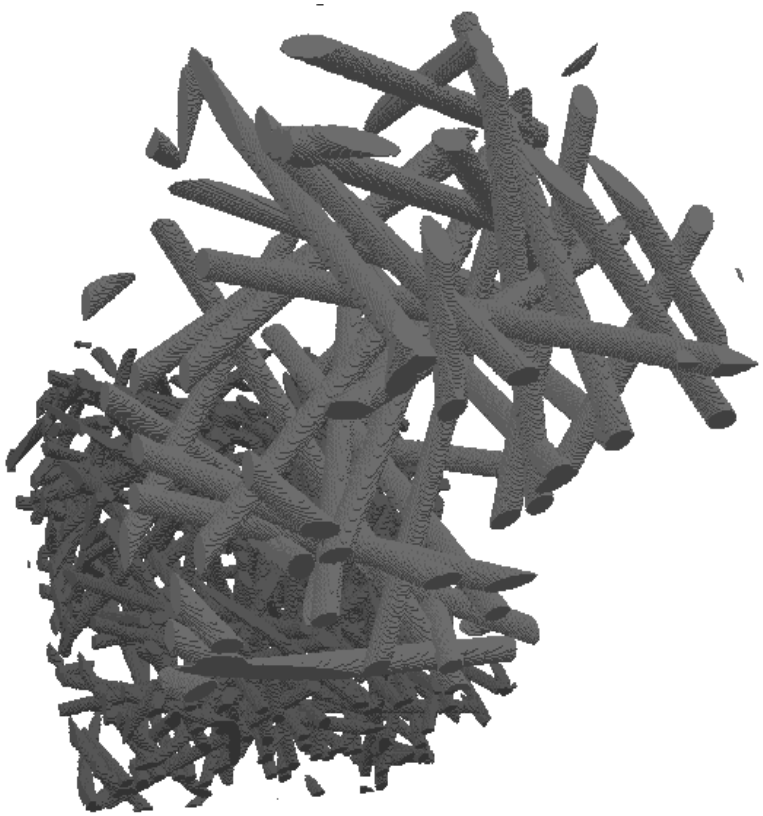
Outline

- Introduction
- Approach
- Results
- Future Work
- Conclusions

Introduction

GEO DICT

- Our Aim: Optimization of Oil Filters
  - Increased Dust Holding Capacity
  - Lower Pressure Drop
  - Higher Efficiency
- Simulation of Multi Pass Test ISO 4548-12
- Media-Scale Simulation by Resolving the Medium's Microstructure
- Use CFD for Flow Field
- Use Fully Resolved Particles for Trajectory Calculation



Approach – Filtration Simulation

GEO DICT

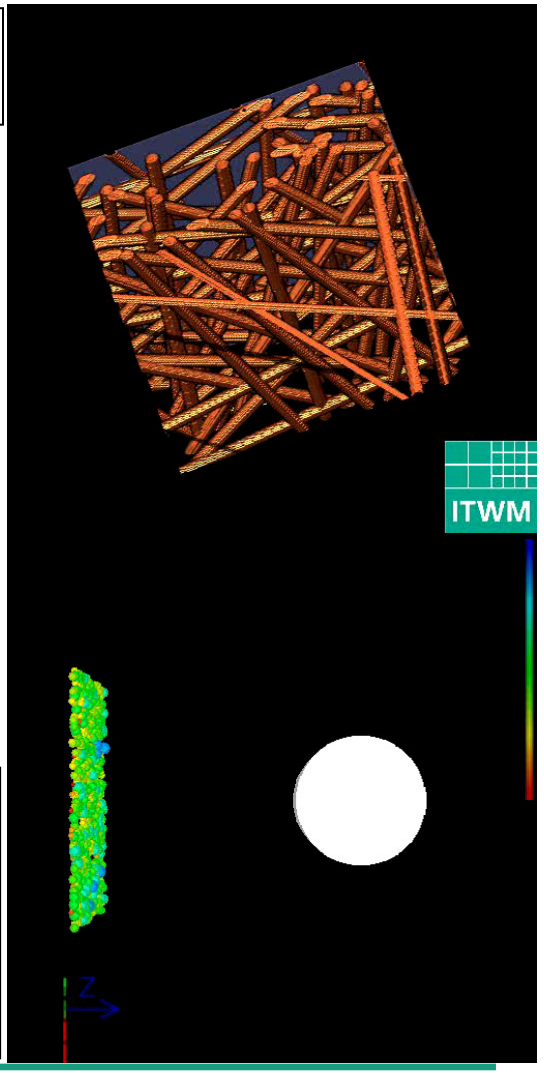
OPTIMIZATION

1. Initial Structure Parameters
2. Generate Structure
3. Solve CFD Problem
4. Compute Particle Transport & Deposition
5. Compute Filter Efficiency and Pressure Drop
6. Choose Better Parameters

TEST TIME

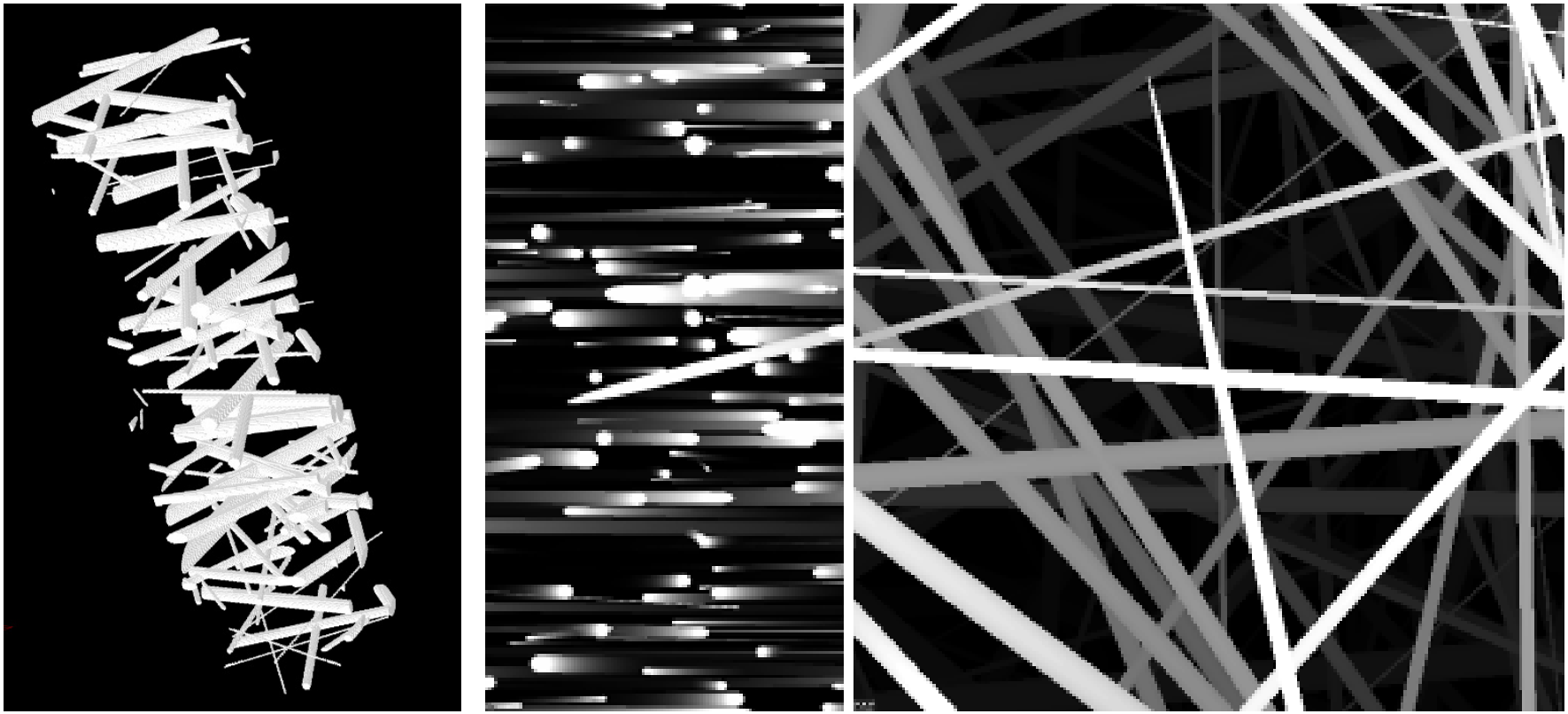
Remark: Steps 2.-5. form a ***Batch***

Fluid Flow



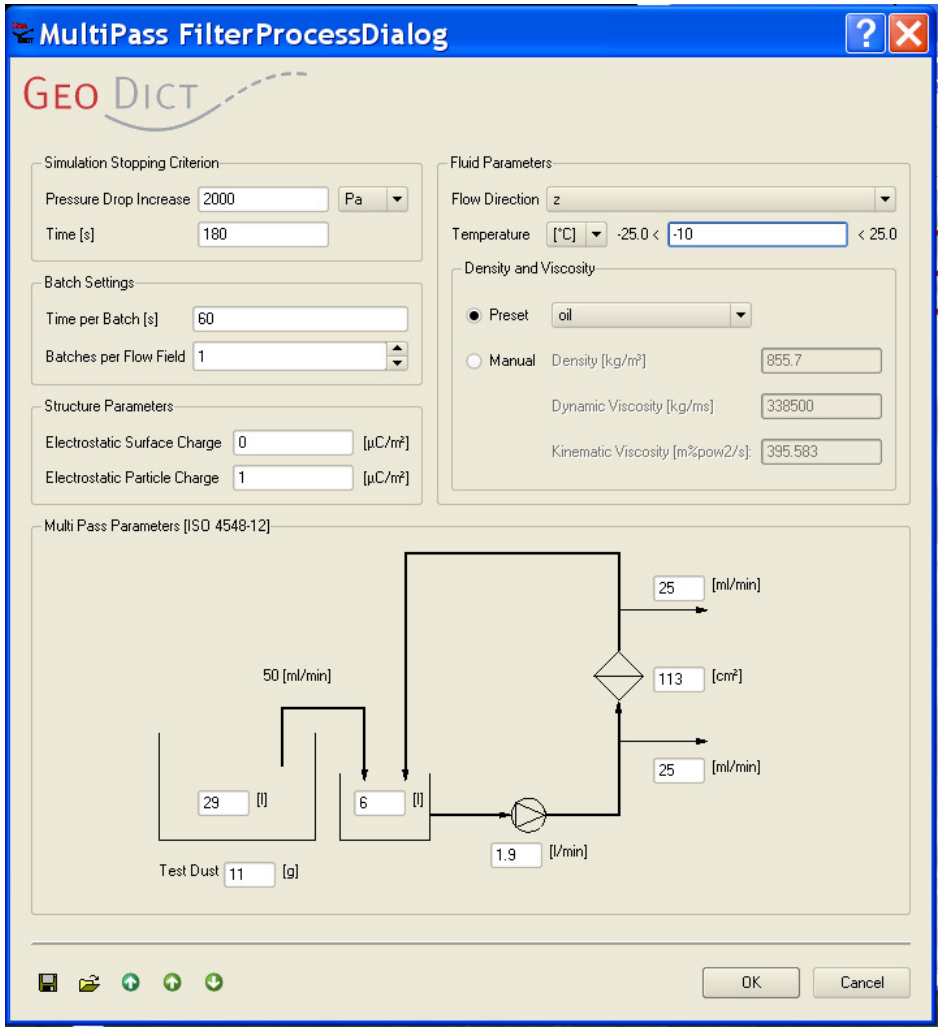
Particle Deposition on a Single Fiber

Approach – Virtual Oil Filter Media



3D Fiber Structure and Cross Sections of a Virtual Medium
(from Lehmann et al, WFC 2008, Leipzig, Germany)

Approach – Simulation Controls

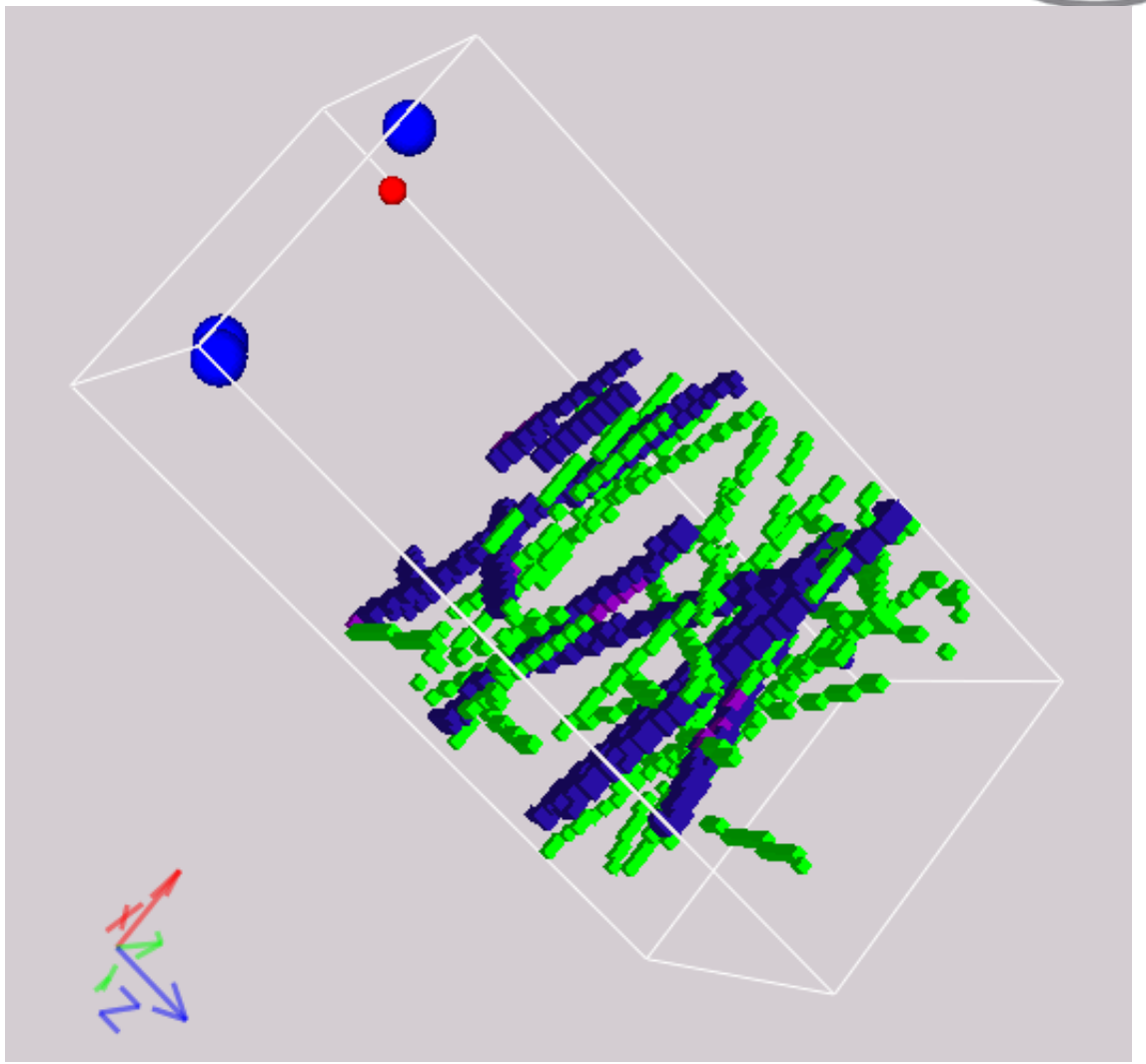


Approach – Latest Improvements

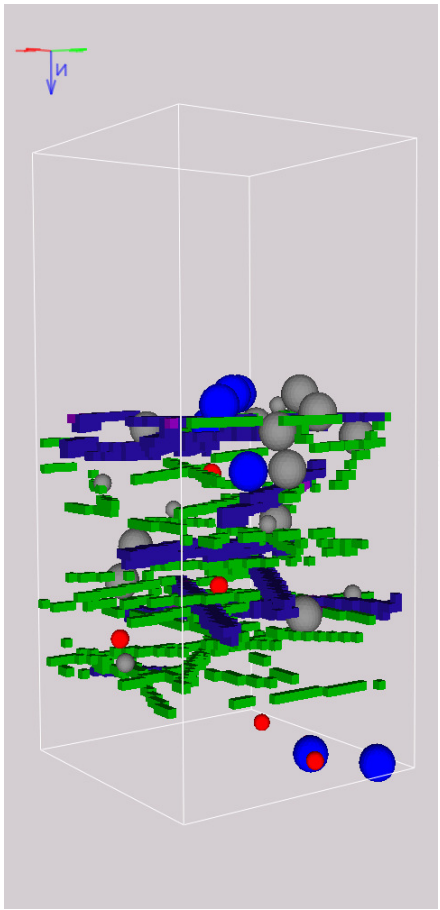
- Accounting for the Transition from Depth to Cake Filtration
- Filling a 3D Volume vs. Depositing on a 2D Surface
- Leading to Big Time Steps in the Beginning of the Multi Pass Simulation
- Providing Accurate Time Stepping in the End

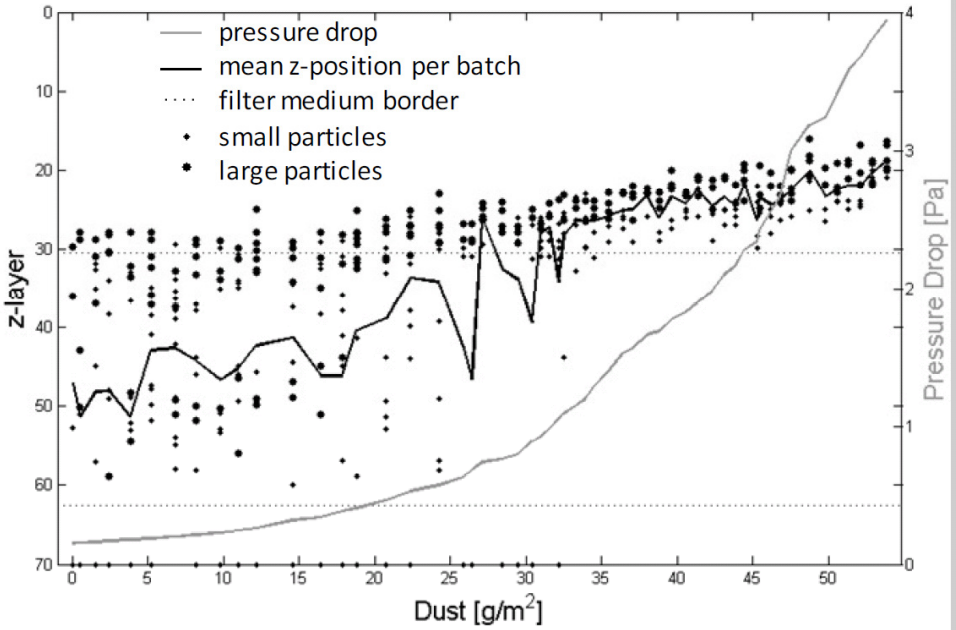
Results

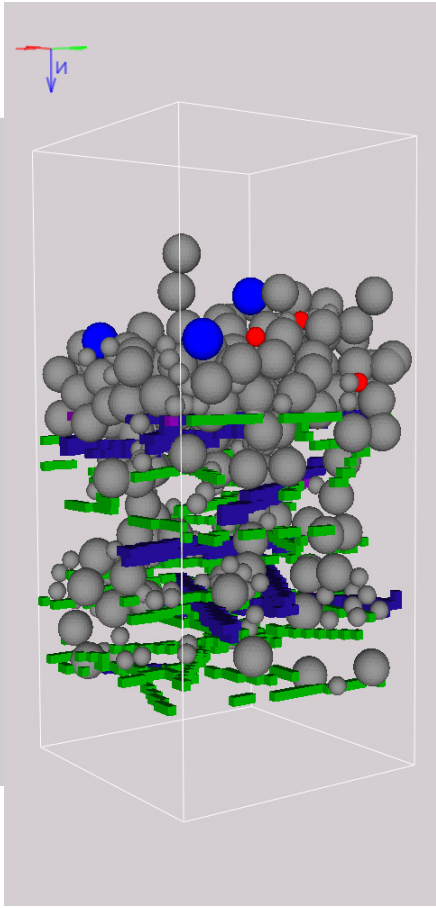
GEO DICT



Results

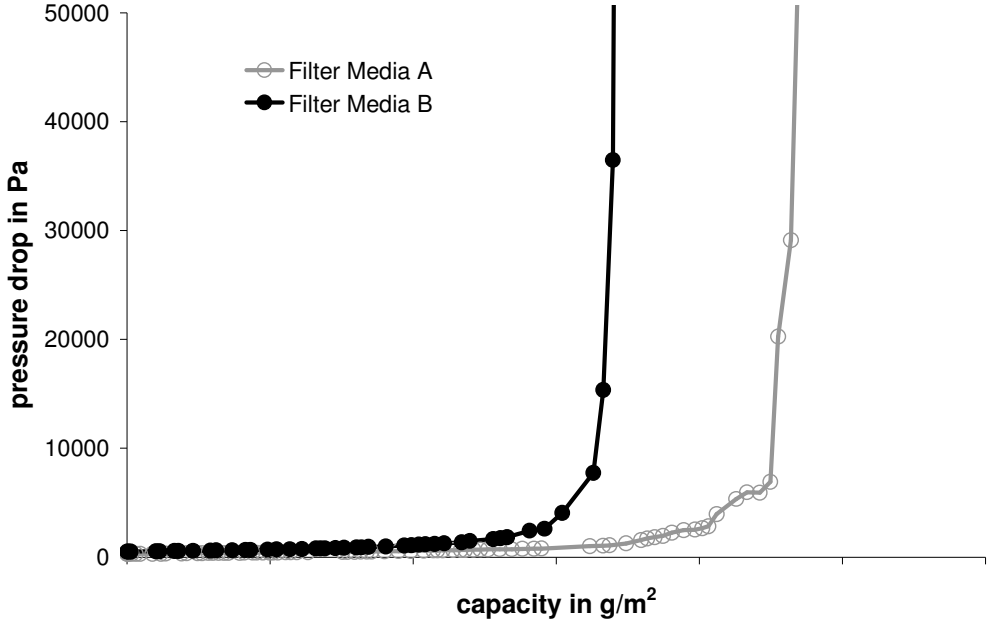



pressure drop
mean z-position per batch
filter medium border
small particles
large particles
z-layer
Pressure Drop [Pa]
Dust [g/m²]
0
10
20
30
40
50
60
70
0
5
10
15
20
25
30
35
40
45
50
0
1
2
3
4



Future Work

- Application of New Methodology to Real Media
- Validation by Experiments
- To be Presented at AFS 2011 Annual Conference, Louisville, KY



Conclusion

- Successful Implementation of Adaptive Time Stepping
- Stepping Applied According to the Filtration Regime
- Deposition Pattern and Slope of Pressure Drop Resembles Testing Results

- Big Time Steps When Acceptable, Small Time Steps When Necessary
  - Speed-up of Simulation Expected
  - Potentially Physically Better Results Due to Reduced Particle Overlap
- Mean Depth Coordinate is a Promising Candidate for Clogging Point Detection