Multiphase Simulation for Powder Chamber

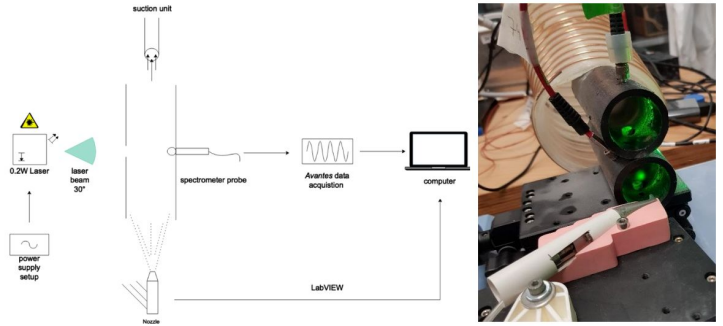
Comparison of Different Software

Ju Wu
12/07/2021

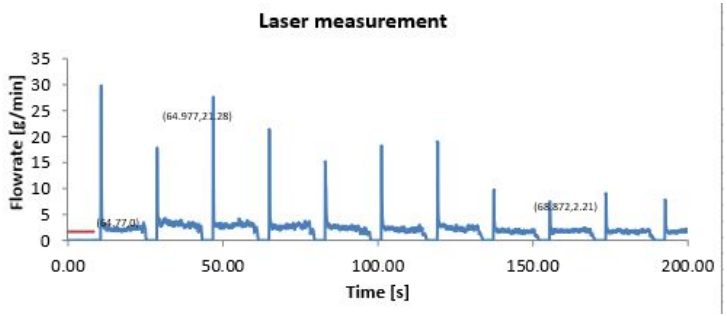
EMS

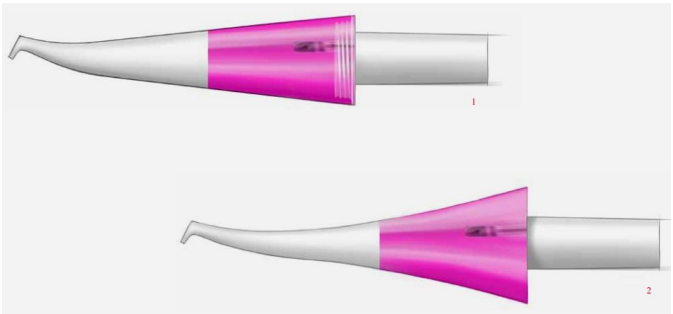
Background | Introduction

- Goals
  - avoid/decrease tests
  - intrinsic behaviors
  - prototype validation
- Physical systems
  - fluidization system
- Methods & software
  - EE/EL

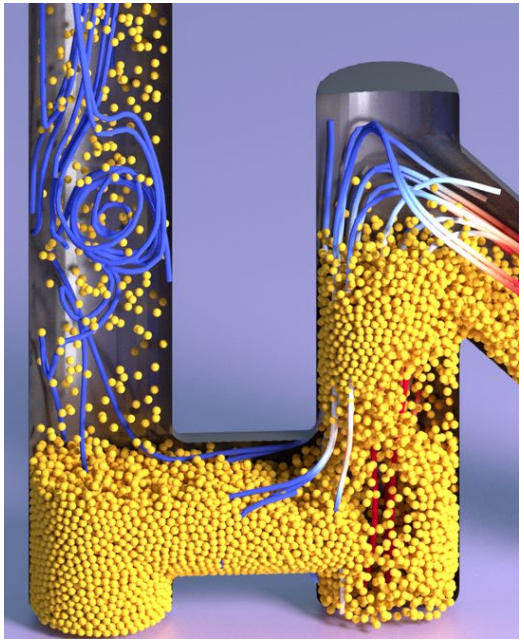


a) Schematic of the setup b) Powder output





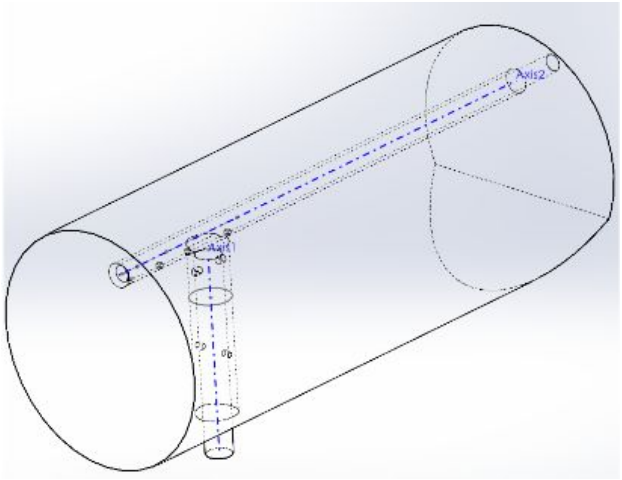
- Multiphase flow method
  - liquid dispersed phase
  - time cost
- DEM (discrete element method)
  - high computation load
- PIC (particles in the cluster)
  - variant of DEM



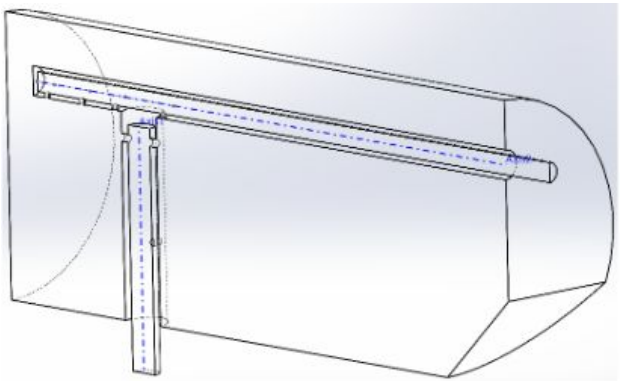
Background | Simulation software

- Cradle scFLOW
  - Multiphase flow method
  - DEM
  - Particle tracking
- MFiX
  - TFM
  - DEM
  - PIC
- COMSOL
  - TFM
  - Mixture model (simplified EE)

Geometry | Solidworks



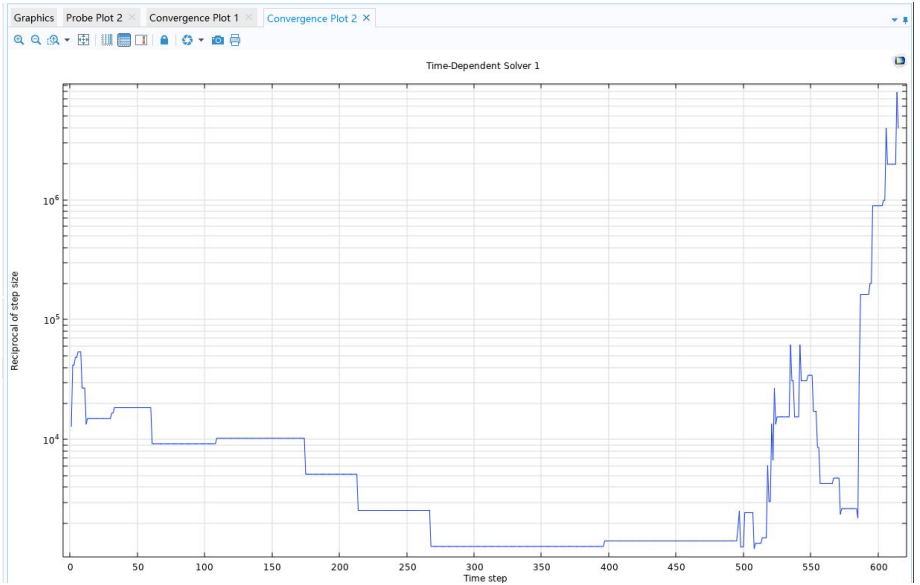
Simplified chamber model of Handy 3.0



Half of the model

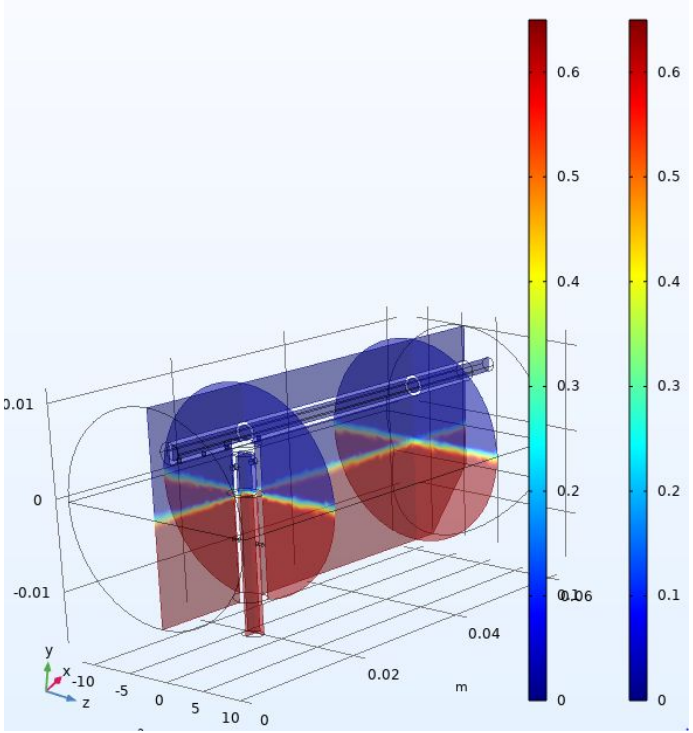
COMSOL | Euler-Euler model

- Hard to converge
  - not work
- Long time to simulate



COMSOL | Mixture model

- Simplified EE model
  - liquids of similar density
- Powder inside chamber cleared too fast
  - near 2 s



COMSOL | Pros & Cons

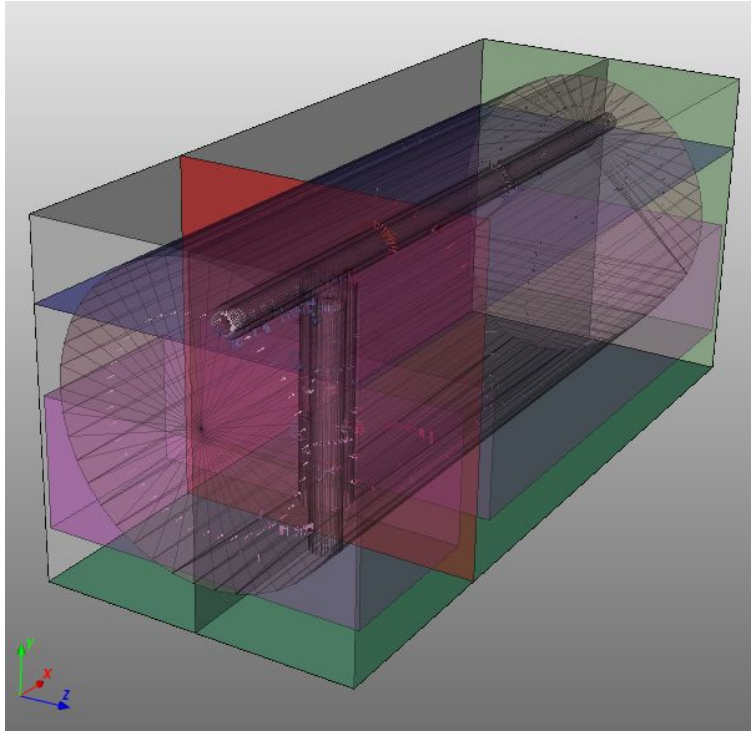
Pros:

- all-in-one software
- online resources
- popularity in academia,
- universality

Cons:

- less support
- quite expensive
- instability
- no middle monitor

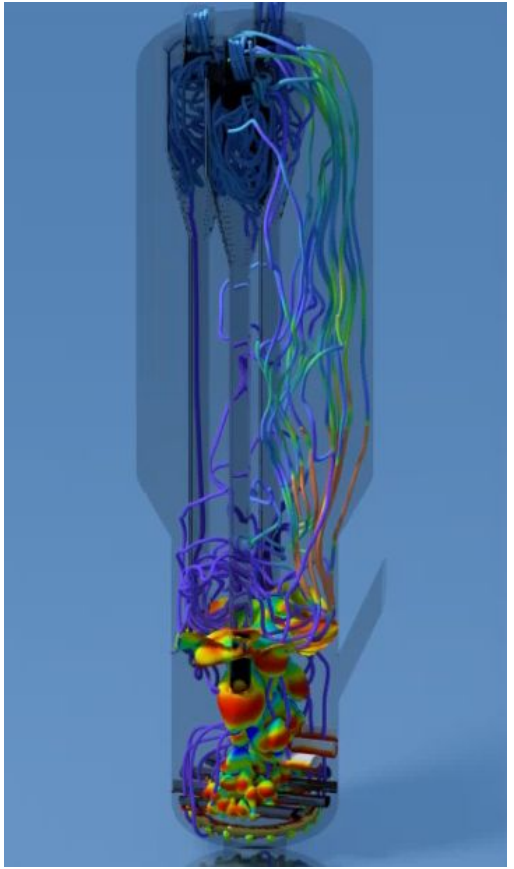
MFiX | General modelling



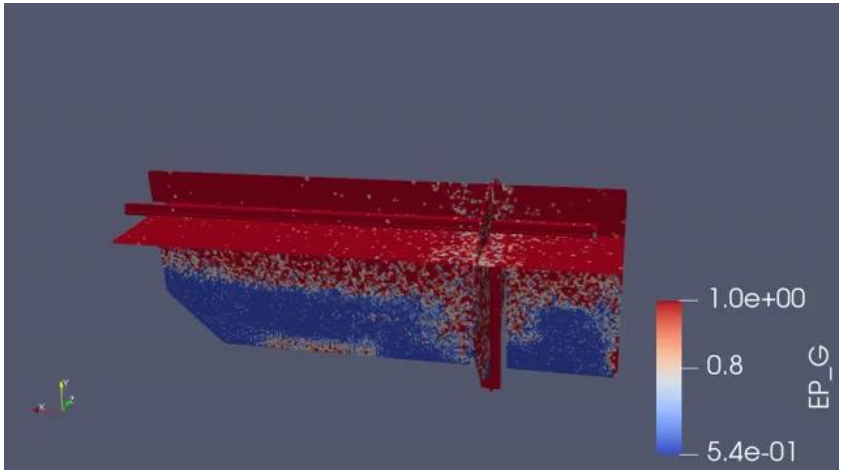
- Open-sourced
  - unexpected bugs
  - free
  - regular updates
- Mesh
  - difficult to set
  - limits on pose
  - non-standard process
- Regions
  - defined at very beginning
  - non-customized

MFiX | Particles-in-the-cells method

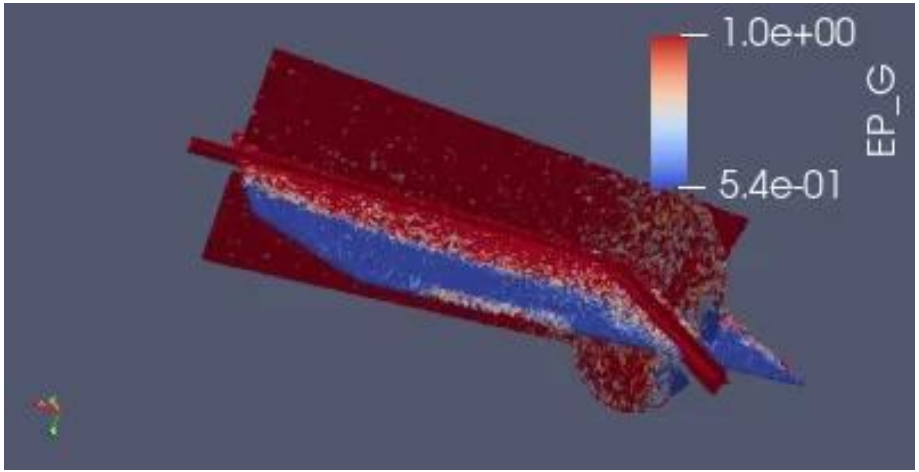
- Trade off statistical weight, number of particles within cluster and mesh size
- Lighter than DEM and TFM



MFiX | Animations (0.1 s)



MFiX PIC powder volume fraction monitor regions (position 1)



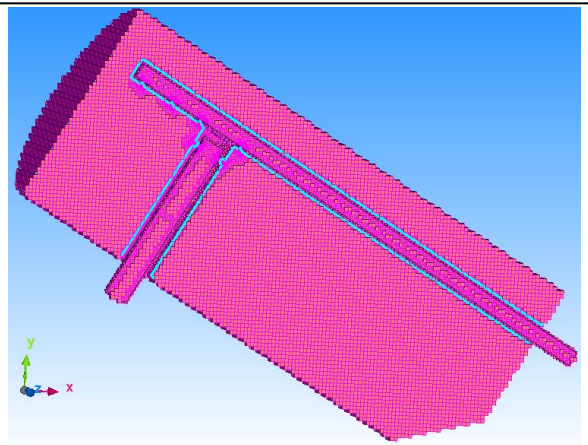
MFiX PIC powder volume fraction monitor regions (position 2)

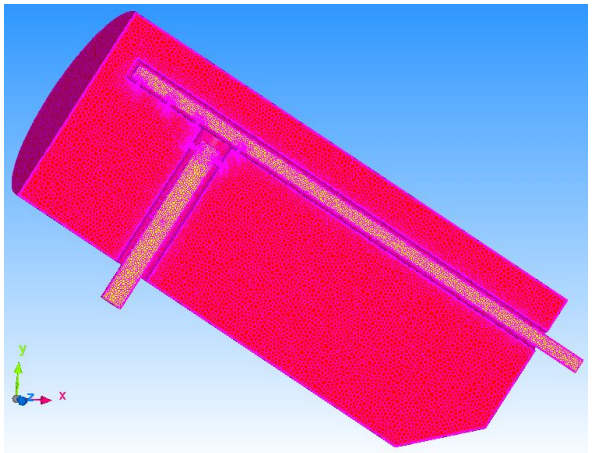
Pros:

- Flexibility
- Free
- Dynamic community
- HPC connection

Cons:

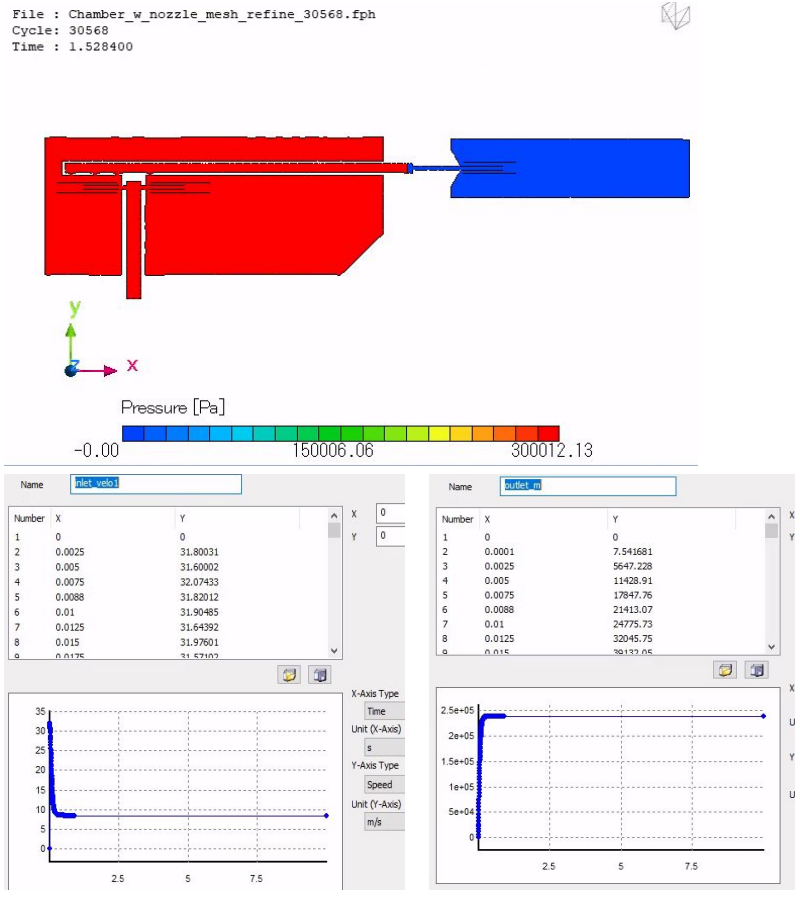
- stabilization
- can not select data later
- unexpected bugs
- geometrical limits
- need help from others



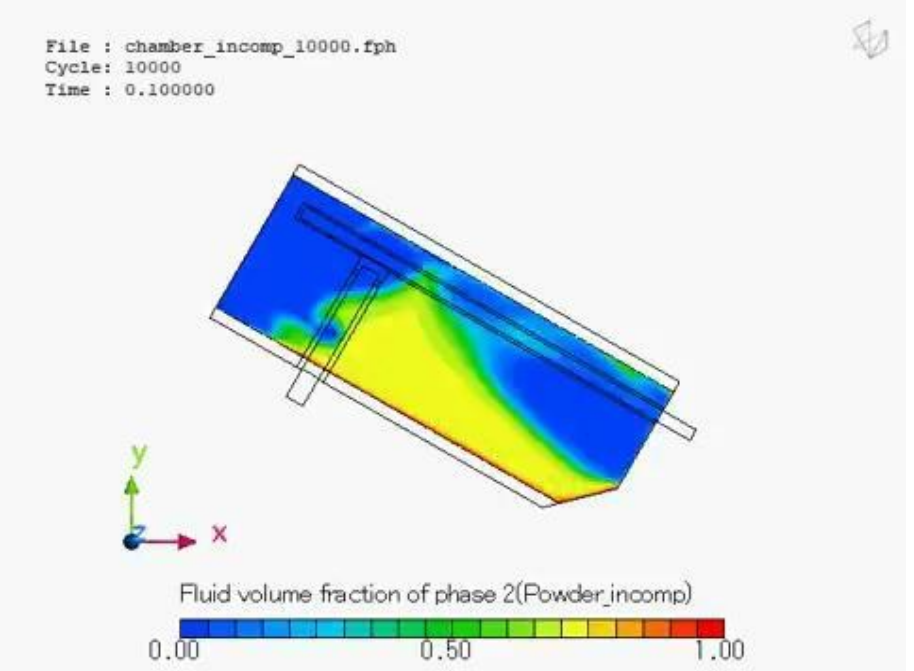


- easy to set up CFD tasks
  - robust solver
  - operation to geometry
  - symmetry
- easy to mesh
  - region specific resolution
  - neighbor element octree

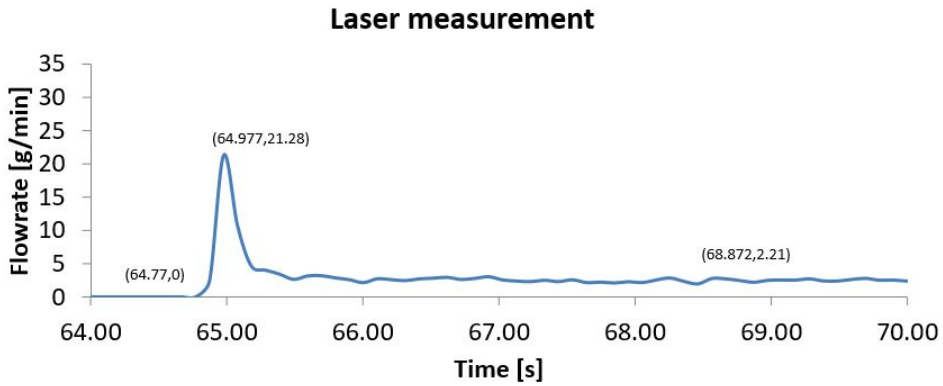
- build full model
  - with outer nozzles
  - with external env
  - set monitor slice
- build self-defined tables
  - inlet velocity
  - outlet pressure



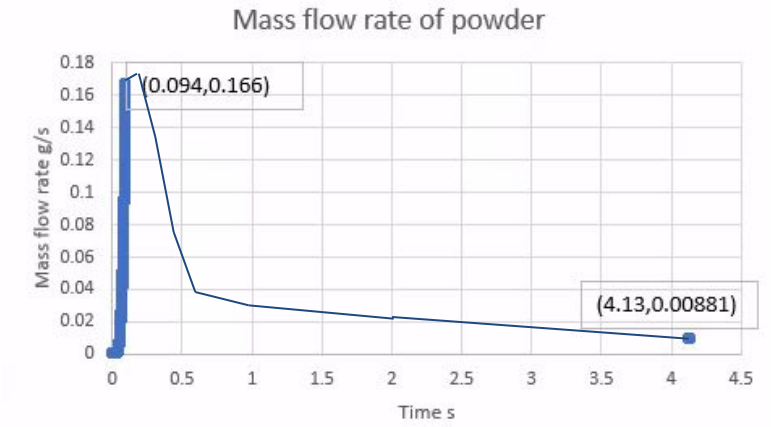
Evolution of powder volume fraction (3D)



Evolution of powder volume fraction (2D)

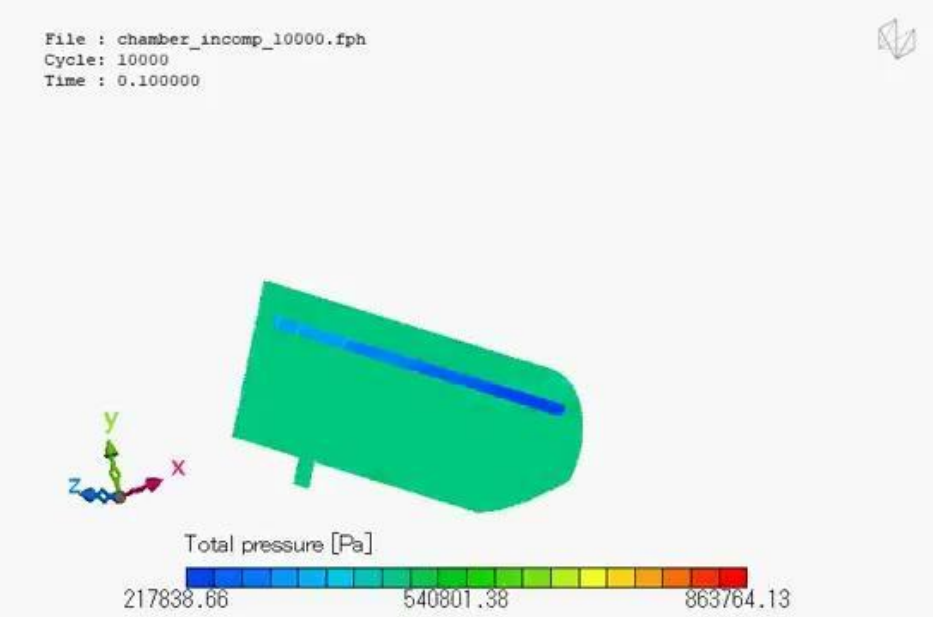


Experimental transient curve for one paddle cycle

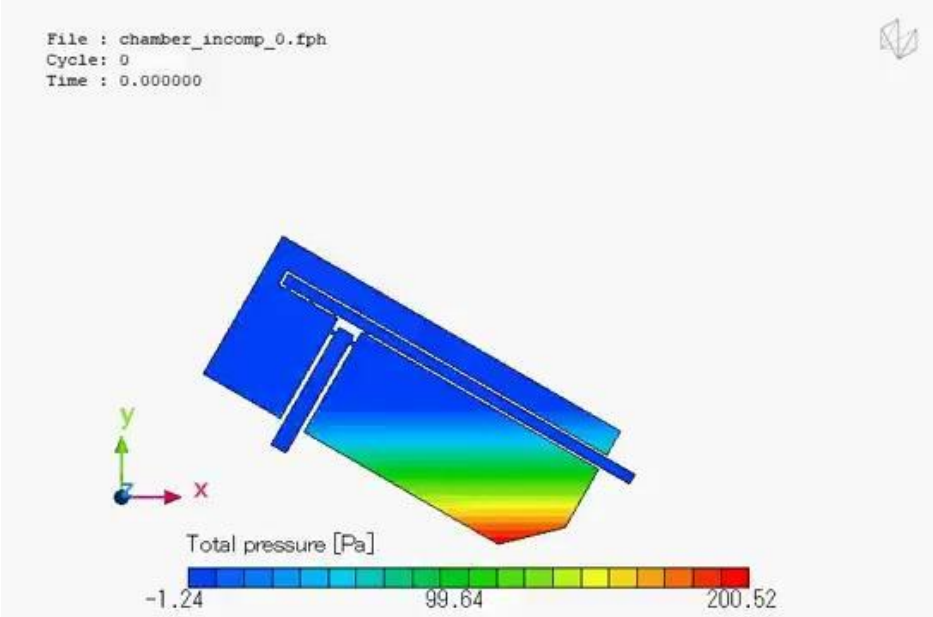


Same ratio of peak and stable mass flow rate for both experimental and simulation data

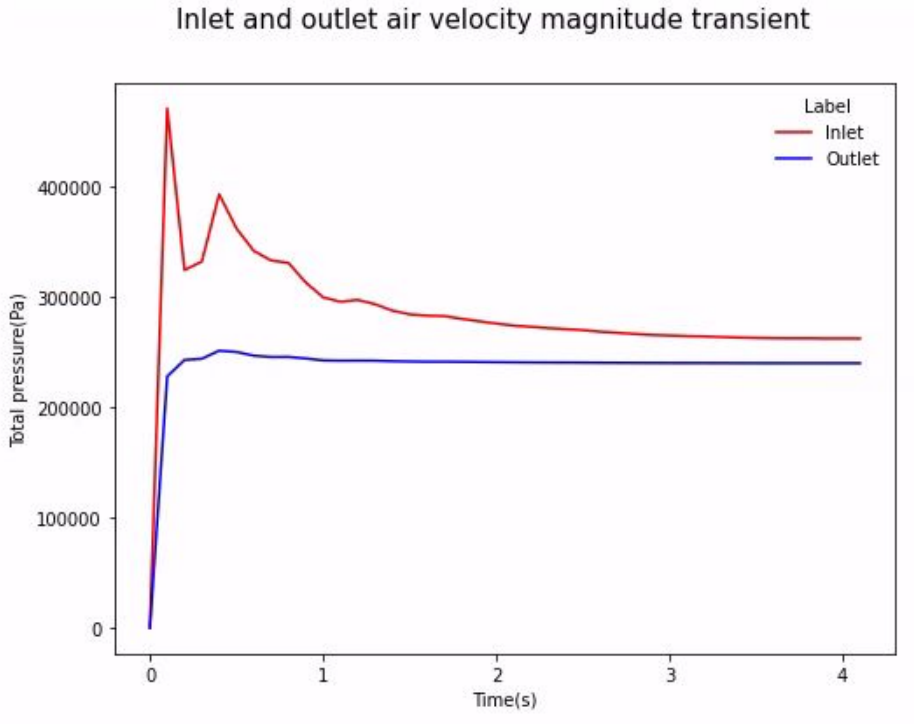
Simulated transient curve for part of one paddle cycle



Evolution of chamber total pressure (3D)

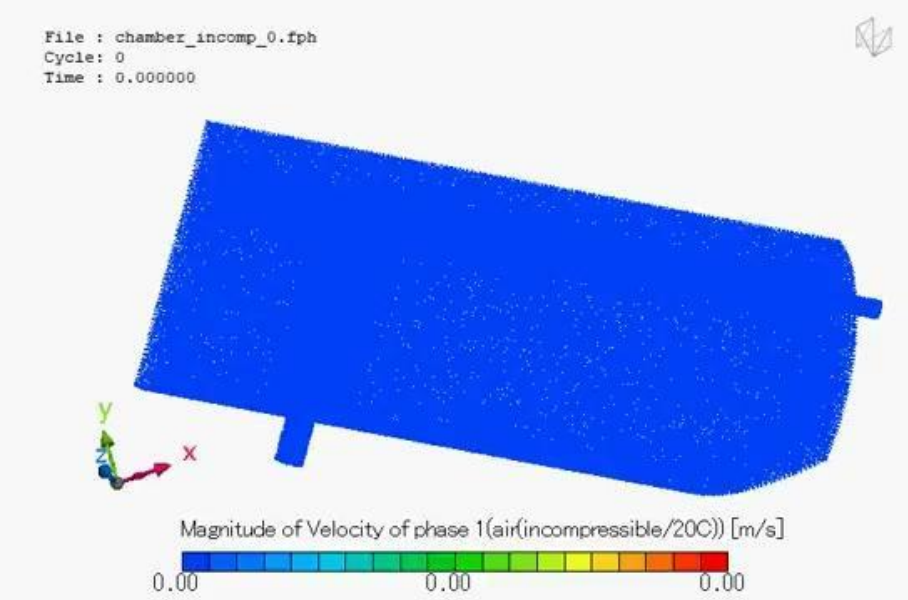


Evolution of chamber total pressure (2D)

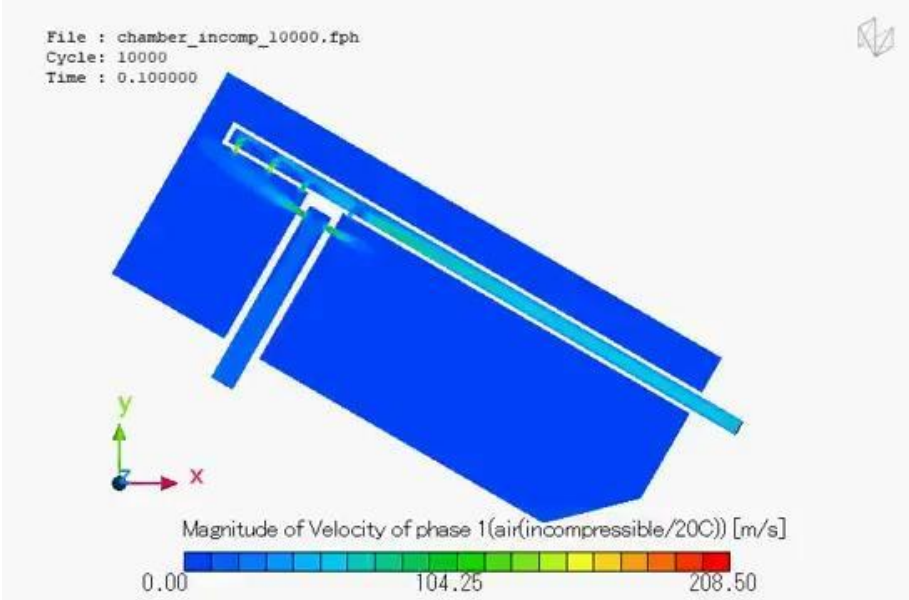


Curve of inlet total pressure

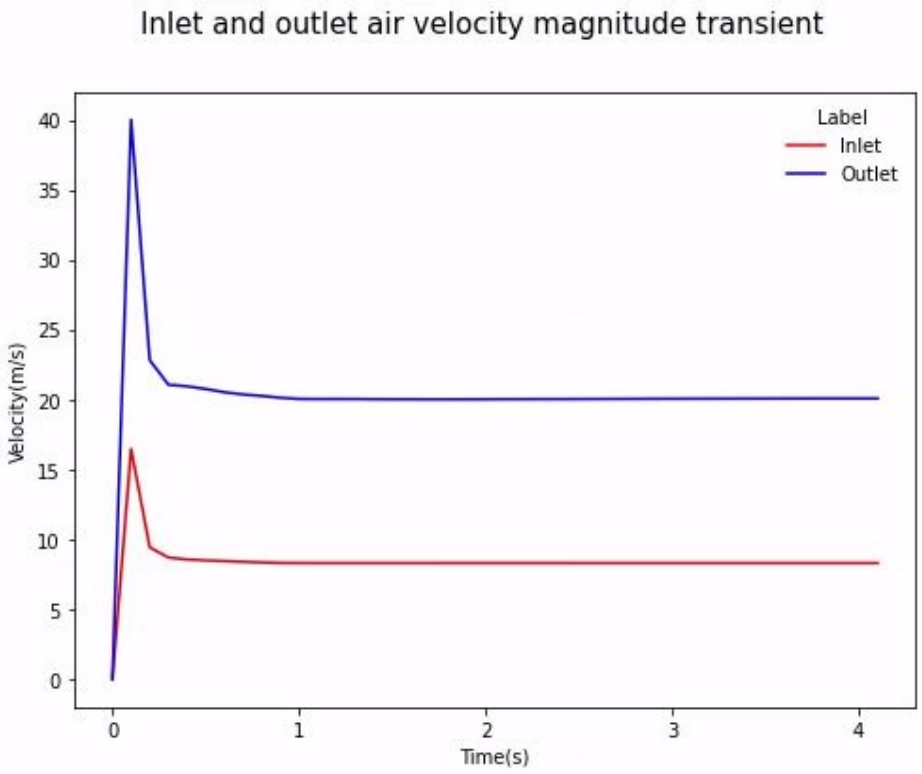
Curve of outlet total pressure



Evolution of air velocity magnitude (3D)



Evolution of air velocity magnitude (2D)



Curve of outlet magnitude of velocity

Curve of inlet magnitude of velocity

Pros:

- stability for convergence
- separate but compact designs
- all of model data reserved
- flexible subscription

Cons:

- less online resources/examples to learn,
- liquid approximates solid

Summary | Pros & Cons

Criteria / Software	Accuracy	Flexibility	Easy-to-use	Price	Stability	Speed
Cradle scFLOW	High	Middle	High	20K CHF/Y & rent	High	High
MFiX	Middle	High	Middle	Free	Middle	Slow
Comsol	N/A	Low	N/A	20K CHF/Y	Low	Middle

Summary | Conclusion

- General issues:
  - geometry details included
  - time cost
  - result analysis
- Work conditions:
  - COMSOL not work
  - MFiX too slow, unstable
  - Cradle captures interesting features

Summary | Outlooks

- Model verification:
  - tune physical paras
  - memory
- Sensitivity analysis:
  - meshes with different resolutions
  - increased step interval
  - table density
- Codes development:
  - automatic post-processing
  - results analysis
- Software rent options:
  - cost balanced


EMS
MAKE ME SMILE.
GUIDED
BIOFILM
THERAPY®