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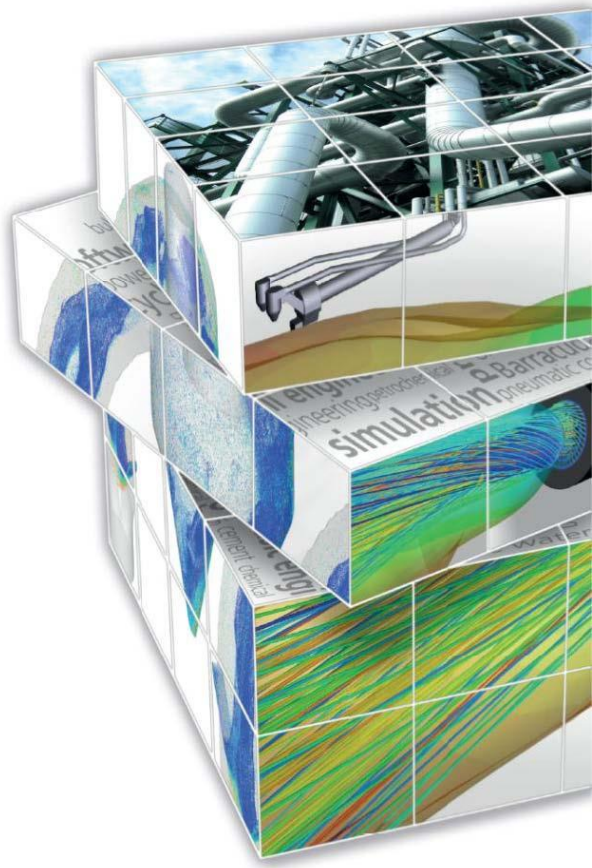
process & flow engineering technology



Martin Weng, Adlan Omer

Barracuda User Meeting April 09, 2018

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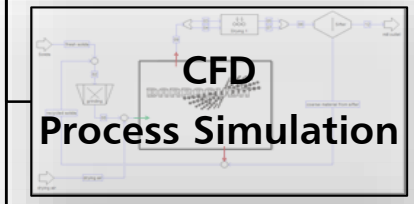
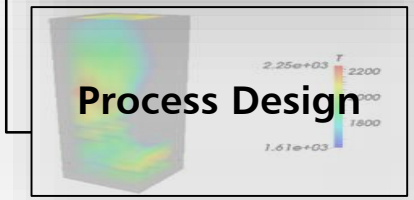
Engineering Services





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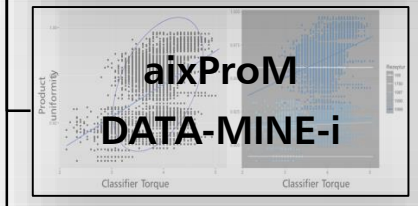
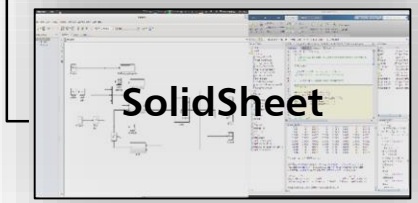
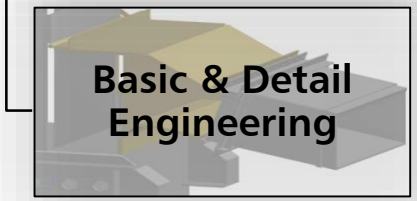




Products



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Industries

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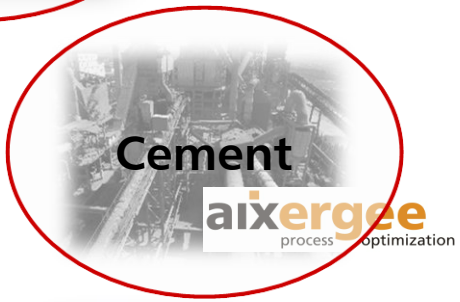

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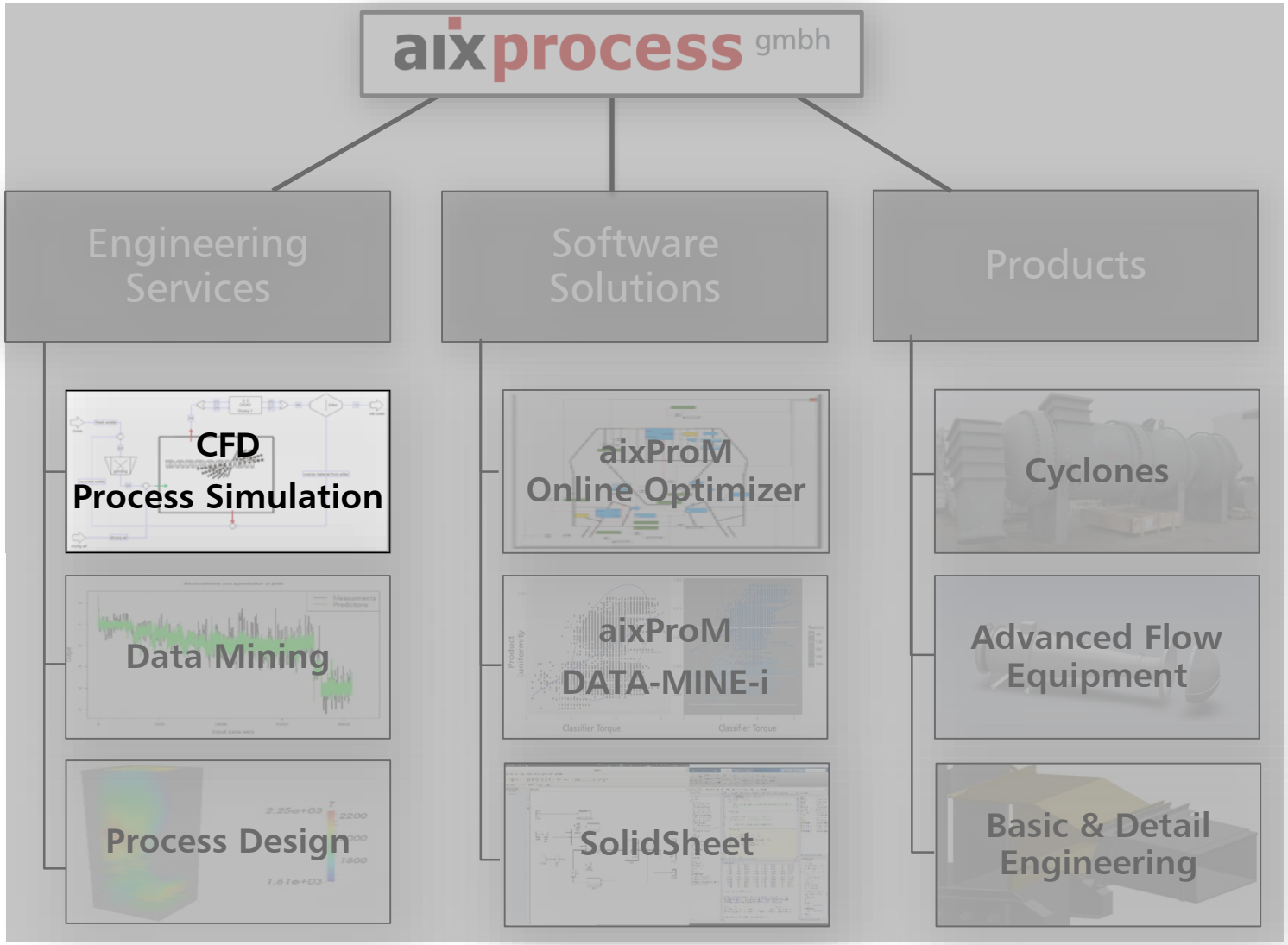

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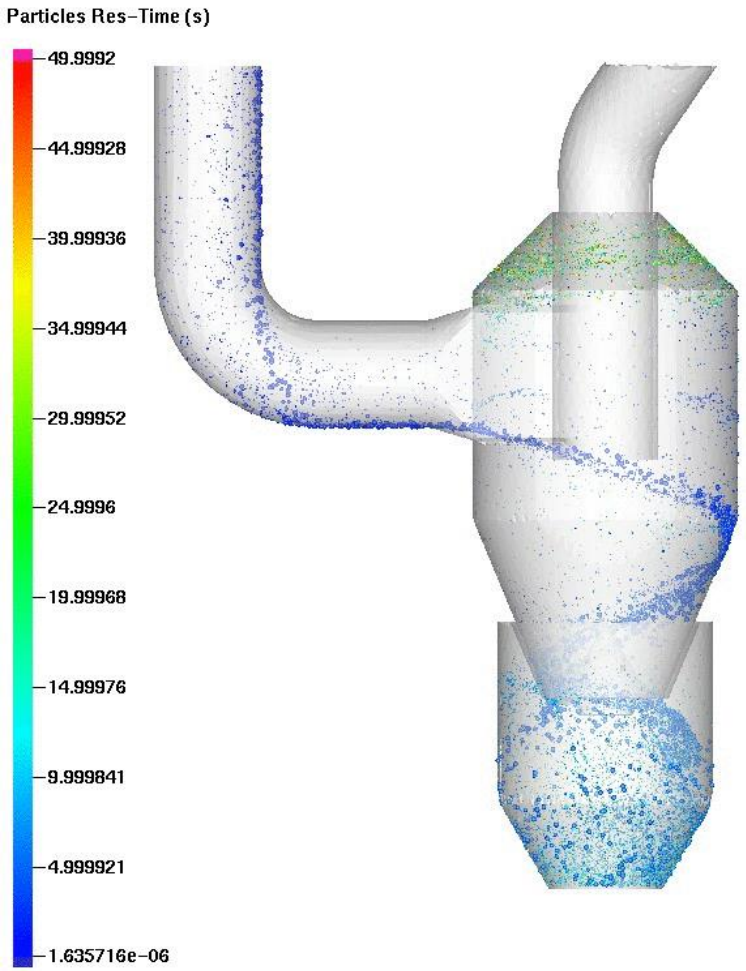
Modeling with Barracuda @ aixprocess
Cyclones



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Modeling with Barracuda @ aixprocess
Cyclones

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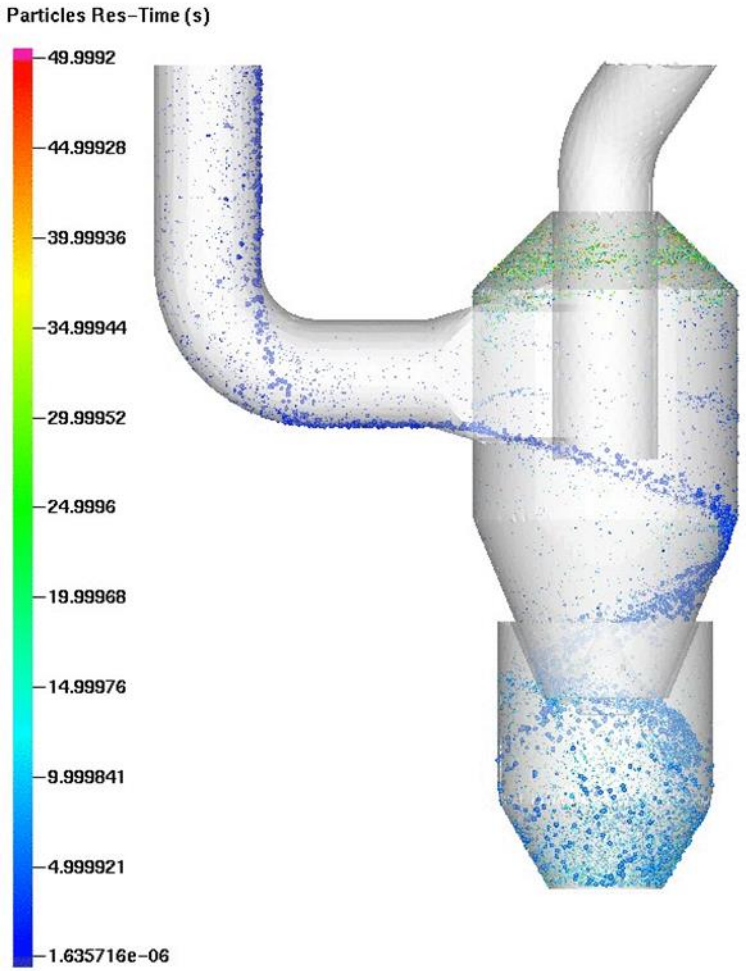

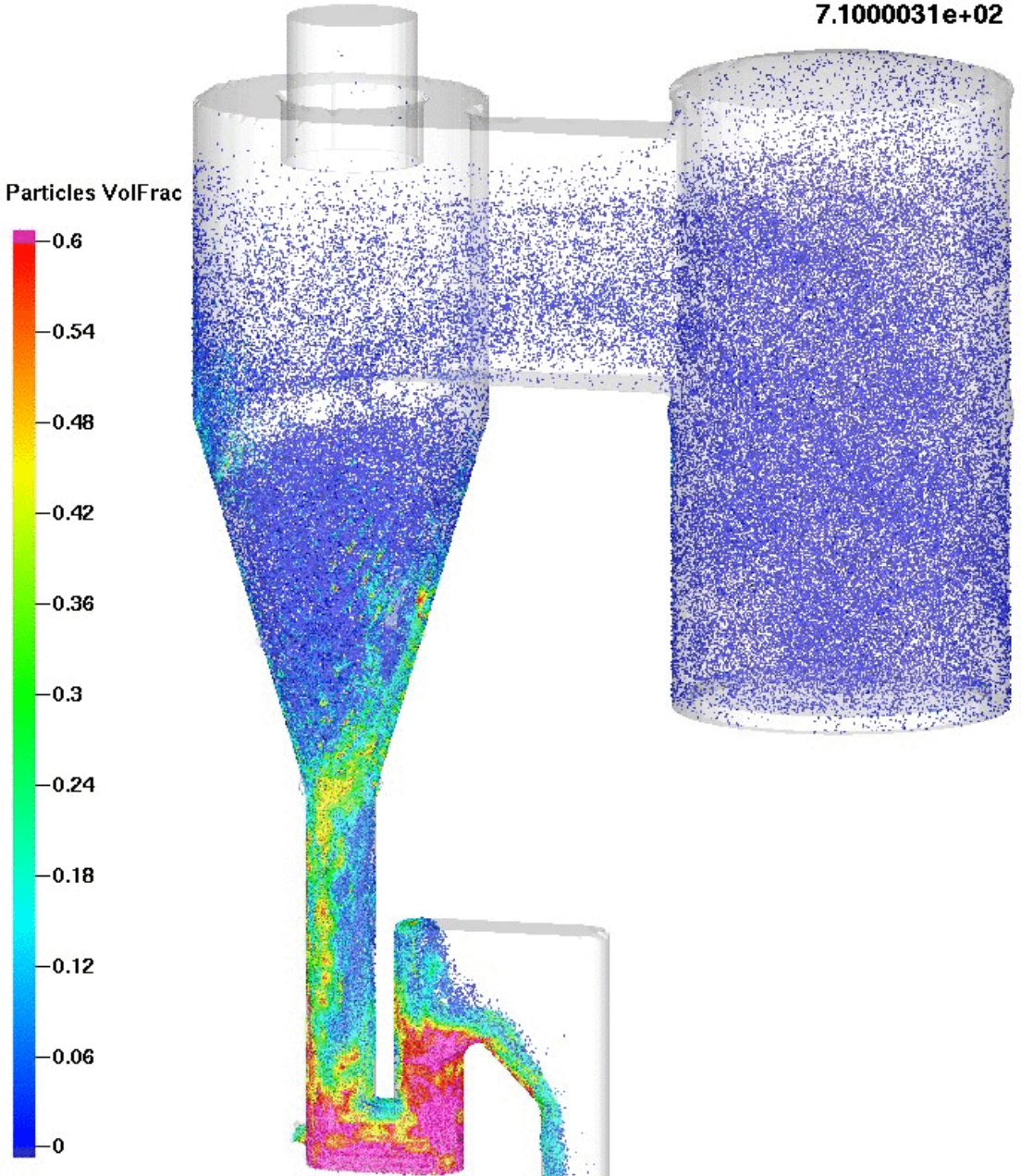

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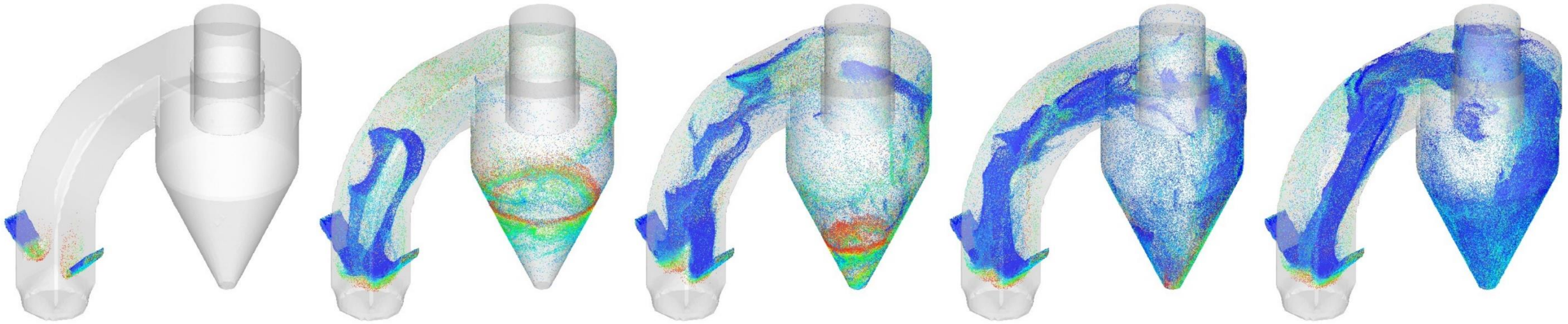
Modeling with Barracuda @ aixprocess
Cyclones



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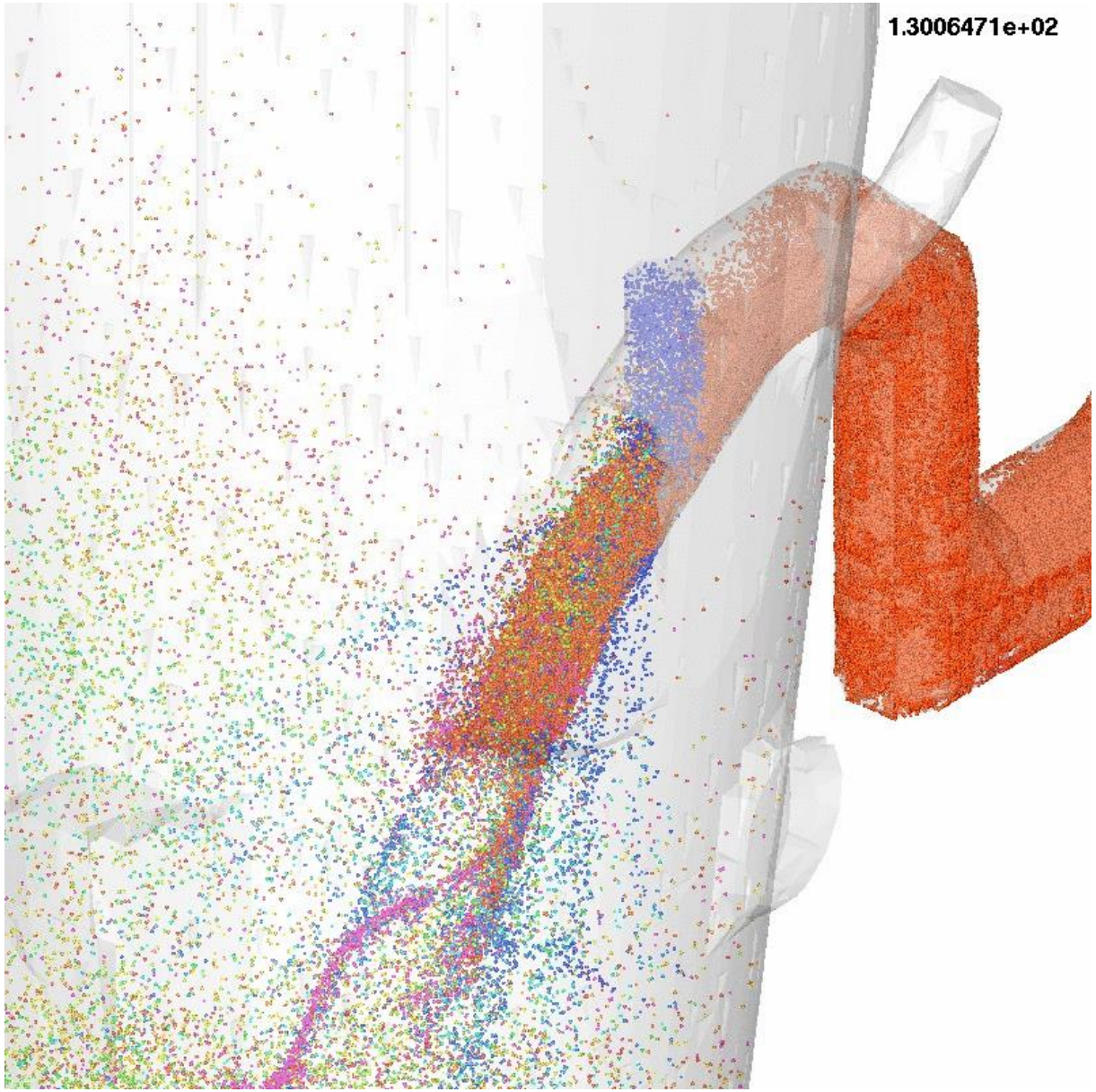
Modeling with Barracuda @ aixprocess
Circulating Fluidized Bed Combustion



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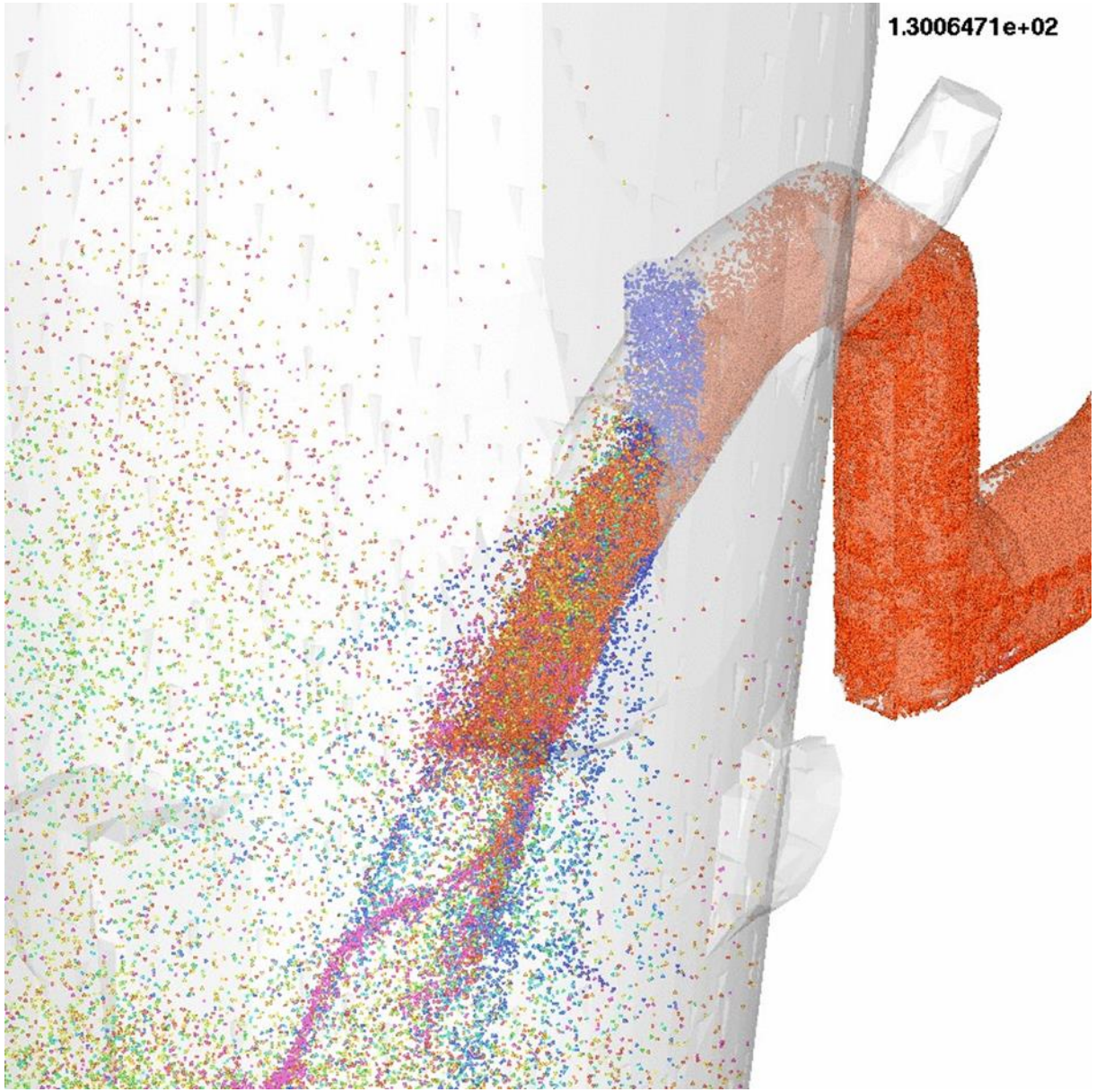
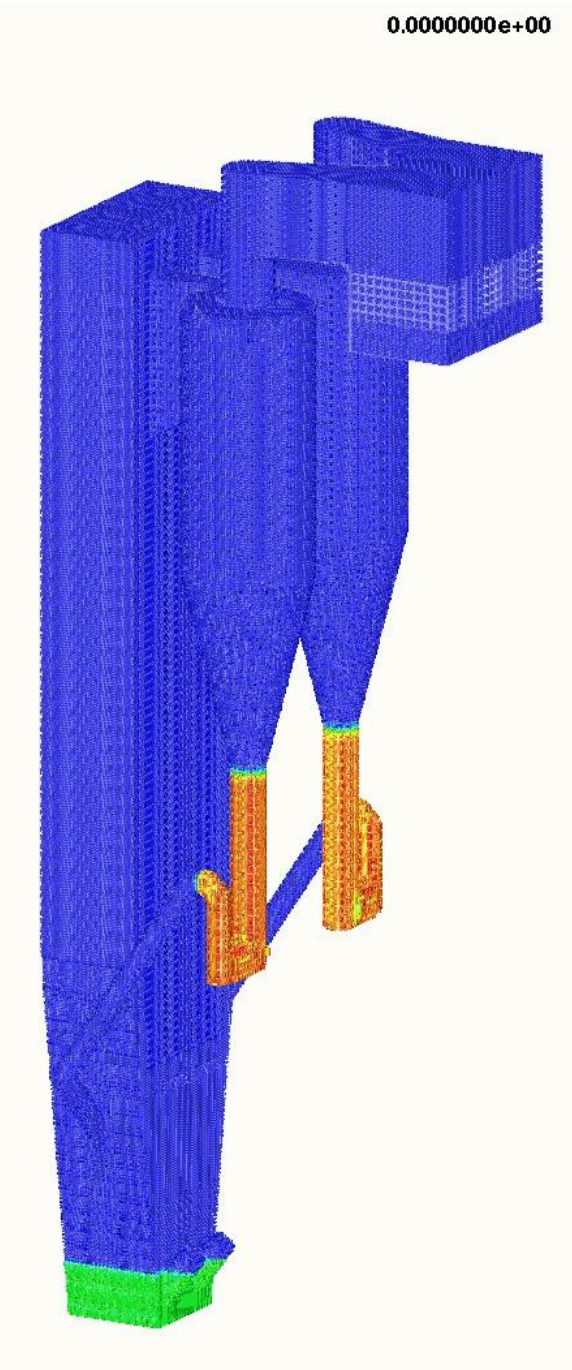
Modeling with Barracuda @ aixprocess
Circulating Fluidized Bed Combustion





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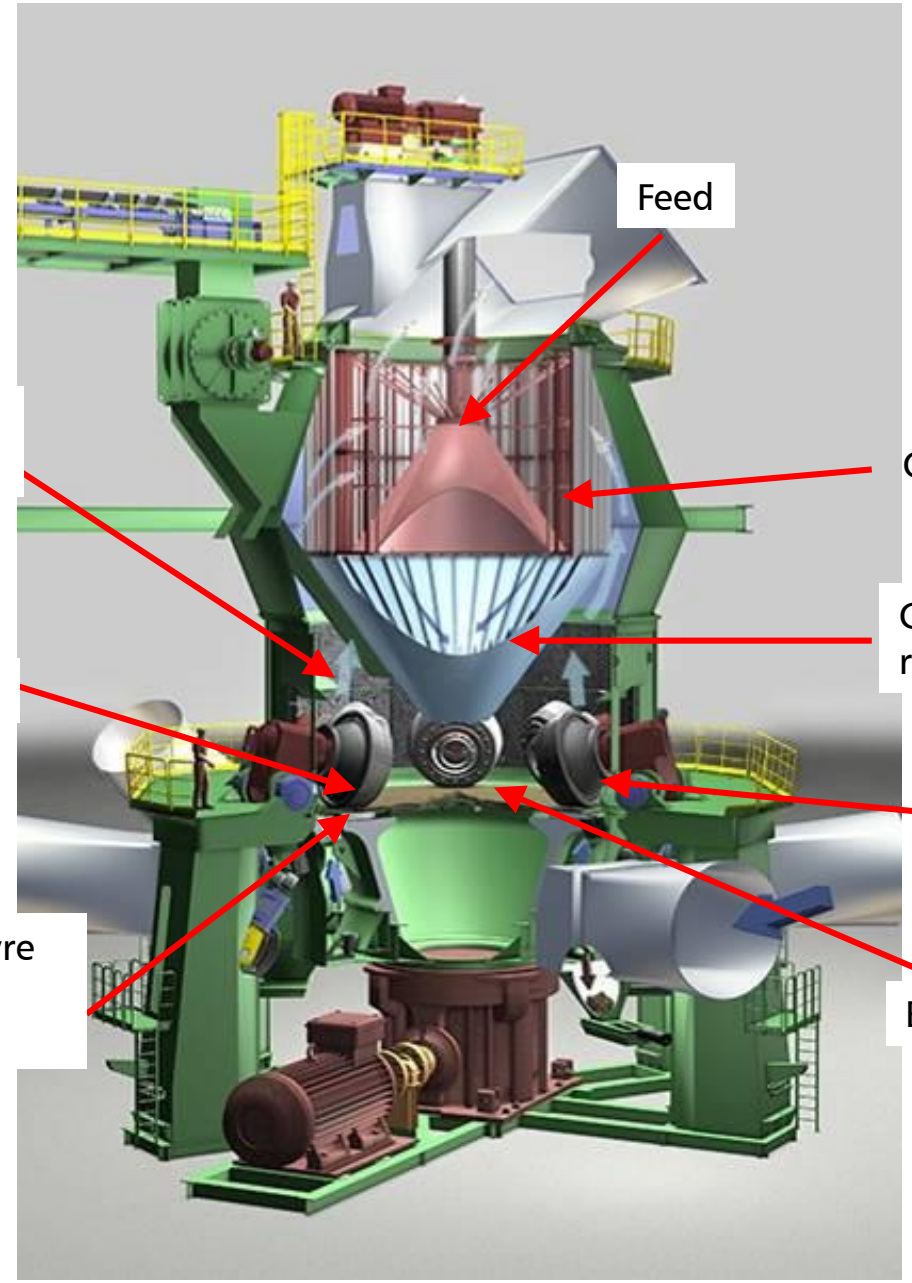

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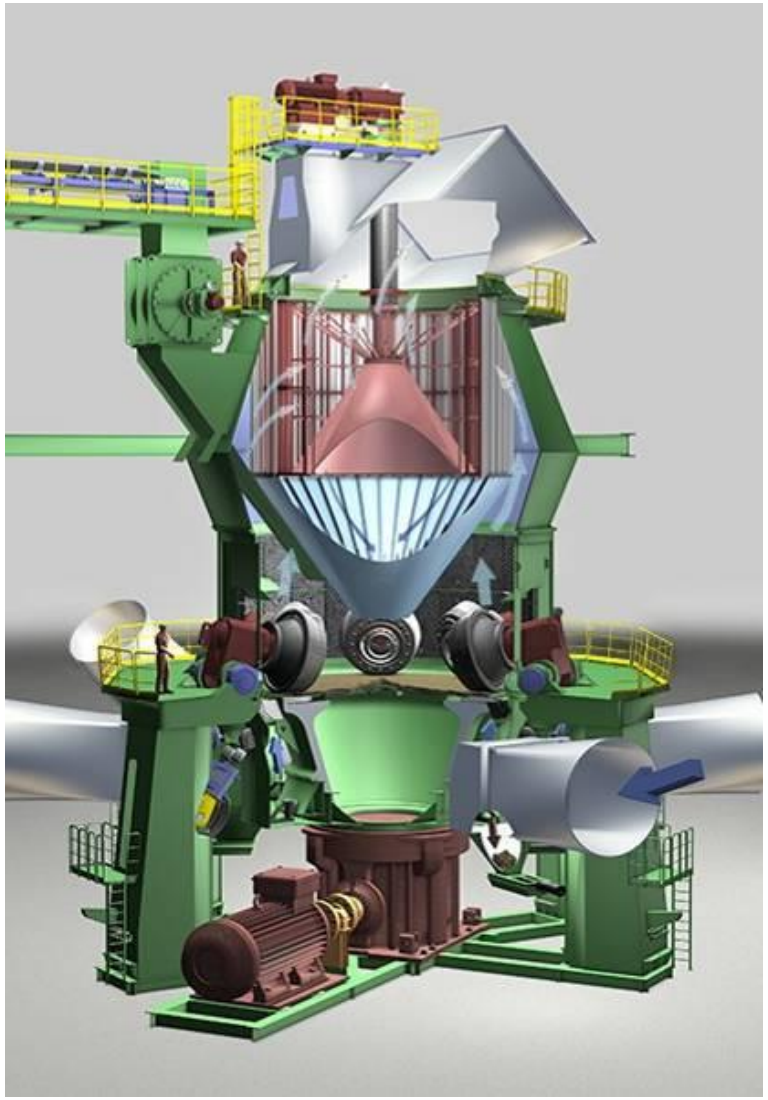
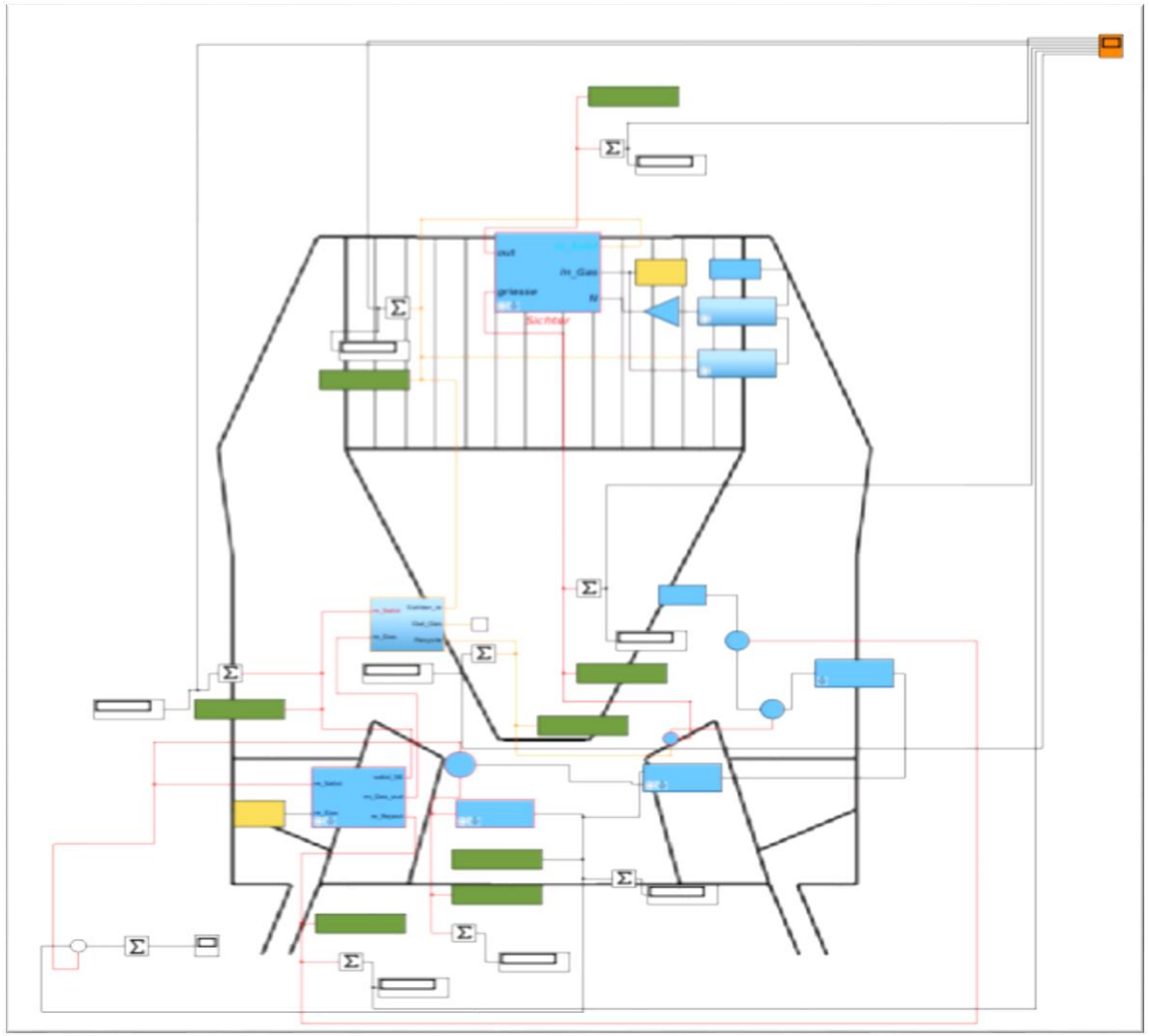
Vertical Mill Principle





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Modeling with Barracuda @ aixprocess
Cement / Ore / Coal Mills

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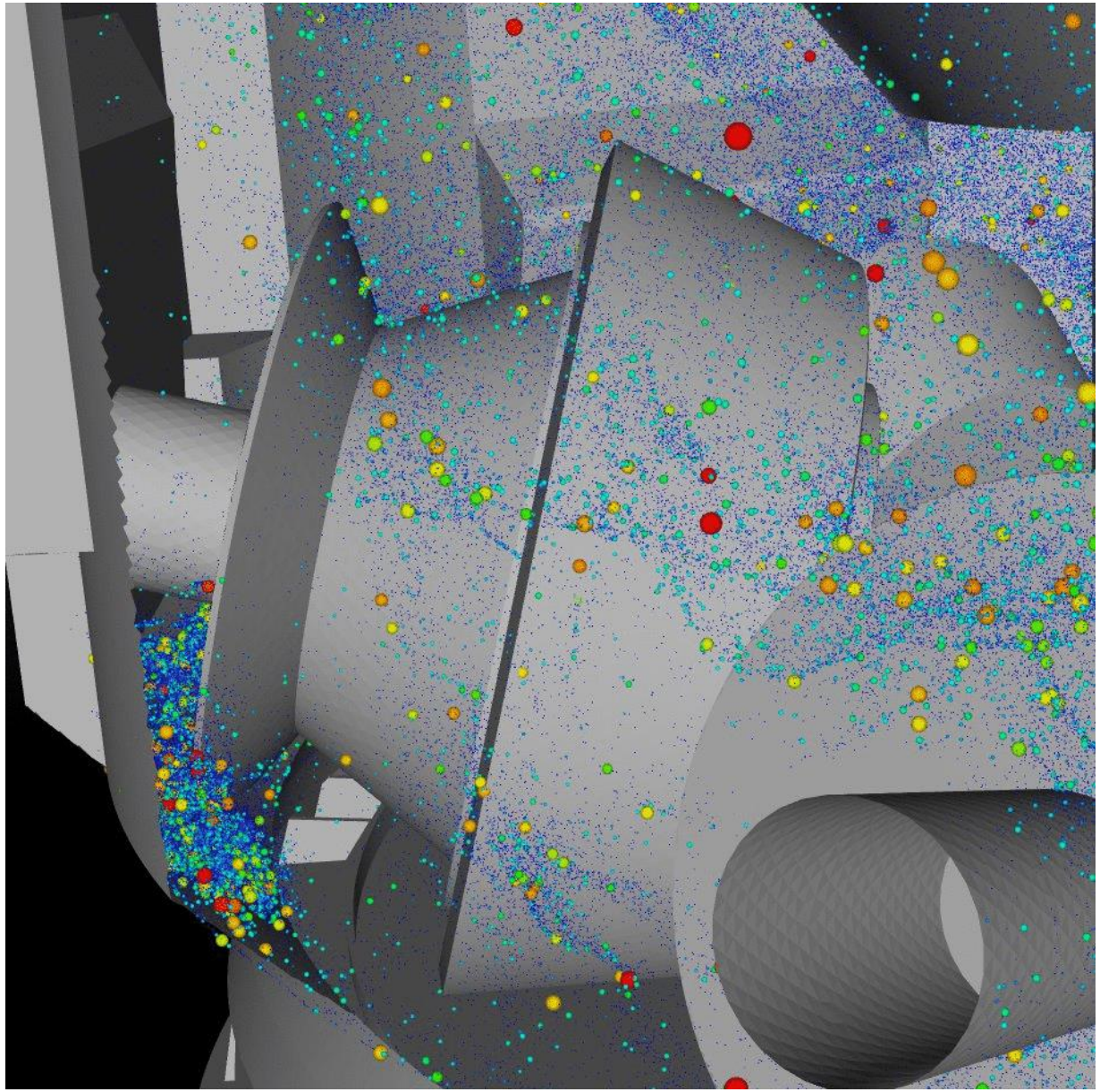

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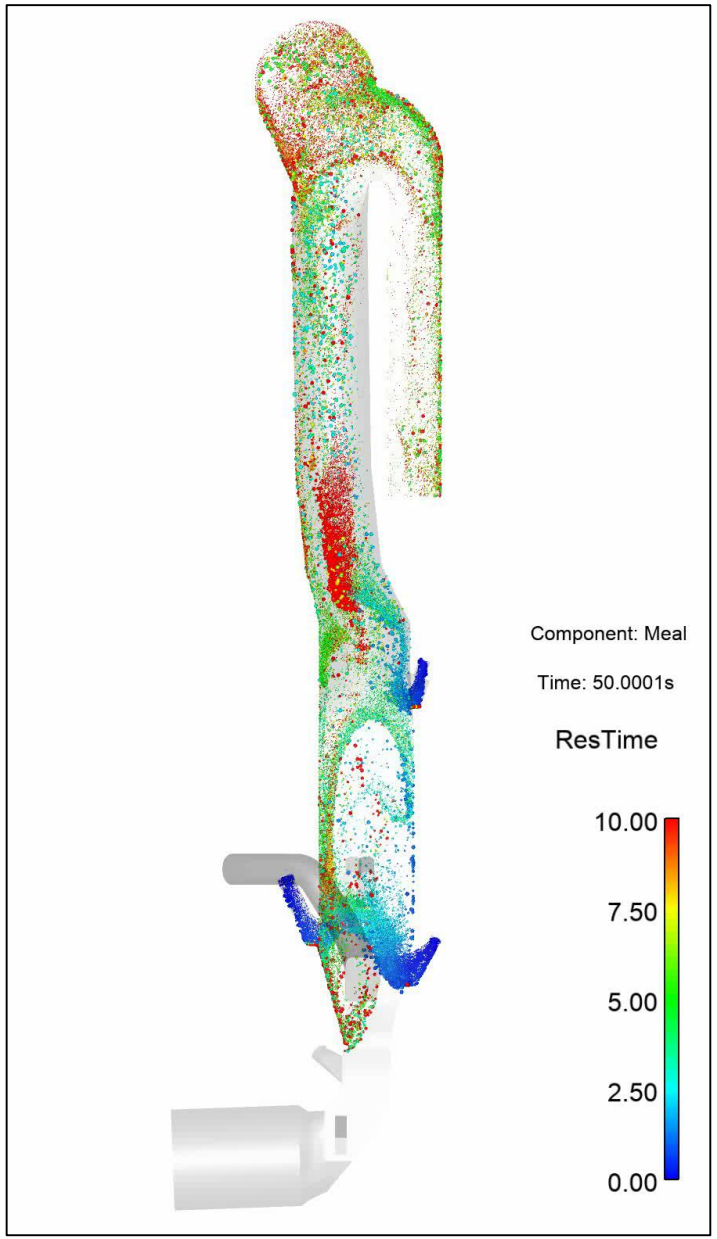
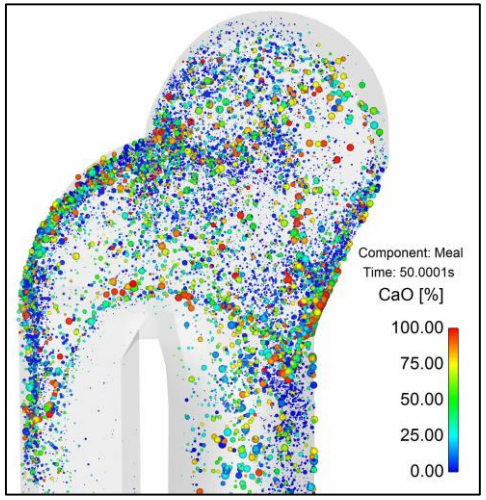
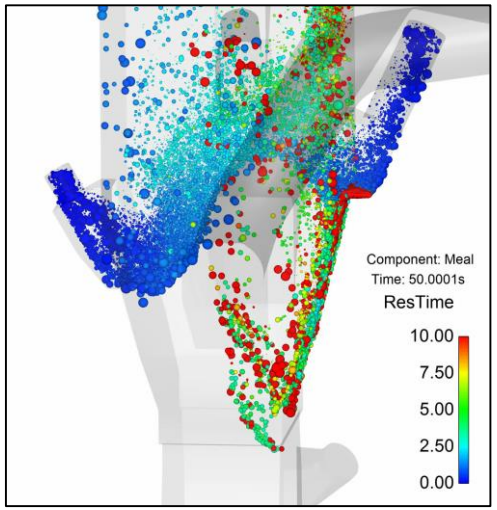
Modeling with Barracuda @ aixprocess
Cement Calciner



Right side view total



Left side view – Zoom to top



Left side view – Zoom to bottom

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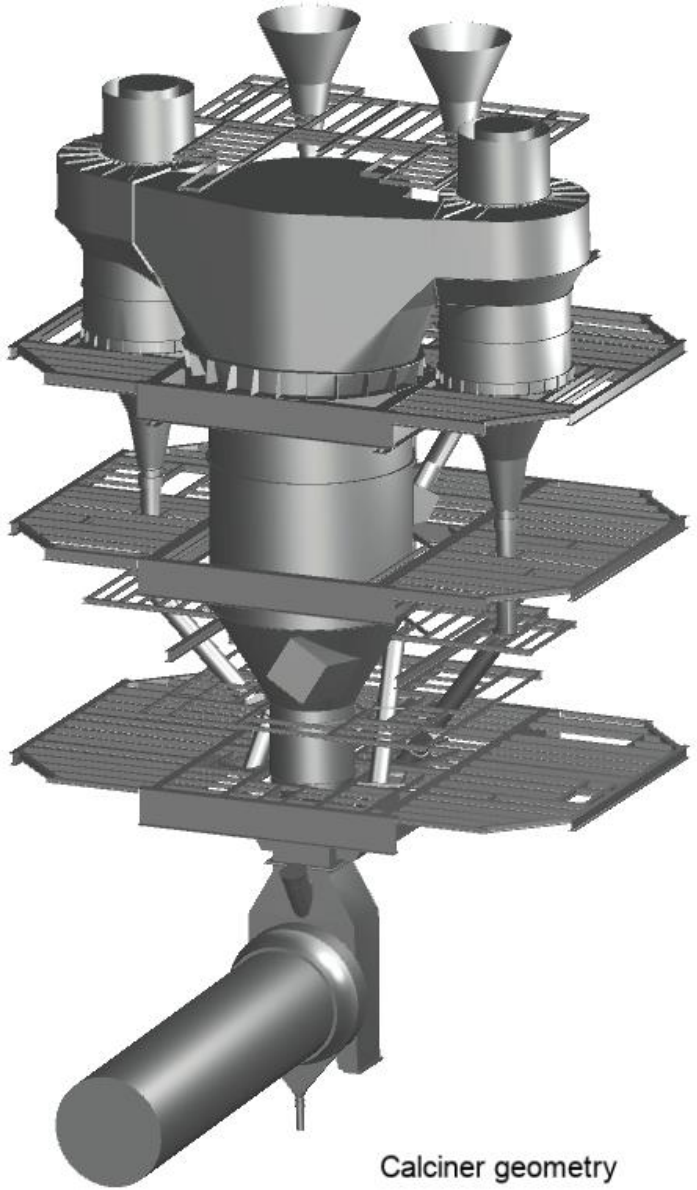
Modeling with Barracuda @ aixprocess
Cement Calciner



Calciner geometry

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Missing Functionality in Barracuda

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Detailed Geometry Representation

Moving Parts

Heat Transfer through Walls

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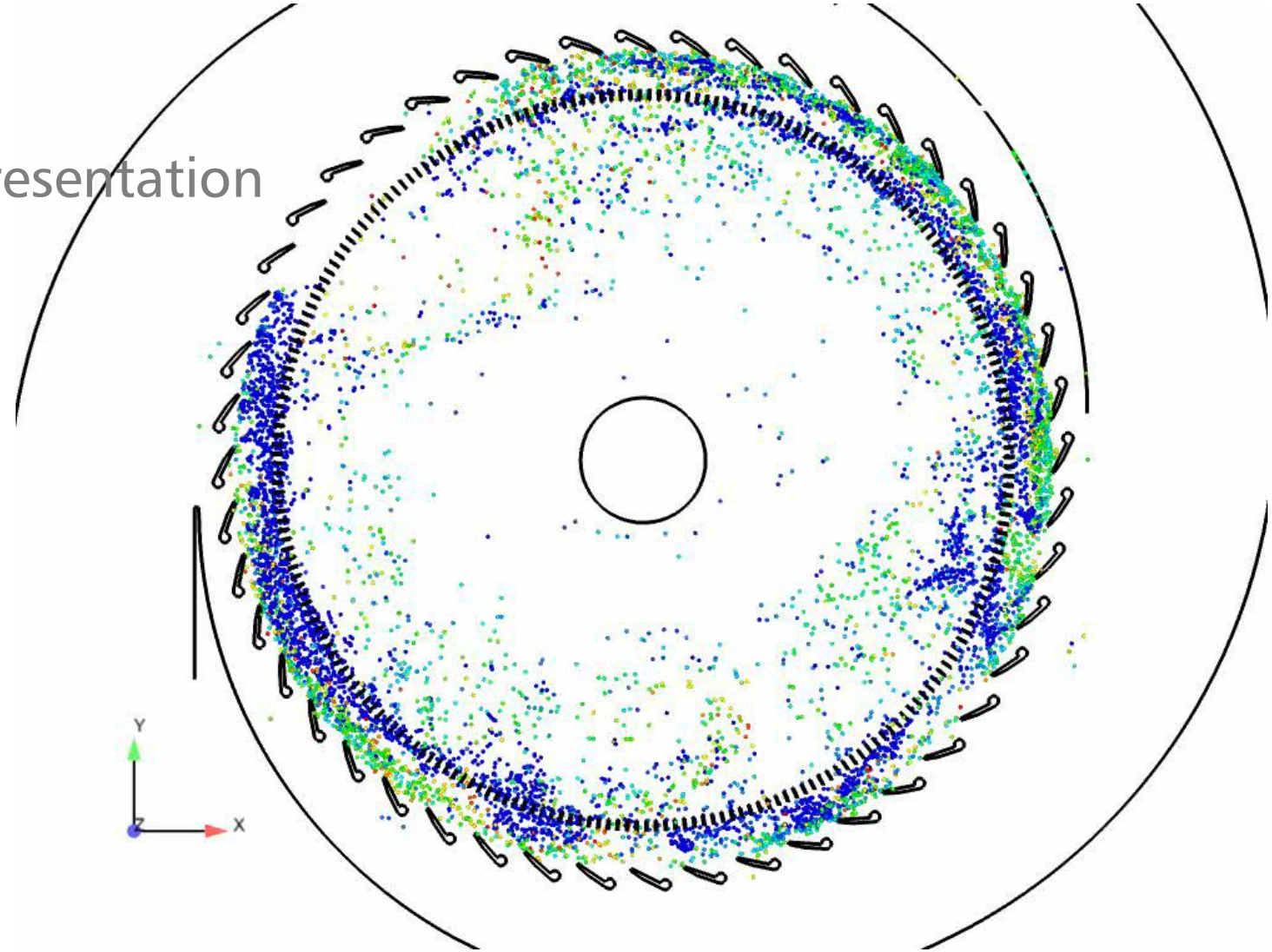
Detailed Geometry Representation

Moving Parts



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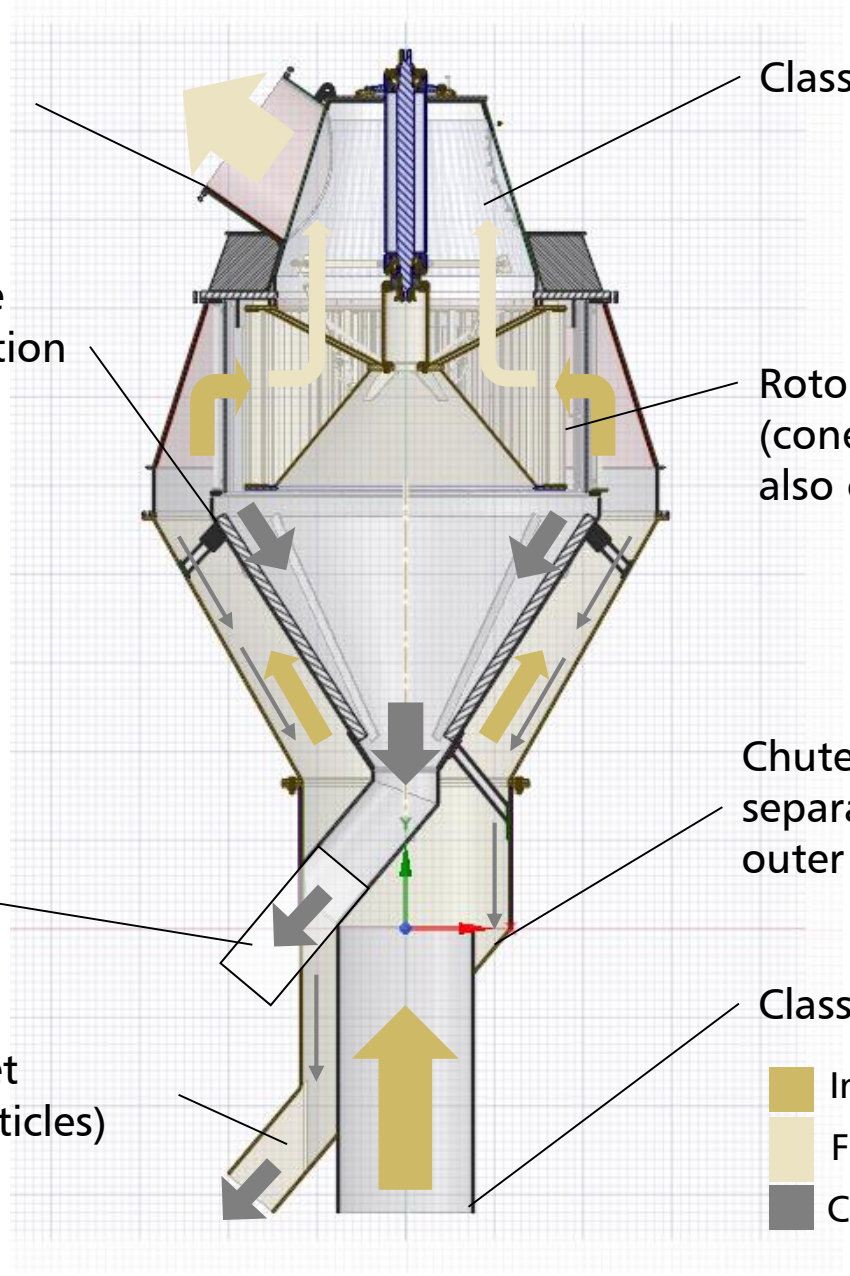
Exemplary Dynamic Classifier Principle



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Combination of CFD Tools
Allothermal Biomass Gasification

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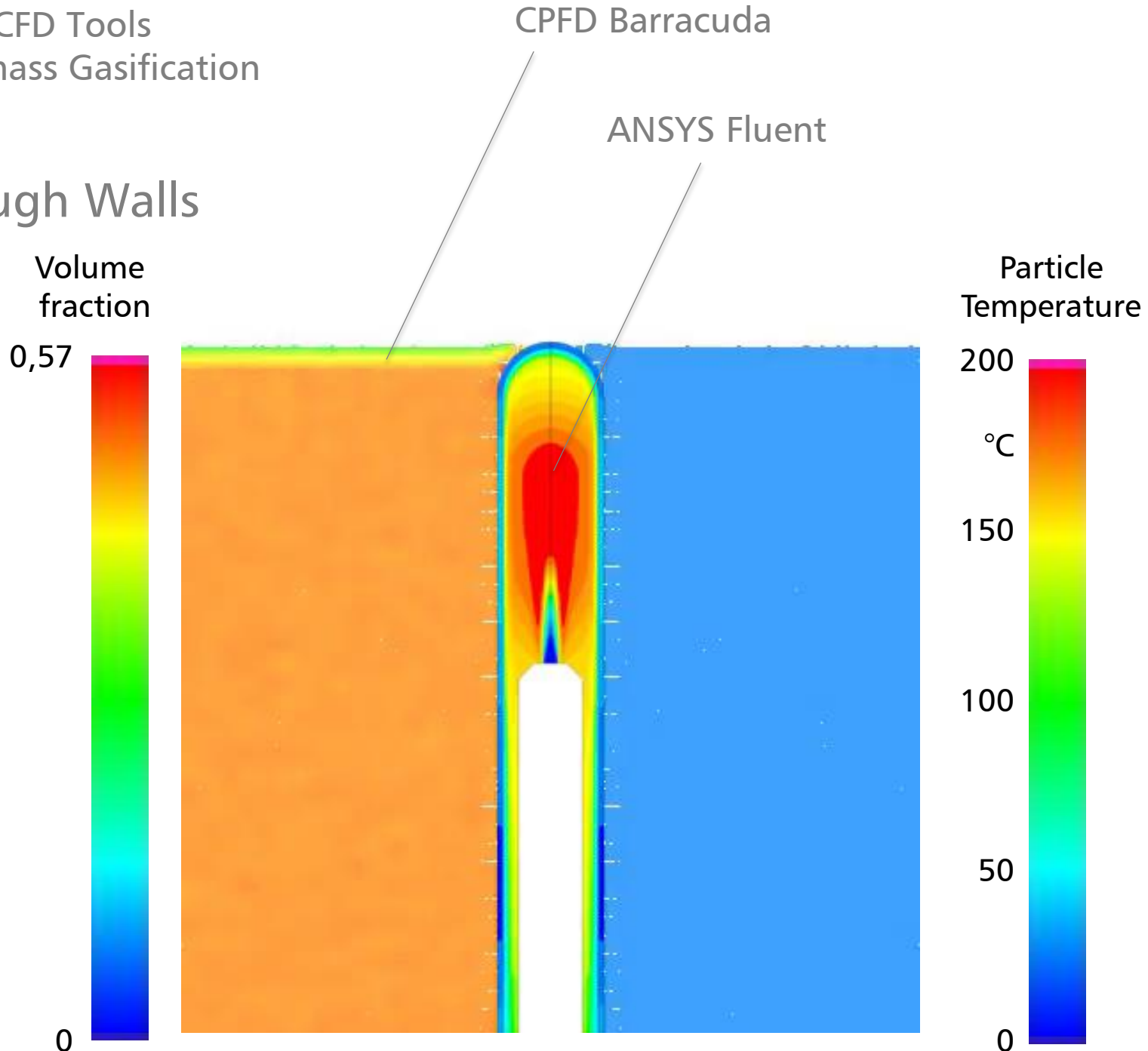
Heat Transfer through Walls



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all examples have one thing in common:

Very Detailed Analysis!

What About the Plant?

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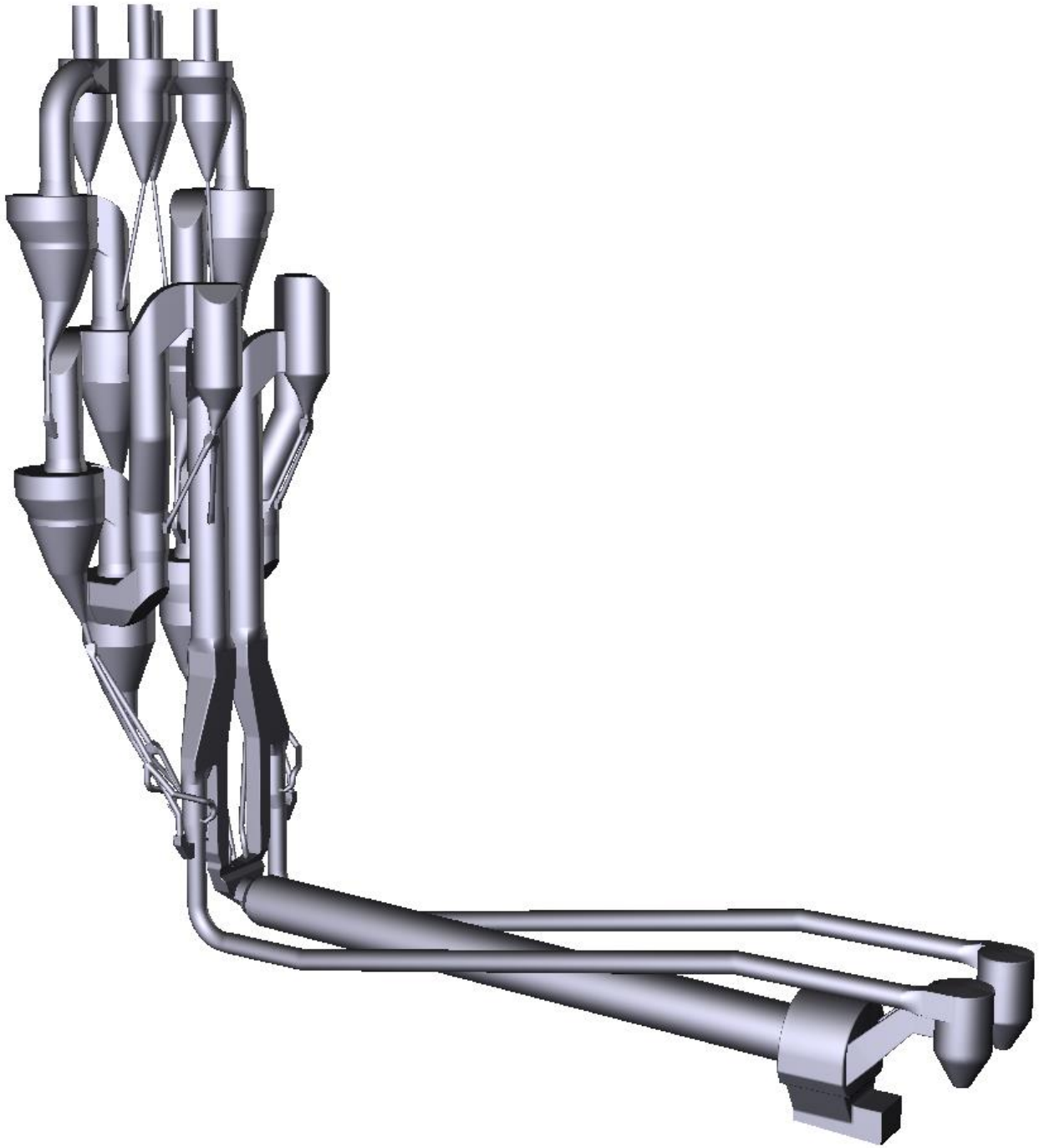
Cement Plant



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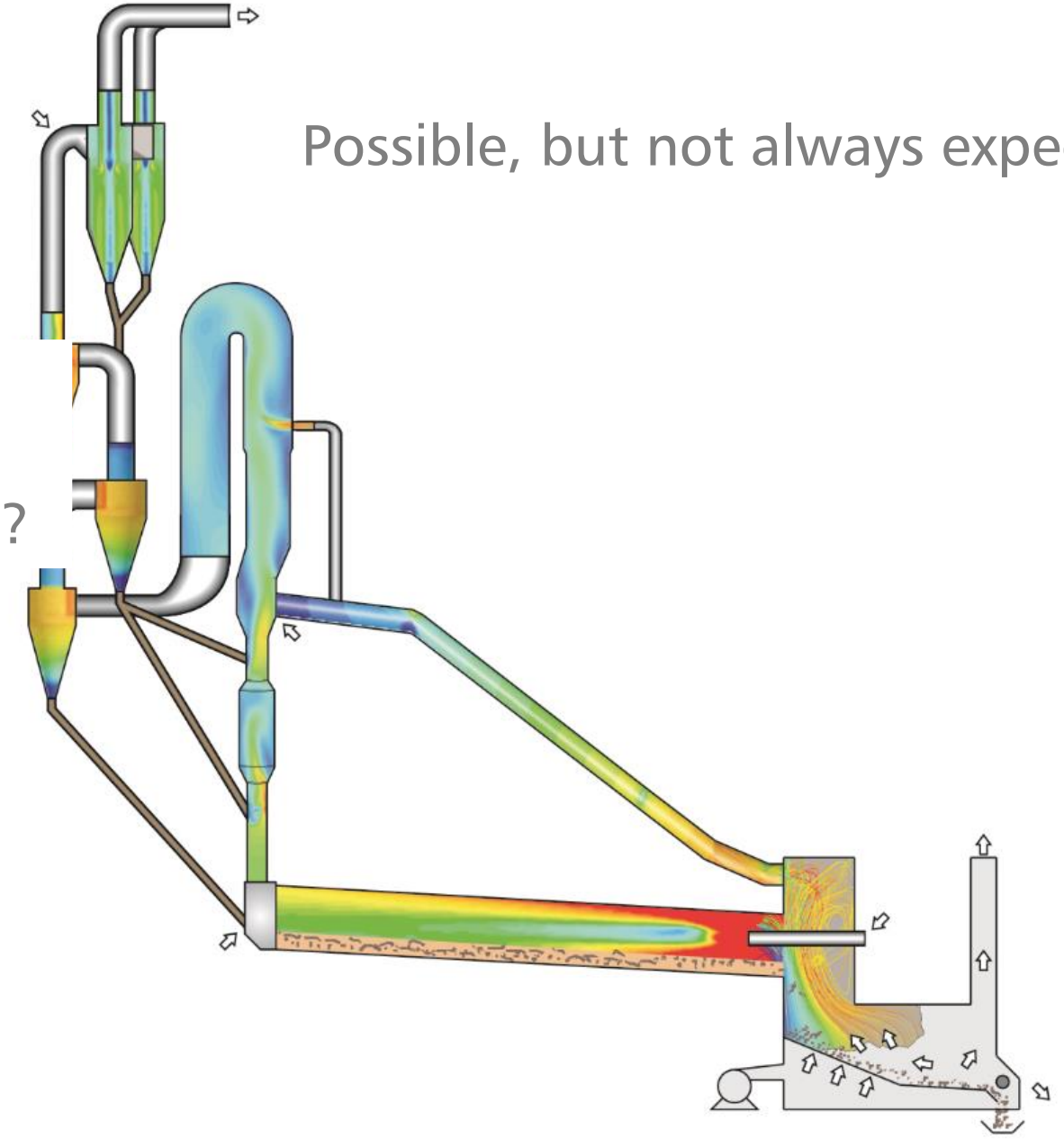
Cement Plant

Possible, but not always expedient!

Closed detailed analysis?

Series of separate analyses?



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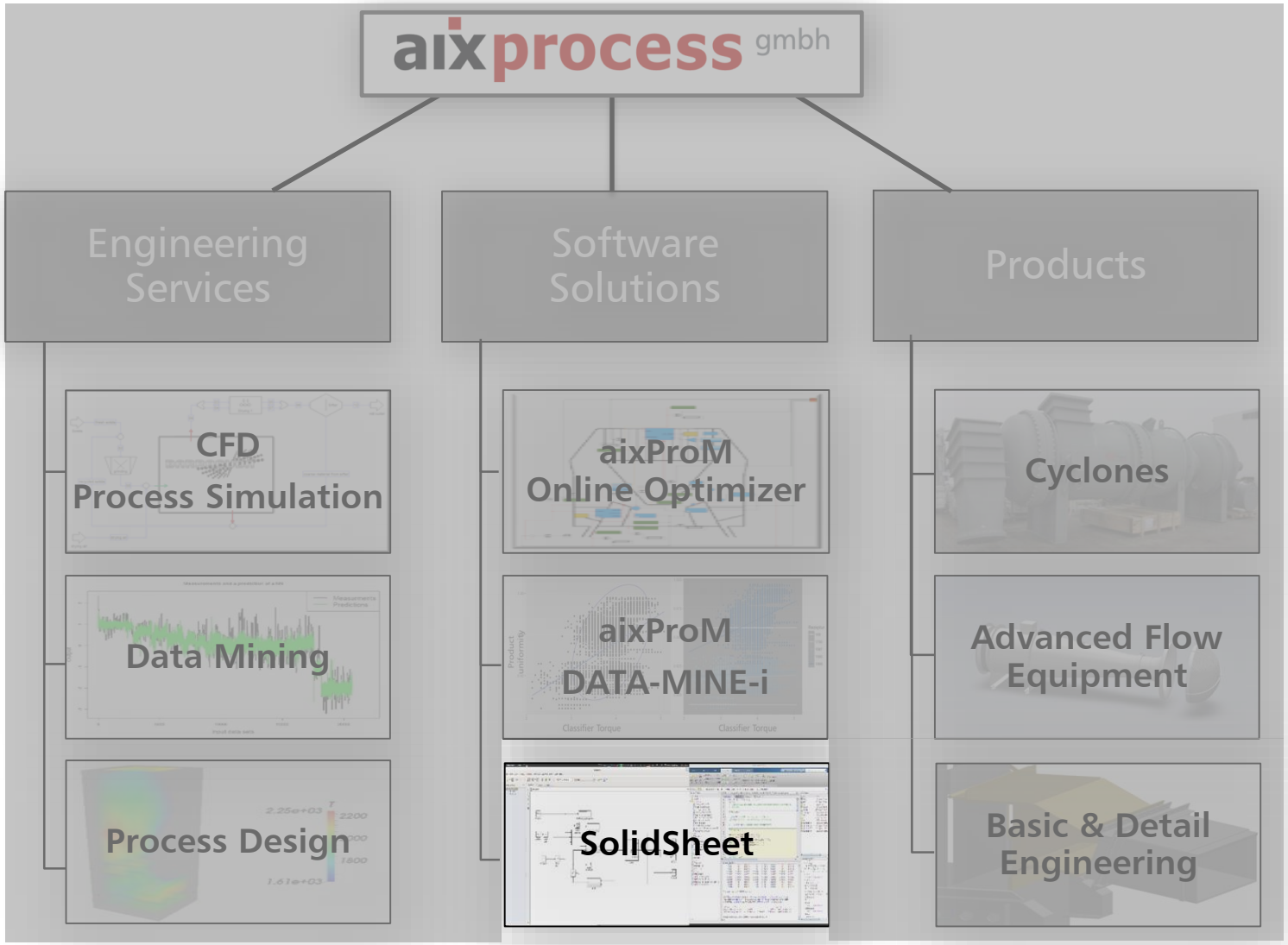

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Dynamic Process Model of the Preheater Tower & Calciner

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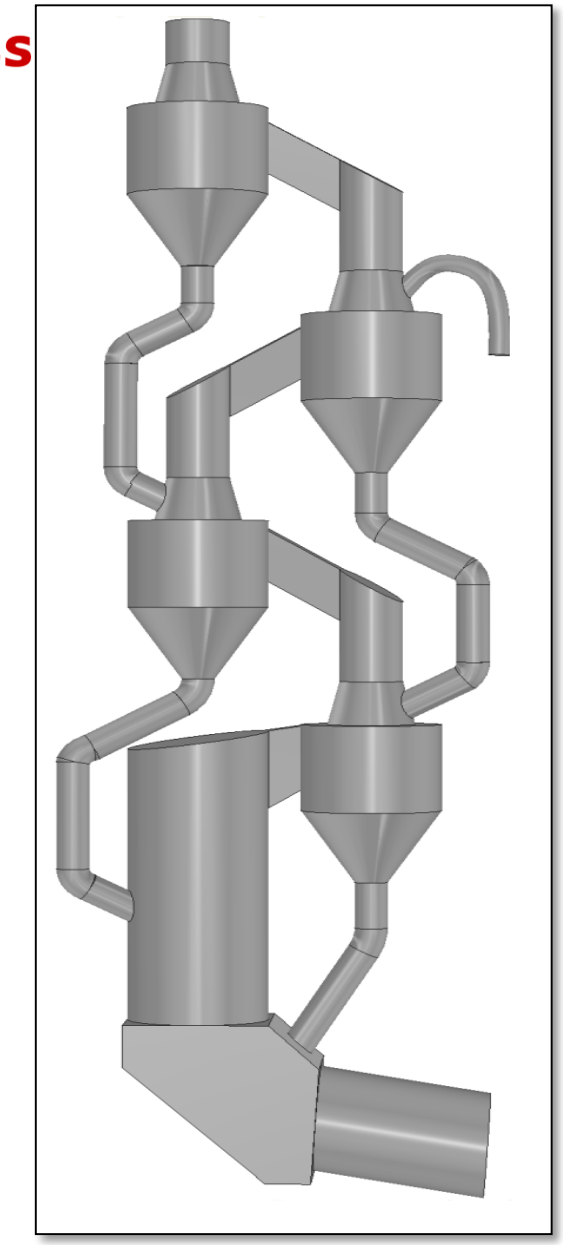

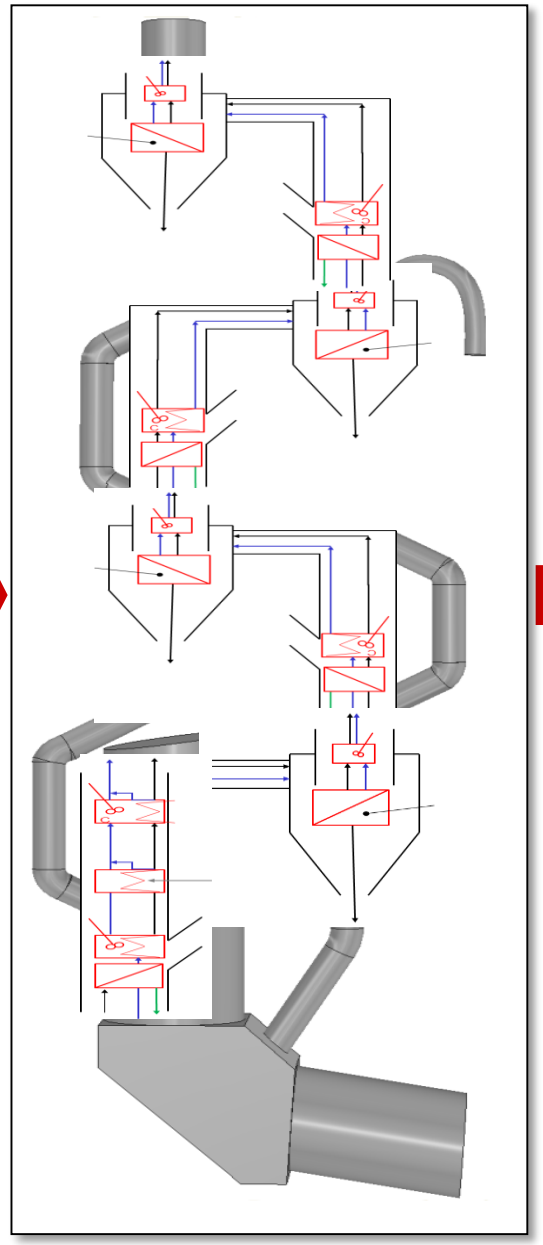

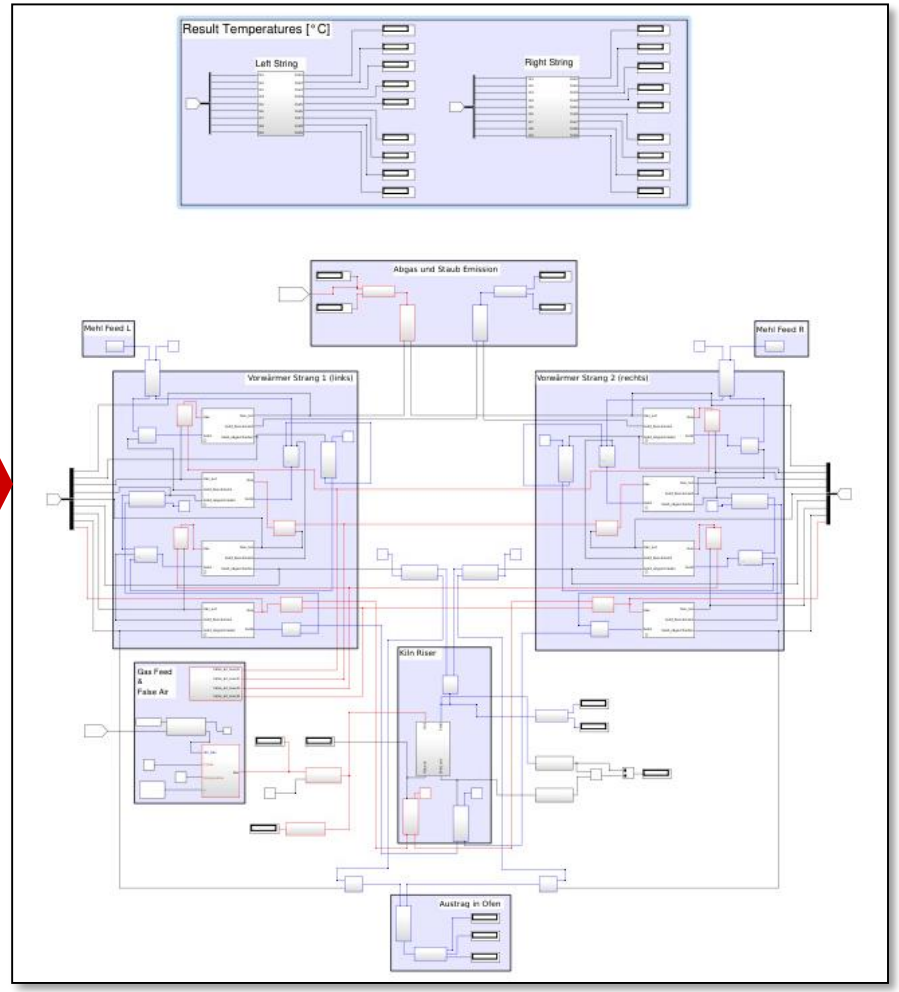

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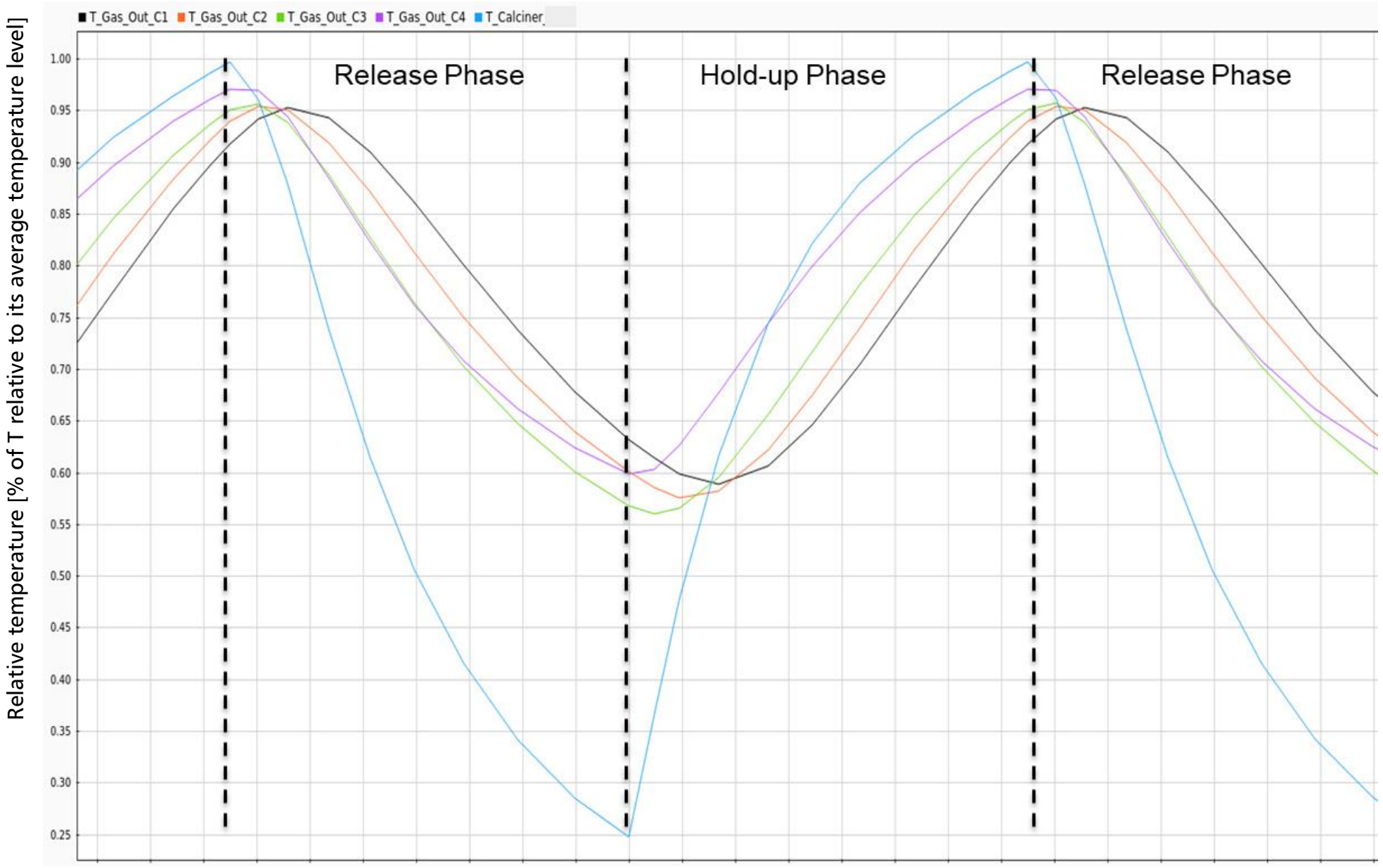
Dynamic Process Model Results



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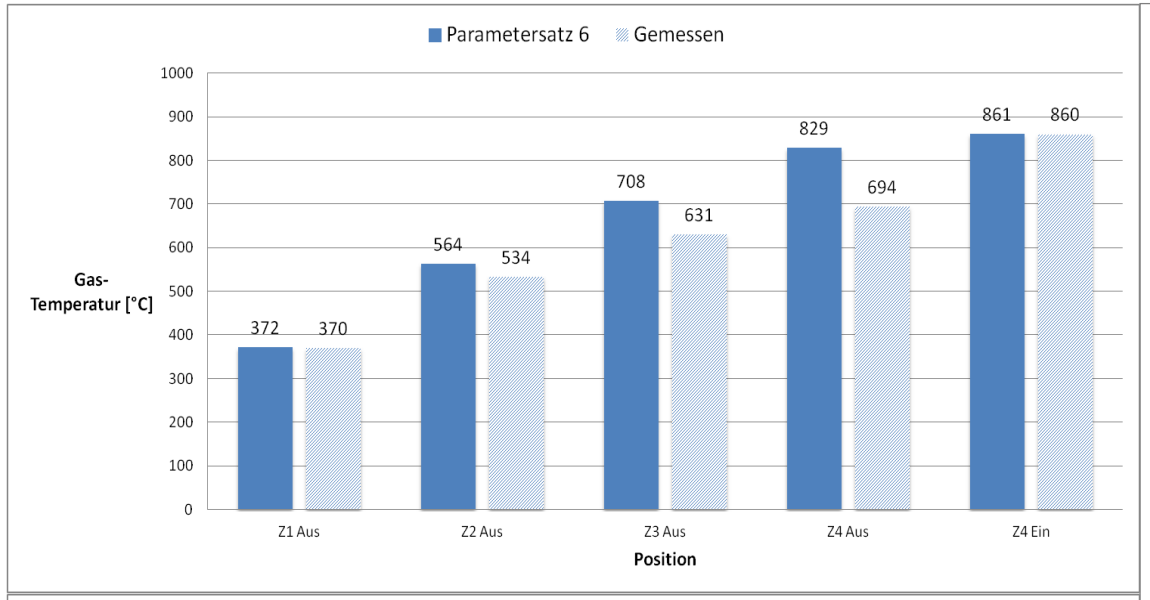
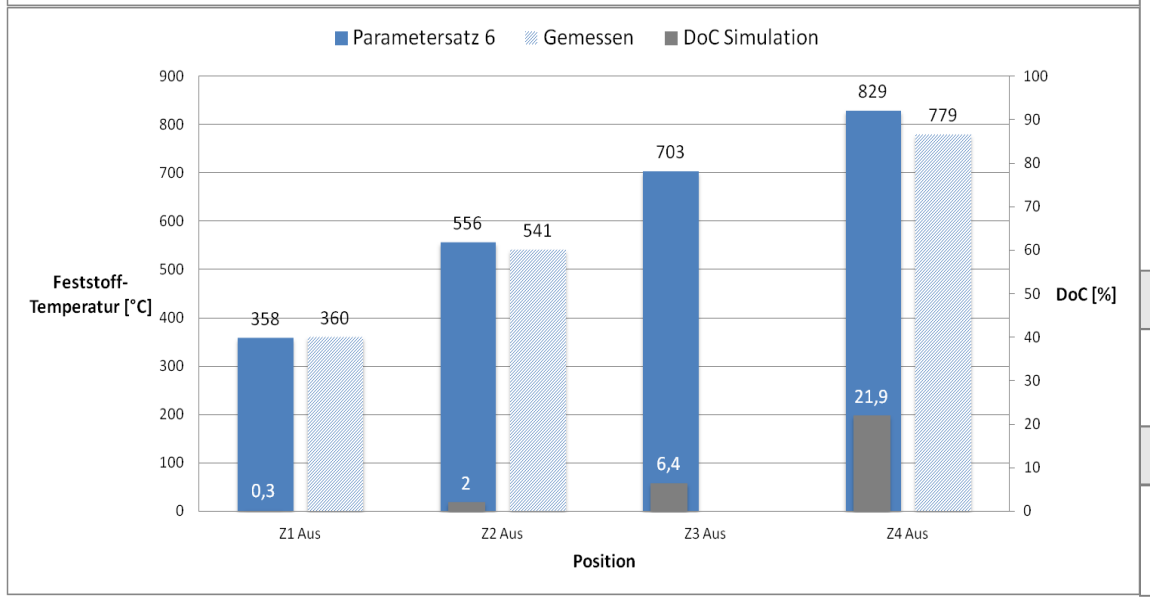
Dynamic Process Model Results





Modell-Parameter:
Mit Falschluft (Gesamt *11 % des Abgasmassenstroms*)
S1: 50 %
S2: 30 %
S3: 10 %
S4: 10 %

Abscheidegrade:
$\eta_{ab,Z1}$: 0,95 %
$\eta_{ab,Z2}$: 0,88 %
$\eta_{ab,Z3}$: 0,75 %
$\eta_{ab,Z4}$: 0,70 %

Wärmeübertragung:
$\eta_{WT,Z1}$: 96 %
$\eta_{WT,Z2}$: 96 %
$\eta_{WT,Z3}$: 96 %

Suspension:
$\eta_{sus,Z1}$: 90 %
$\eta_{sus,Z2}$: 90 %
$\eta_{sus,Z3}$: 90 %
$\eta_{sus,calc}$: 90 %

Staubmitriss aus dem Ofen:
10 % des Rohmehls
(*keine vollst. Kalzination*)

Abgasstrom:	
Simulation: 1,6 Nm^3/kg_{kli}	**Gemessen:** Unbekannt
Staubemission:	
Simulation: 107 g/Nm^3	**Gemessen:** Unbekannt

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Dynamic Process Model Cement Plant

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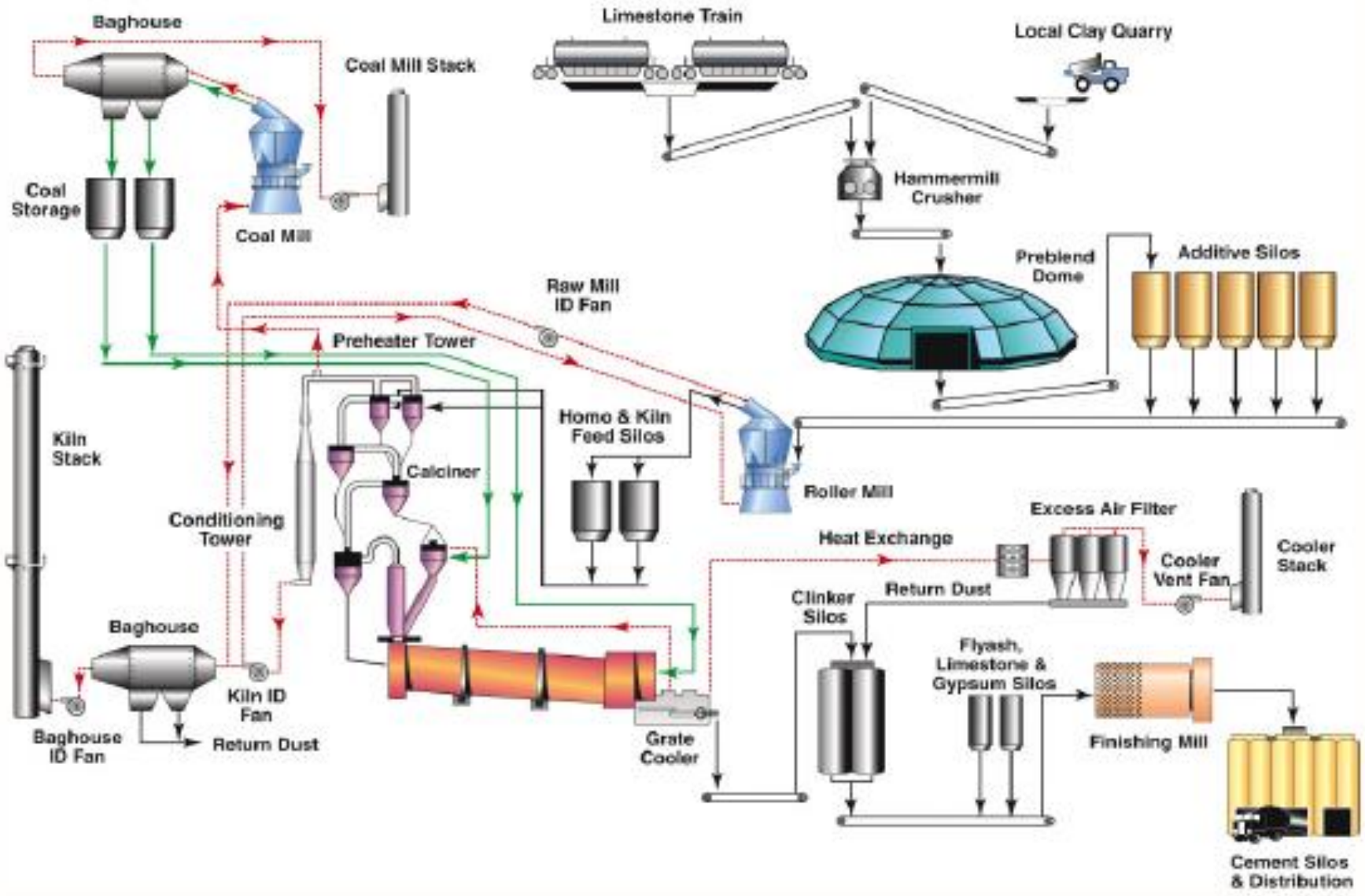

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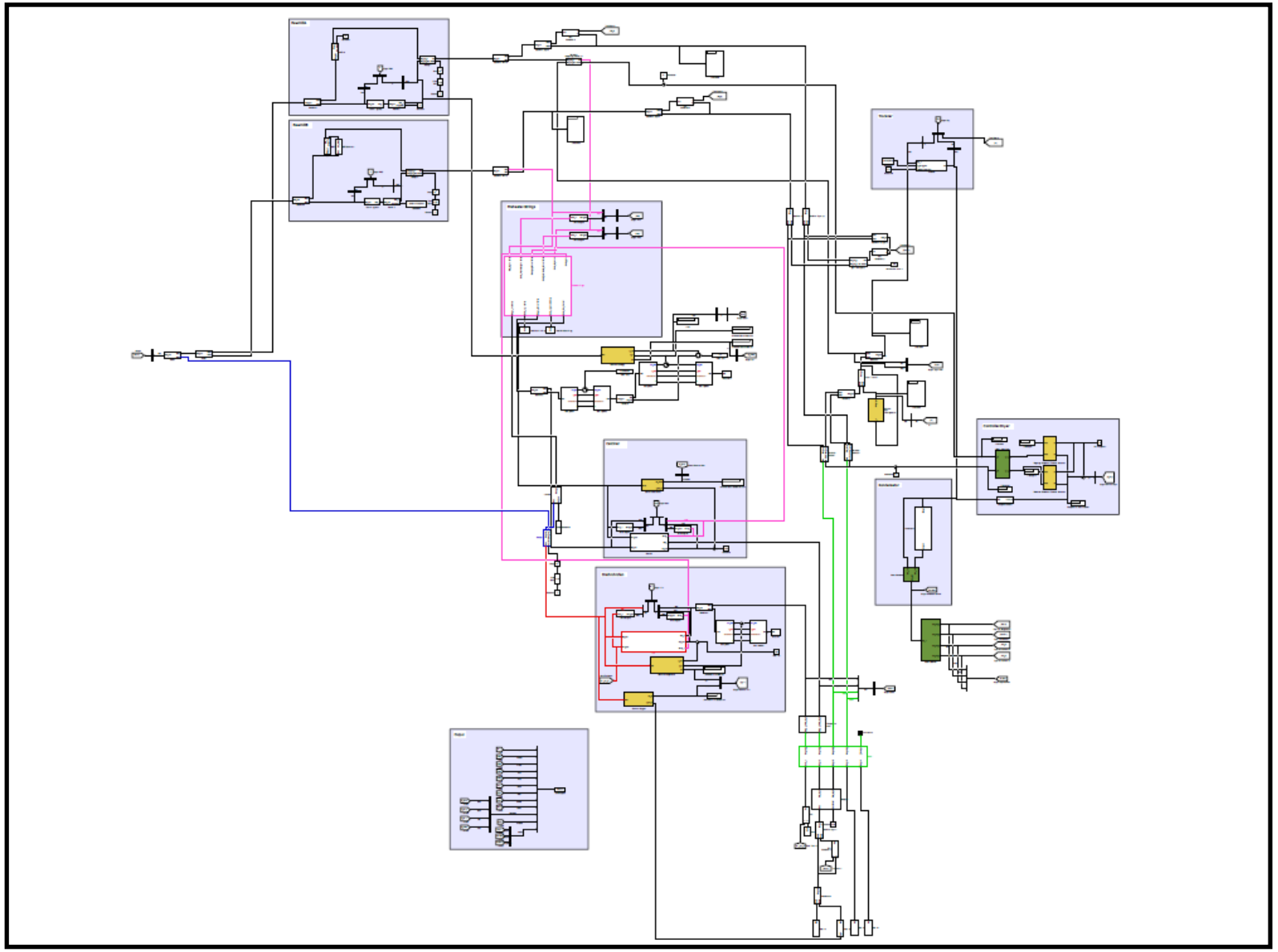
Dynamic Process Model Cement Plant

Integration Of A Dryer Into A Complex Dynamic Plant Flowsheet Model



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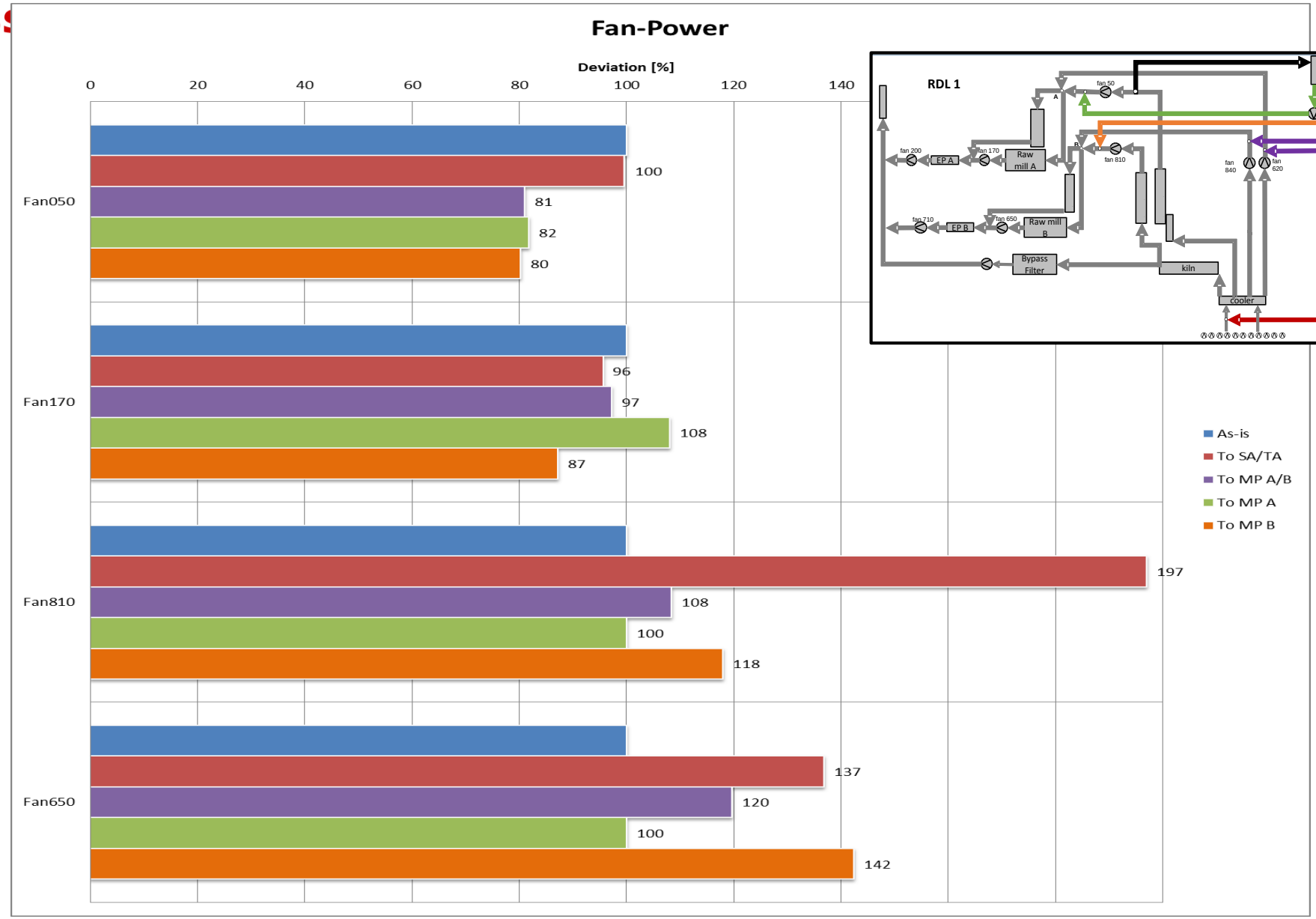
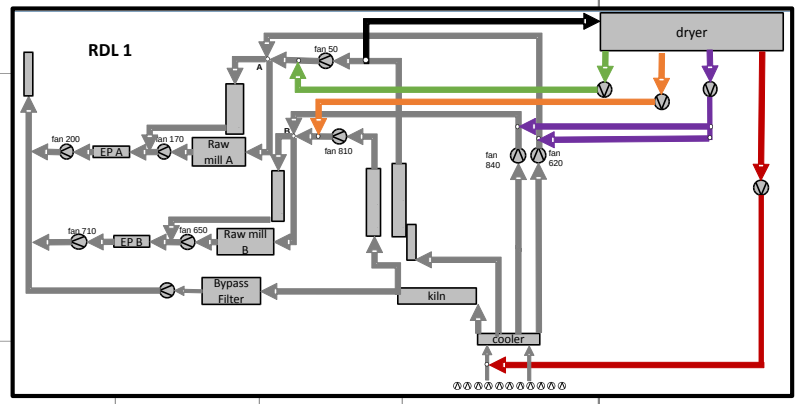
Results Plant Simulation: Required Fan Power





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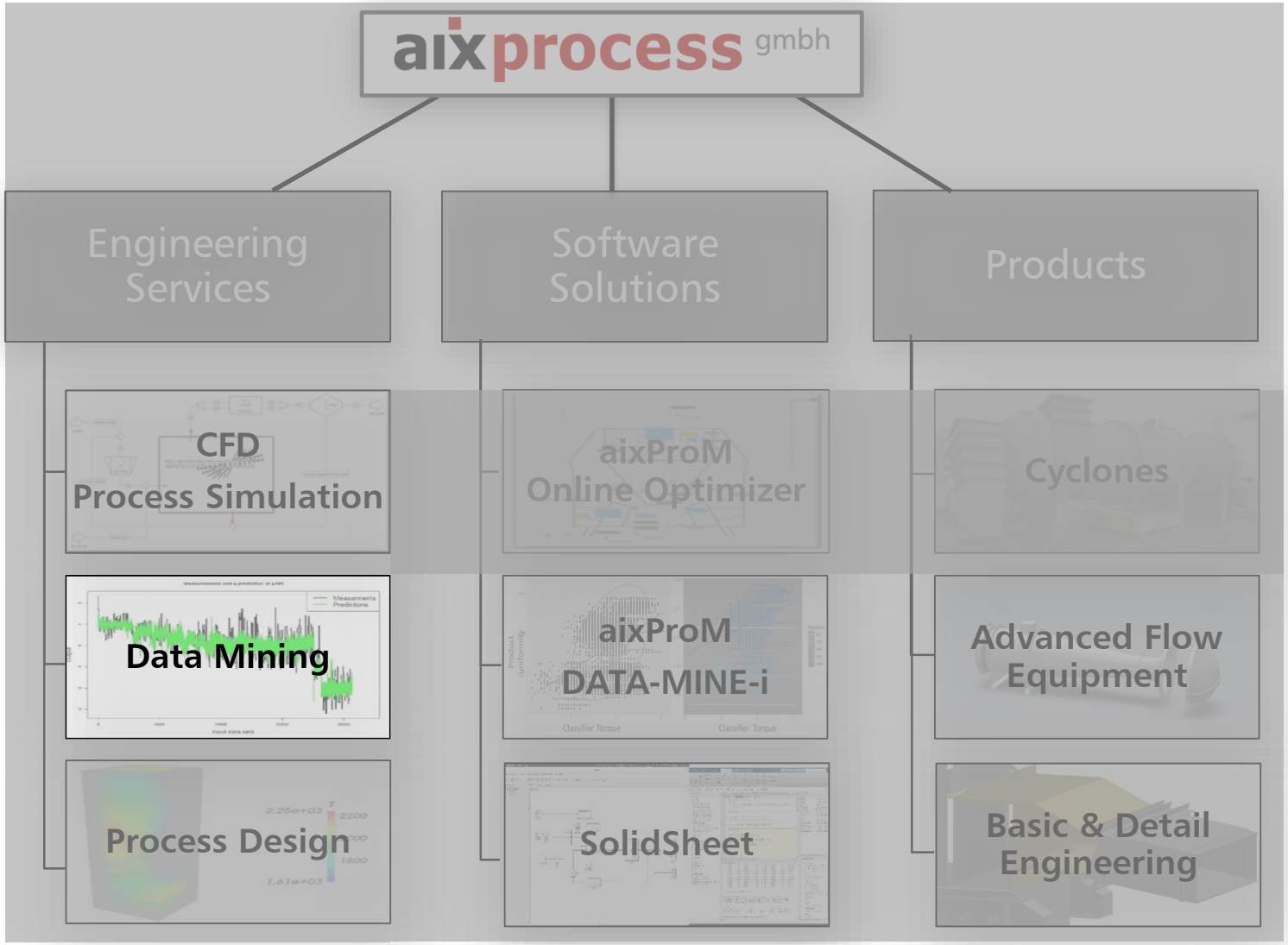

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Measured process parameters from the PCS

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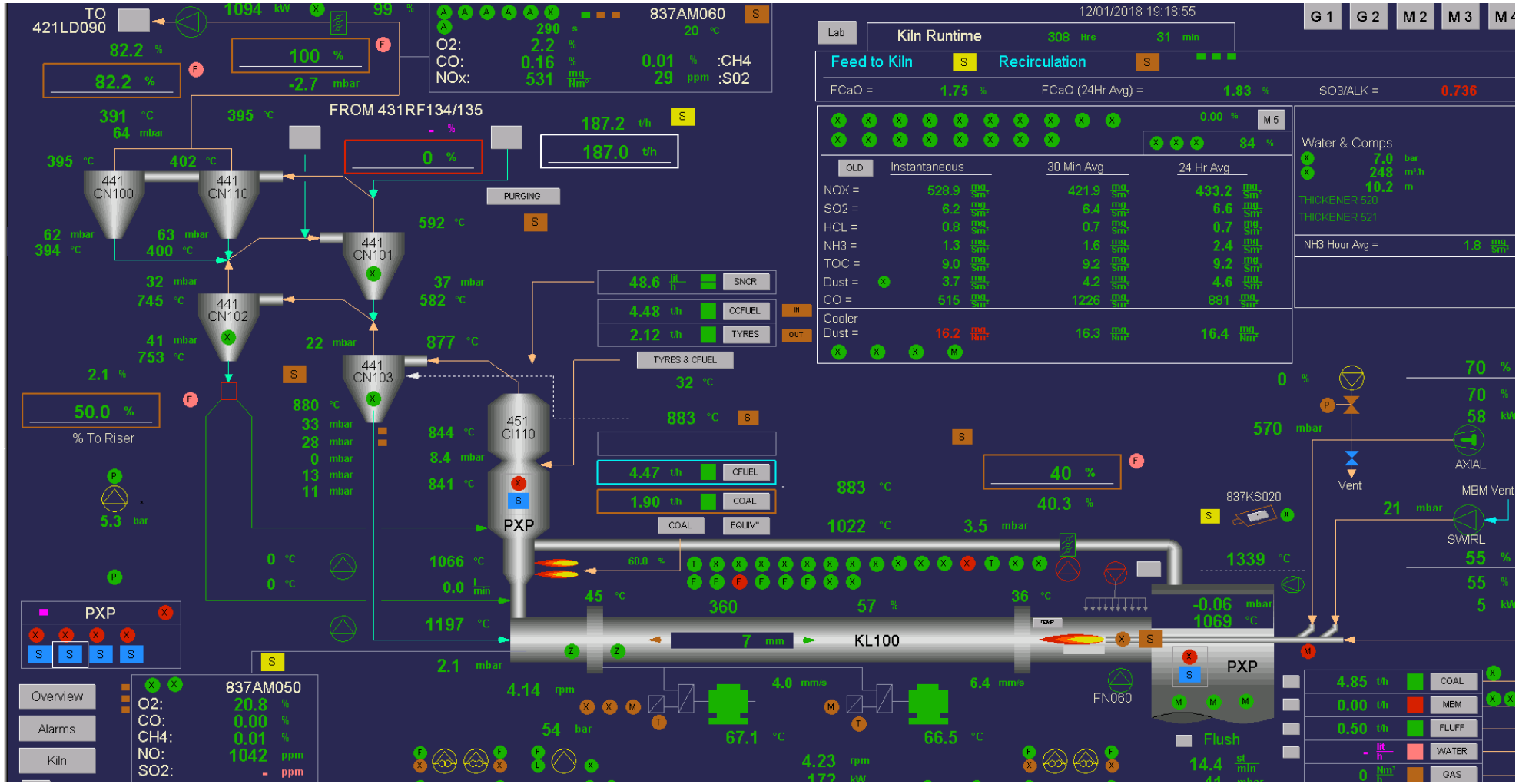

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Data Acquisition and Preperation

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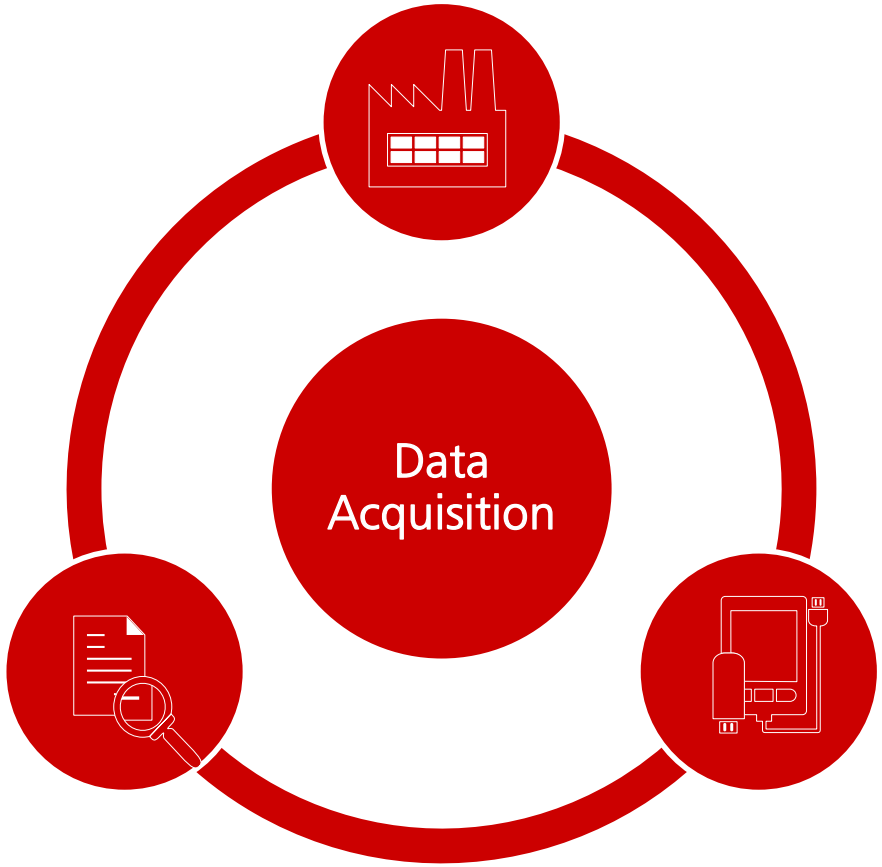
Plant Site
- Data availability
- Description
- Problem statement

Data collection
- Organization
- Documentation

Data filtration
- Filter data
- Select data
- Tidy data



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Data Set

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Control Data

ECS679	441CN103N01T01	CN103 Gas Tmp - 481BU781	C001
ECS679	481PP200I01_SPA	Calc. Coal Feed Control	C002
ECS679	481PP200I01_SPM	Belt Conveyor Current	C003
ECS679	481PP200A01F01	Pfister Feeder Flow	C004
ECS679	461KL100I01_SPM	Kiln Speed Control	C005
ECS679	461MD160U01S01	Kiln Drive Motor Speed	C006
ECS679	461MD160U01J01	Kiln Drive Shaft Power	C007
ECS679	471KH100N02P01	Kiln Hood Pressure	C008
ECS679	471FN550I01_SPA	Pressure Control	C009
ECS679	471FN550I01_SPM	Pressure Control	C010
ECS679	471FN550U01S01	Cooler Filter Fan Motor	C011
ECS679	471CN600N02P01	Cooler Hot Air Pressure	C012
ECS679	471FN700I01_SPA	Pressure Control	C013
ECS679	471FN700U01S01	Hot Gas Fan Motor Speed	C014
ECS679	431FB170A01W01	Hot Gas Fan Motor Speed	C015
ECS679	431FB170A01F11	LOW feeder aut. feed SP	C016
ECS679	431FB170A01X07	LOW model Zmodel	C017
ECS679	431FB170A01Z13	Flow gates divided SP	C018
ECS679	431FB170A01Z12	Flow gate pos correction	C019
ECS679	431FB170A01X06	LOW flow errror after PI	C020
ECS679	431FB170A01F21	LOW feeder flow error	C021
ECS679	431FB170A01X01	LOW model constant X1	C022
ECS679	431FB170A01X01	LOW model constant X1	C023
ECS679	431FB170A01X03	LOW model constant X3	C024
ECS679	431FB170A01F01	LOW feeder actual feed	C025
ECS679	431FG172M01Z21	Flow gate setpoint	C026
ECS679	431FG172M01X01	Flow gate motor torque	C027
ECS679	431FG172M01Z01	Flow gate position	C028
ECS679	431FG172M01Z02	Flow gate pos. error	C029
ECS679	431FG174M01Z01	Flow gate position	C030
ECS679	431FG174M01X01	Flow gate motor torque	C031
ECS679	431FG174M01Z21	Flow gate setpoint	C032
ECS679	431FG174M01Z02	Flow gate pos. error	C033
ECS679	431FB170A01Z11	LOW manual setpoint	C034
ECS679	431BF170A01Z12	Flow gate man sp,	C035
ECS679	431FB170A01Z01	LOW model Zmodel	C036
ECS679	431FB170A01K01	CF silo sequence time	C037

Gas Data

ECS679	837AM050A01A01	Gas Analyser % O2	C048
ECS679	837AM050A01A02	Gas Analyser % CO	C049
ECS679	837AM050A01A04	Gas Analyser % CH4	C050
ECS679	837AM050A01A03	Gas Analyser ppm NO	C051
ECS679	837AM050A01A05	Gas Analyser ppm SO2	C052
ECS679	837AM060A01A01	Gas Analyser % O2	C053
ECS679	837AM060A01A02	Gas Analyser % CO	C054
ECS679	481FN740N01F01	Primary Air Flow	C055
ECS679	837AM060A01A04	Gas Analyser % CH4	C056
ECS679	837AM060A01A06	Gas Analyser ppm SO2	C057
		Sampling Time	C000
ECS679	421FN090U01S01	ID Fan Motor Speed	C058
ECS679	421FN090U01J01	ID Fan Motor Shaft Power	C059
ECS679	461KL100A01S01	Kiln Speed	C060

Temperature Data

ECS679	441CN100N05T01	Cyclones Exit Temp.	C105
ECS679	441CN100N06T01	Lower Cyclone Exit Temp	C106
ECS679	441CN100N01T01	Cyclone CN100 Gas Temp.	C107
ECS679	441CN100N03T01	Cyclone CN100 Matr. Temp	C108
ECS679	441CN110N03T01	Cyclone CN110 Matr. Temp	C109
ECS679	441CN101N01T01	Cyclone CN101 Gas Temp.	C110
ECS679	441CN101N03T01	Cyclone CN101 Matr. Temp	C111
ECS679	441CN102N01T01	Cyclone CN102 Gas Temp.	C112
ECS679	441CN102N03T01	Cyclone CN102 Matr. Temp	C113
ECS679	441CNN103N01T01	Orig Cycl Temp Direct IP	C114
ECS679	441CN103N01T01	CN103 Gas Tmp - 481BU781	C115
ECS679	441CN103N03T01	CN103 Gas Tmp - 481BU781	C116
ECS679	451CI110N01T01	Calc. Reduct. Zone Temp.	C117
ECS679	451CI110N02T01	Calc. Reduct. Zone Temp.	C118
ECS679	451CI110N03T01	Tertiary Air Duct Temp.	C119
ECS679	837KS060N01T01	Calc. Reduct. Zone Temp.	C120
ECS679	837KS030N01T01	Kiln Inlet Pyrom. Temp.	C121
ECS679	837KS040N01T01	Burning Zone Temperature	C122

Pressure Data

ECS679	421FN090N02P01	After ID fan Pressure	C061
		lone CN100 Top Press	C062
		lone CN102 Top Press.	C063
		lone 2 bottom pressure	C064
		lone CN103 Top Press.	C065
		lone CN103 BottomPres	C066
		ciner Chute Pressure	C067
		tiary Air Duct Press.	C068
		n Inlet Pressure	C069
		n Hood Pressure	C070
		W feeder actual feed	C071
		irl Air Fan Pressure	C072
		rner Axial Blower Pressure	C073
		wing line Pressure	C074
		wing line Pressure	C075
		MS Rot.Valve Outlet Press	C076
		oler Hot Air Pressure	C077
		oler Filter Diff Press	C078

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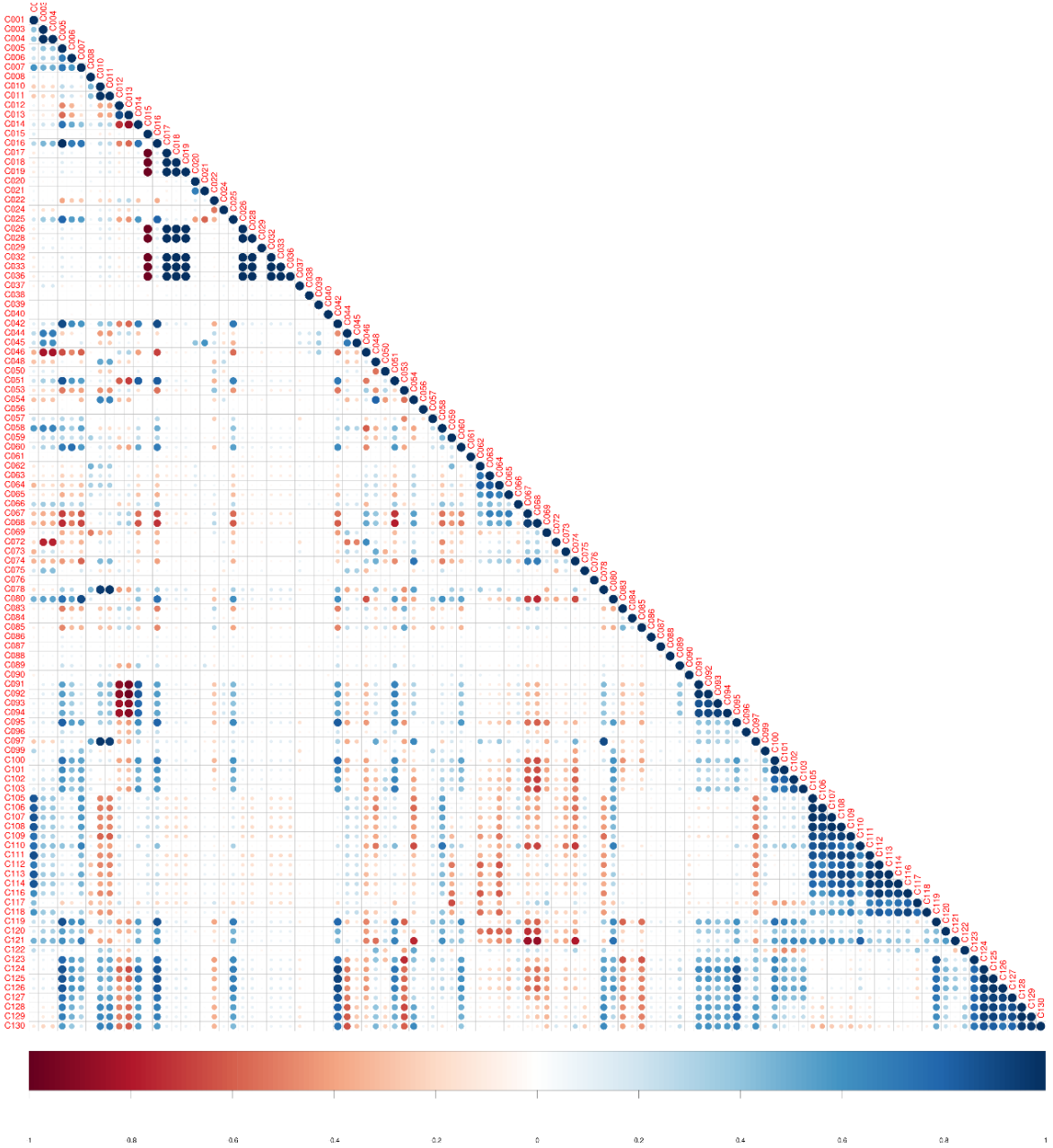
Correlation matrix full data set



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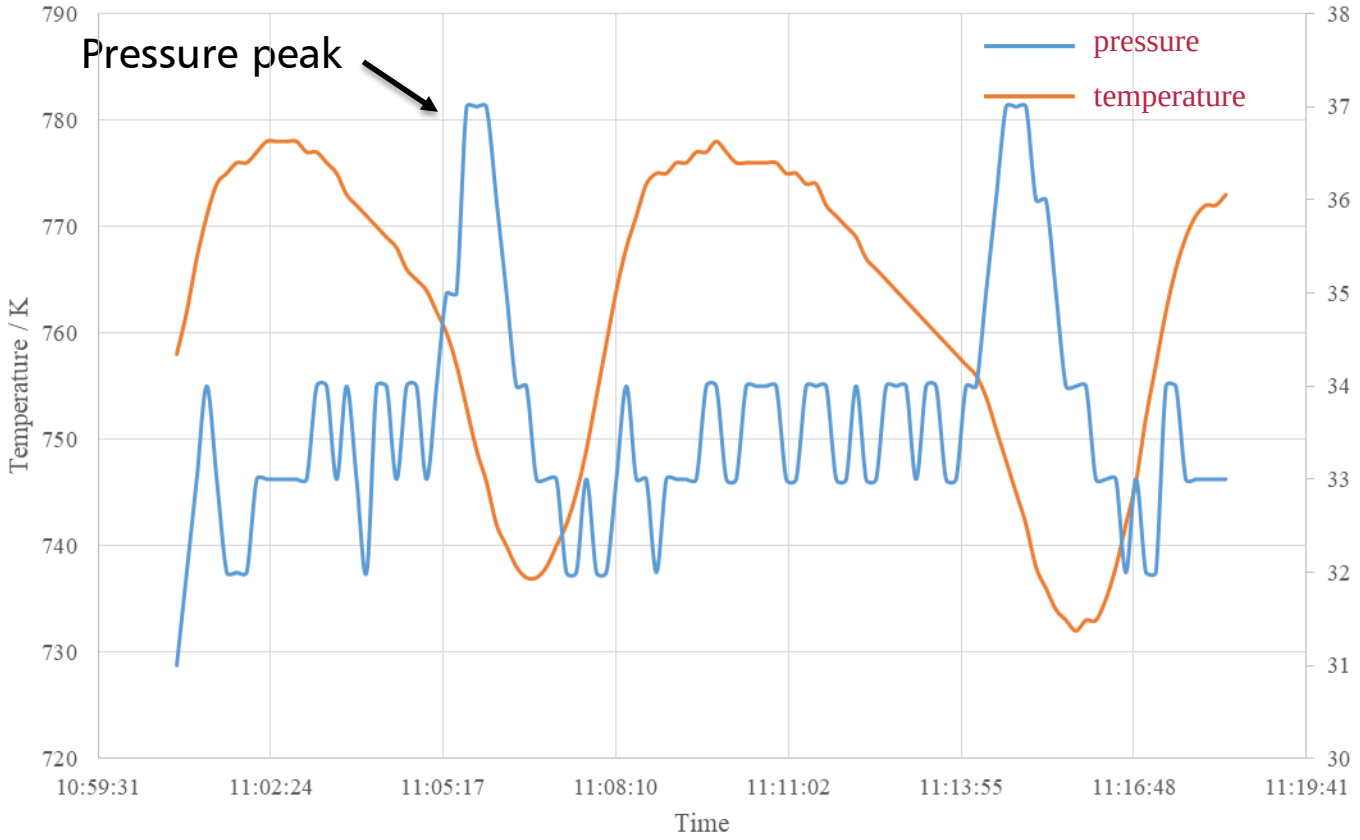
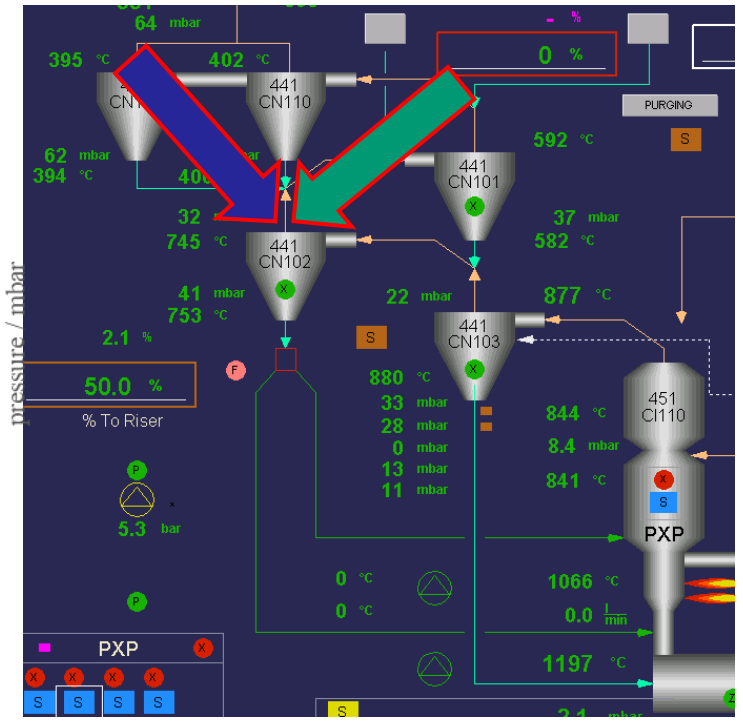
Time Depended Data





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Use CFD or not?

Aberdeen-Group (2011): *How Best-In-Class Companies Amplify Engineering with CFD*

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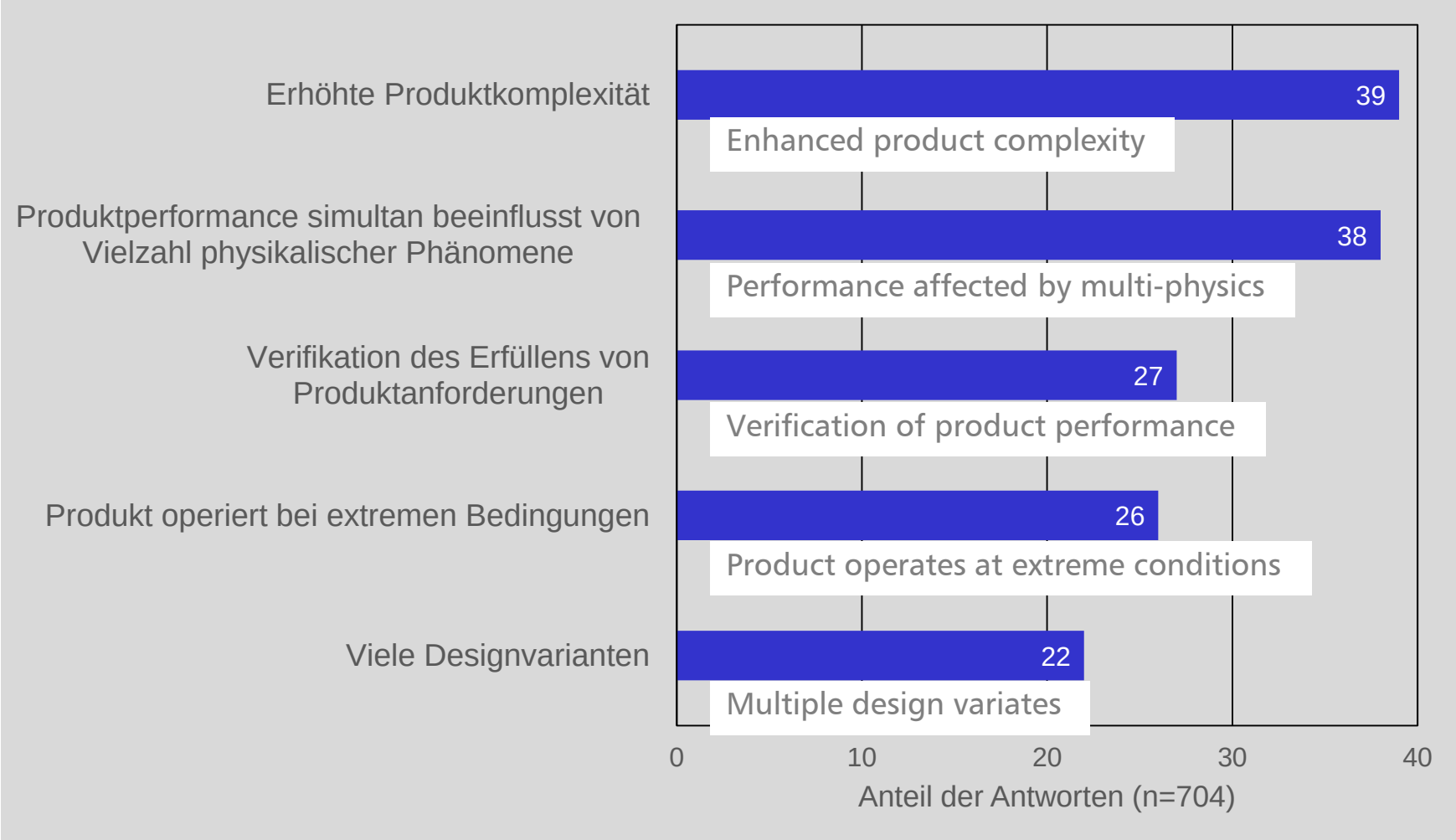
Why companies use CFD
Top 5 challenges in understanding processes



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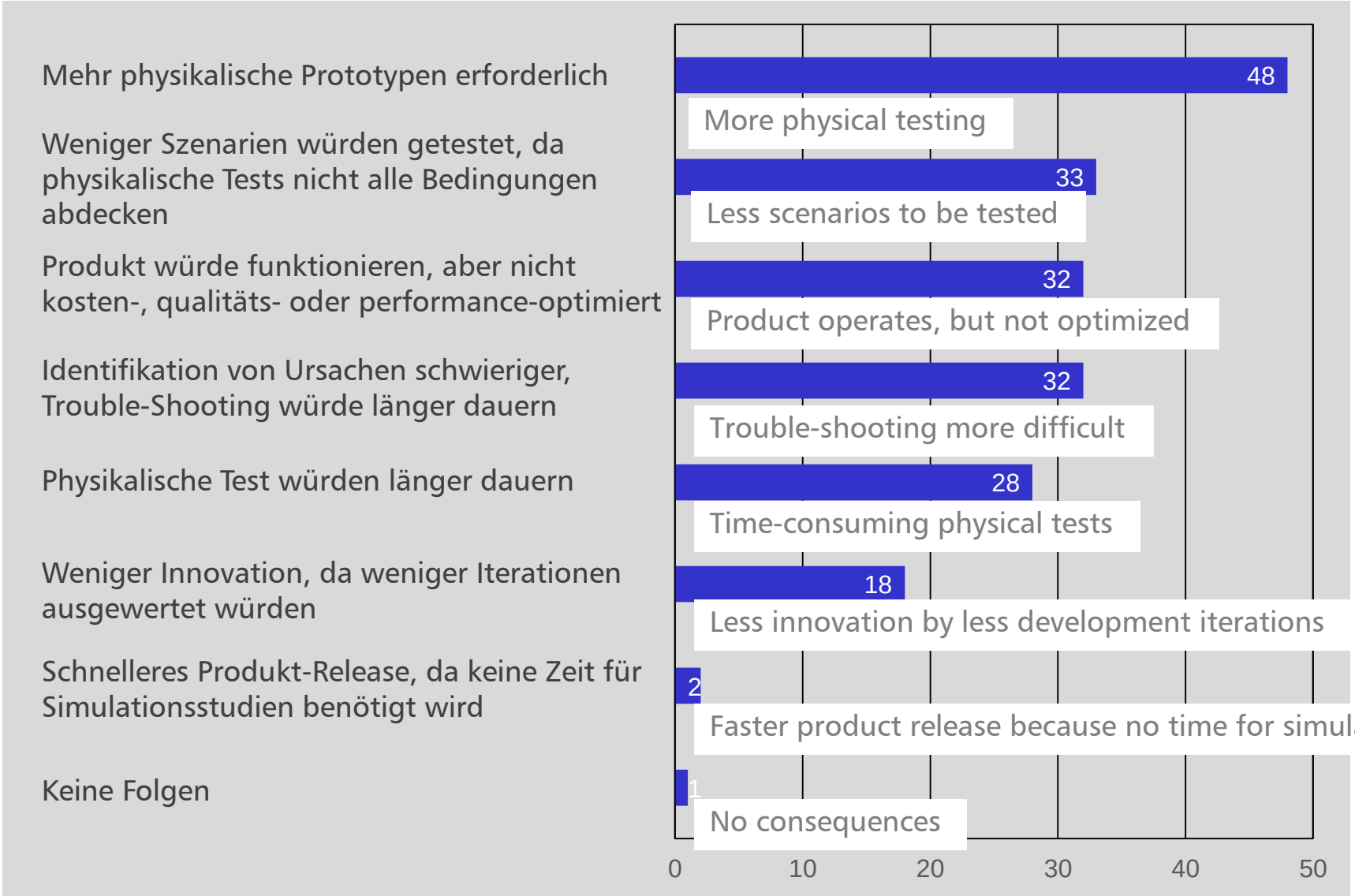
Consequences when not-using CFD



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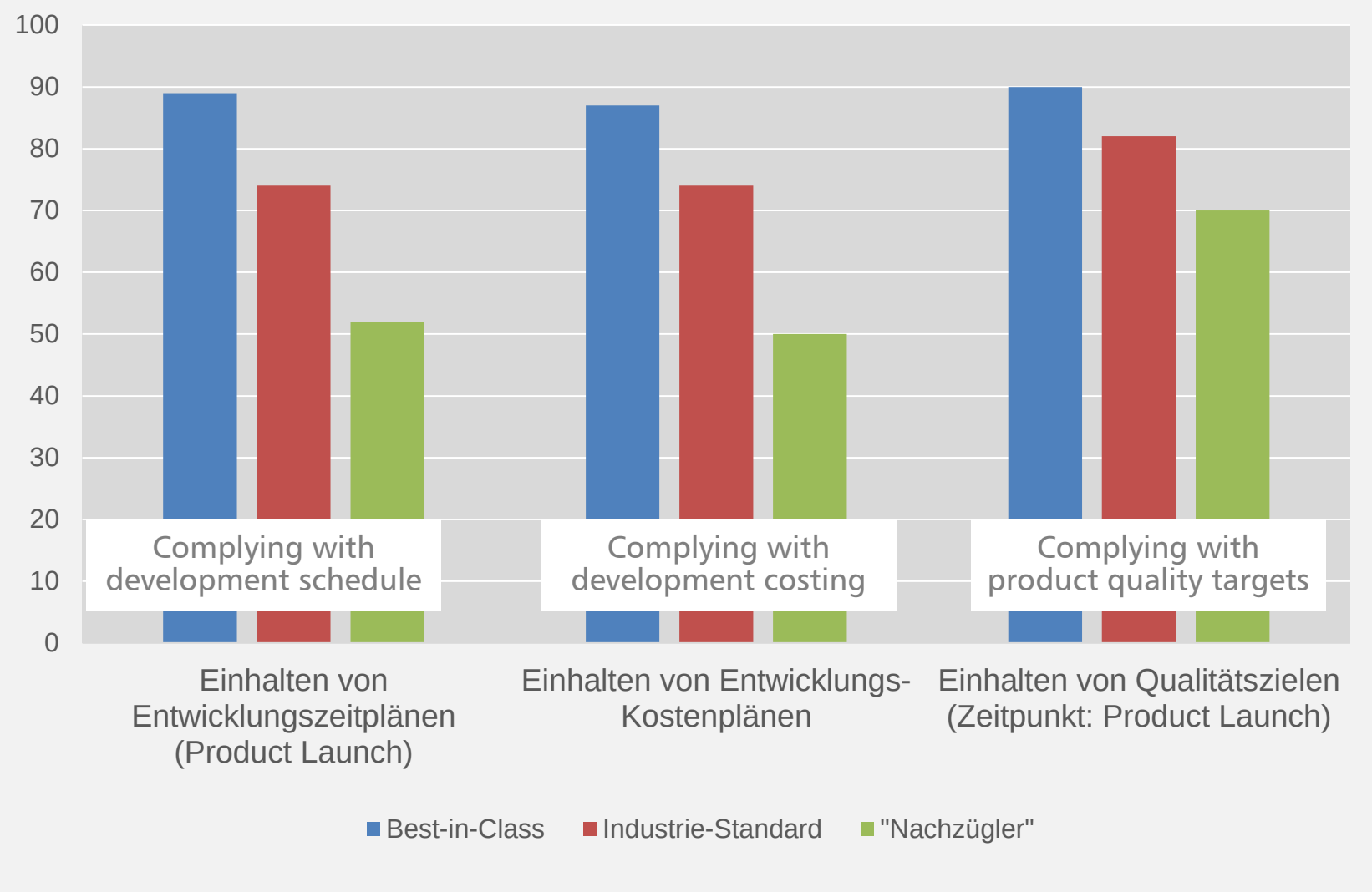
Performance advantages for “best-in-class” companies



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Make or buy?

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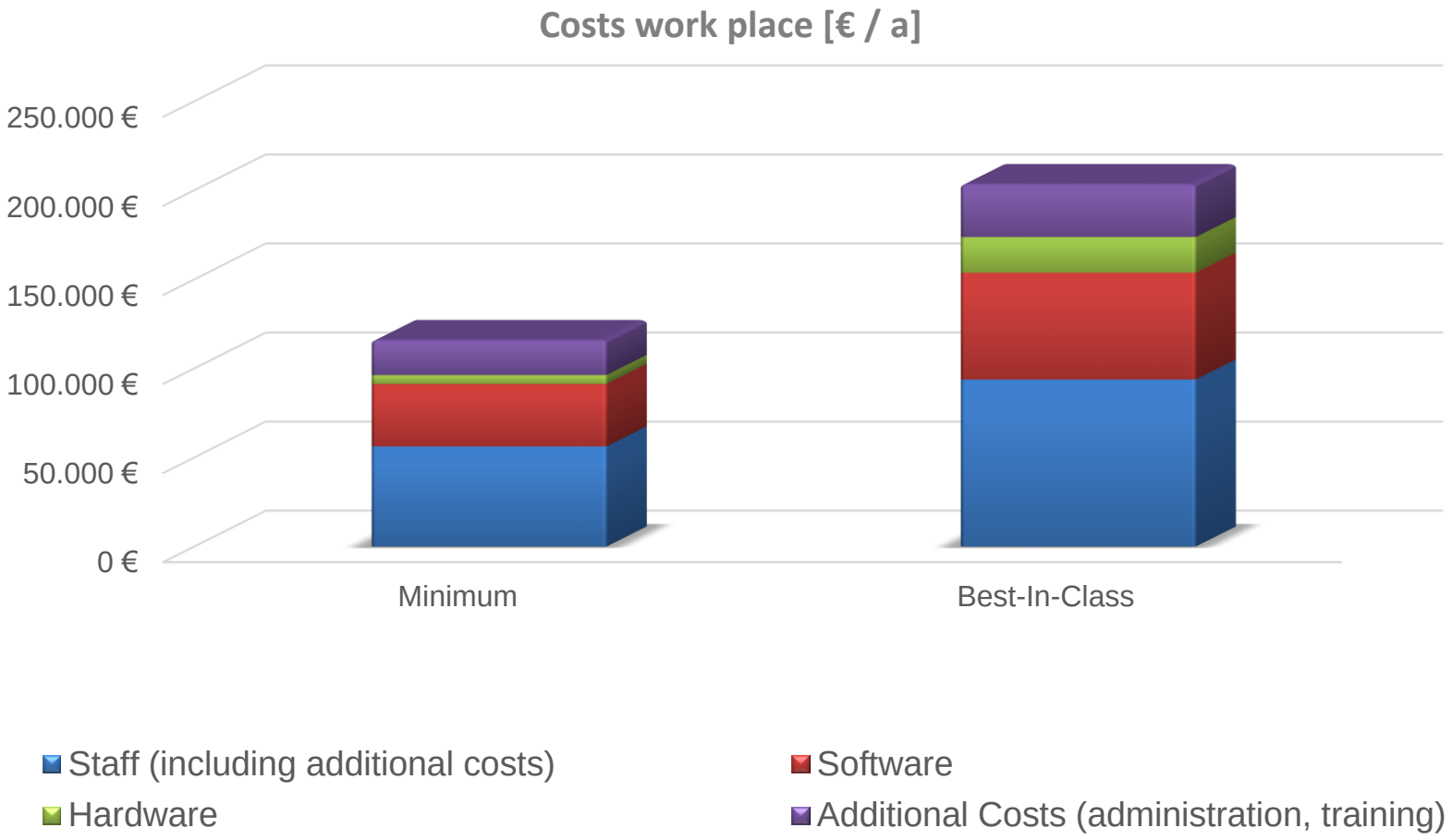

Minimum: moderately skilled employees, serial software, serial / low parallelized Software, 8-Core-Server

Best-In-Class: highly skilled employees, parallelized software + HPC Hardware

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Conclusion

- All processes including multiphase flows are complex and dynamic
- There is not the ONE tool available to model all processes
- From aixprocess experience, Barracuda provides quick and fast insight in details of solids process equipment

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- To be **Best In Class**, you need to have
  - deep knowledge about the piece of equipment
  - broad knowledge about the system
- In order to get insight into the whole system, combination with other (experimental & numerical!) tools is required
- Once you've managed to get **System Insight**, you gain an *unfair advantage*

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