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FloEFD for Engineering Consulting

Maarten Groothoff

Ingenieursbureau HEC

29-11-2017

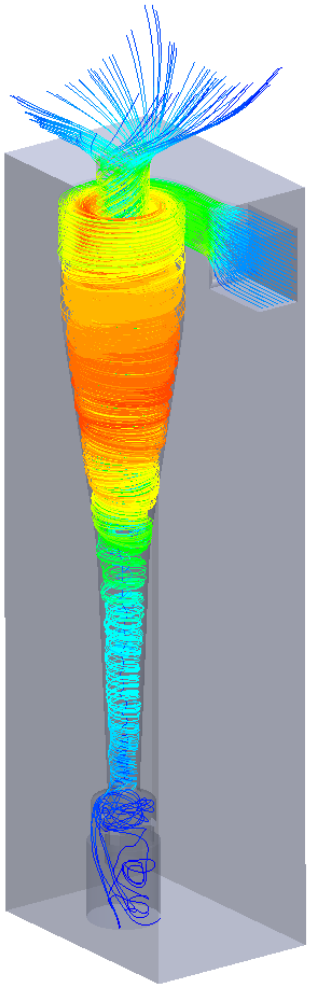
HOLLAND ENGINEERING CONSULTANTS

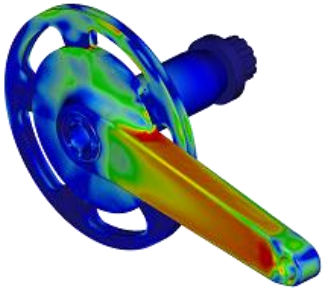
Introduction HEC

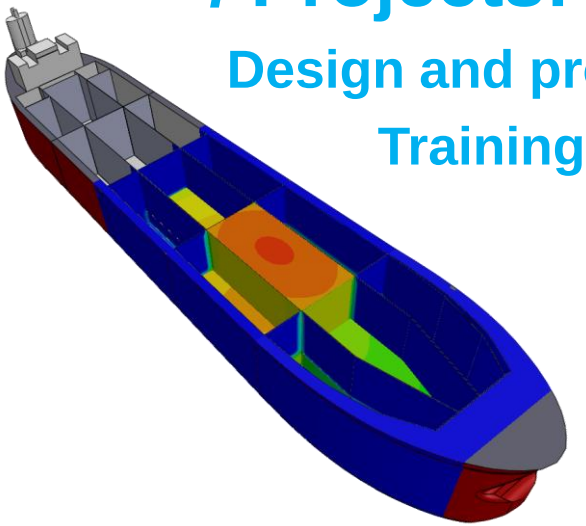
Ingenieursbureau HEC / Holland Engineering Consultants / Projects: CFD and FEM

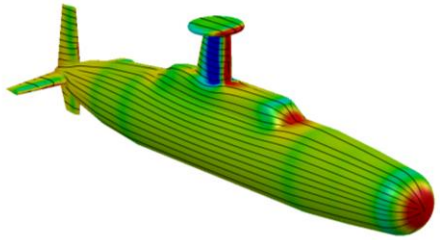
Design and product optimisation

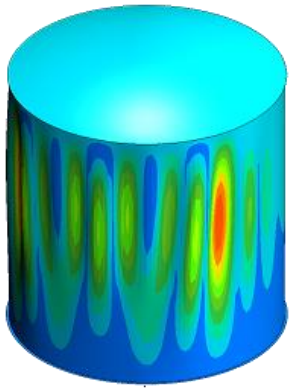
Training and support

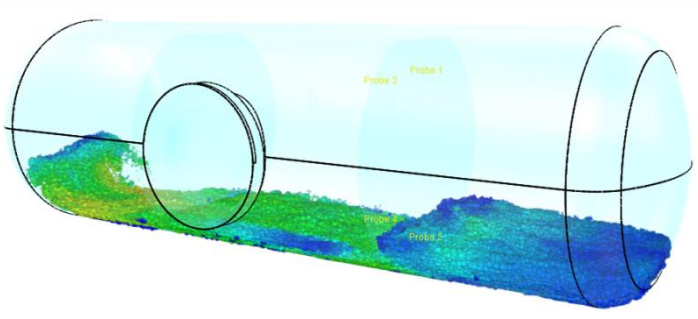


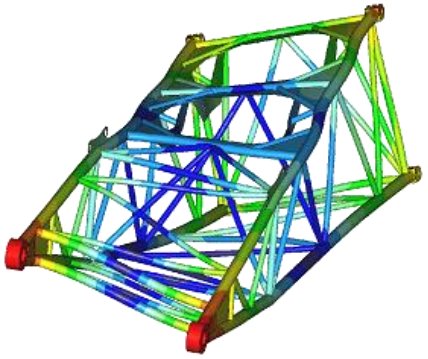








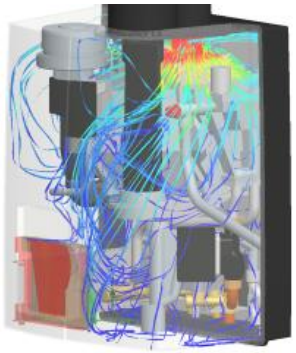


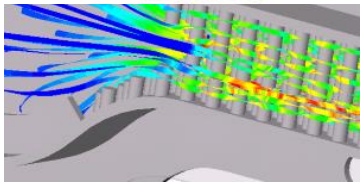


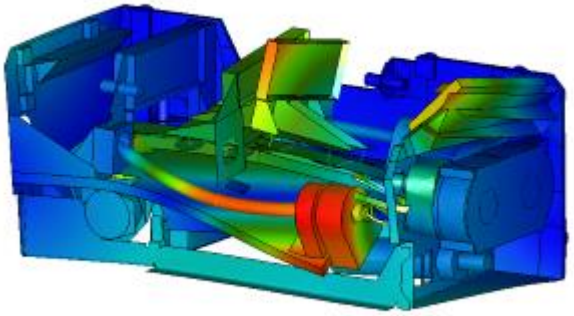
Introduction HEC

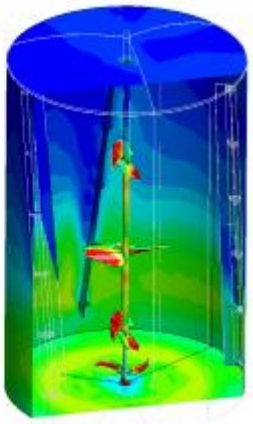
Project types:

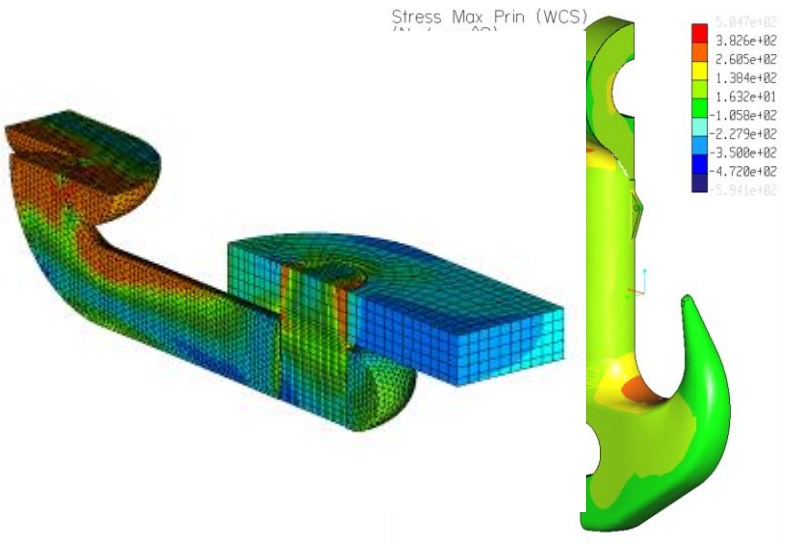
- Just a check or validation
- Design or design optimization
- Problem solving / cause
- A study to get insight











HOLLAND ENGINEERING CONSULTANTS

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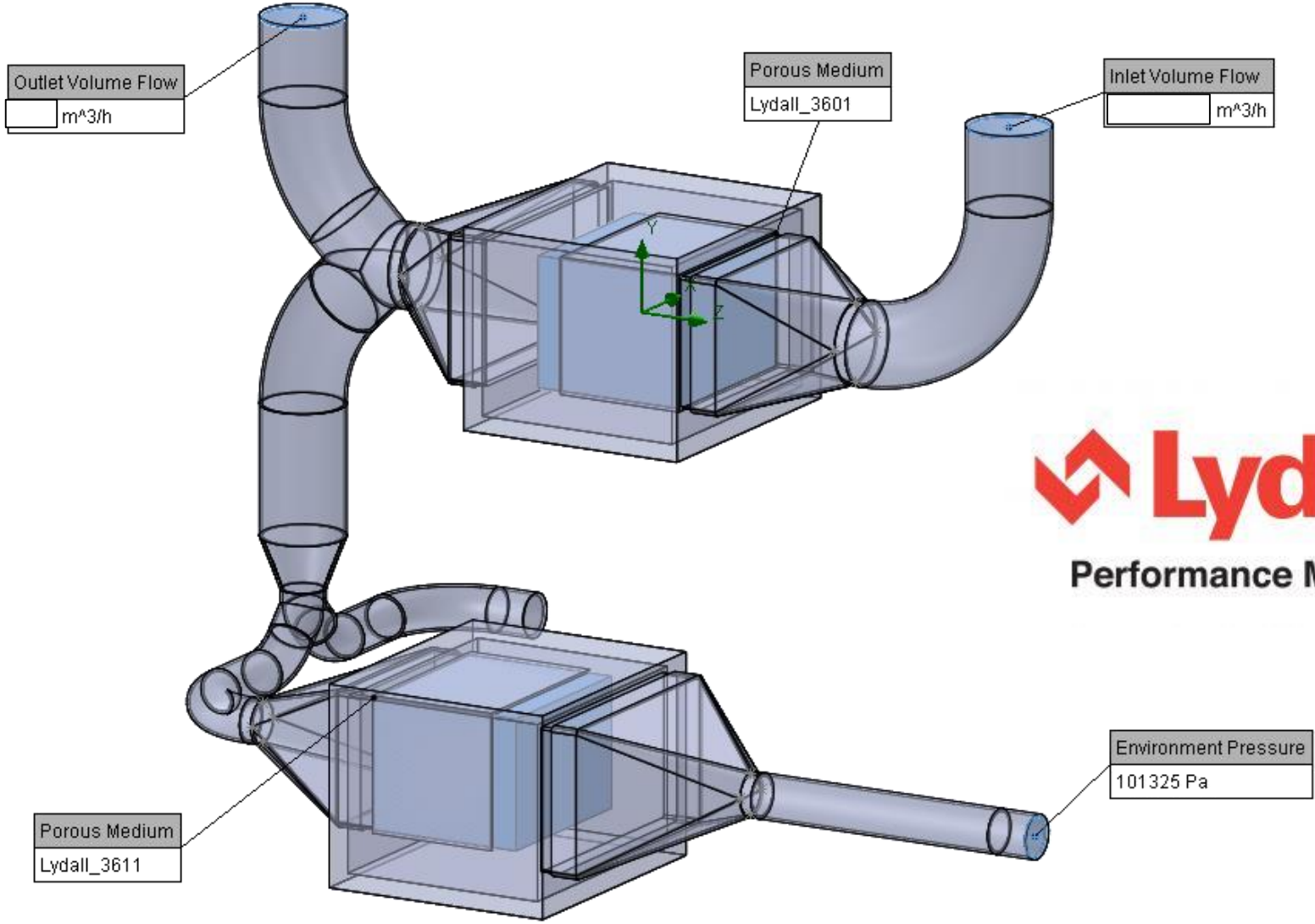
Lydall® Performance Materials

HOLLAND ENGINEERING CONSULTANTS

Lydall: Air treatment unit



HOLLAND ENGINEERING CONSULTANTS

Goals to optimize: uniformity and pressure drop

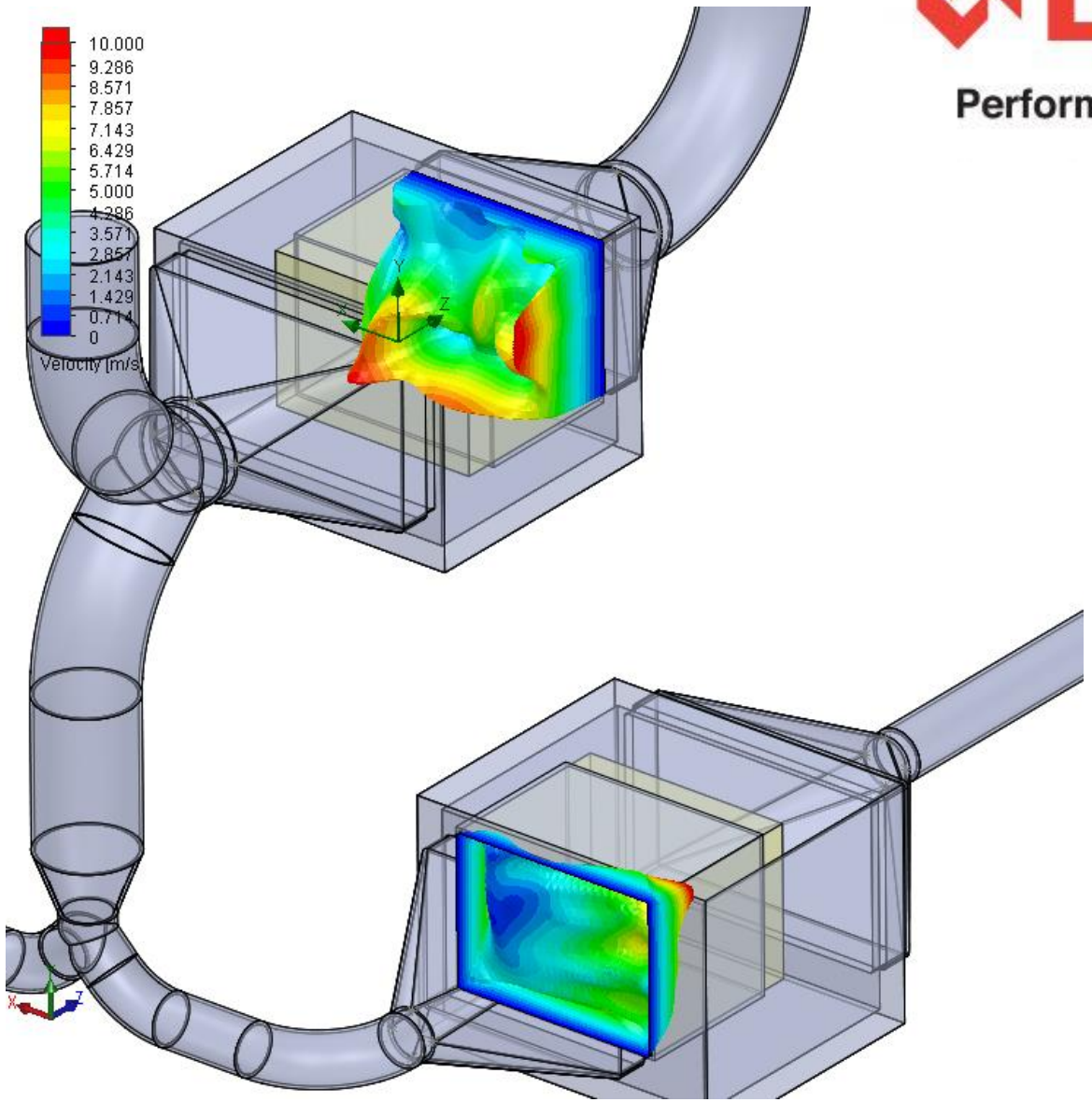
	Unit	Design Variant				
		Original	1	2	3	4
Pressure drop	[Pa]	**1347**	**934**	**931**	**906**	**928**
Uniformity Index 3601*	[-]	**0.75**	**0.77**	**0.72**	**0.82**	**0.96**
Uniformity Index 3621*	[-]	**0.58**	**0.77**	**0.77**	**0.84**	**0.93**

$\gamma = 1 - \frac{1}{2VS}\int \sqrt{(v_x - V_x)^2 + (v_y - V_y)^2 + (v_z - V_z)^2}\,ds$, where V is the average velocity, S is the fluid area, and v_i and V_i are the components of local velocity and average velocity, respectively. The parameter value varies in the range of 0 to 1 (1 means fully uniform flow).

Lydall® Performance Materials

HOLLAND ENGINEERING CONSULTANTS

Lydall®
Performance Materials



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Goals to optimize: uniformity and pressure drop

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Lydall® Performance Materials

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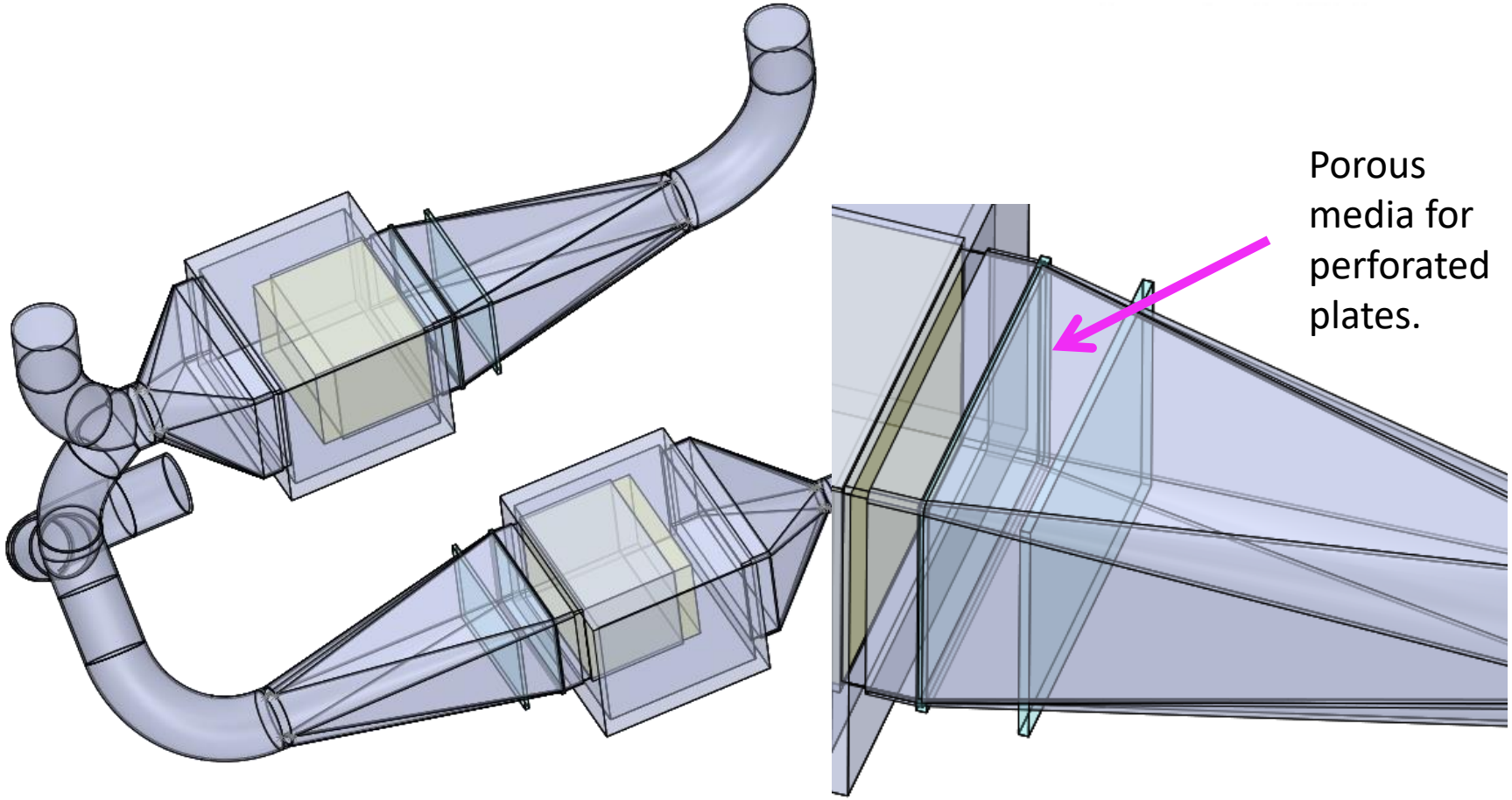
Lydall® Performance Materials



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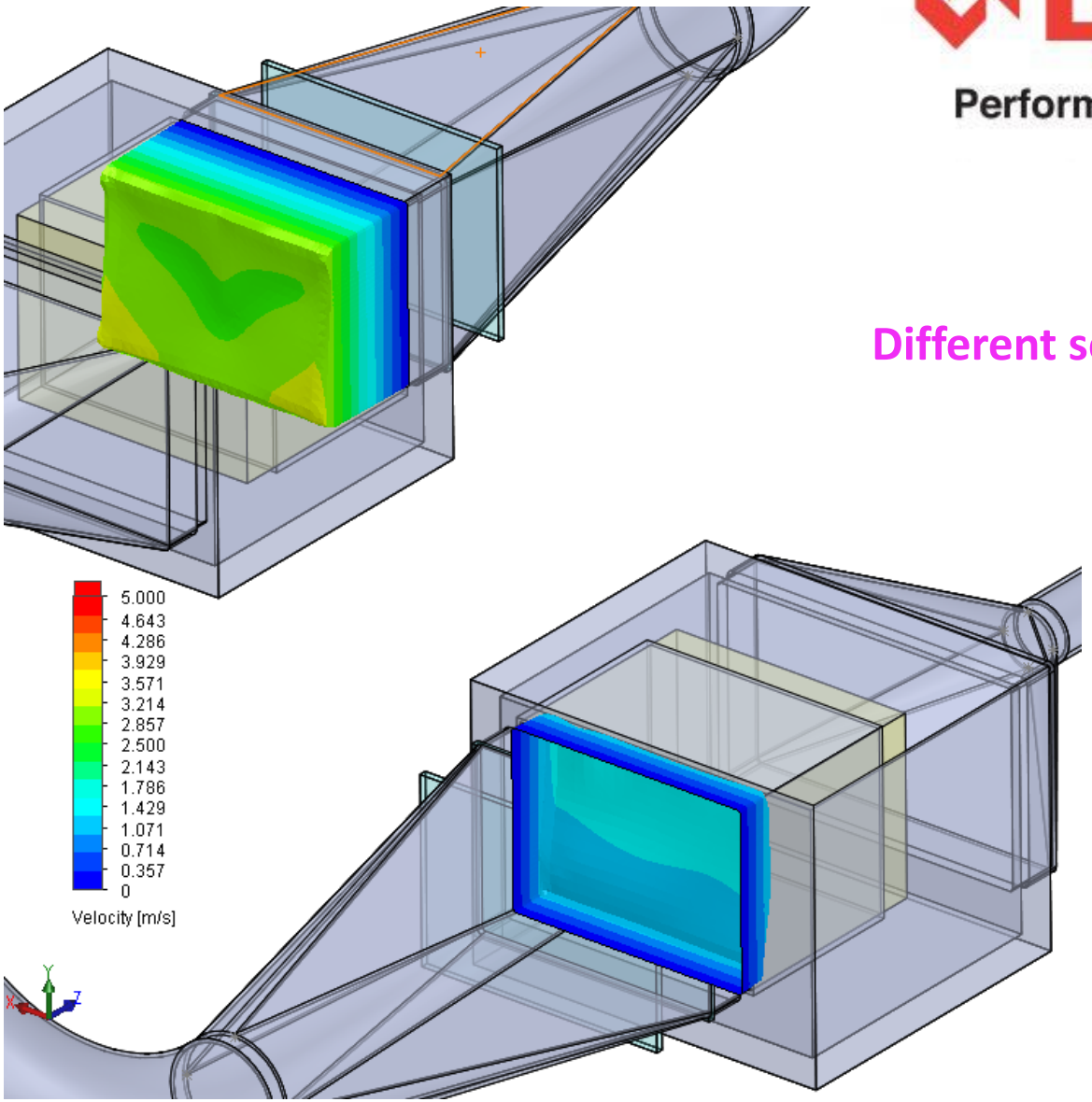
Lydall® Performance Materials



Different scale !

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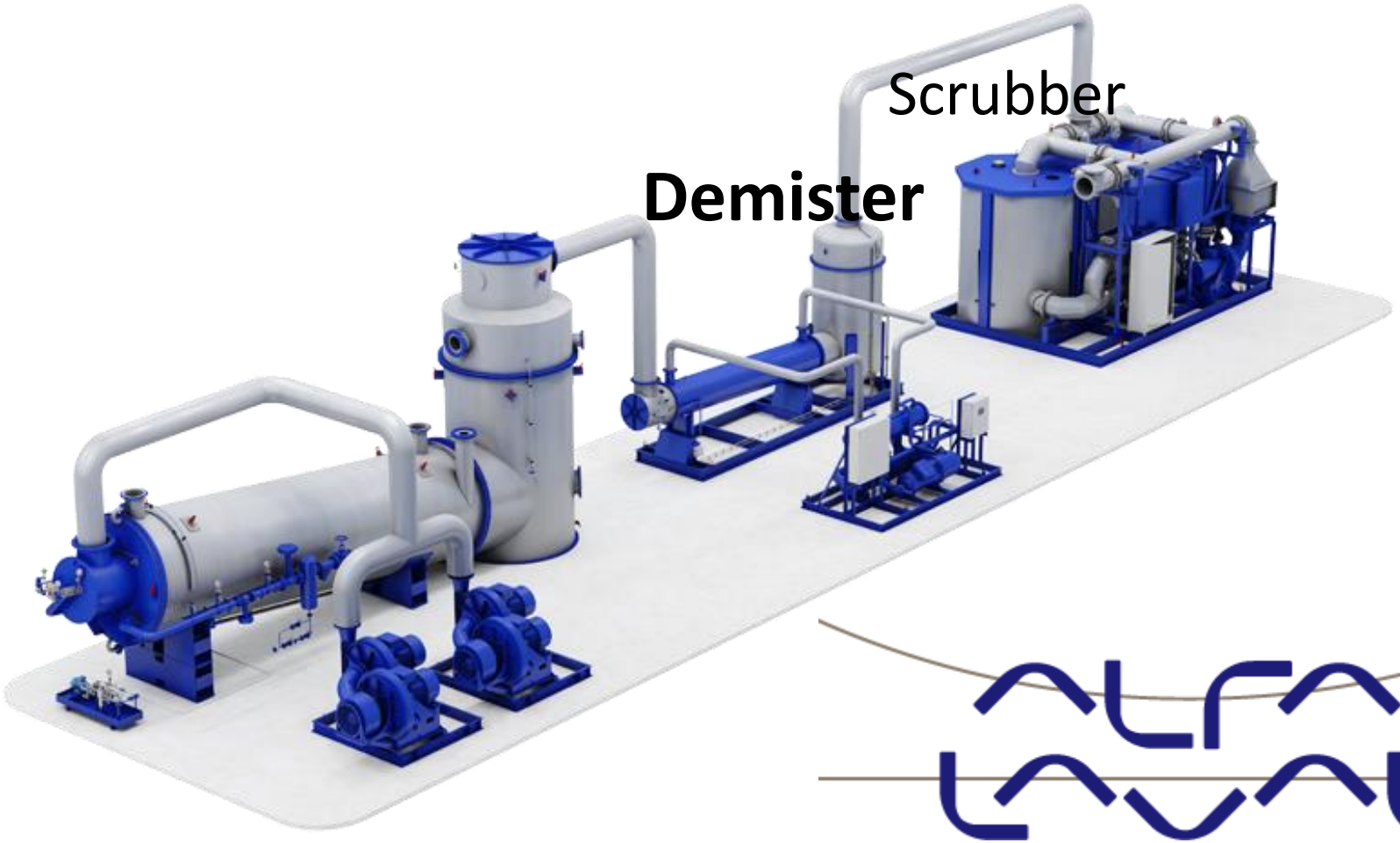
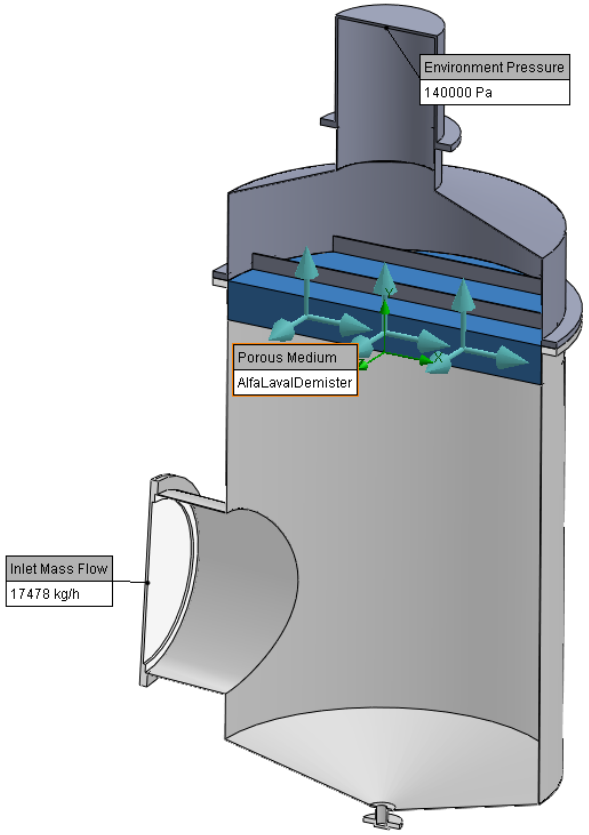
Alfa Laval Inert Gas

HOLLAND ENGINEERING CONSULTANTS

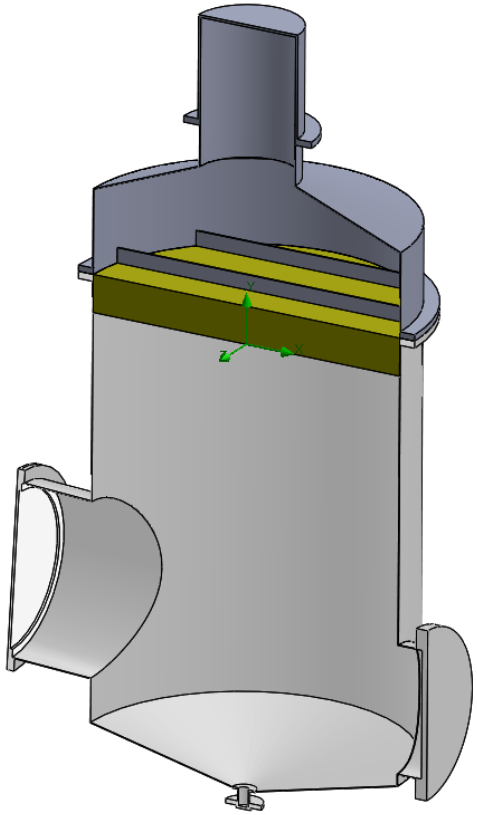
Inert Gas System



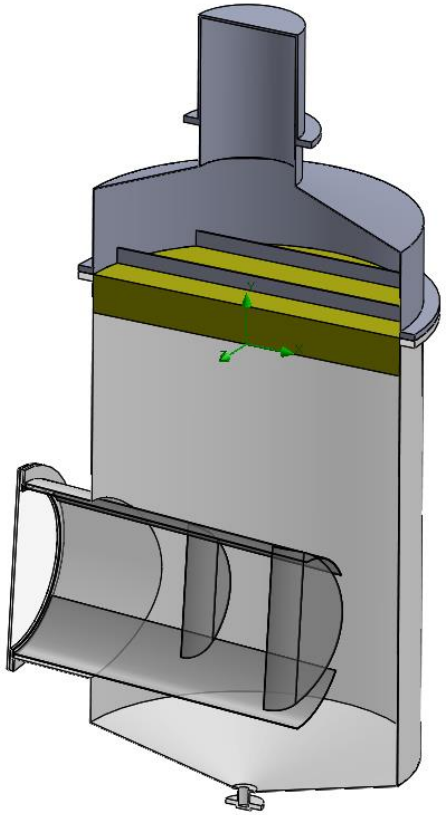
Original Model



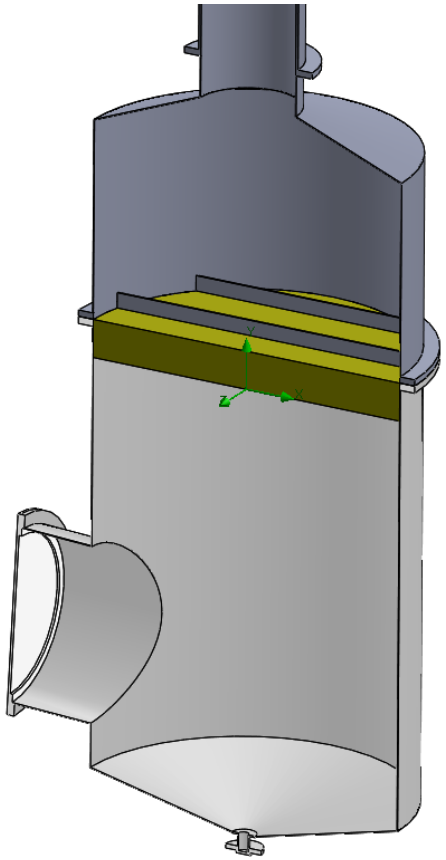
Man hole



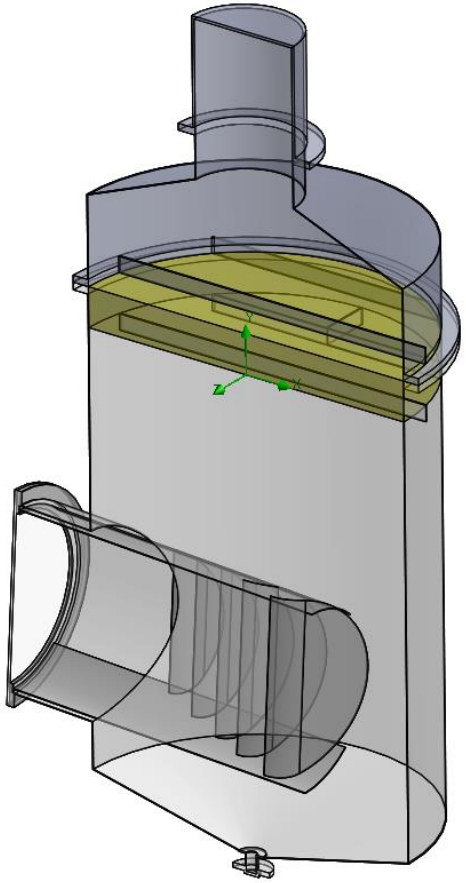
vanes



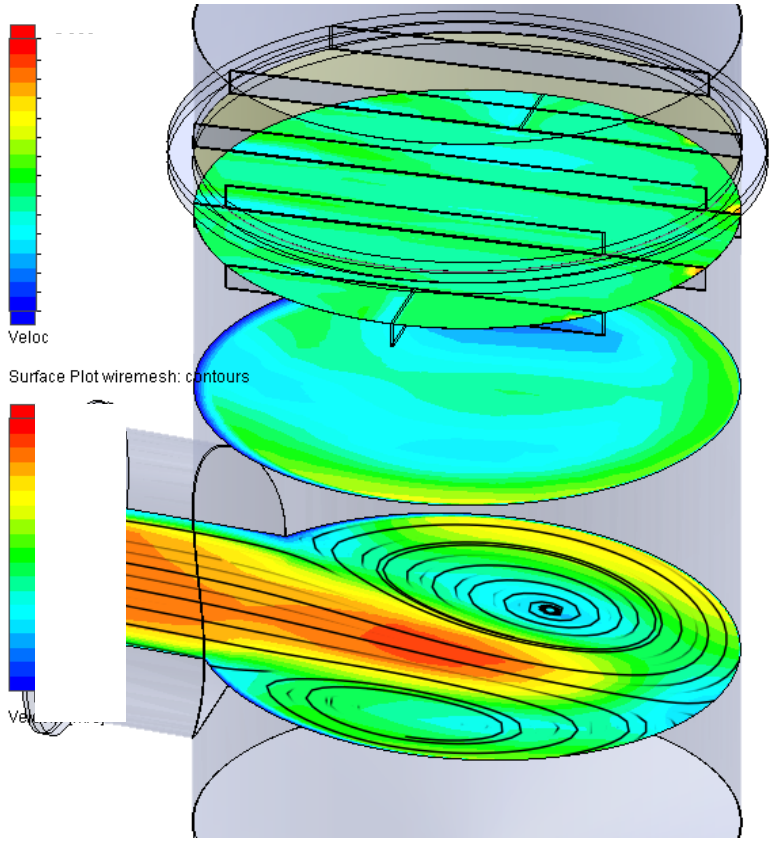
Higher hat



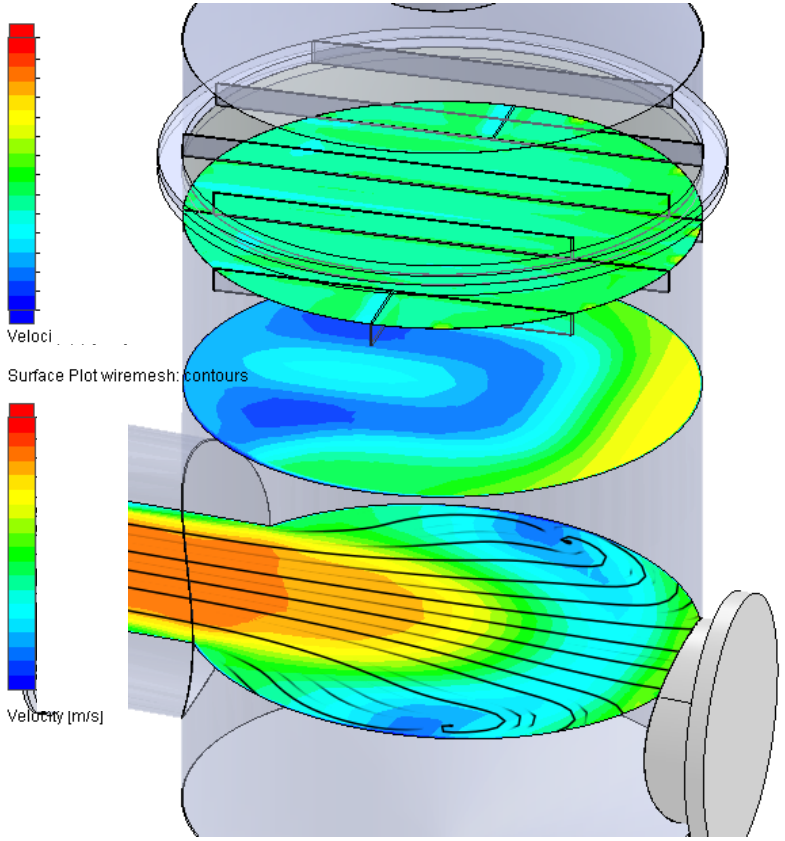
More vanes



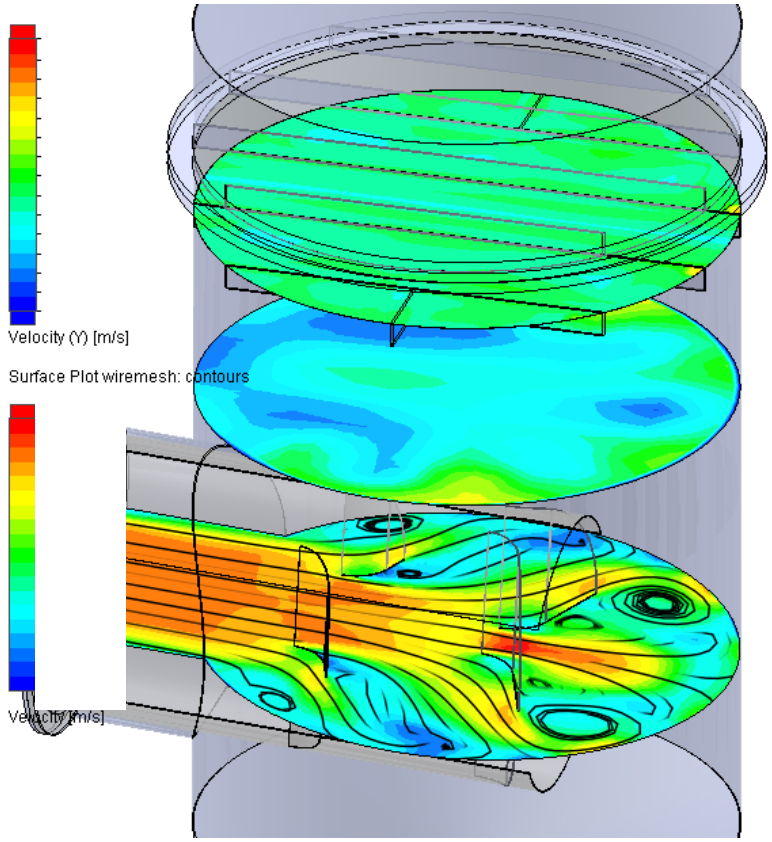
Original



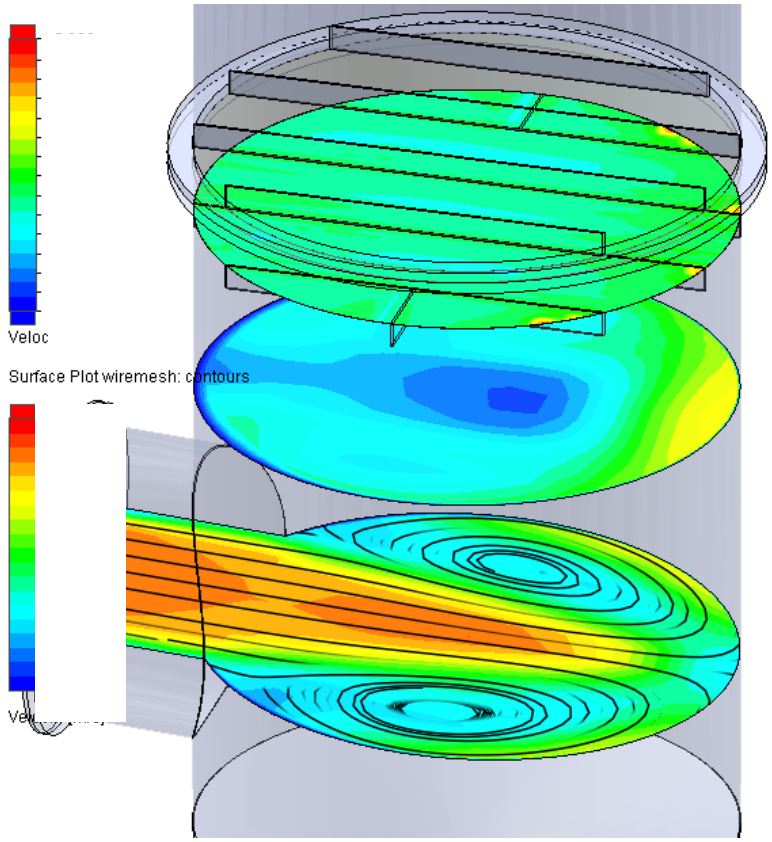
Man hole



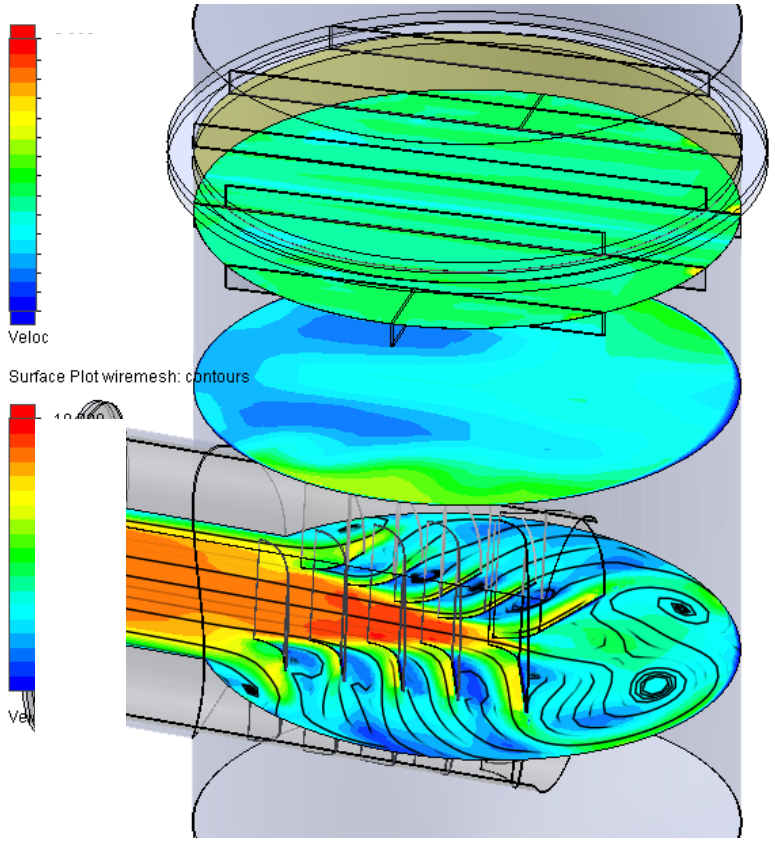
vanes



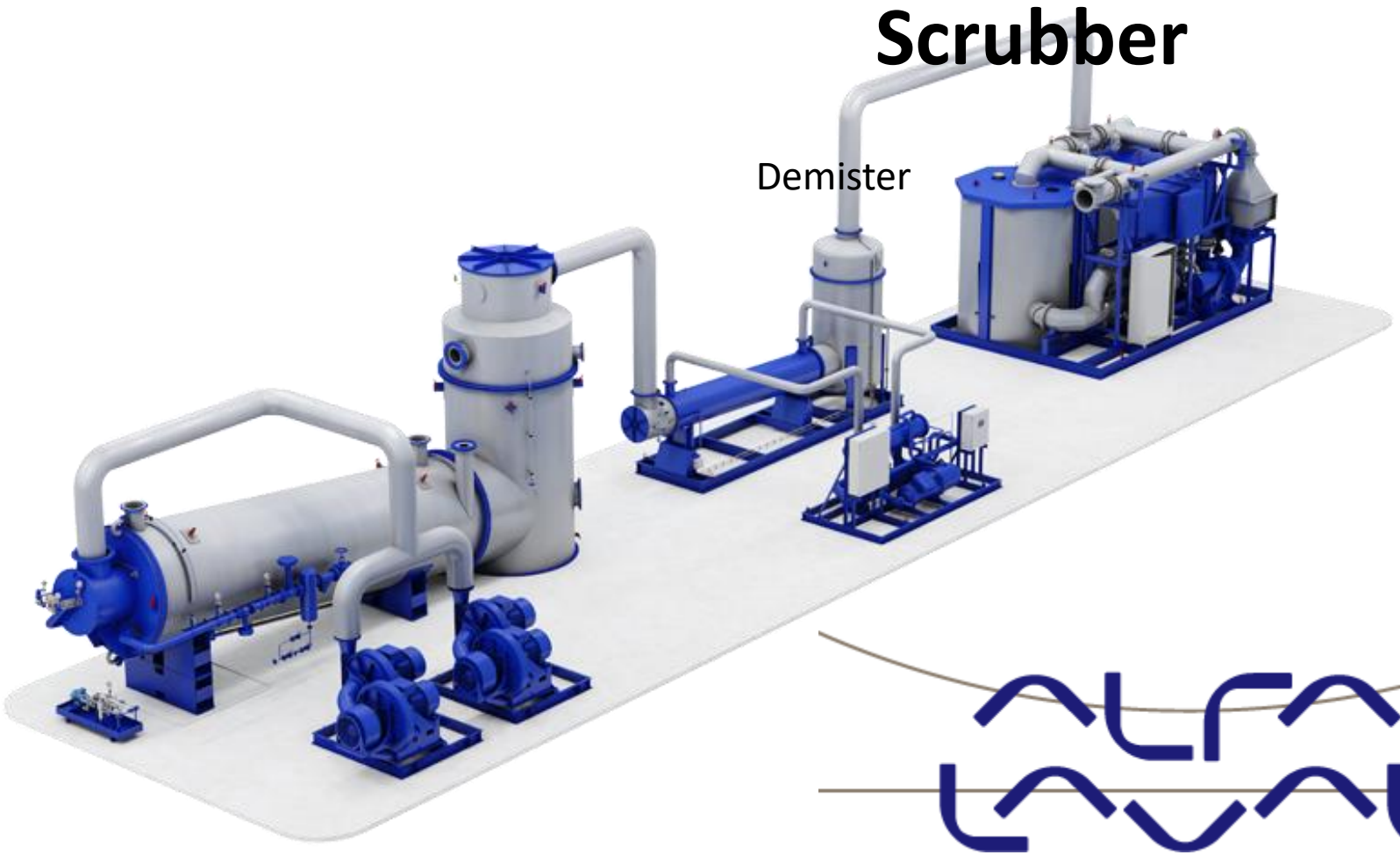
Higher hat



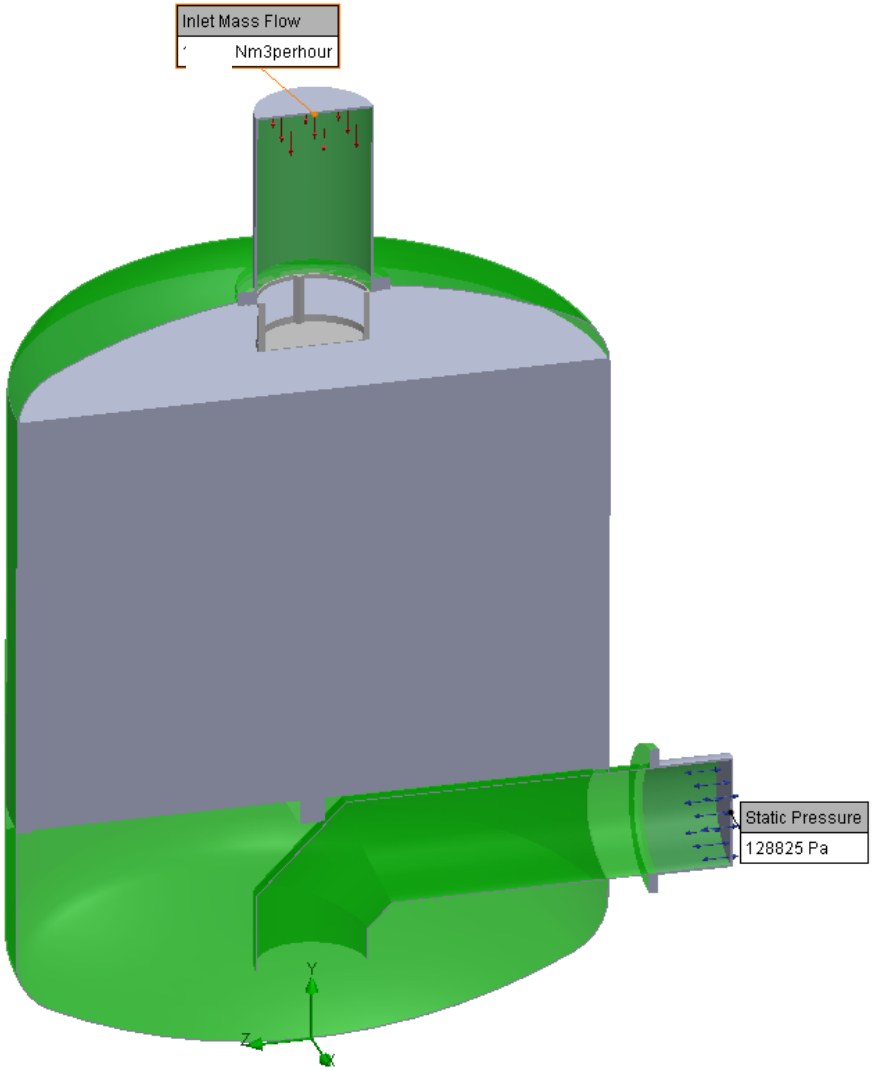
More vanes

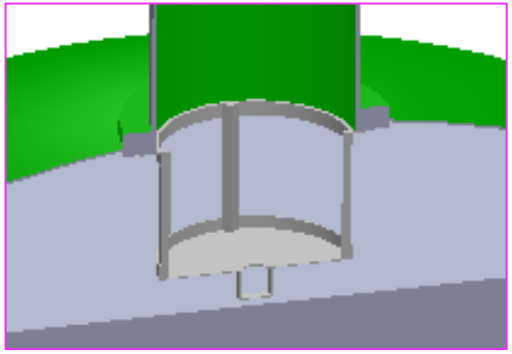


Inert Gas System

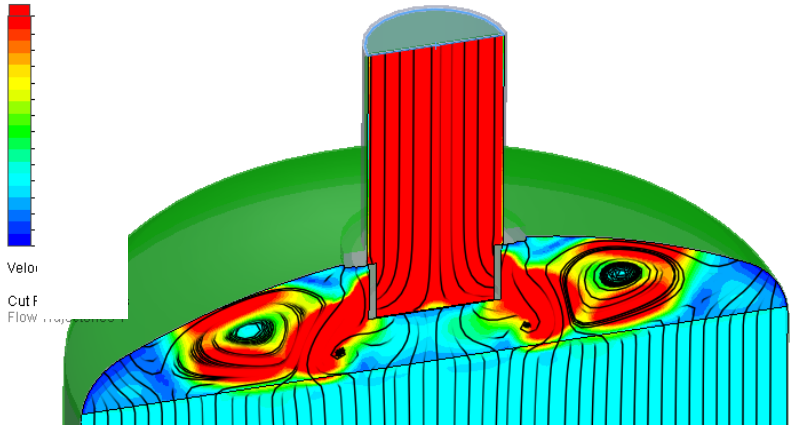


Scrubber

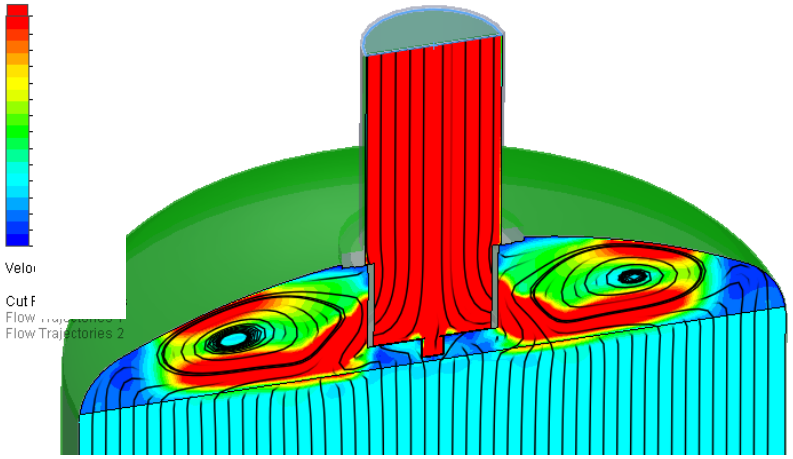




Cut plot, velocity, short distribution plate

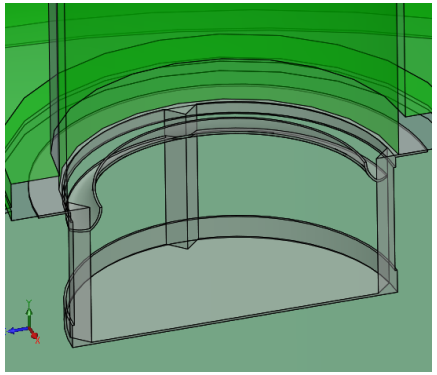


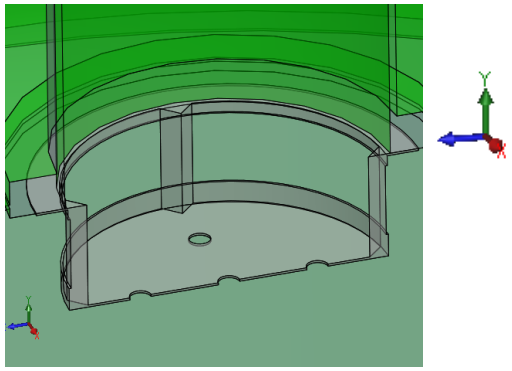
Cut plot, velocity, long distribution plate



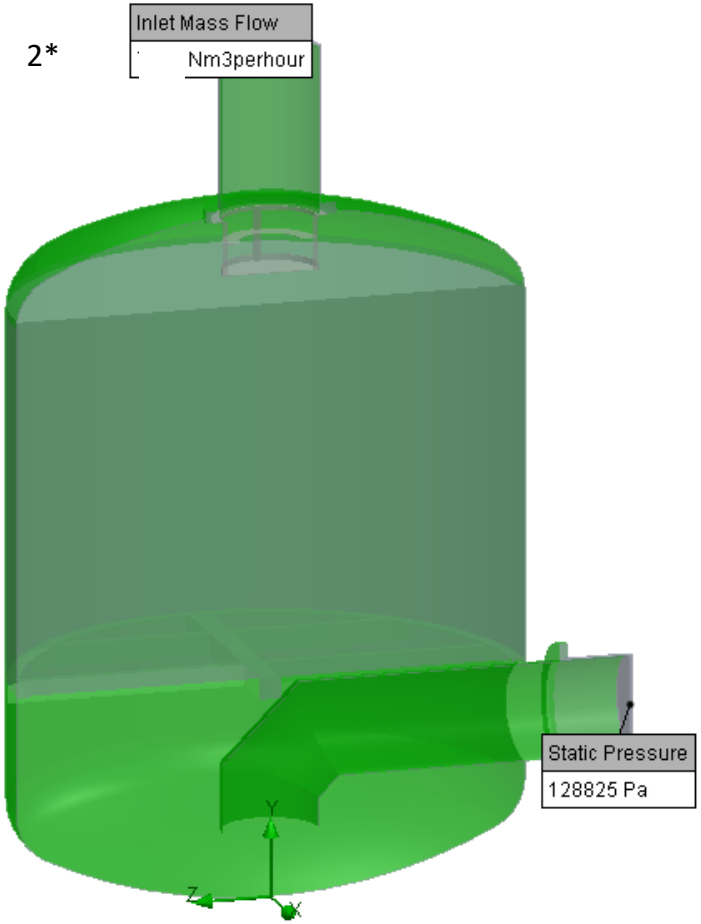
Half Model

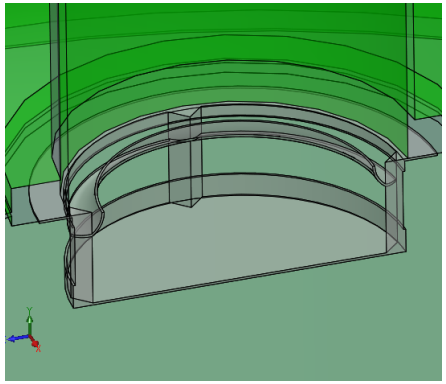
A half model with symmetry was used for optimization
2x as fast

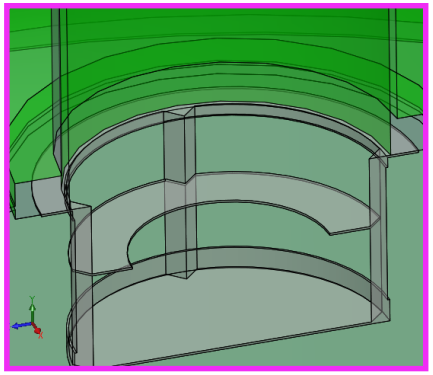




2*

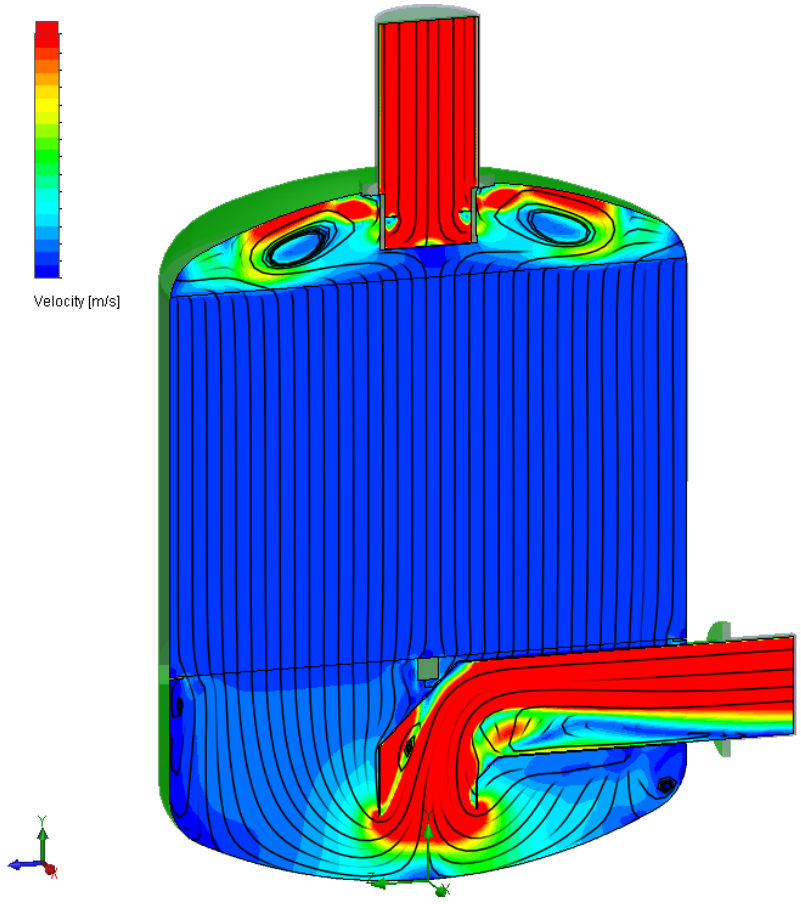






Parameter studies Vane position and inlet length

Cut plot, velocity, optimized distribution plate



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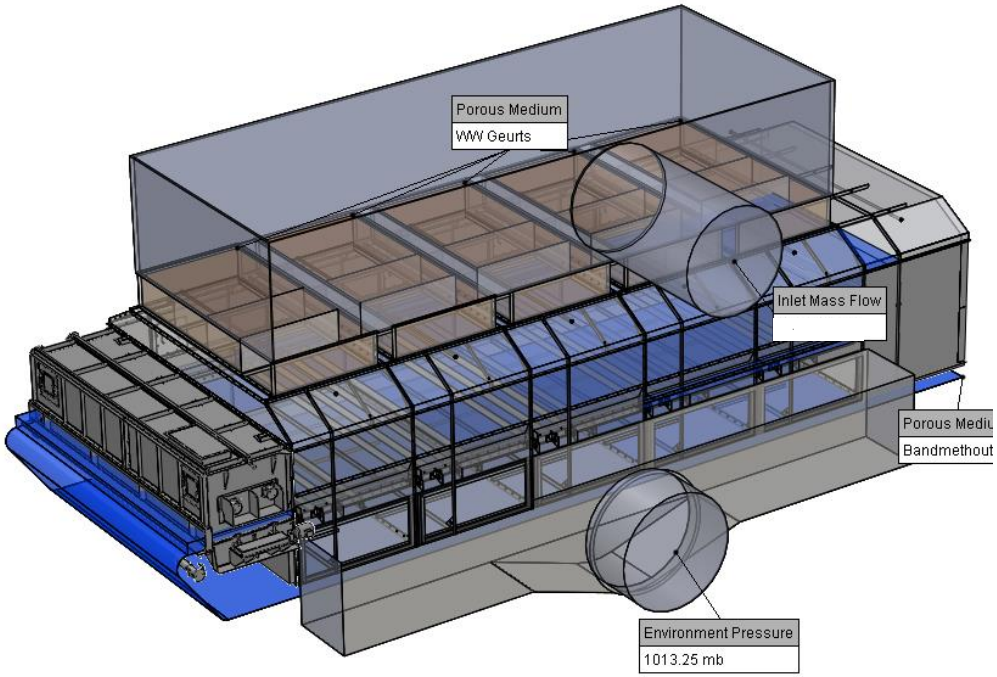
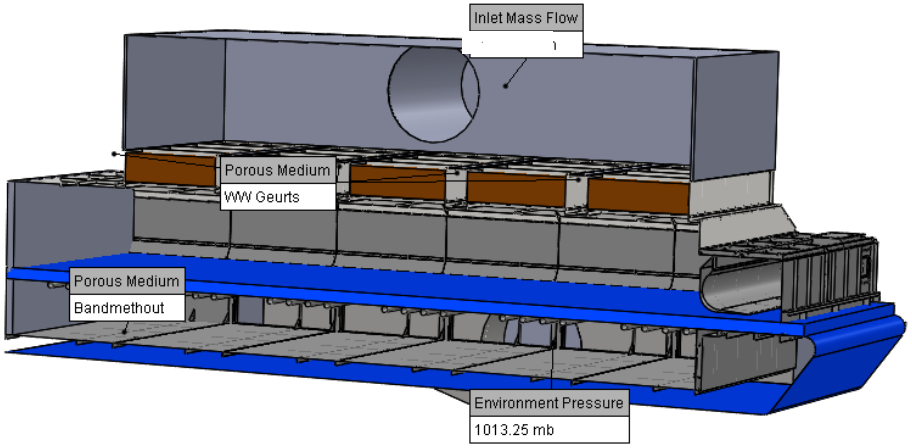
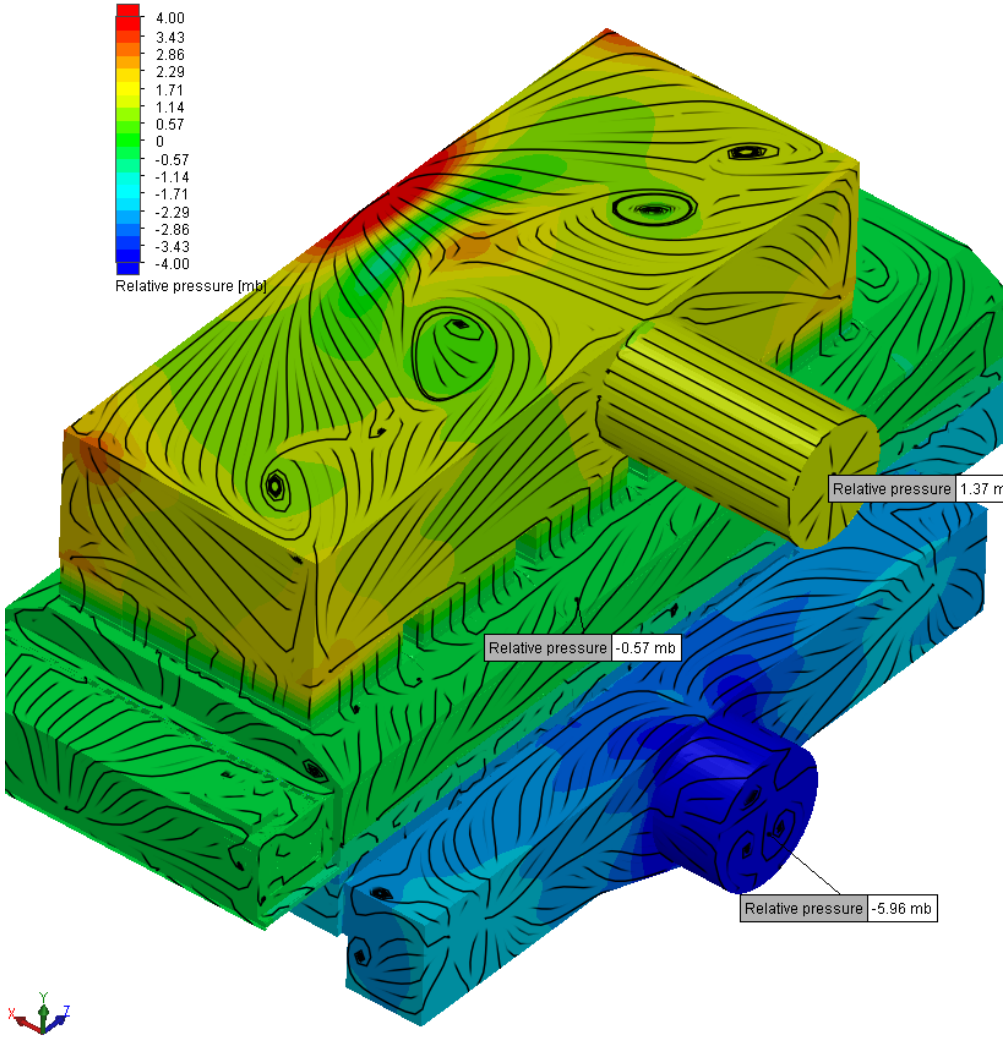
Wood chip belt dryer

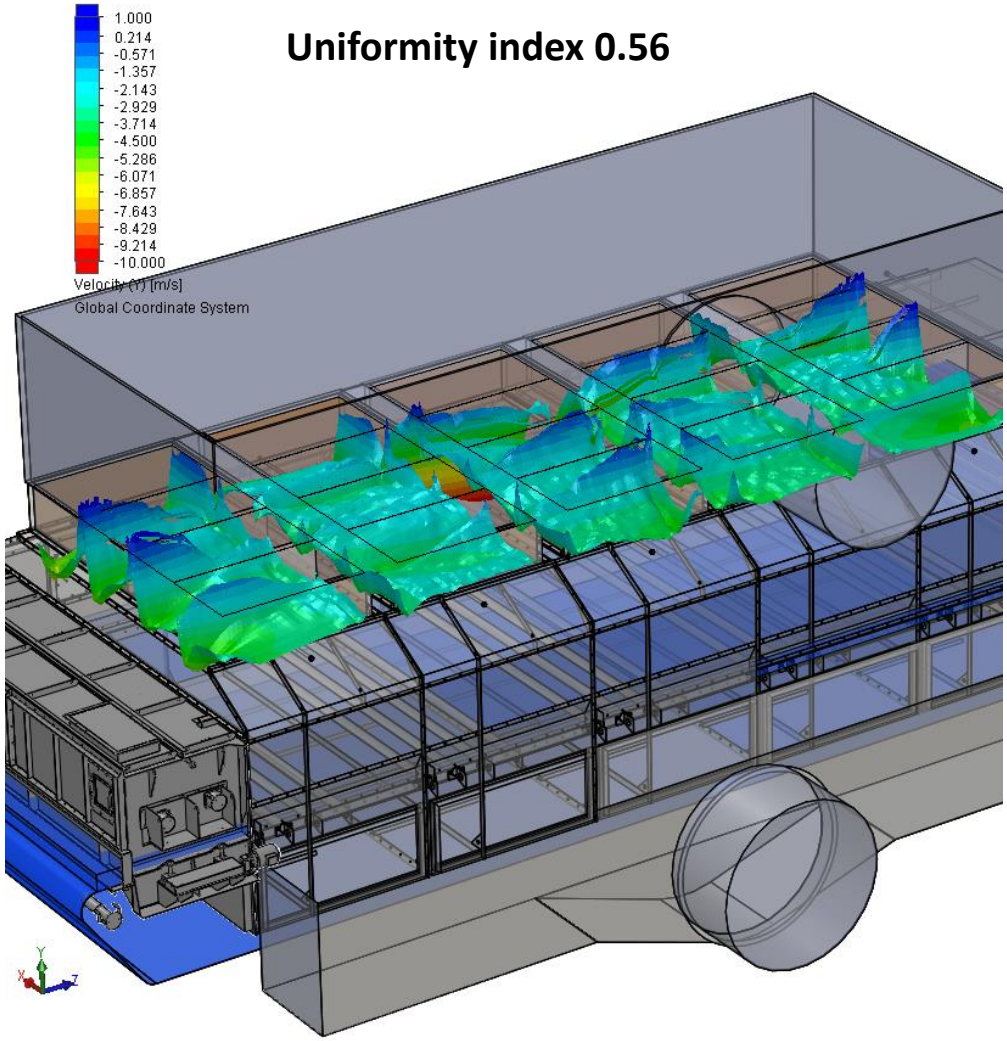




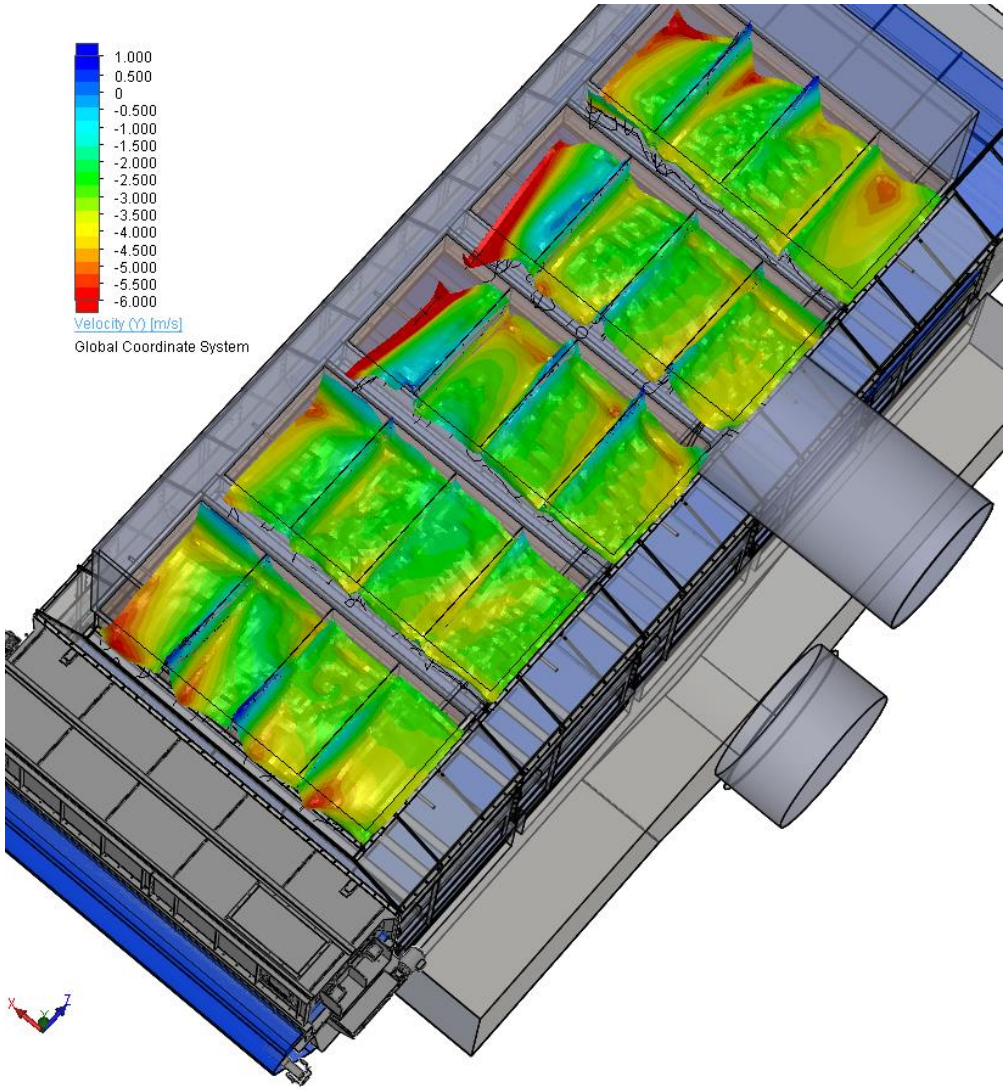
Pressure


4.00
3.43
2.86
2.29
1.71
1.14
0.57
0
-0.57
-1.14
-1.71
-2.29
-2.86
-3.43
-4.00
Relative pressure [mb]
Relative pressure 1.37 m
Relative pressure -0.57 mb
Relative pressure -5.96 mb

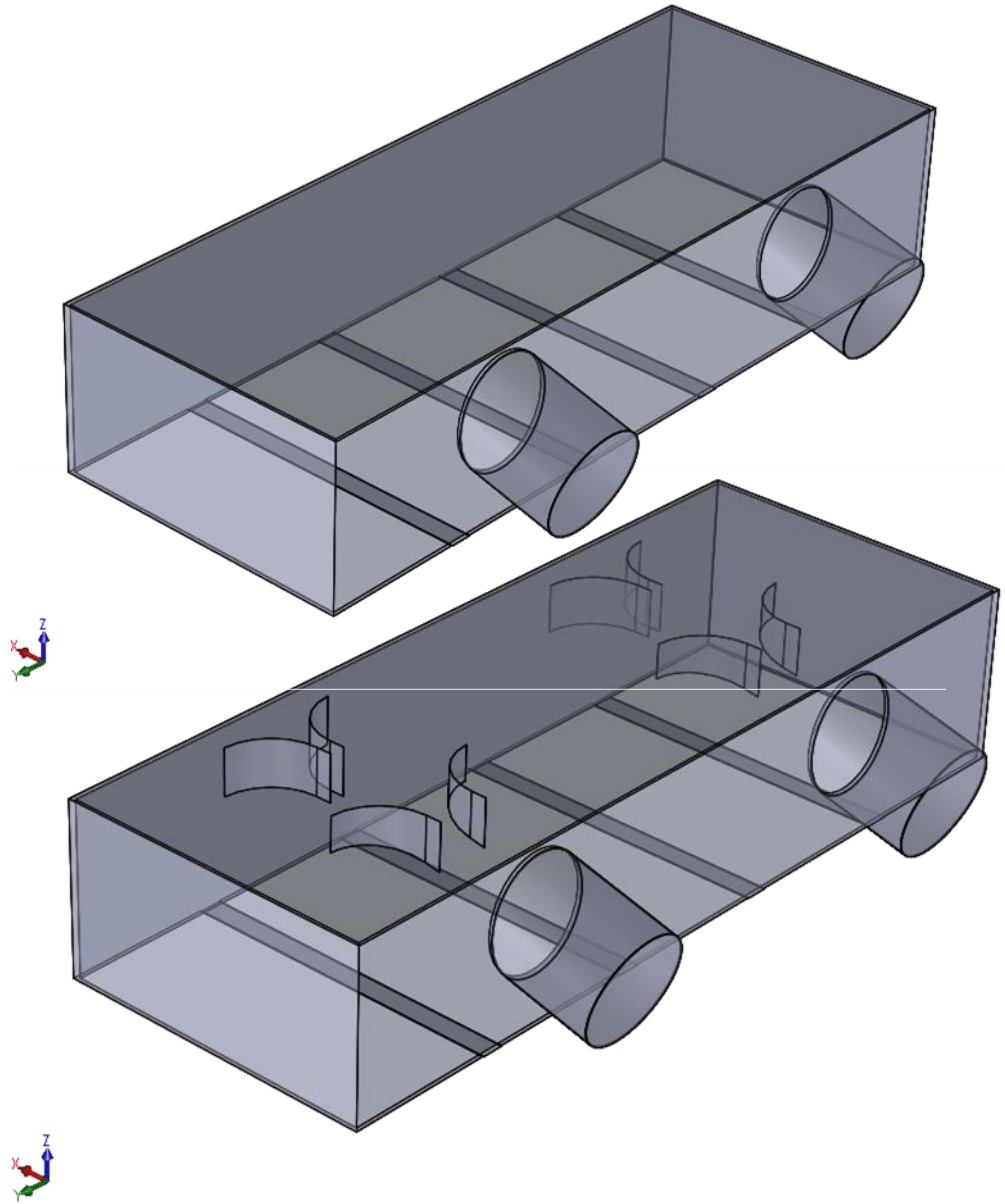
Vertical velocity



Vertical velocity

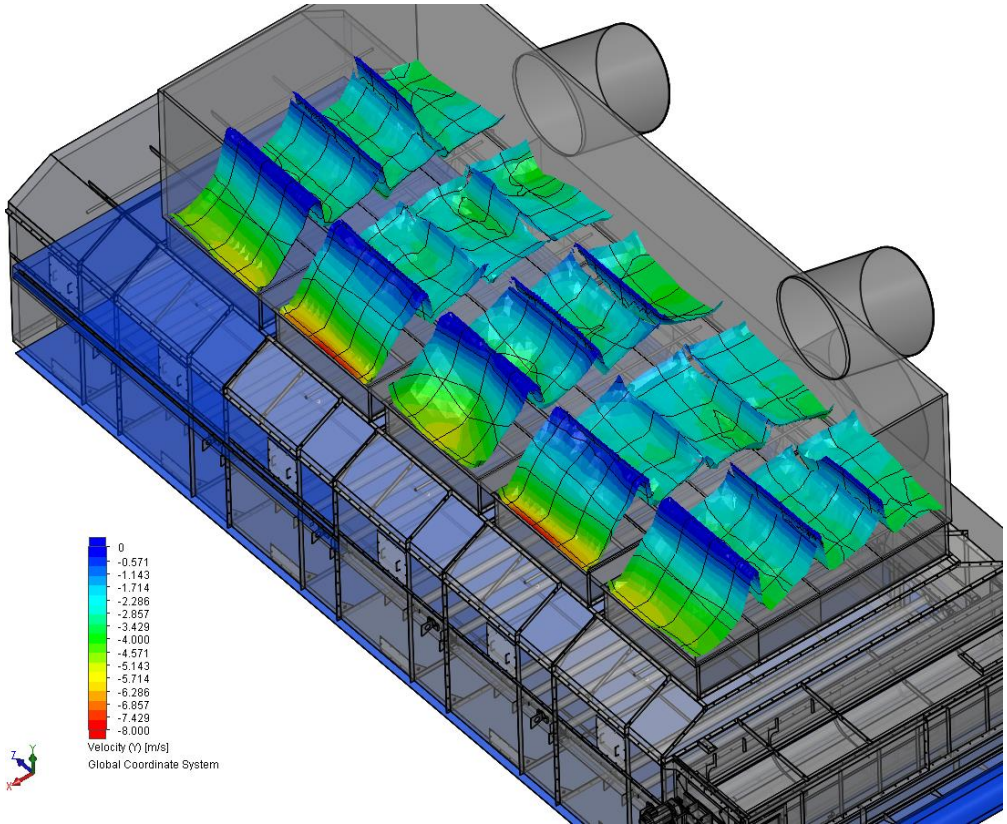


2x inlet at 15°, vanes at roof



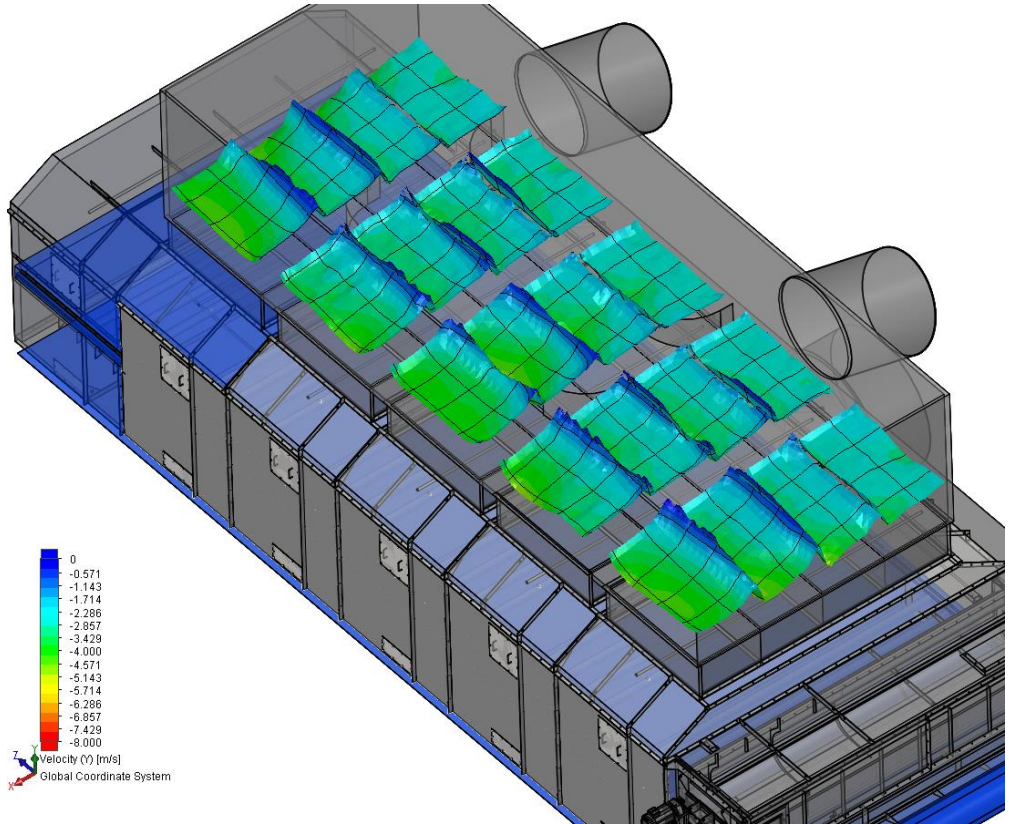
2x inlet

Uniformity Index [ ] 0.66



2x inlet , roof vanes

Uniformity Index [ ] 0.75



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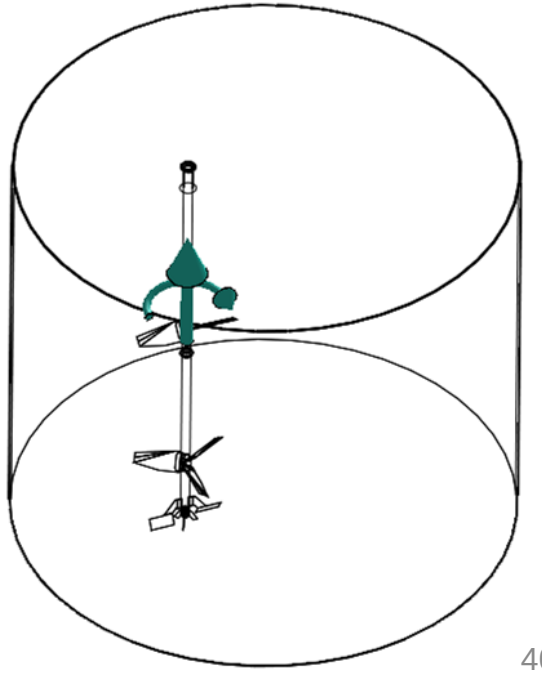
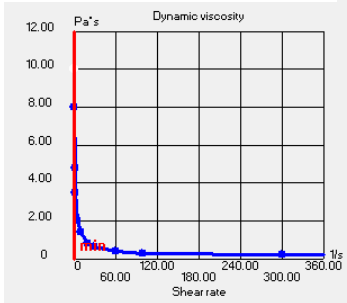
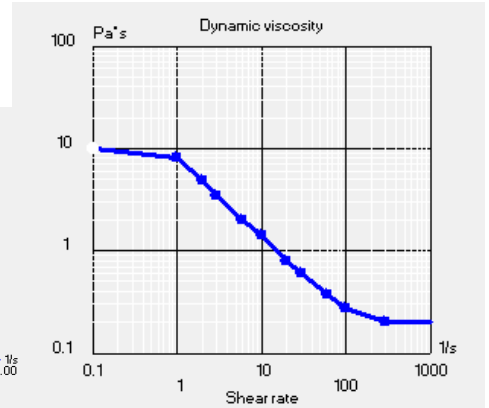


Condities

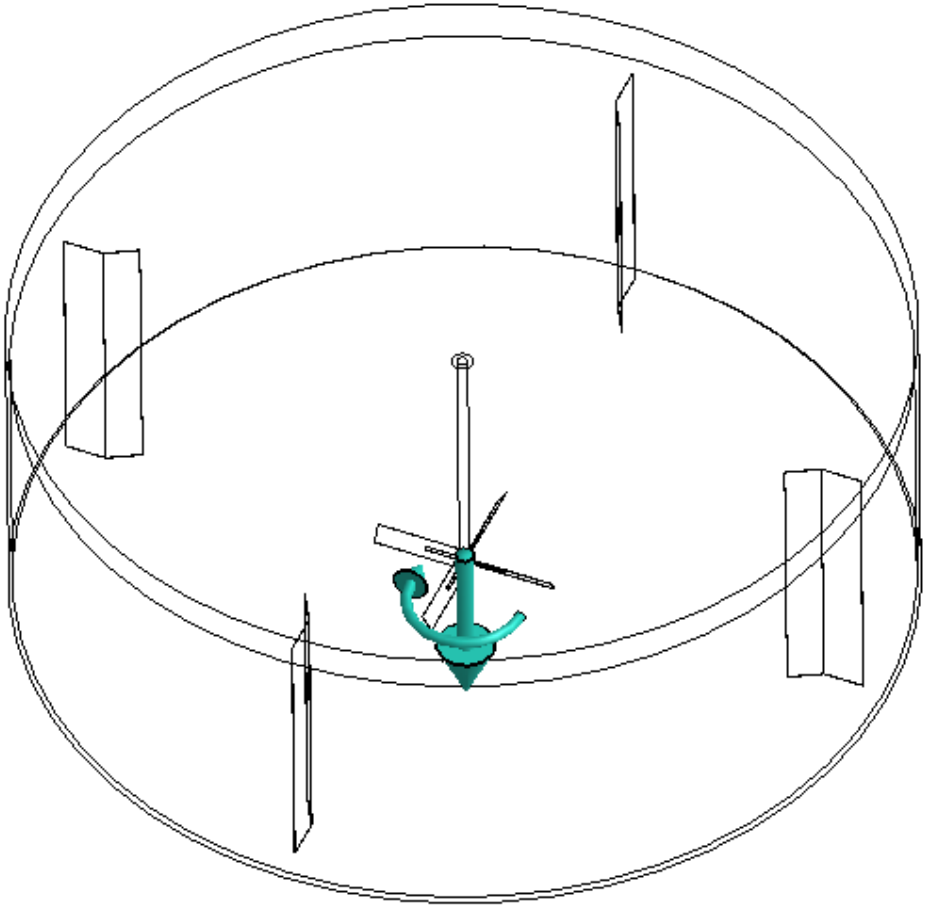
Liquid "Newtonian":
Viscosity 1000 cP= 1 Pa.s

Liquid "Non-Newtonian":
Viscosity:





Rotation
High level 10 RPM
Low level 5 RPM



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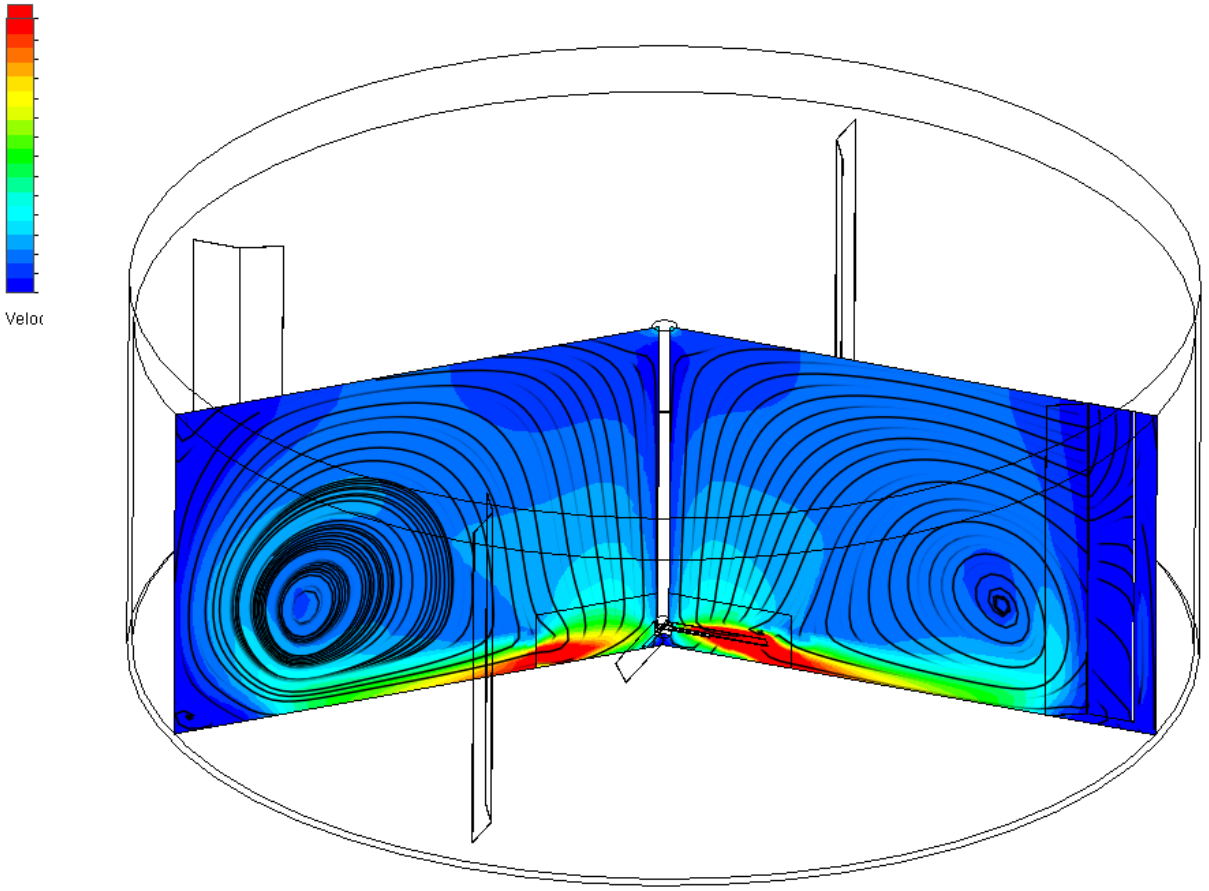
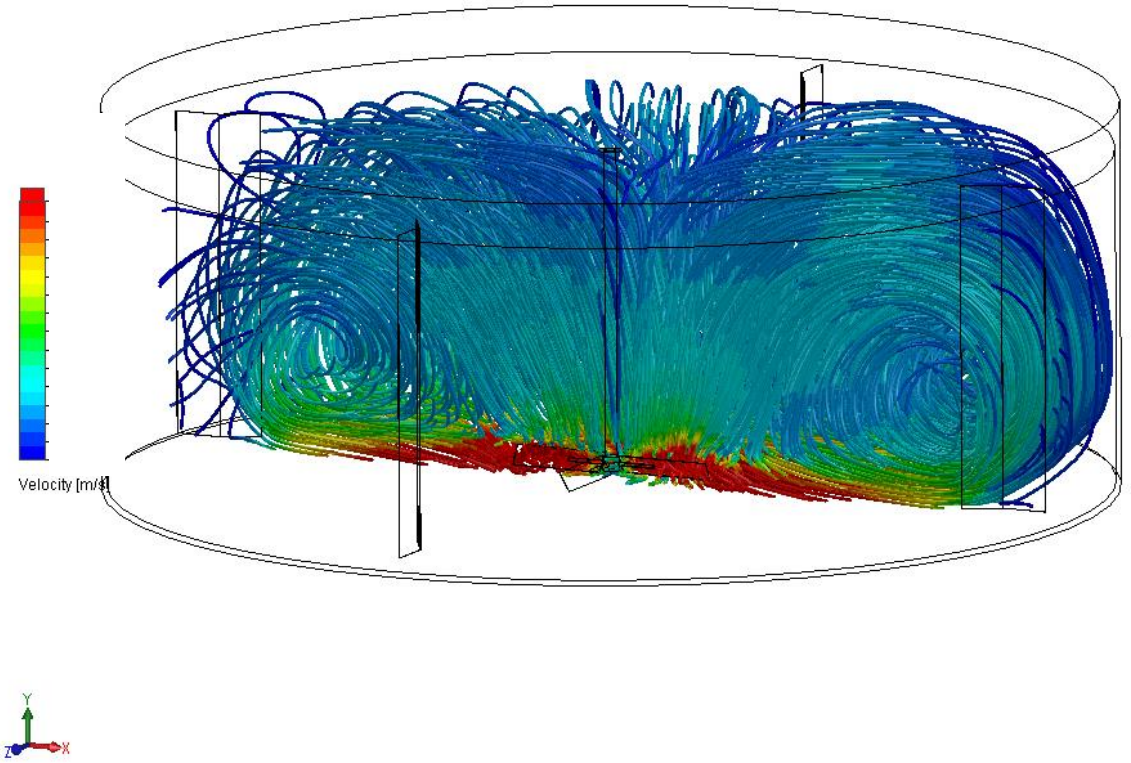
Velocity, max level, non-newtonian



max level

Flow trajectories



max level

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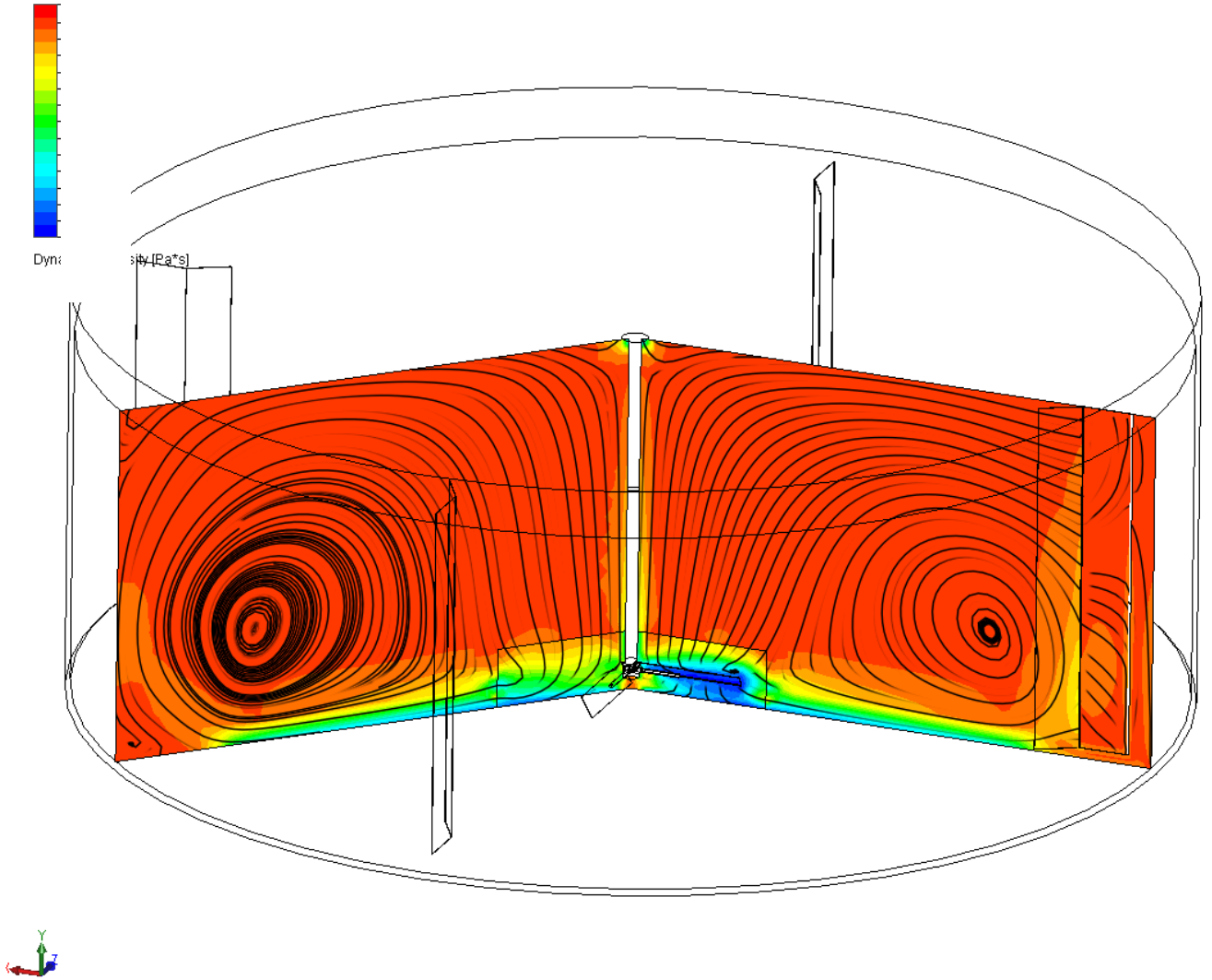
Viscosity



max level

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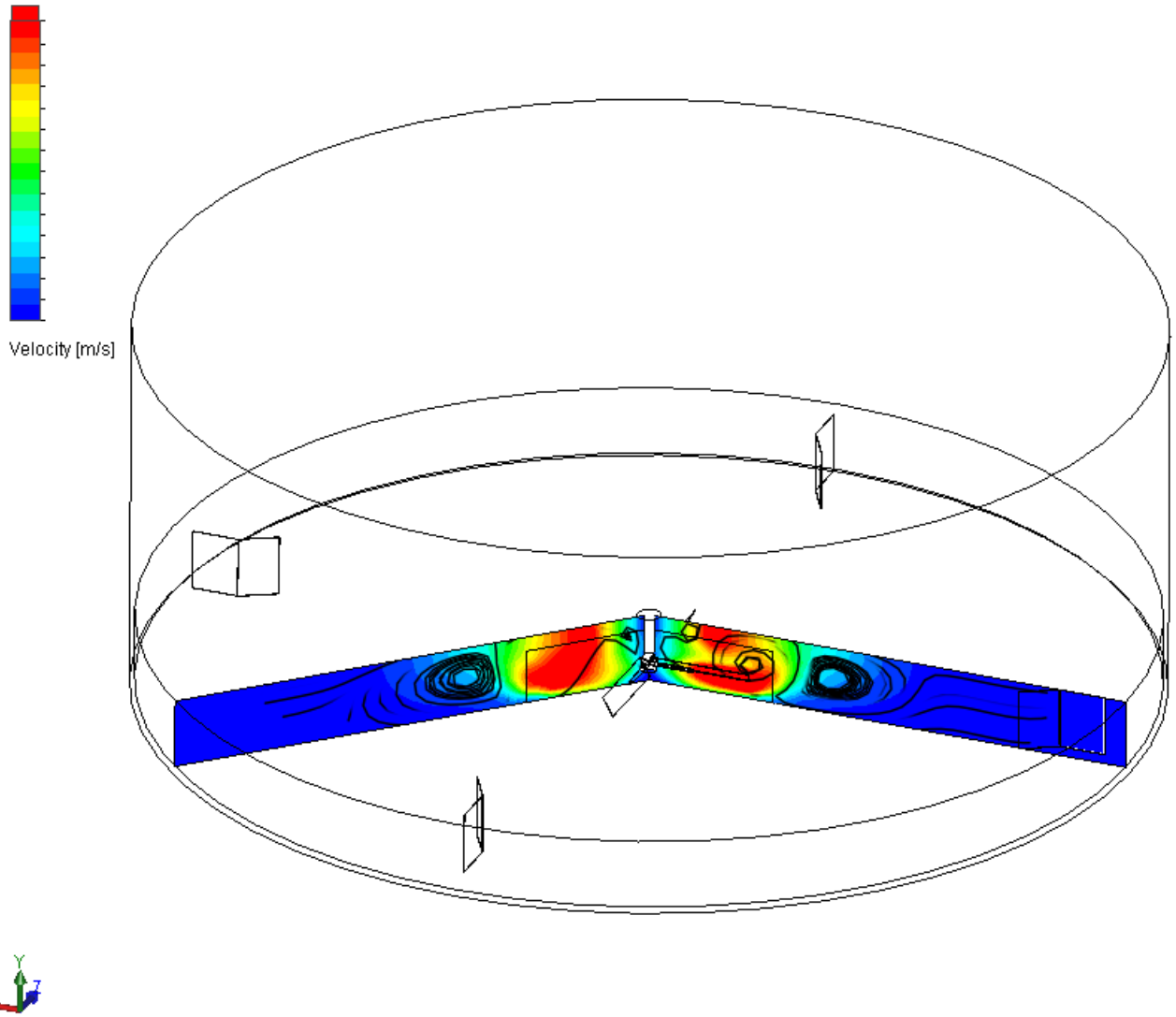
min level



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TNO report

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CFD benchmark for wind loads on a high-rise building

TNO innovation for life

Date	November 22, 2016
Author(s)	ir. A. J. Bronkhorst dr. ir. C. Hulsbosch-Dam

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Participants and solvers

Study	Software	Solver	Method	Closure
RANS studies				
HEC	FloEFD	compressible	RANS	Modified k-ϵ
2	OpenFOAM	simpleFOAM	RANS	k-ω SST
3	ANSYS CFX	CFX-solver	RANS	BSL-RSM
4	ANSYS Fluent	-	RANS	RNG k-ϵ
5	Autodesk CFD	-	RANS	RNG k-ϵ
LES studies				
6	OpenFOAM	pimpleFOAM	DDES	Spalart-Allmaras
7	ANSYS CFX	CFX-solver	SAS-SST	k-ω SST
8	ANSYS Fluent	Pressure/coupled	ELES	Realizable k-ϵ
9	OpenFOAM	pimpleFOAM	DDES	Spalart-Allmaras

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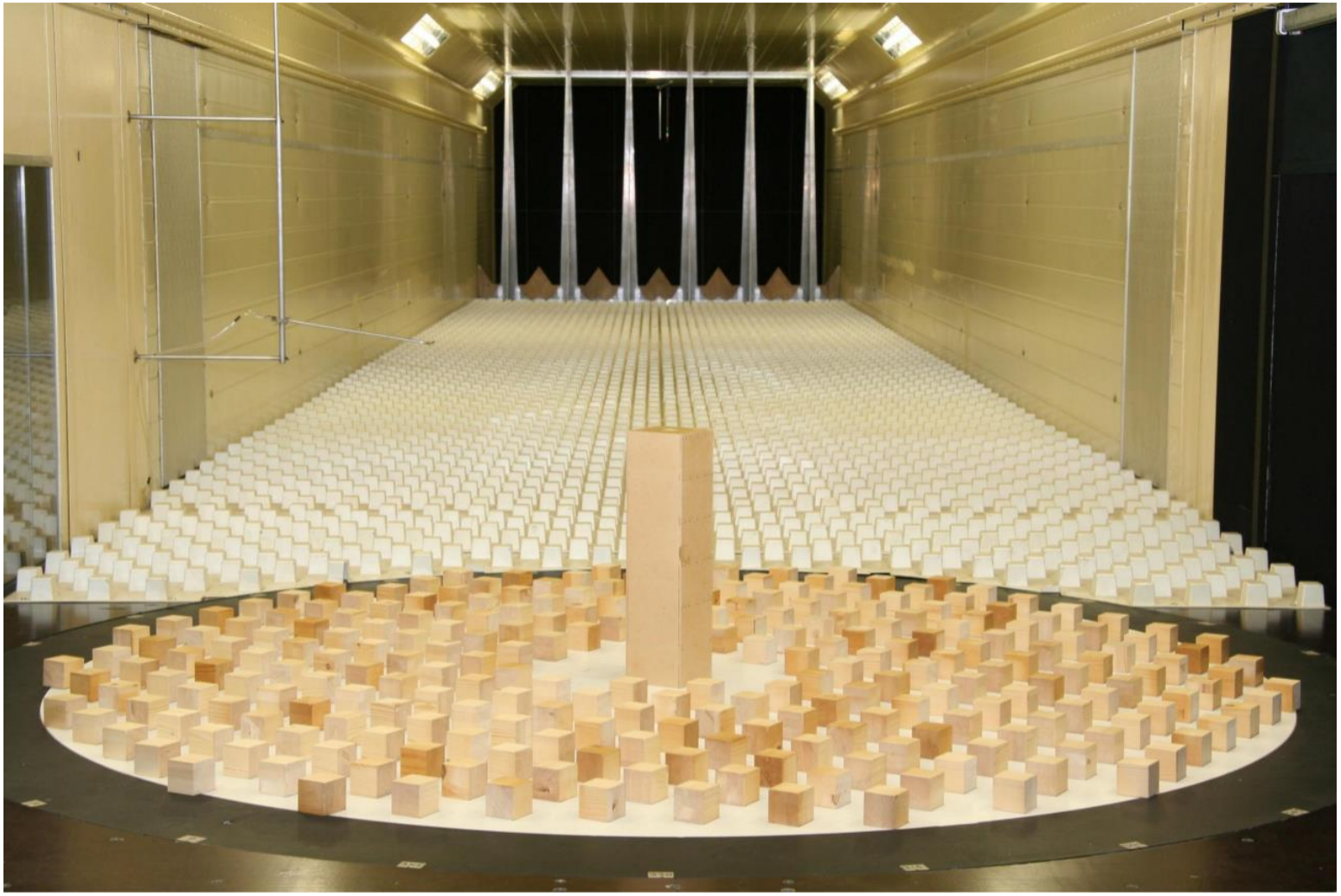
Comparison of CFD simulations with a benchmark wind tunnel test for wind loads



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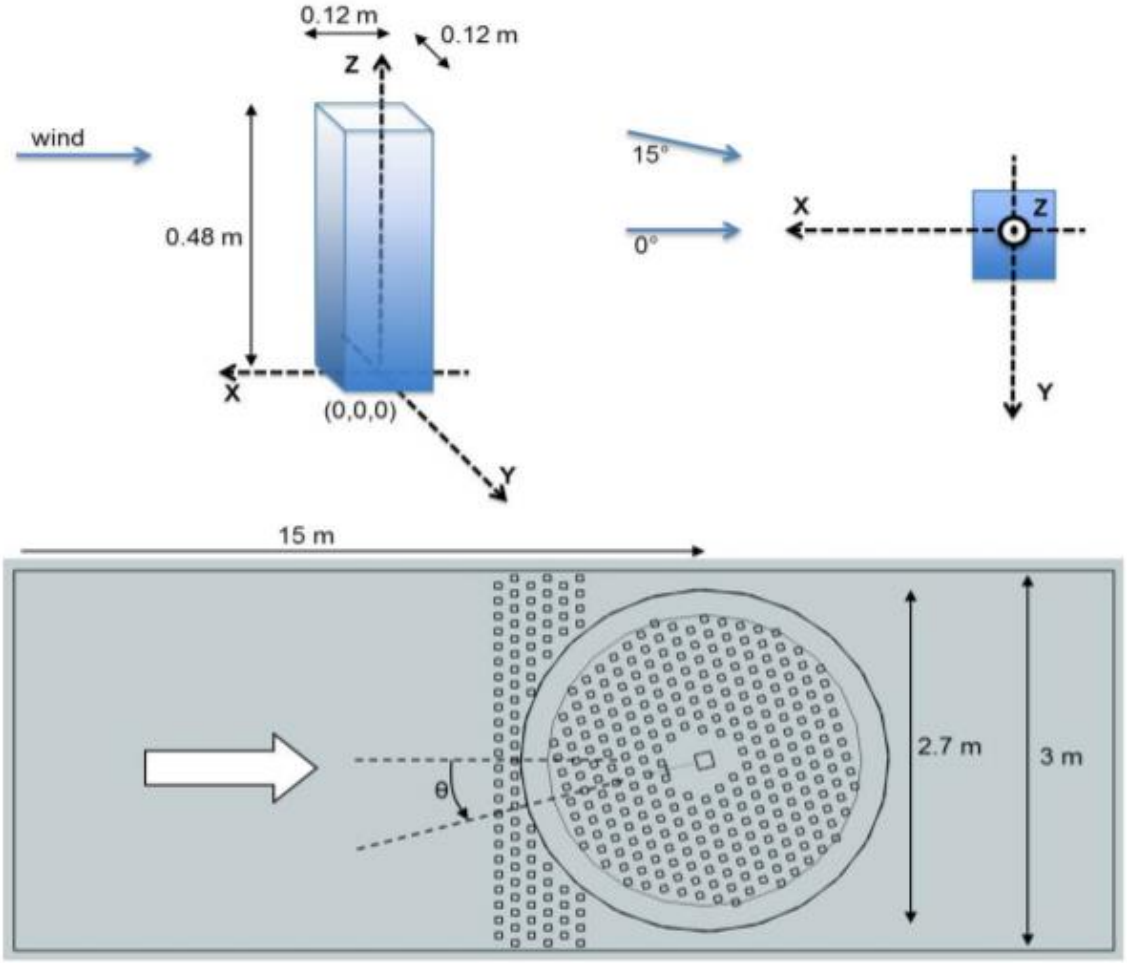
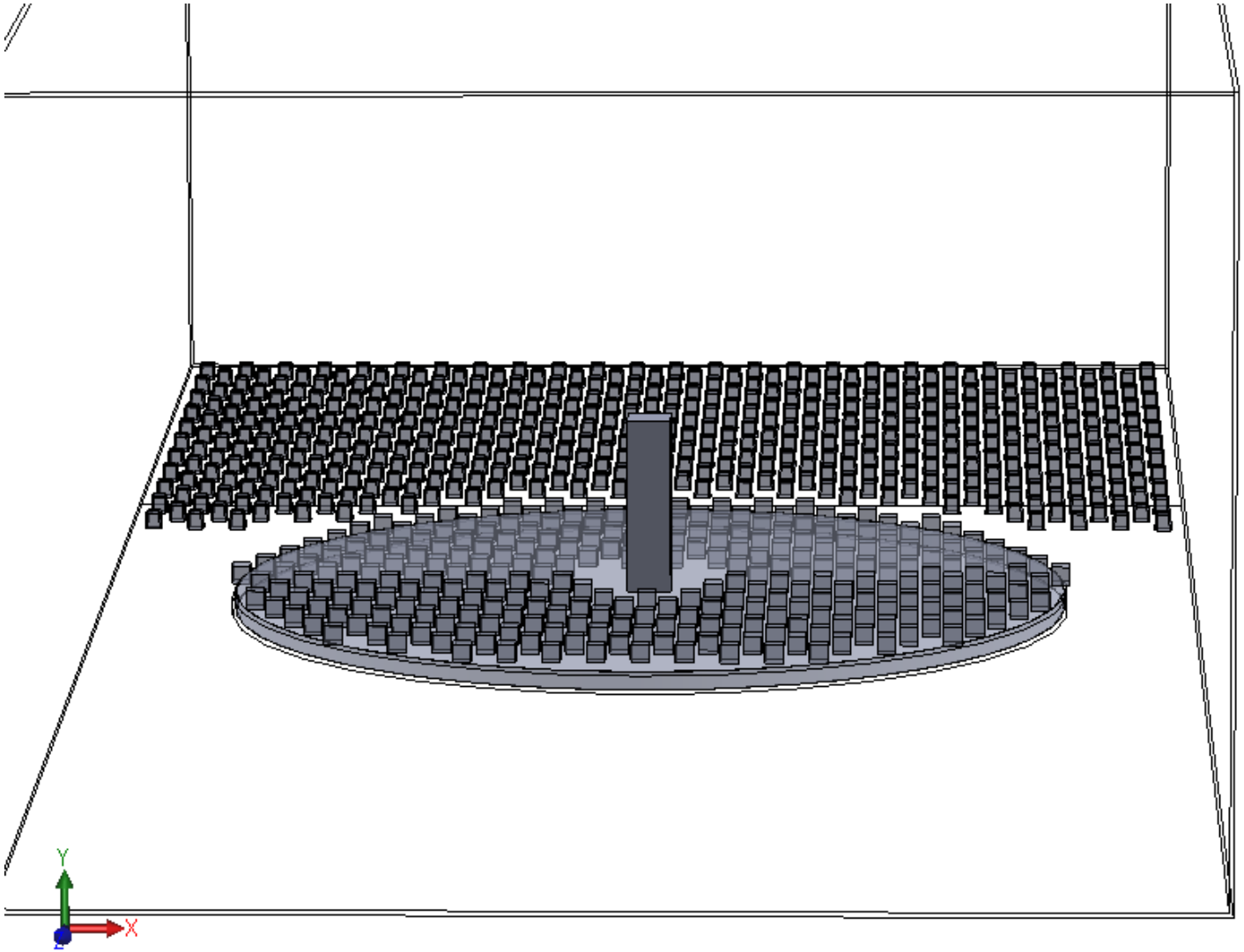
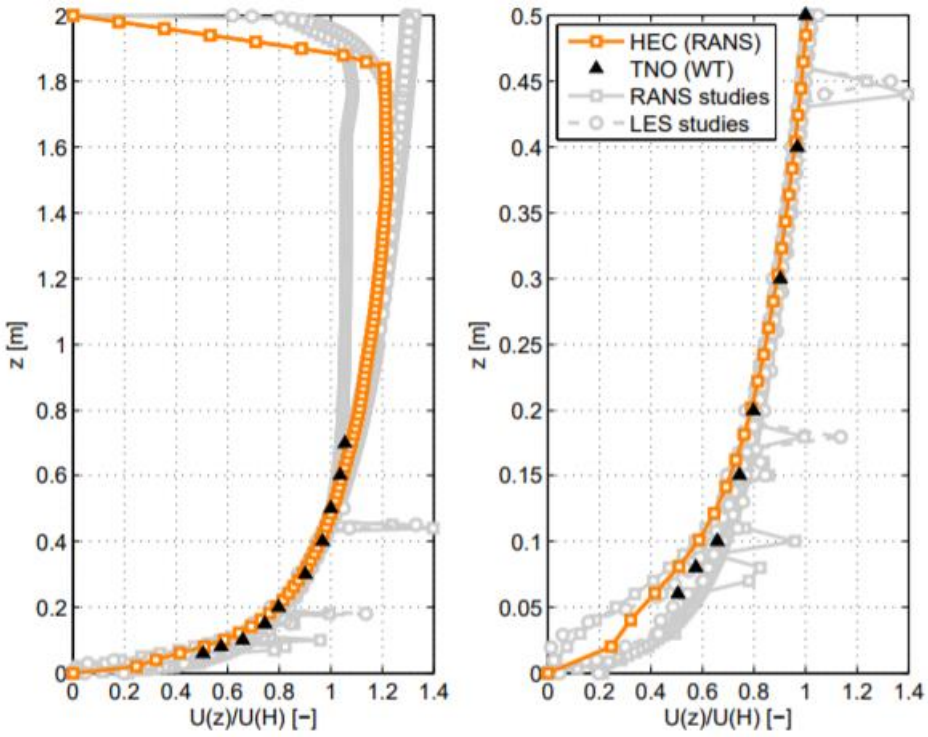
Set-up



FloEFD model



Boundary layer



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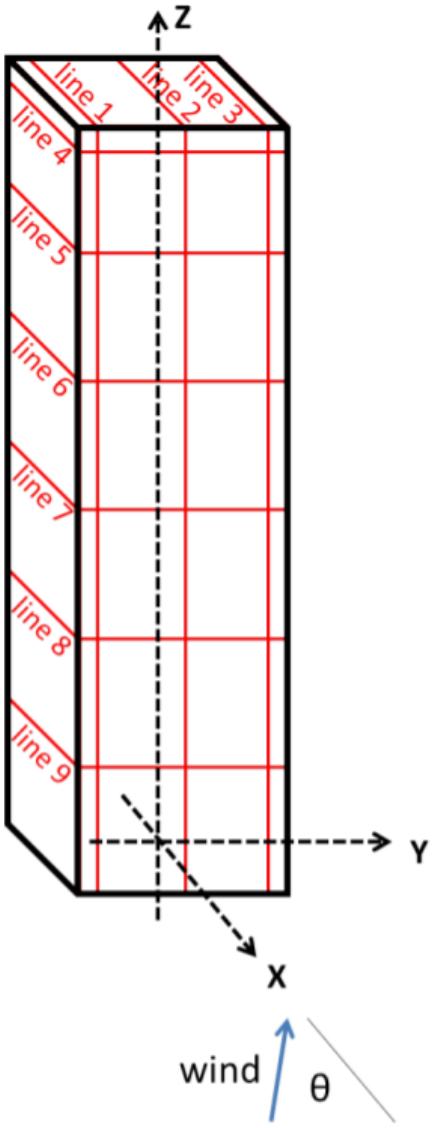
CPU time, wall time

Study	Clock speed	Nodes	Processors per node	Wall time
RANS studies				
HEC	3.07 GHz	1	4	5 hr
2	3.33 GHz	1	10	23 hr
3	2.8 GHz	2	12	6 hr
4	3.3 GHz	1	12	6 hr
5	2.93 GHz	1	8	24 hr
LES studies				
6	Cloud	1	16	550 hr
7	2.8 GHz	2	12	900 hr
8	3.3 GHz	8	2	1500 hr
9	2.0 GHz	1	6	904 hr

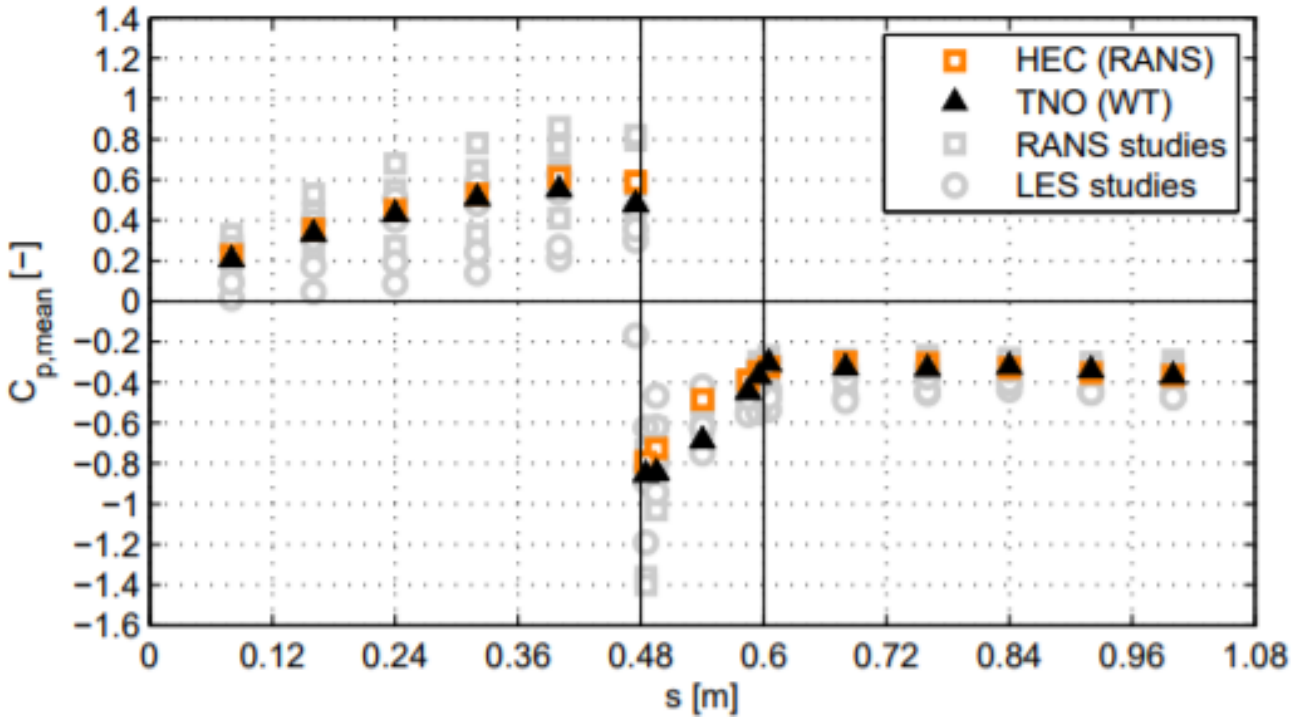
Mesh

Study	Cell number	Grid topology	Grid boundary	Cell type
RANS studies				
HEC	2.7 x 10^6	Cartesian	Immersed boundary	Cartesian
2	2.1 x 10^6	Hybrid	Boundary-fitted	Hexahedral/ Hexagonal
3	18.2 x 10^6	Unstructured	Boundary-fitted	Tetrahedral
4	2.9 x 10^6	Hybrid	Boundary-fitted	Hexahedral
5	9.8 x 10^6	Unstructured	Boundary-fitted	Tetrahedral
LES studies				
6	2.1 x 10^6	Hybrid	Boundary-fitted	Hexahedral/ Hexagonal
7	18.2 x 10^6	Unstructured	Boundary-fitted	Tetrahedral
8	7.0 x 10^6	Hybrid	Boundary-fitted	Hexahedral
9	3.6 x 10^6	Cartesian	Boundary-fitted	Hexahedral

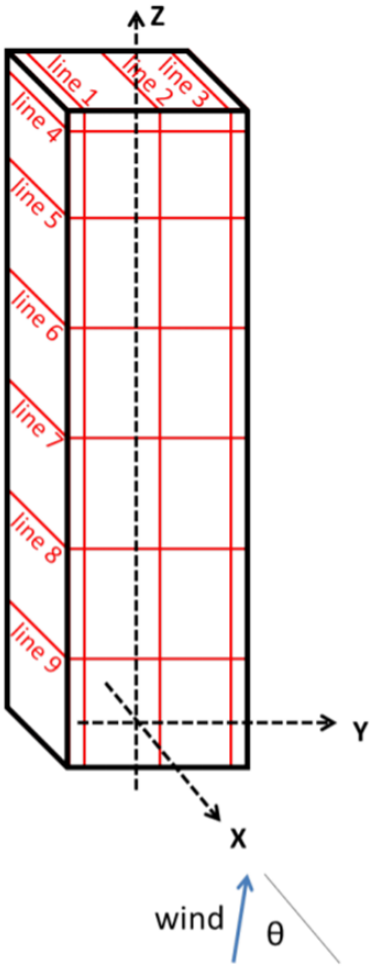
Results comparison



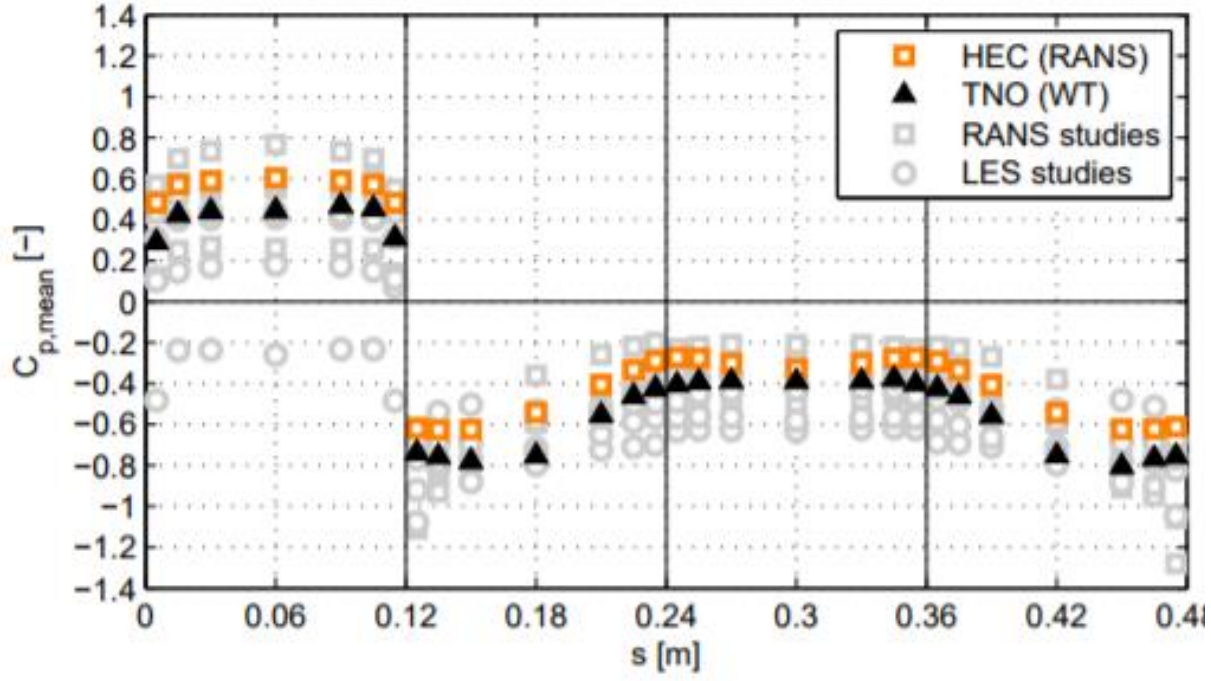
Results comparison

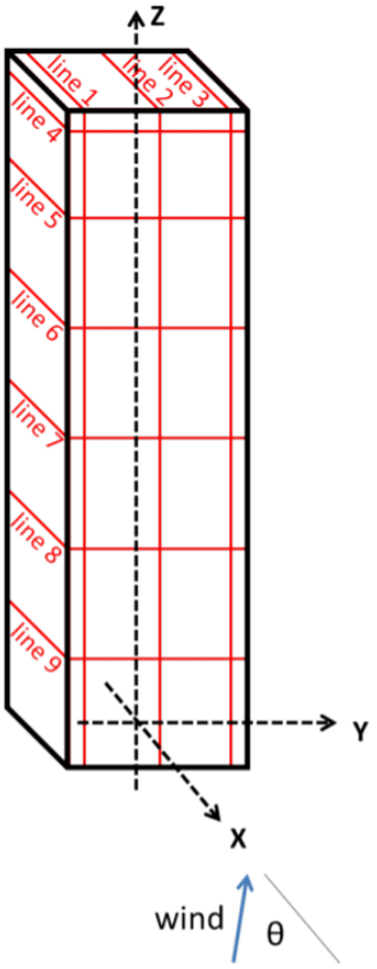


Line1, 0°

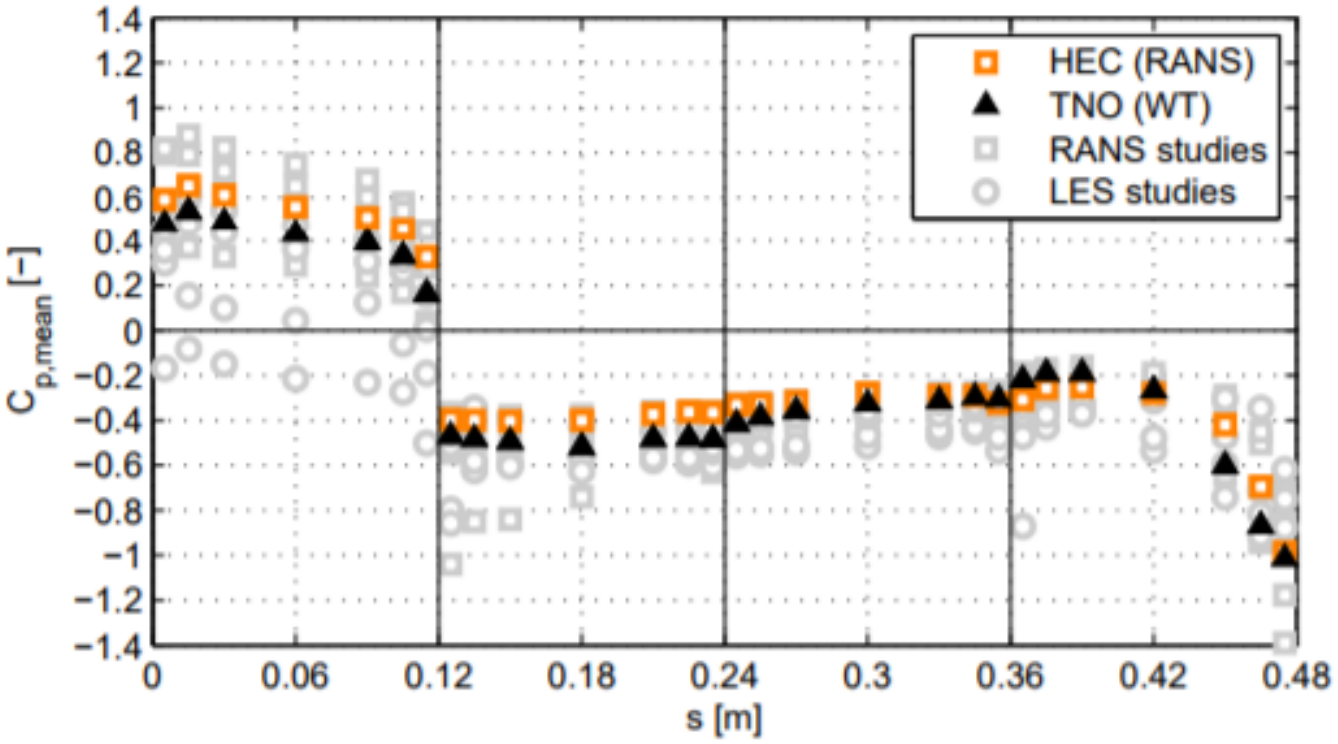


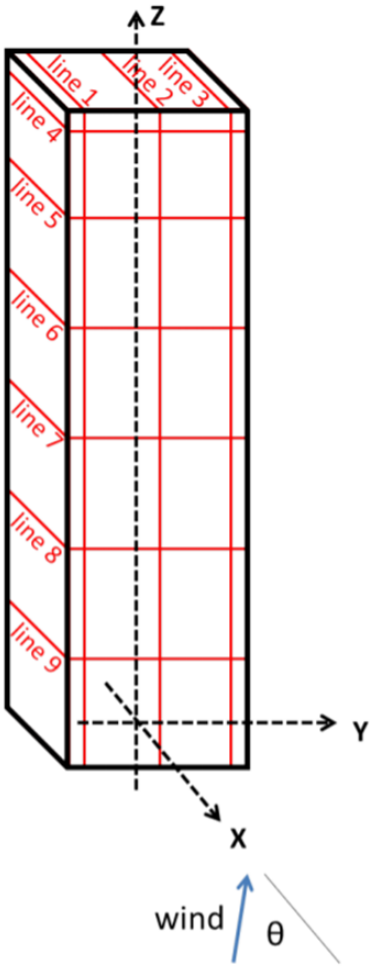
Results comparison





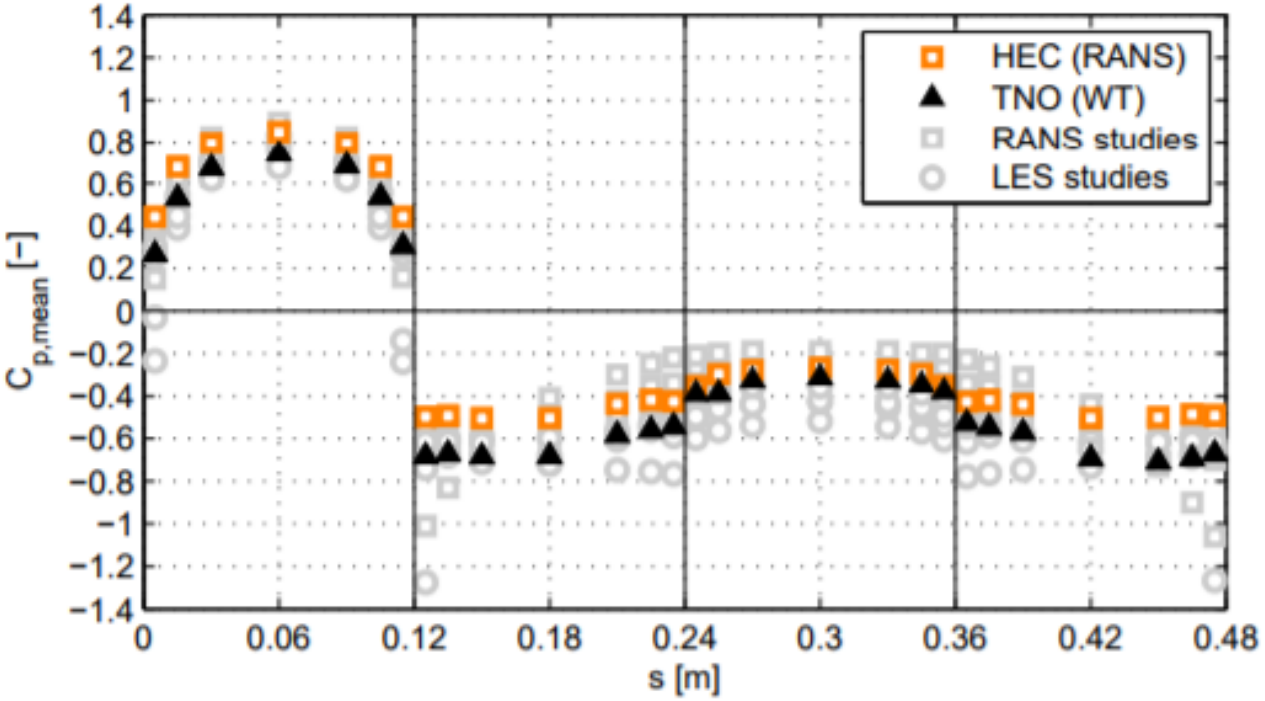
Line 4, 0°


HEC (RANS)
TNO (WT)
RANS studies
LES studies
$C_{p,mean}$ [-]
s [m]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
0
0.06
0.12
0.18
0.24
0.3
0.36
0.42
0.48

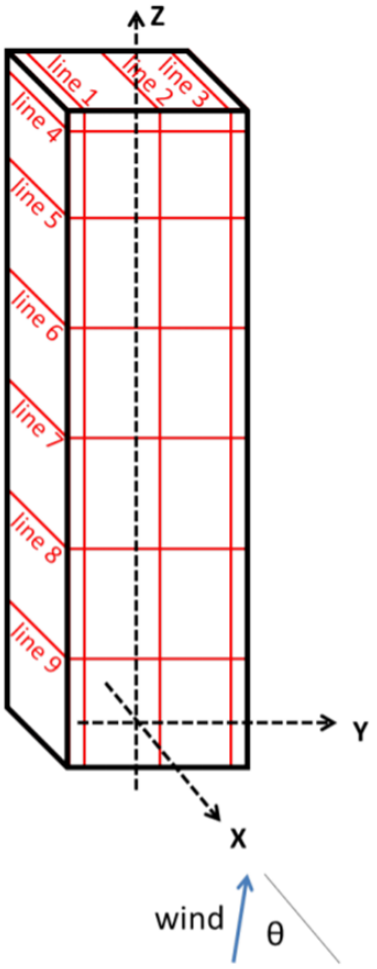

Z
Y
X
line 1
line 2
line 3
line 4
line 5
line 6
line 7
line 8
line 9
wind
θ

Line 4 , 15°

Results comparison



Line7, 0°



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Conclusions wind load comparison

- **Report conclusion: The results of the RANS studies are generally closer to the windtunnel results than the results of the LES studies.**

- **My conclusion: FloEFD quality is good, the best k-epsilon and possibly best RANS CFD.**
- **LES makes no sense for commercial wind load applications**

- **FloEFD is fast.**

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Conclusion of my presentation

- **FloEFD is very good to do consulting work.**
- **FloEFD is fast, variants are easy**
- **Frm TNO benchmark: FloEFD quality is good for wind load, the best k-epsilon and possibly best RANS CFD.**

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Thank you for your attention