SULZER

Mega columns: challenges and solutions

Mario Roza, VP Technology Management and Process Innovation

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Why a joint presentation?

The Shell – Sulzer alliance

- Since 2001 Shell has licensed Sulzer to design, manufacture, and sell Shell trays to others
- Included in this license are Shell Calming Section™, Shell HiFi™, Shell HiFi™ extraction trays, Shell ConSep™ and Shell Calming Section Grid™ trays
- Also included are Shell Schoepentoeters™ and Shell VersiSwirl™ separators
- Sulzer will market these devices directly to all customers world-wide
- Shell and Sulzer cooperate on several 'joint' developed R&D projects.

Agenda Part 1

- Mega-towers overview
- Mechanical challenges
- CO2 capture; even larger towers
- Phase distribution challenges

Mega-towers overview

Very large diameter towers

More than 100 packed columns with D> 10m

Type of column	Max. D (mm)	Comments
Refineries		
VDU	15'300	
HCVU	12'750	
Lube vacuum tower	12'200	
Main fractionator	11'000	
CDU	10'800	
Wet Gas Scrubber	10’200	
Upgrader Vacuum Tower	15'240	
Steam crackers		
Gasoline Fractionator Ethylene Plant	13'000	
Water Quench Etylene Plant	12'300	
Flue gas or CO2 capture		
SO2 absorber	15'000	
Flue gas quencher (carbon capture)	12’500	rectangular 10 x 12 m
CO2 absorber (carbon capture)	12’200	rectangular 10 x 12 m
CO2 stripper (carbon capture)	10'012	

Courtesy Larsen & Toubro

One of the largest packed towers

Three sections ID 11000 mm / 14200 mm / 9000 mm

Very large diameter towers

More than 20 tray columns with D> 10m

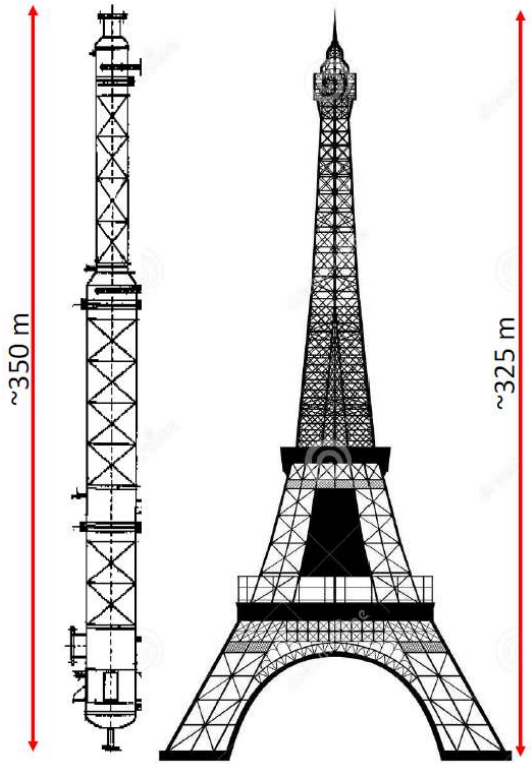
Type of Column	Max. D (mm)
Refineries	
Main fractionator	12'500
CDU	12'000
Deisohexanizer	12'000
Product fractionator	10'500
Upgrader vacuum tower	12’800
Steam cracker, petrochemicals	
PP Splitter	10'400
Gasoline fractionator Ethylene Plant	14’000
Para-xylene plant	10'800

Courtesy Mammoet

Extremely tall columns

Aria project - ^{40}Ar to detect dark matter particles, WIPMs

- Purification of Liquid Argon from underground sources
- Key components ^{39}Ar and ^{40}Ar -> α = 1.0015
- 112 beds of Sulzer CY™ structured packing
- Close to 3000 theoretical stages
- Target product pure ^{40}Ar, ^{39}Ar reduced by factor 10 per run
- 1 part per 1'000 of total flow is product
- Diameter about 0.32 m in cold box of 0.7 m
- Installed in a mineshaft in Sardinia



Courtesy A. Renshaw, UCLA

Mechanical challenges

Mechanical design challenges

Support rings sized to cope with column roundness quality

ASME Code (Section VIII Division 1 UG-80) states

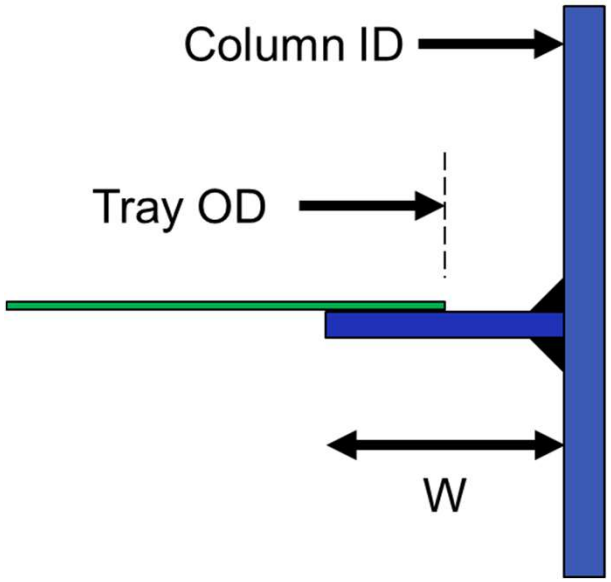
- Pressure Vessels need to be round to within +/- 1% of Tower Diameter
- Support Rings and Beam Seats need to be large enough to cover this tolerance range

Example

ID = 12’000 mm

Minimum W = 120 mm

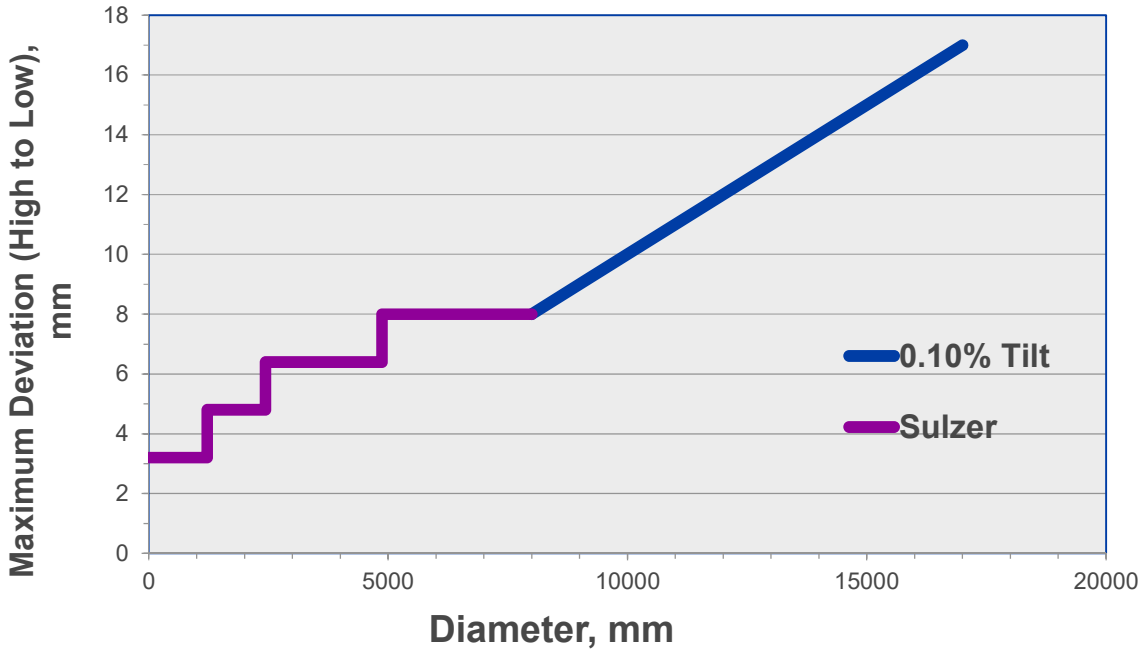
Overlap minimum half a ring width -> 60 mm



Mechanical challenges

Support ring levelness

- History typically +/- 3 mm before large towers
- Burdensome for vessel fabricators
- Reasonable approach is a degree of tilt
- Practical approach is to provide a “stair step” allowable levelness for both fabricators and inspectors alike
- Criteria should hold for both trayed and packed towers



Mechanical challenges

Tray levelness

- Biggest worry “sag” in tray design
- Possible effect seen in practice
  D= 11.6 m with deflection
  -> 30% efficiency loss
- Typical deflection criterion today -
  -> 1/900 of Tower ID
- Obtained by combination of
  - Clever beam configuration
  - Panel span width optimization
  - Clever use of downcomer walls to provide mechanical strength

Mechanical challenges

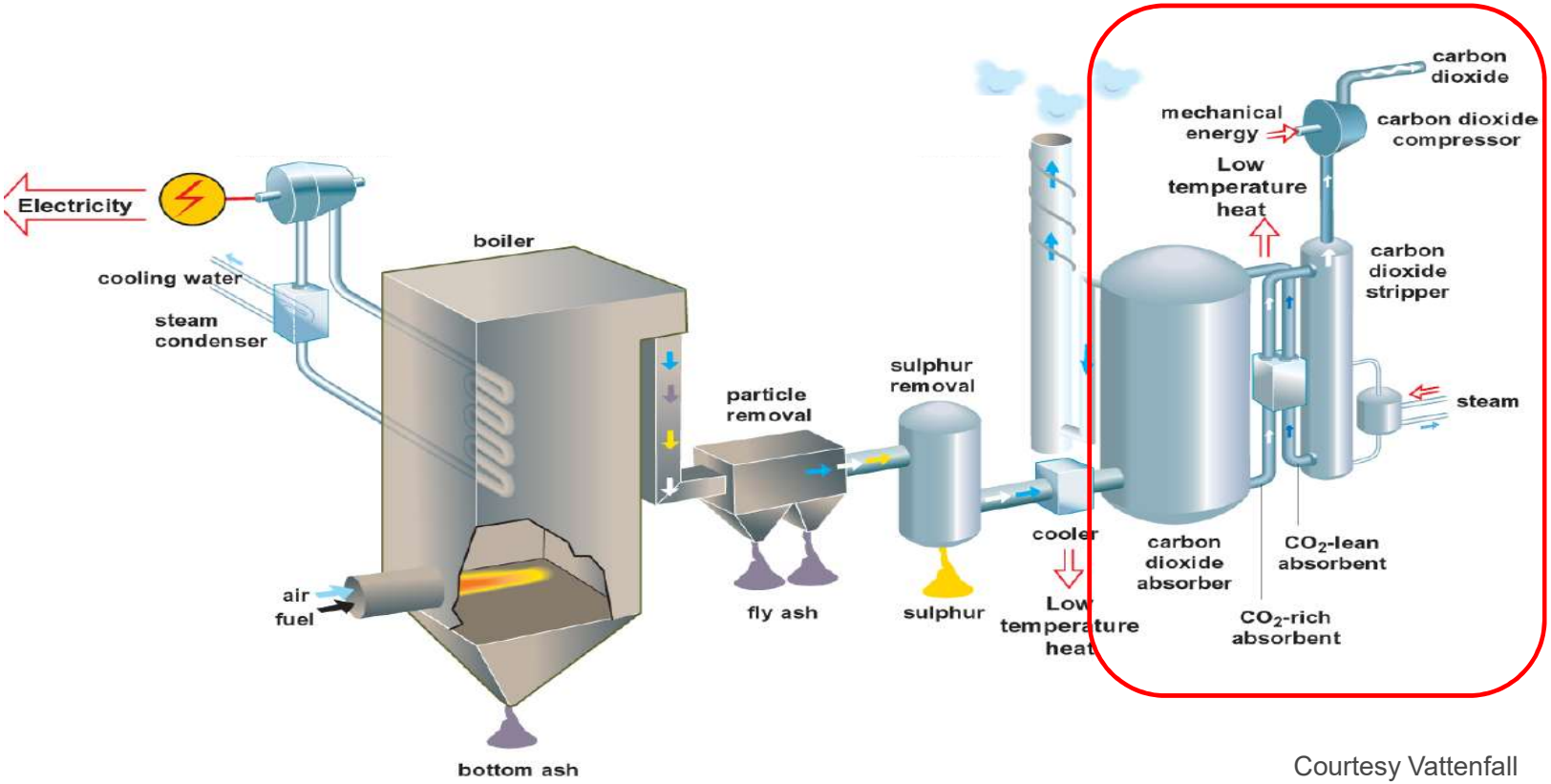
Beam and downcomer design

- Use downcomers for strength with thicker panel design
- Use lattice truss beams to tie two or more trays together
- Pay attention to beam seat size to cope with unroundness
- Pay attention to beam thermal expansion -> 304L nearly double thermal expansion of Carbon Steel
- Adapt beam width to cope with slight seat misalignments

CO_2 capture; even larger towers

CO_2 Capture : Post-Combustion

Could require even larger towers than seen today



Courtesy Vattenfall

Post-Combustion typical values

Full size plants will require several very large towers

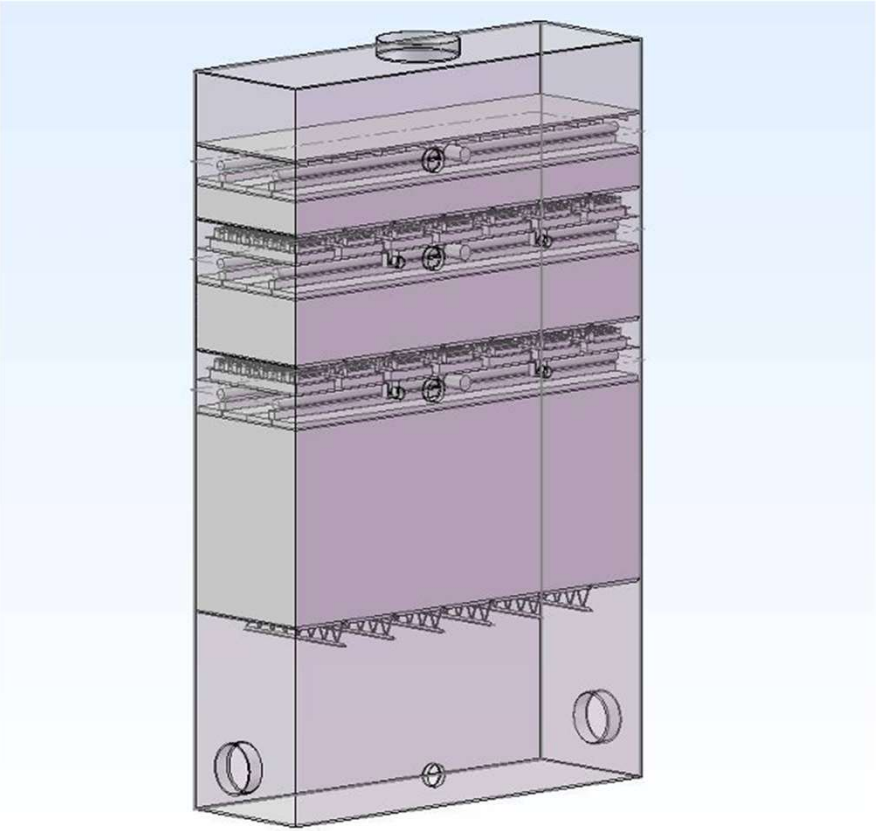
400 MWe Gas fired (NGCC)

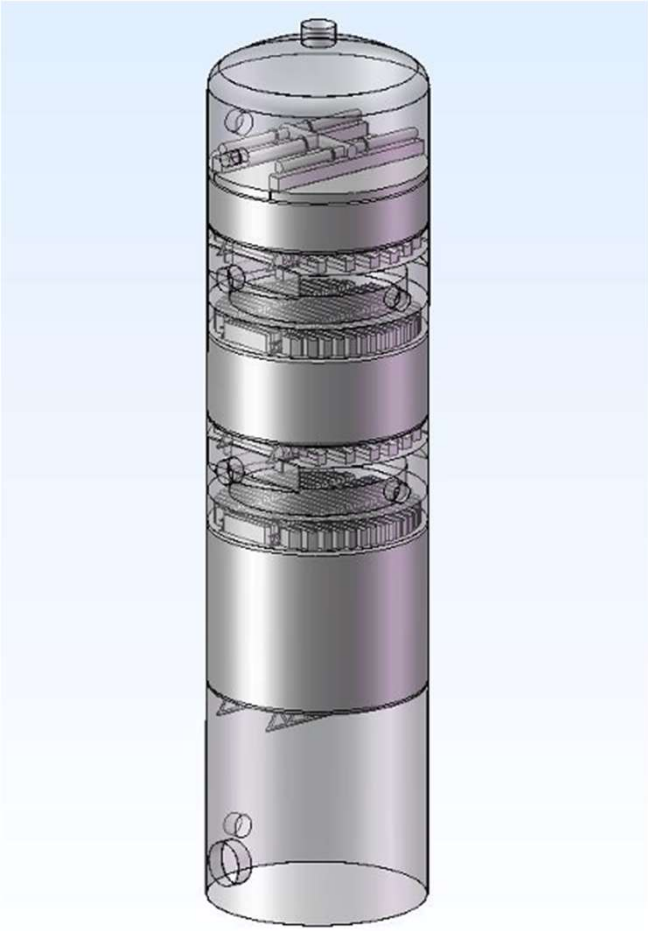
Gas flow rate:	2’000’000 Nm3/h
CO2 in inlet	4 mol-%
CO2 captured	1’000’000 t/y
Absorber area	250 m^2 (10 m x 25 m or ID = 18 m)

400 MWe Coal fired

Gas flow rate:	1’300’000 Nm^3/h
CO2 in inlet	14 mol-%
CO2 captured	2’500’000 t/y
Absorber area	200 m^2 (10 m x 20 m or ID = 16 m)

Rectangular or round columns possible





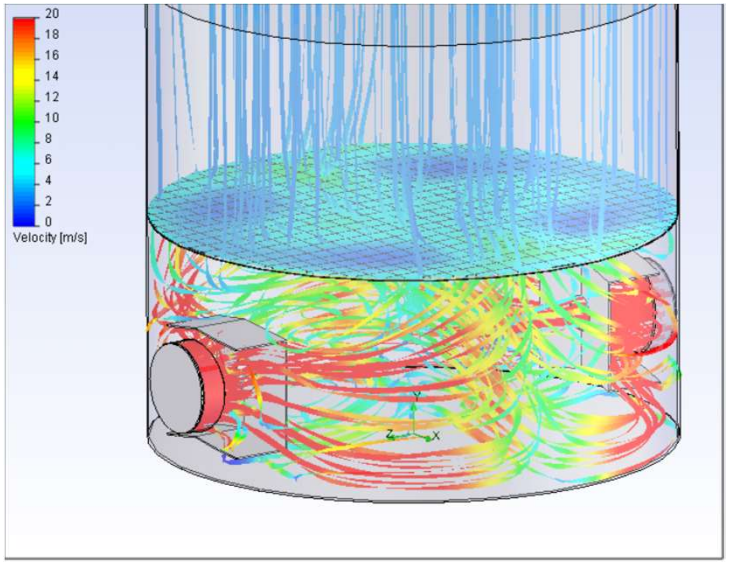
Phase distribution challenges

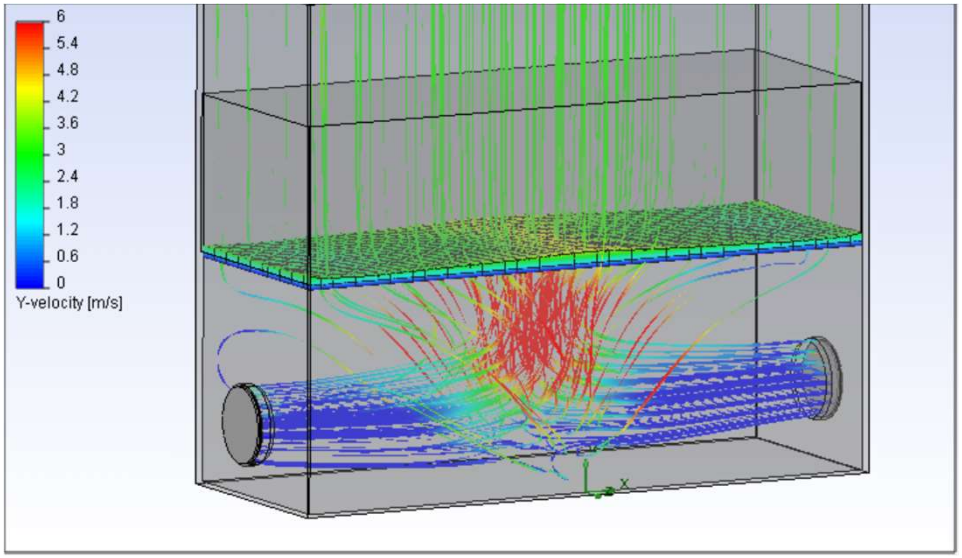
Challenge: vapor distribution

Evaluation of distribution quality for vapor inlet devices with CFD

Taking into account

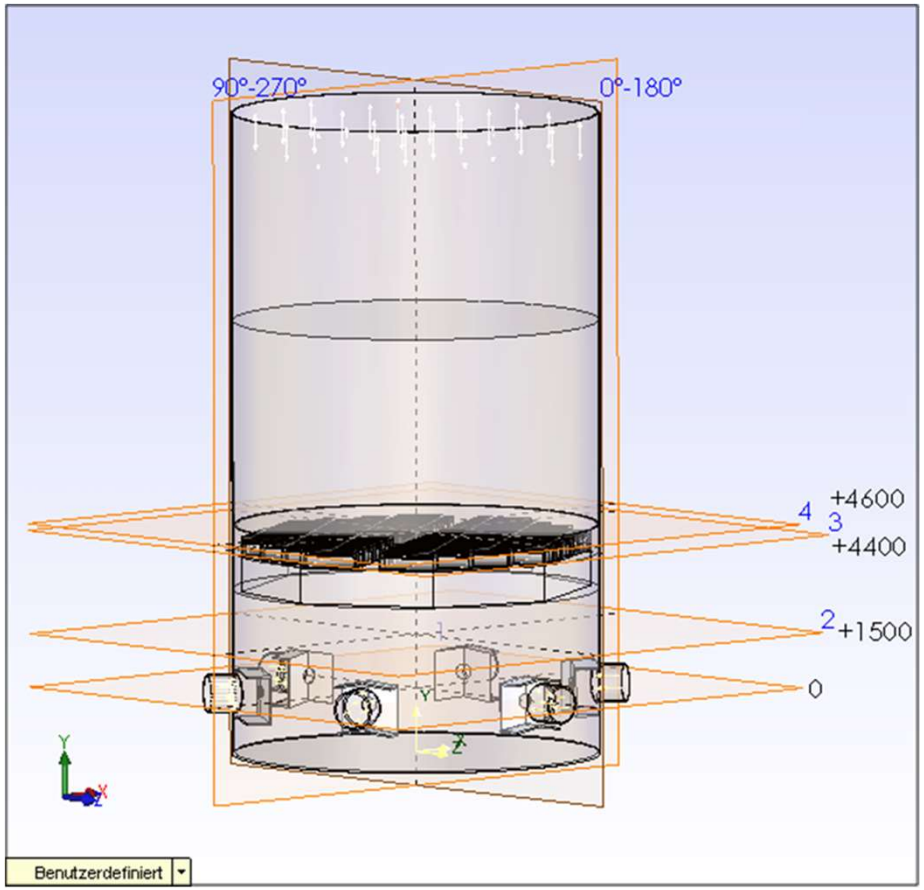
- Number of inlet nozzles
- The challenging relatively low F-factors in these towers -> minimum pressure drop design

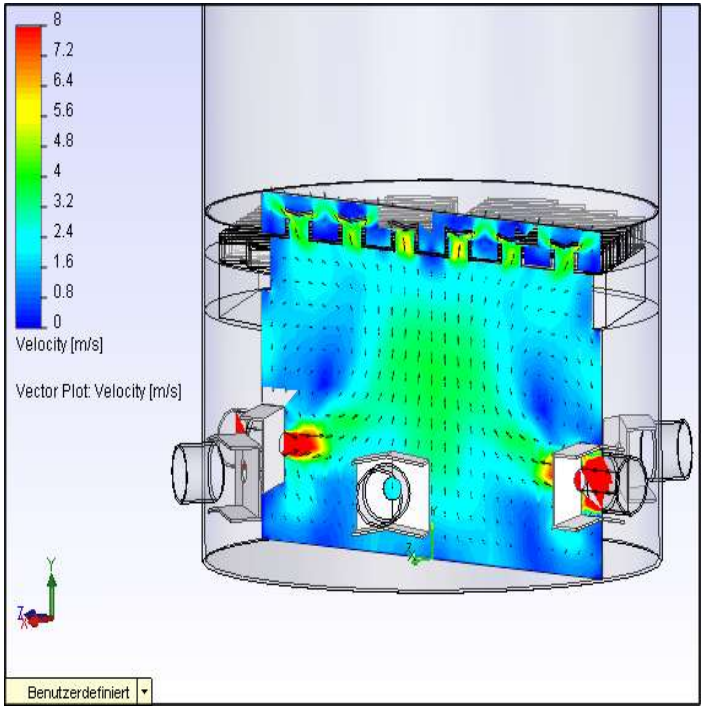




CFD analysis for vapor distribution

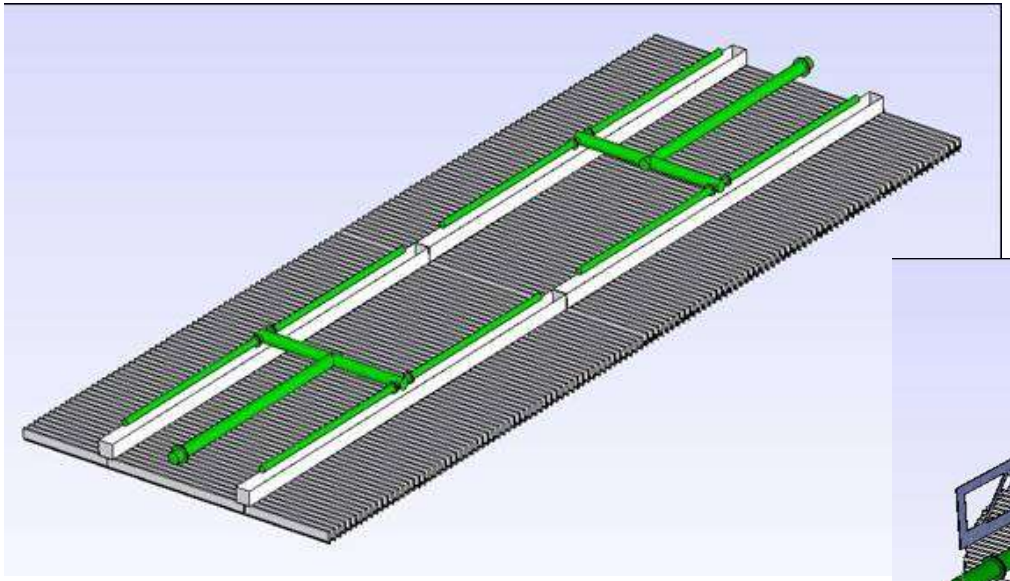
Diameter 10 m, 6 inlet nozzles, effect of chimney tray



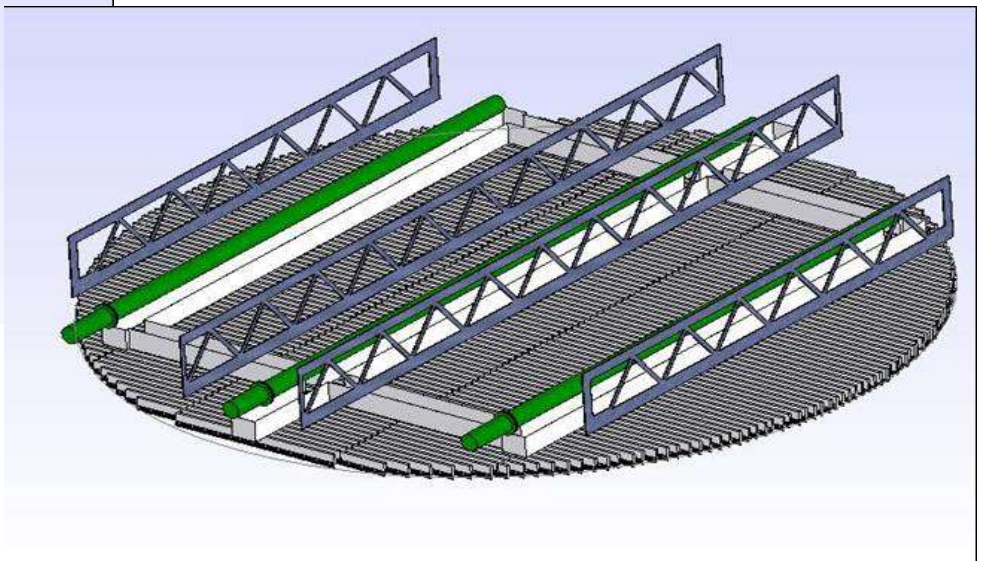


Liquid distributors

Challenge: pre-distribution quality to the arms



Rectangular distributor



Circular distributor

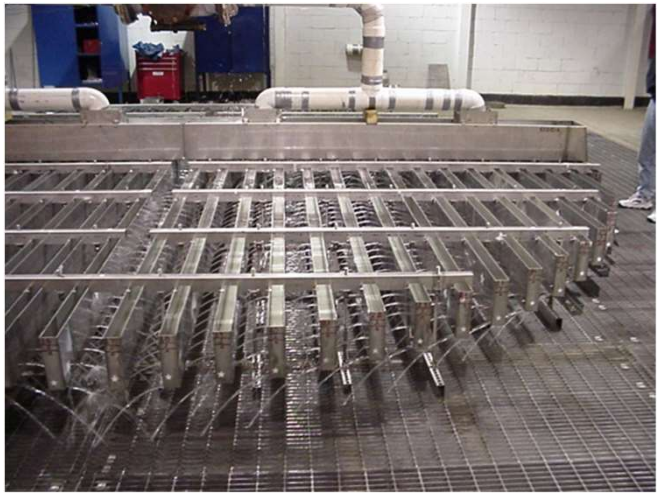
Distributor test facilities

Challenges are size and water consumption

For 10 $m^3/m^2/hr$

- D= 10 m you need 800 m^3/hr
- D= 15 m you need 1’800 m^3/hr

Solution: test ½ or even ¼ of the distributor and pre-distribution stage



Questions?