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Energy & Process

Alex Read, Director, Industries

Simcenter Nordics, May 4th, 2018, Gothenburg

Global energy trends

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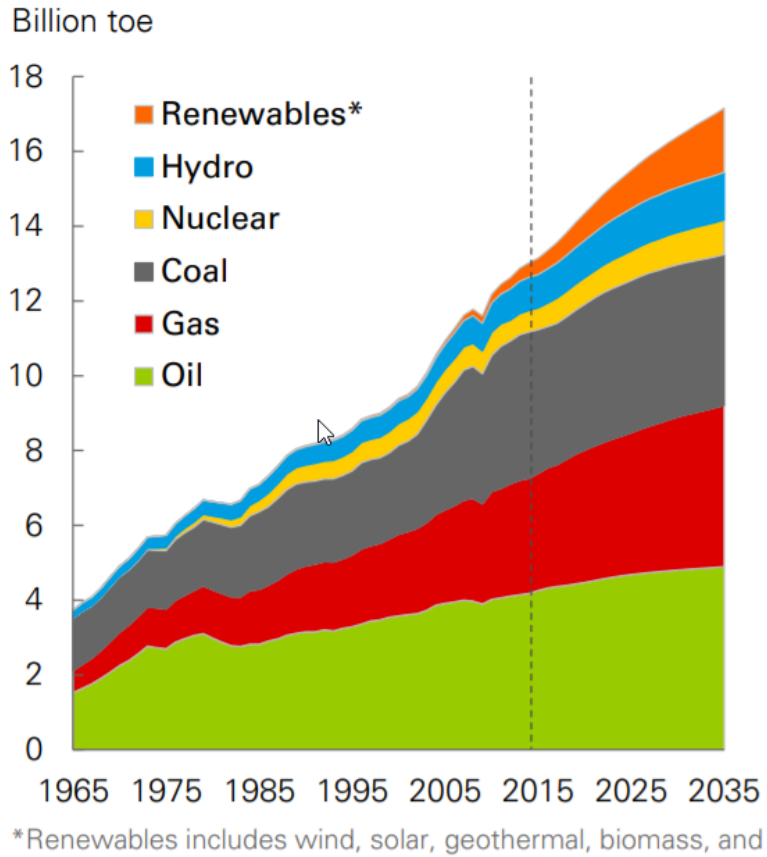
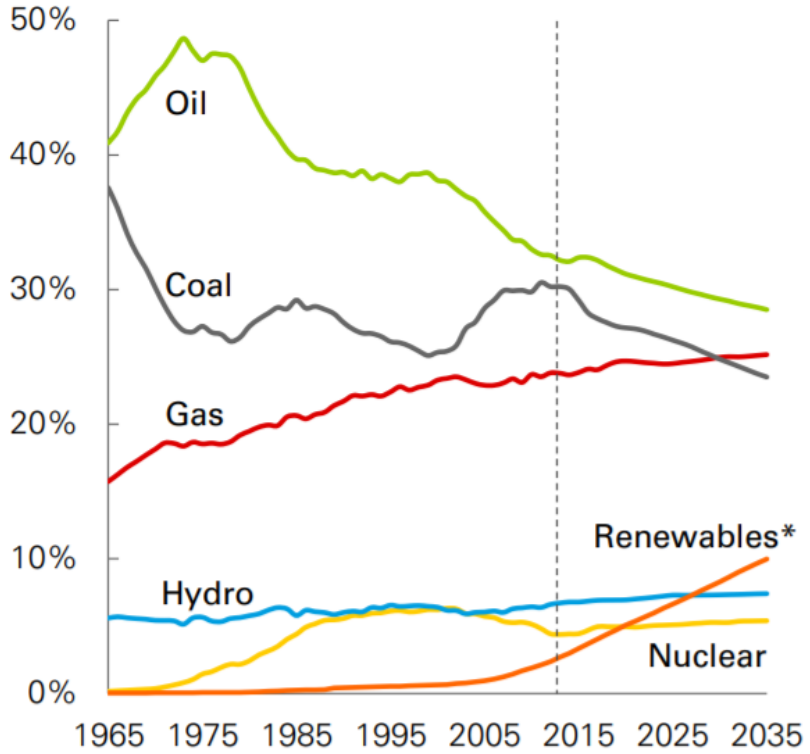
Primary energy consumption by fuel



*Renewables includes wind, solar, geothermal, biomass, and ofuels

Shares of primary energy



Implications

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Highly competitive market

Focus on efficiency (in design and operation)

Move to distributed generation and need for energy storage

Increase in R&D spend and need to get to market faster

Driving innovation through simulation

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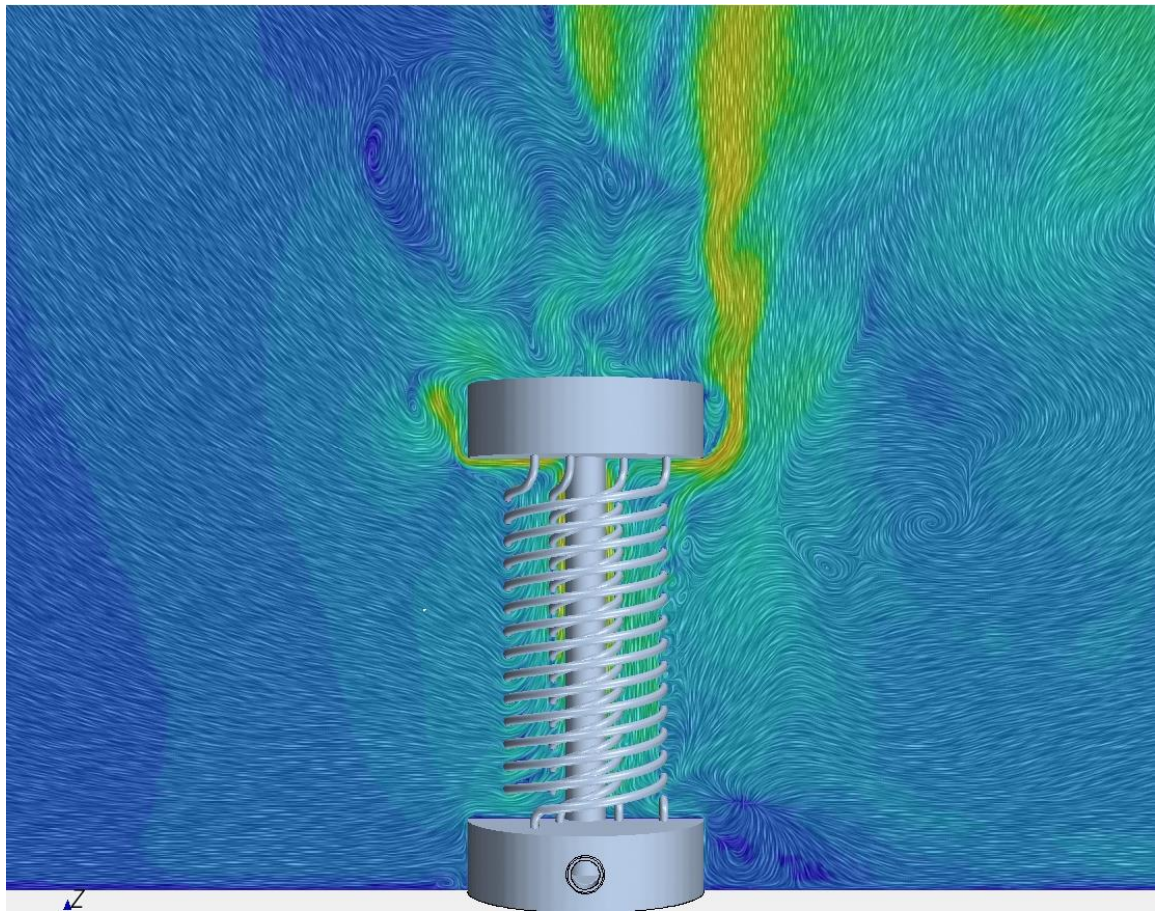
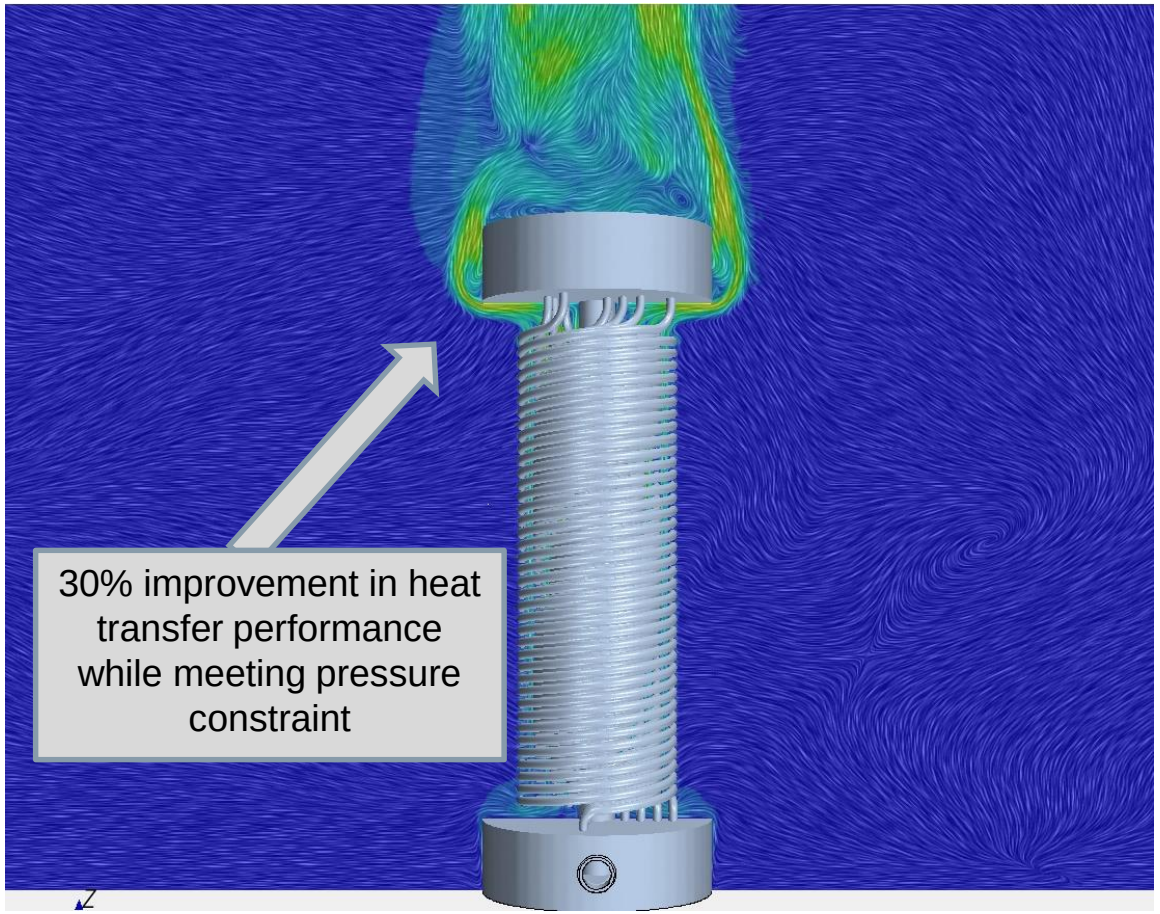


Baseline Design



Improved Design

Redefining Nuclear Performance Engineering for the Digital Twin

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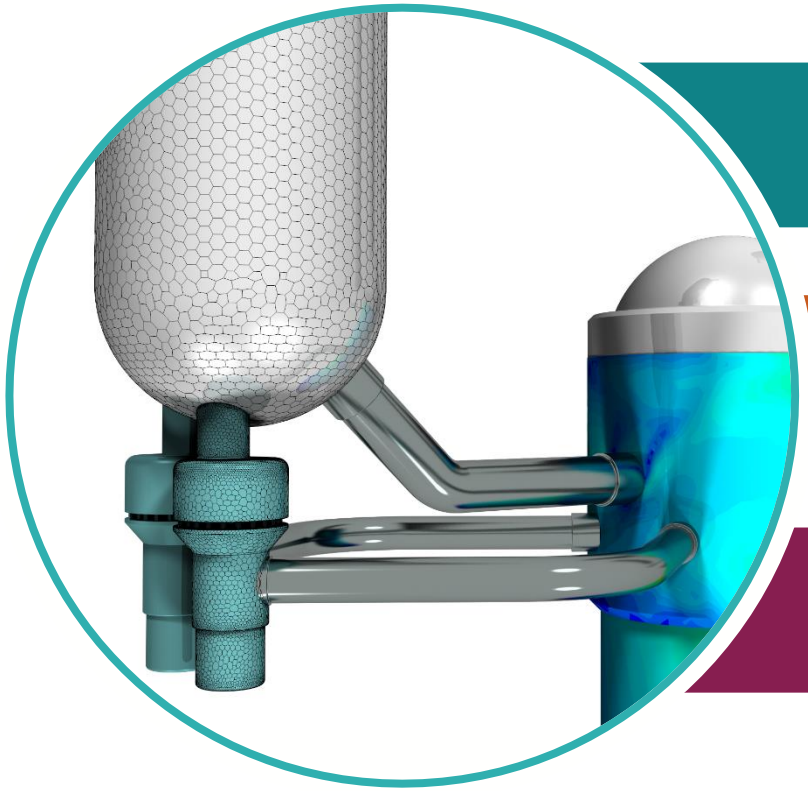
Performance Engineering



Productivity
Saving engineering time

Realism
Increasing confidence

Continuity
Enabling enterprise collaboration

Exploration
Delivering insight

→ Engineer Innovation

Examples

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Offshore platform design

Flow induced vibration

Thermal fatigue

Flow distribution

Wind turbine fatigue

Operational condition exploration mixing

Design of Floating Platforms: VIM

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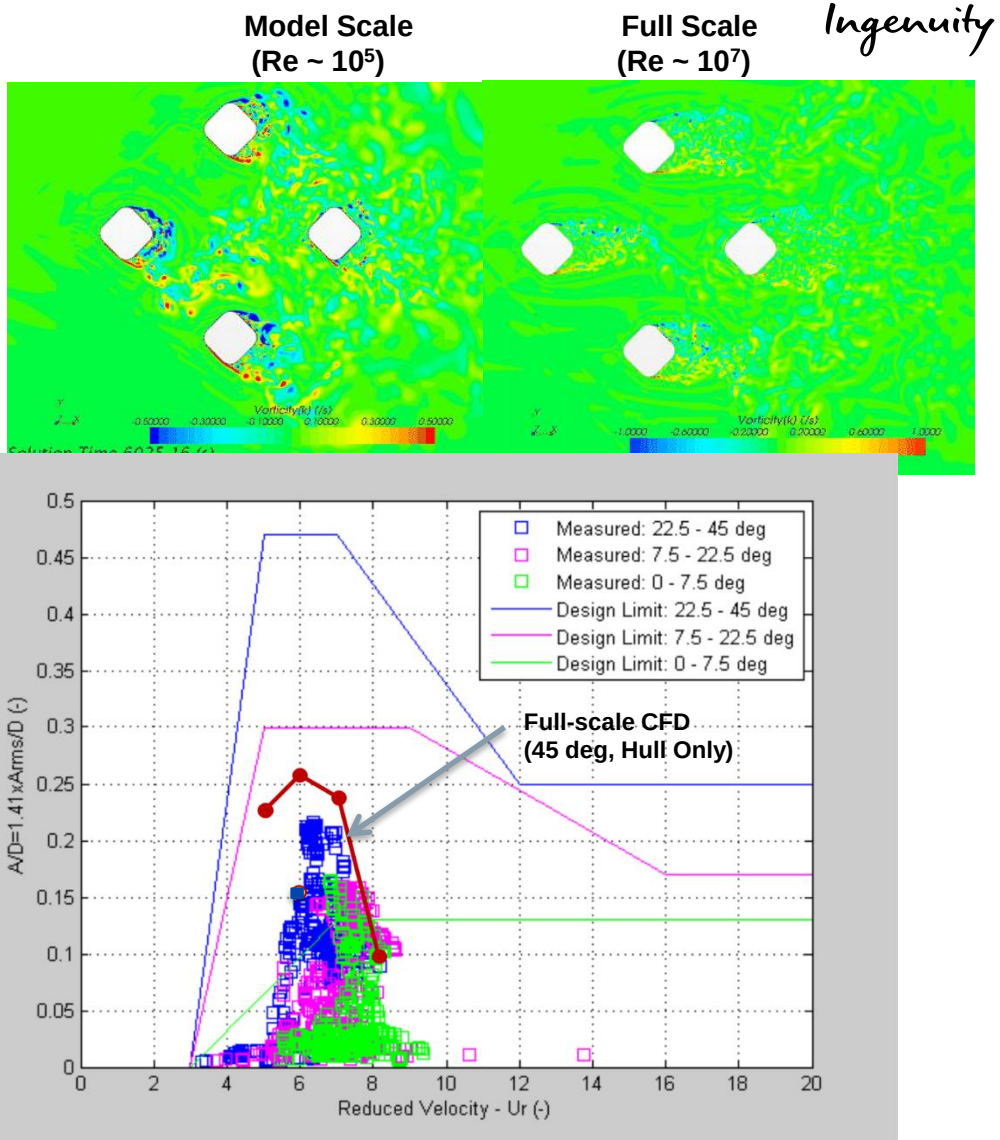
- **Field data of a Semi VIM motion showed no correlation with VIM model test data**

- **Chevron ETC & TP Houston initiated CFD study (Aug 2013)**
  - Scale effect (Reynolds number)
  - Mooring / Riser damping

- **Achievements**
  - Validation in both model and full scale
  - Identified main source of VIM response difference
  - High-Reynolds number (12 million) wind-tunnel test for full-scale benchmark



DOT2014: VORTEX-INDUCED MOTIONS OF A COLUMN-STABILIZED FLOATER
PART II: CFD BENCHMARK AND PREDICTION, G. Wu et al.

Courtesy of Technip

Simulation-Based Design of Offshore Floater @ Technip

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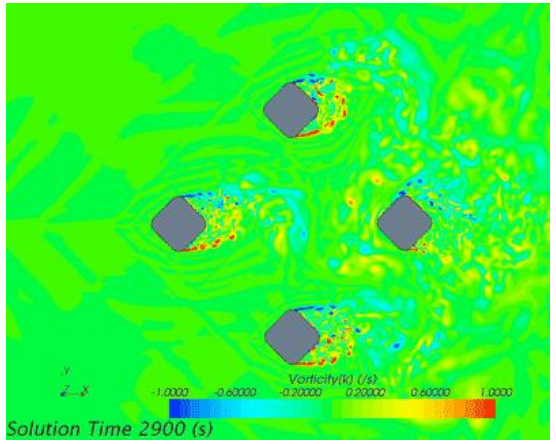
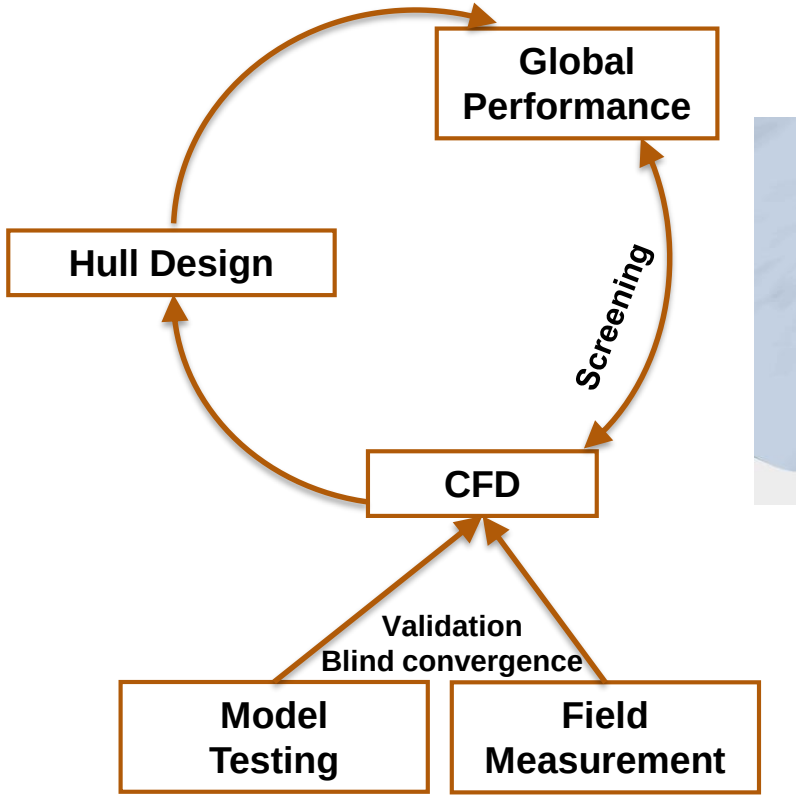
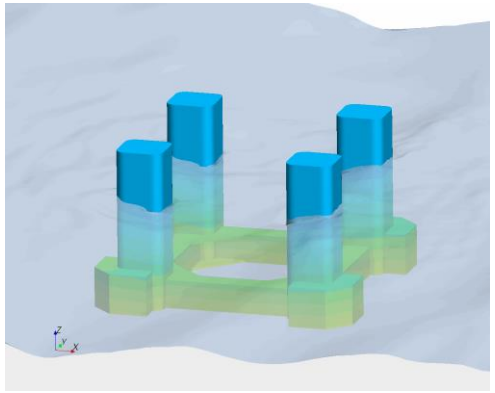
Full-scale VIM





Global performance



- **Less assumptions and uncertainties**
- **Shorter design cycle for “changes”**
- **Optimization without compromising safety**

Courtesy of Technip

Floating platform design

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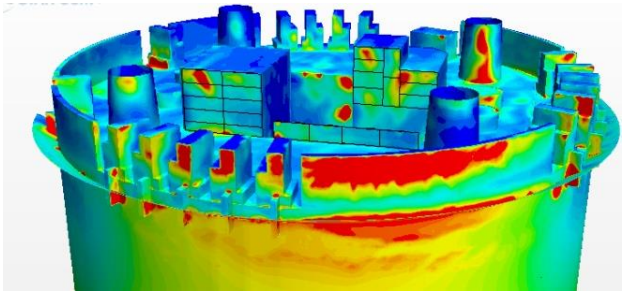
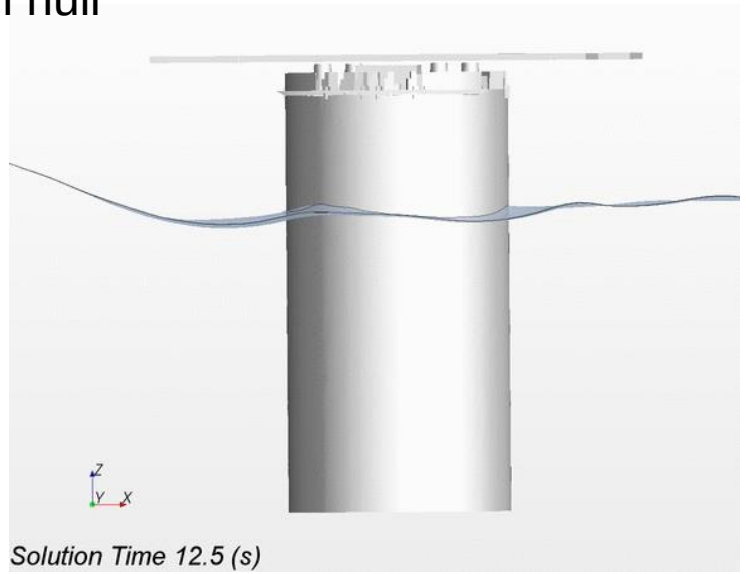
- **Green water and air gap**
  - Extend model test results to all headings by CFD
  - Support run-up barrier & bulwark design
  - Wave load on spar deck equipment and structures



Wave slamming on hull



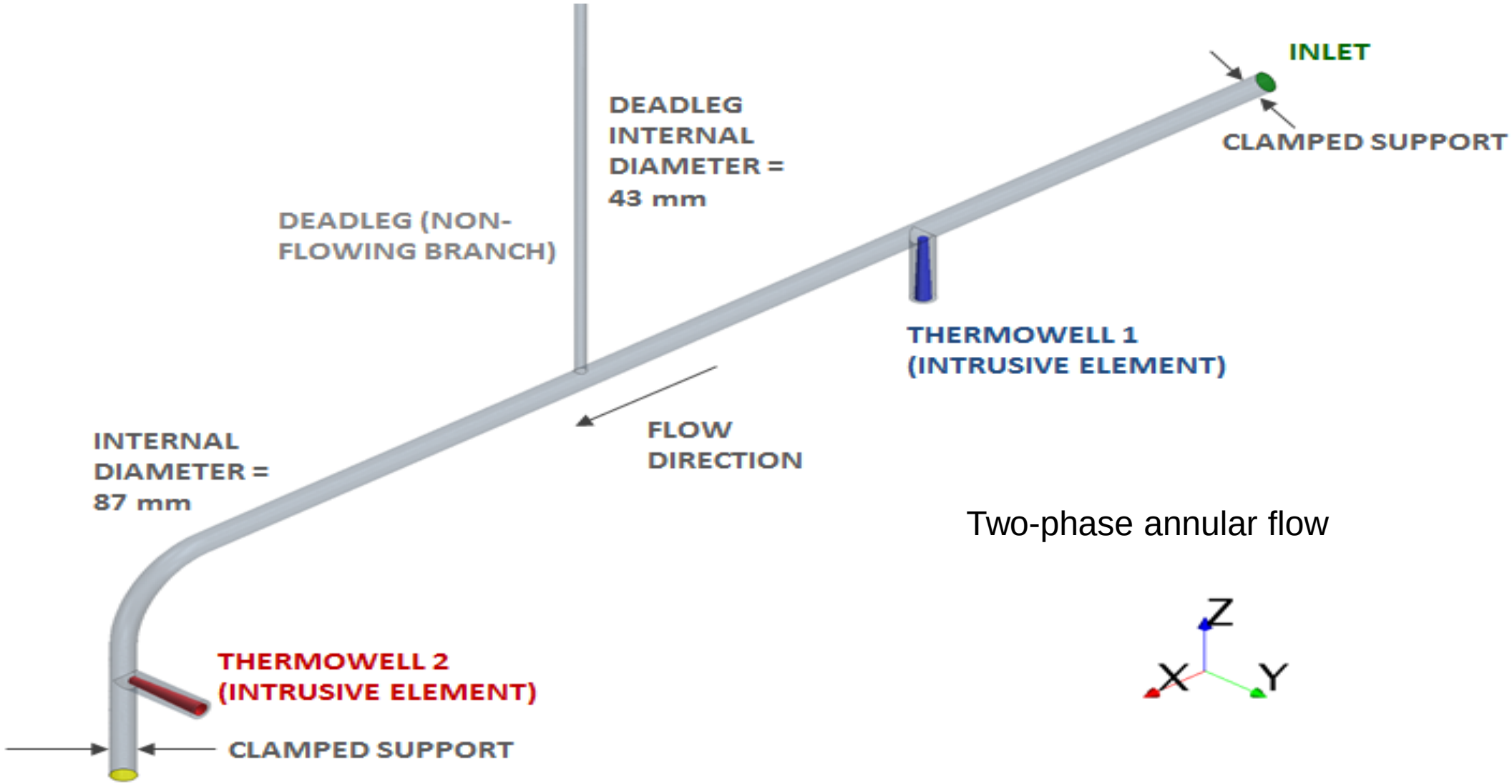
OTC-25423-MS • CFD-FE Simulation of Wave Slamming on an Offshore Platform in Extreme Sea States, J. Kim et al.

Courtesy of Technip

Flow Induced Vibration (FIV)

- Vibrations caused by internal flow: multiphase, turbulence, choked flow
- Structural integrity and fatigue failure concern from Subsea to Refinery
- Energy Institute (EI) Guidelines provide screening tool, but not suitable for design
- Over-design and/or Field failures costly (potential to miss production targets)
- Methodology for conducting quantifying FIV with STAR-CCM+
- Methodology validated through Multiphase Flow JIP (Xodus & TNO)

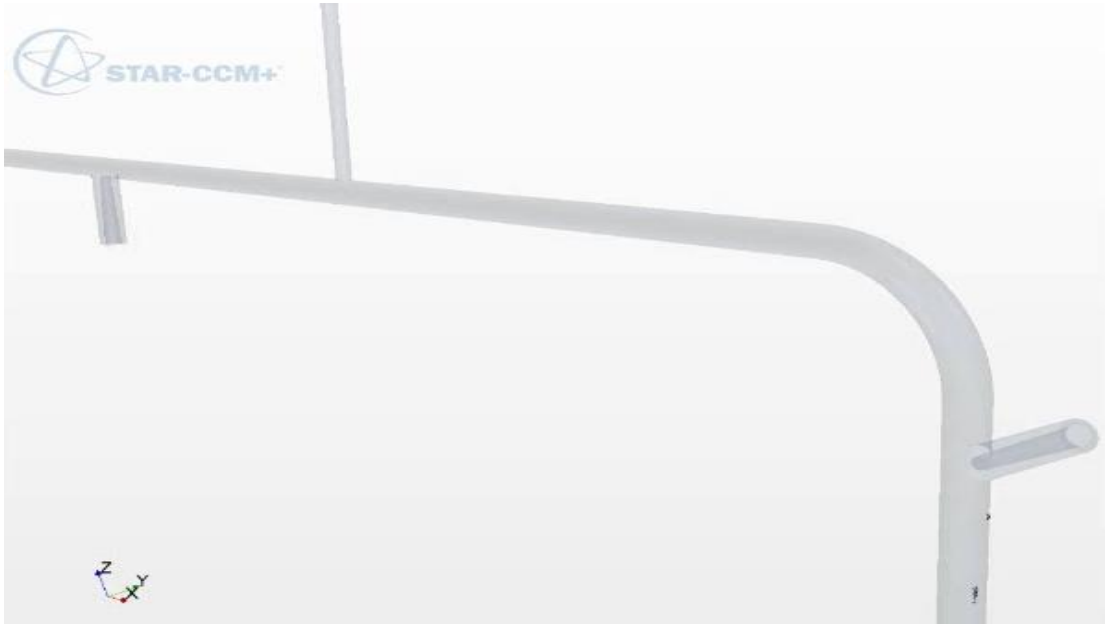
Piping geometry

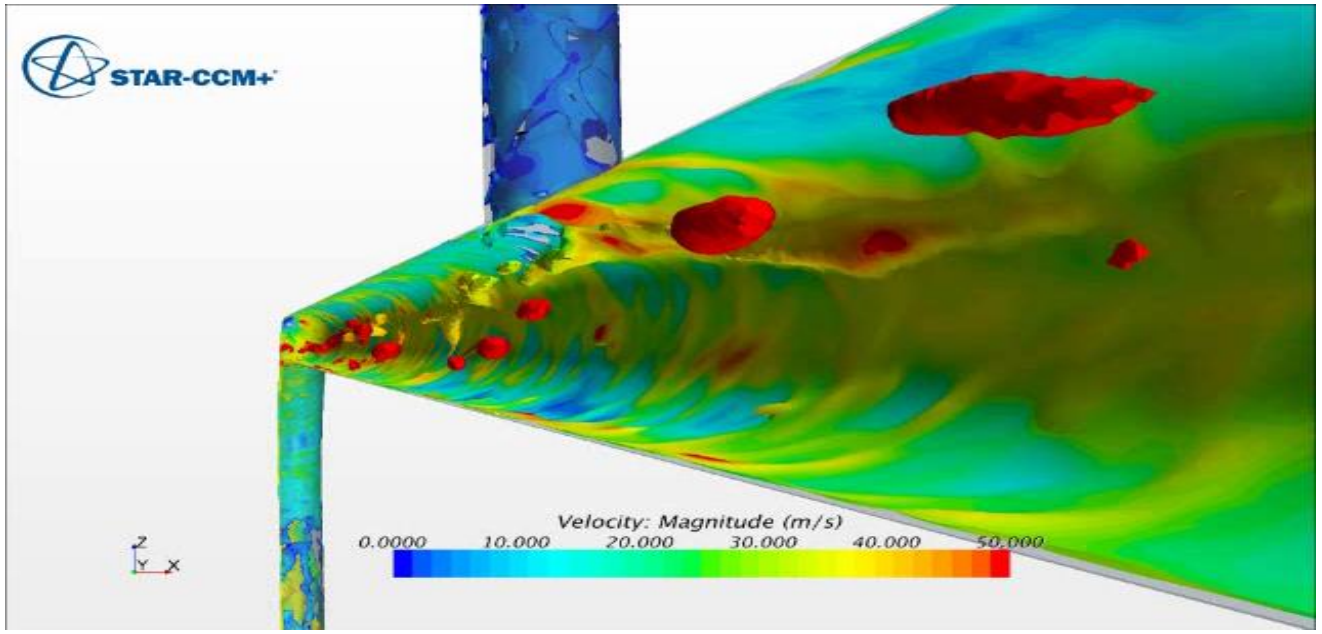


Two-phase annular flow

CFD: Qualitative Results

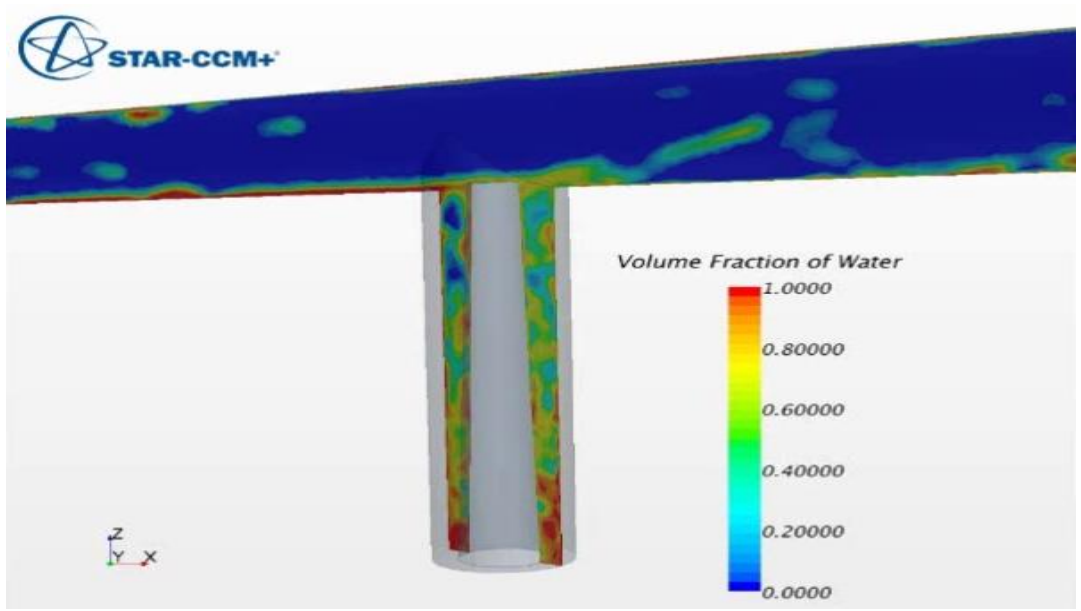
- Some low frequency pulsation visible in deadleg

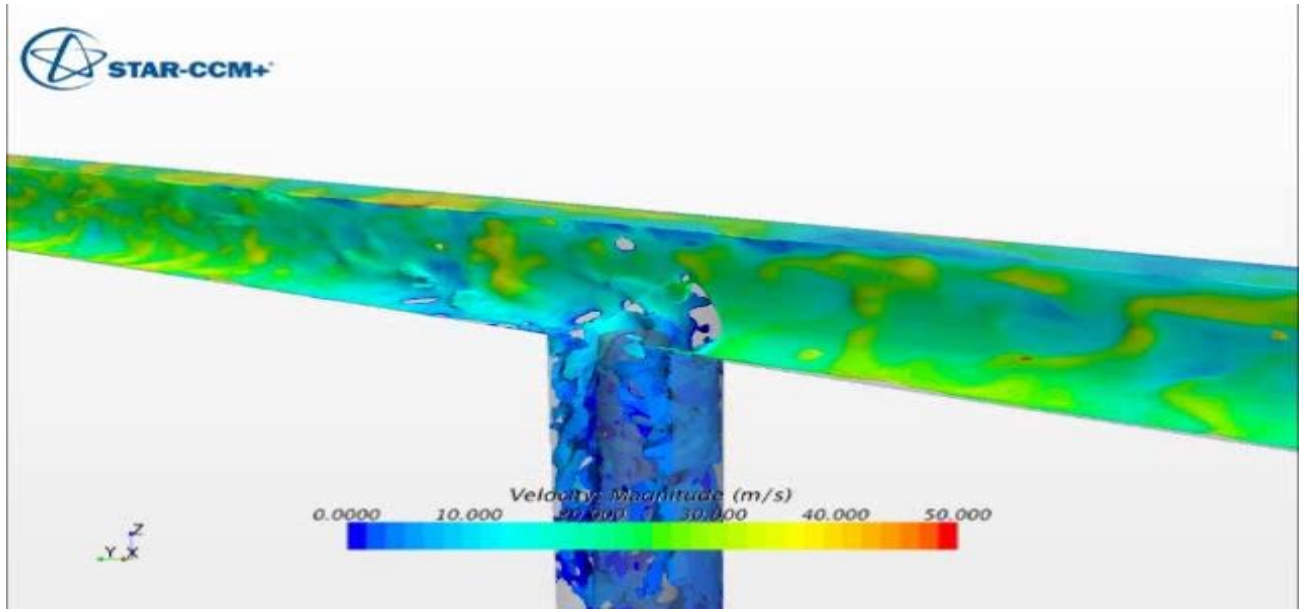




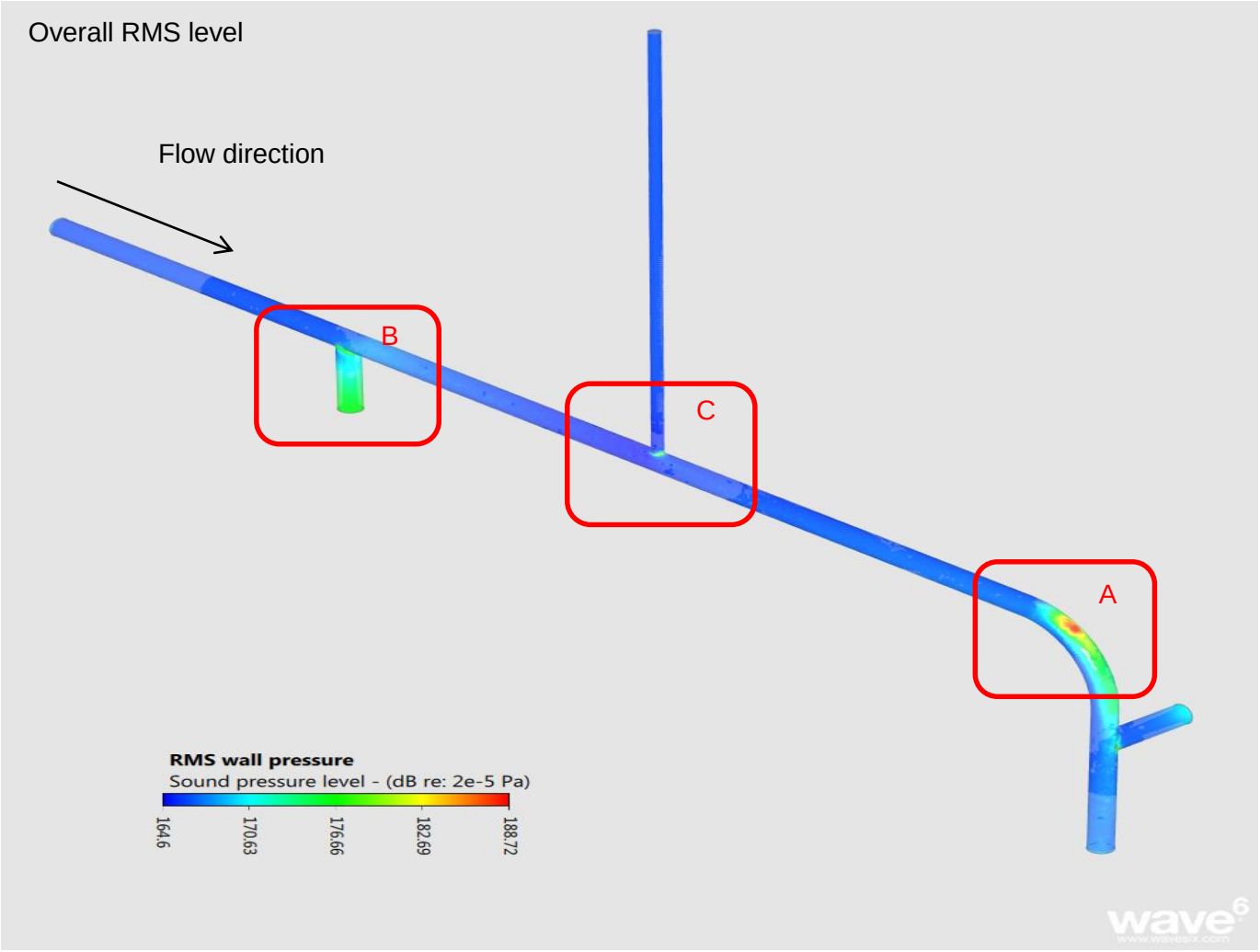
CFD: Qualitative Results

The intrusive thermowell interacts with the fluid film and gas streams (vertical thermowell, Case 2 shown)
An unsteady ‘pumping’ mechanism results. From time domain data it is difficult to discern a characteristic frequency



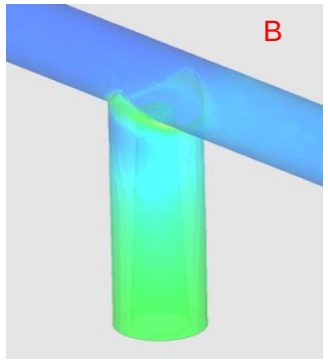


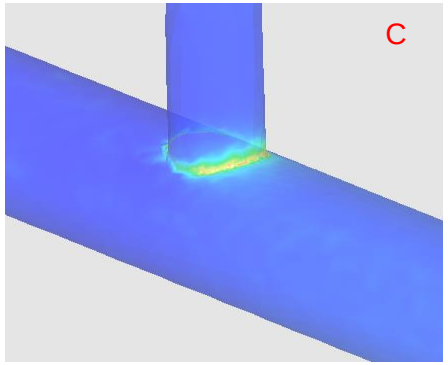
Spatial diagnosis of RSM pressure on pipe wall

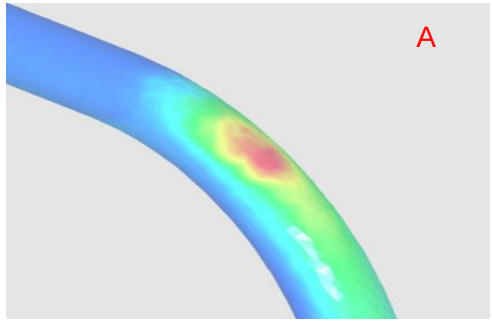


Highest levels associated with:

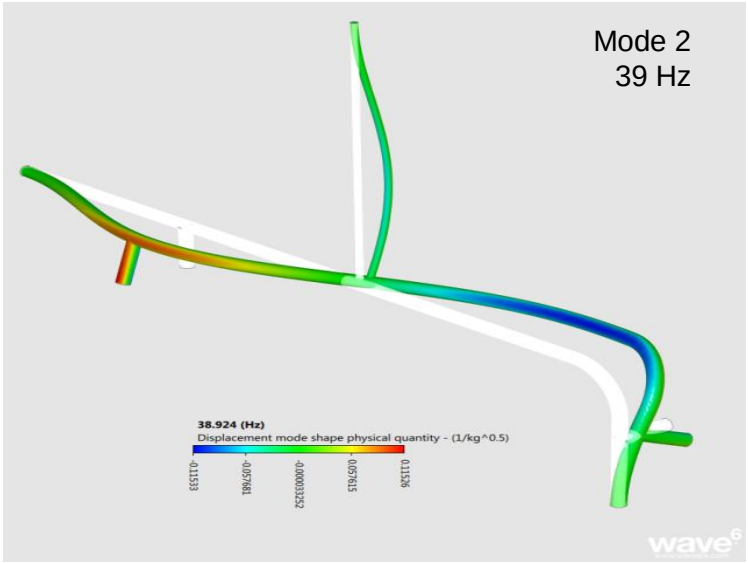
- Separated flow at the bend
- Near the first thermowell
- Around the deadleg tee





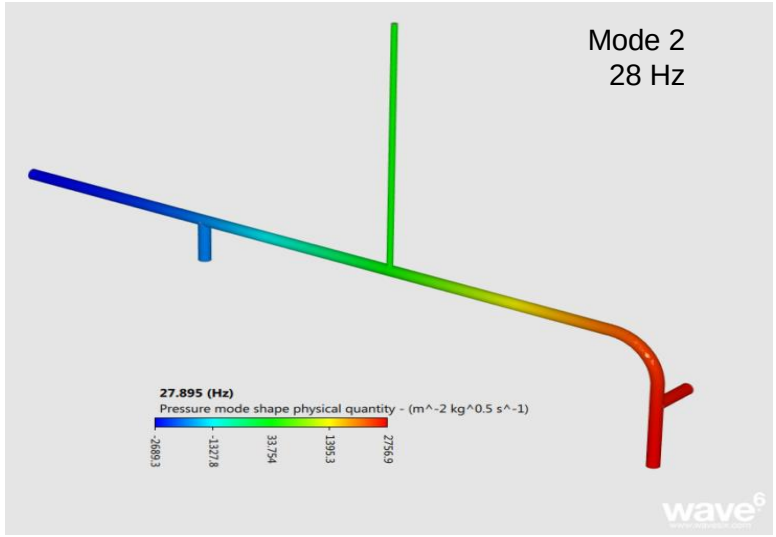


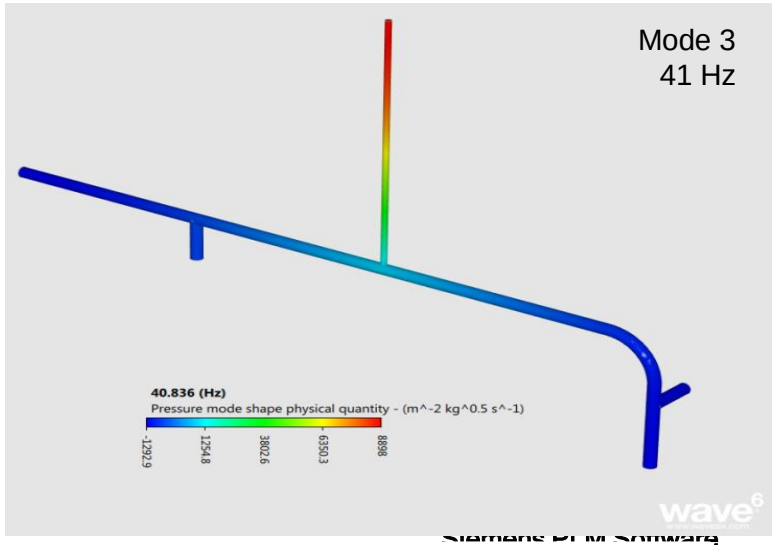
Structural & Acoustic Modes



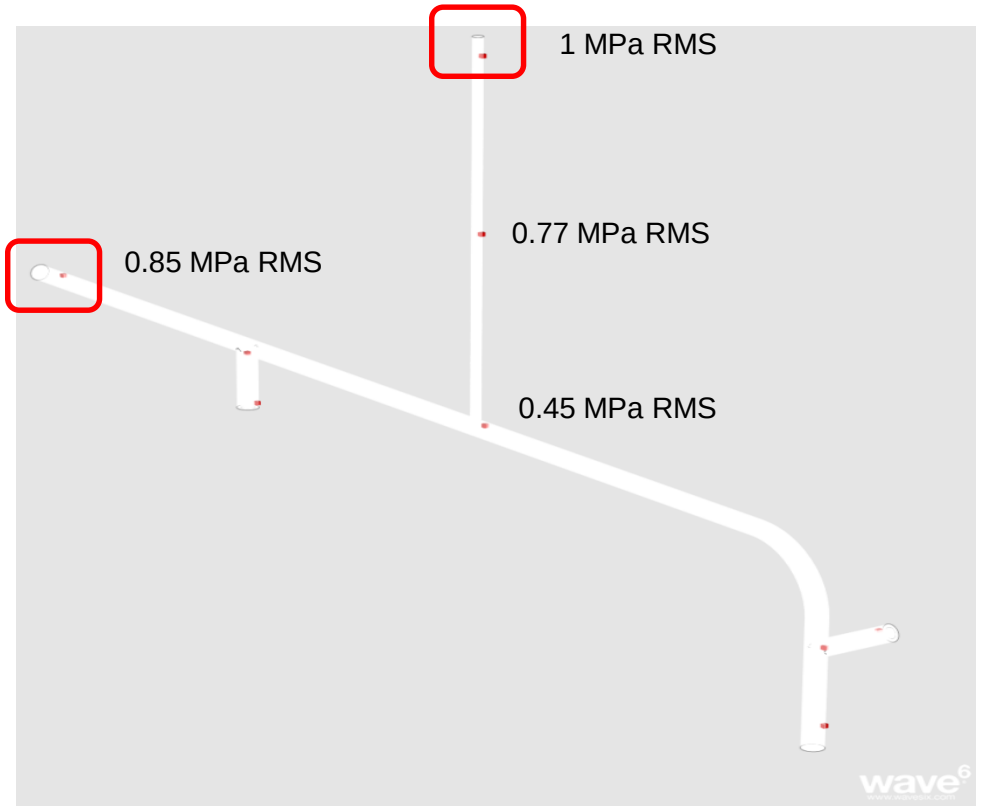
Structural Modes

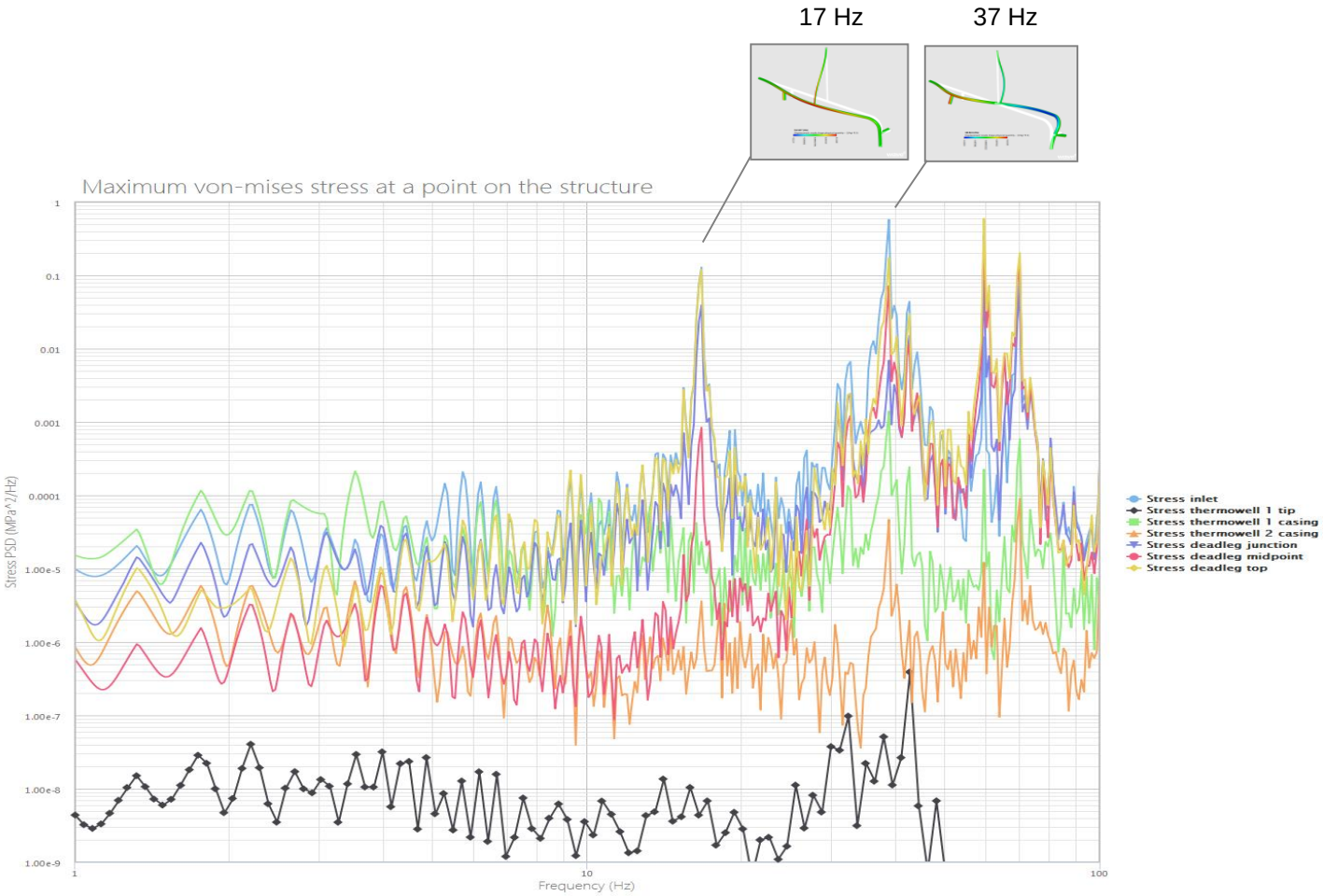
Acoustic Modes





Stress response





Highest Von-Mises stress responses occur at structural resonances (17Hz, 37Hz and 42Hz) near the support locations

Nuclear: Beating Thermal Fatigue

Boosting the economic operation of Nuclear Power with STAR-CCM+

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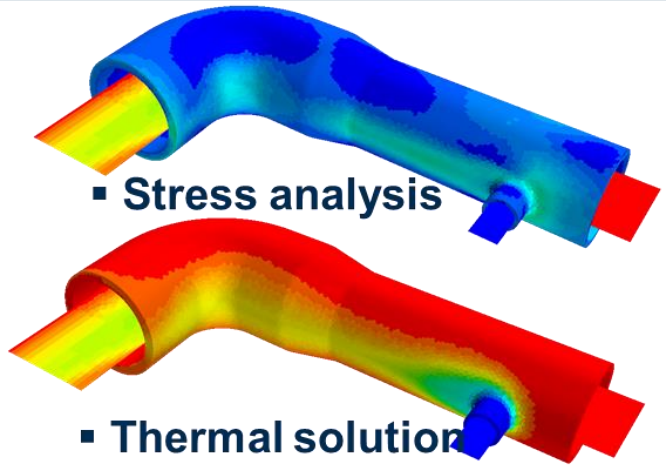
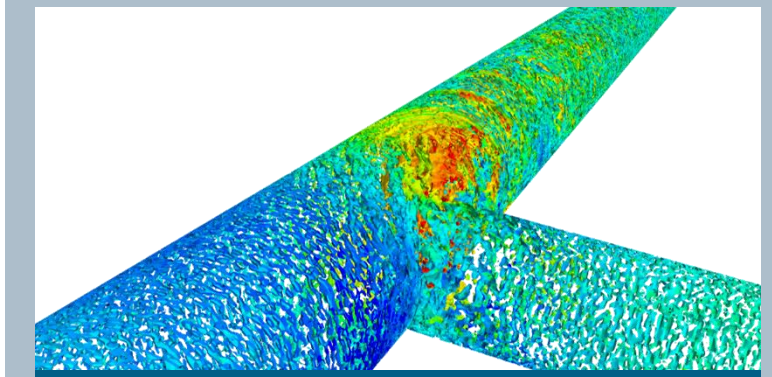
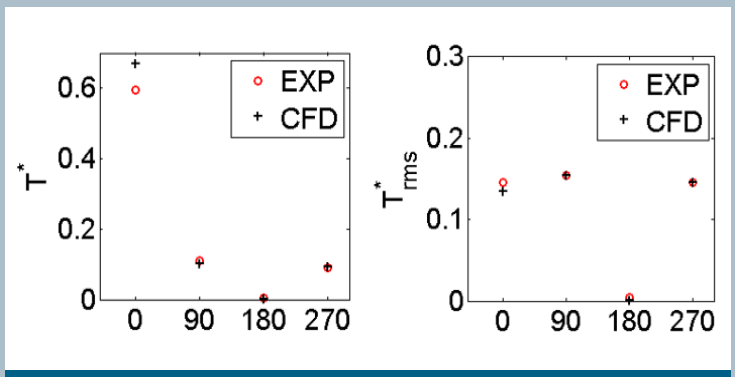


- **Reduced O&M cost for reactor fleet**
- **Elimination of costly testing**
- **Reduced thermal fatigue susceptibility through better design**

Predicting the degradation mechanism induced by thermal fluctuations



Thermal fluctuations in pipe junction



Mean and fluctuating temperature prediction

- Efficient CAD to solution workflow processes complex pipe junctions with ease
- Validated “LES based approach” enables prediction of thermal fluctuations with optimal computational efficiency

“Effective prediction of Thermal Fatigue is key to life management and economical operation of operating NPP’s”

S.T. Jayaraju, Nuclear Engineering and Design 240

Flow Distribution

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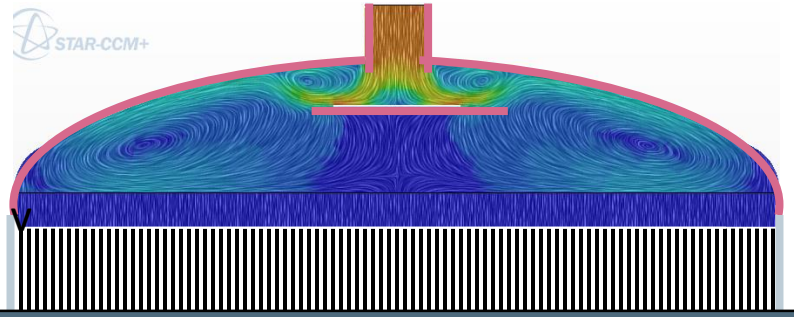
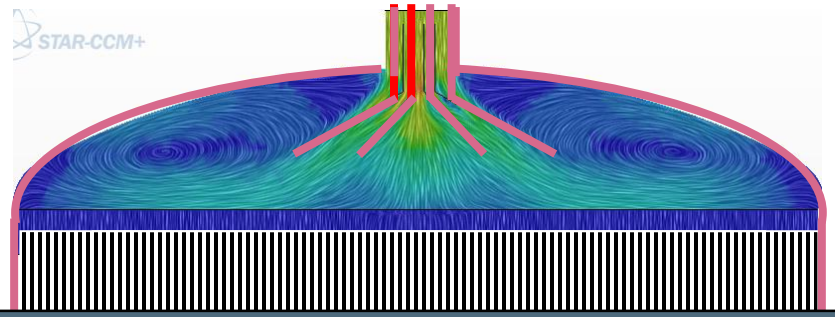
Impact plate



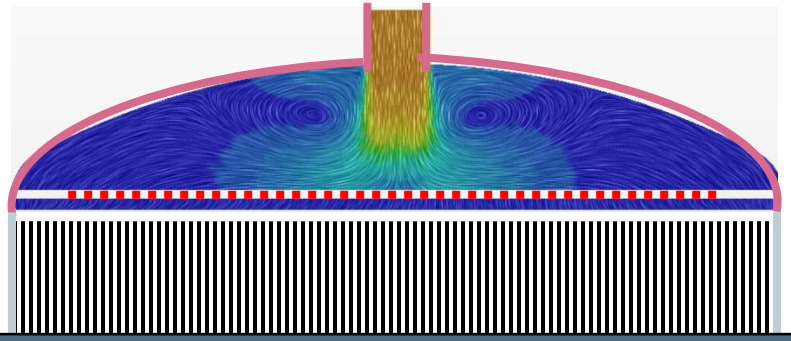
Advantage: simple, Disadvantage:Effectivness

Guide Vanes



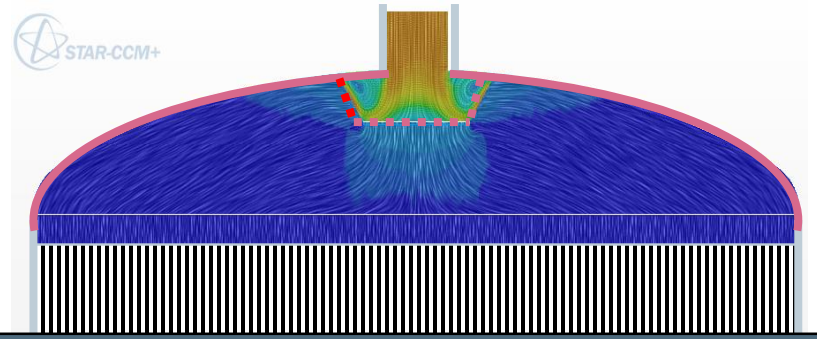
Advantage: low Dp, Disadvantage : Effectviness

Perforated plate



Advantage : Effective, Disadvantage: high Dp

Perforated plate



Advantage : low Dp, effective, Disadvantage: clogging

Simcenter for Separation Equipment

Covering a wide range of performance indicators

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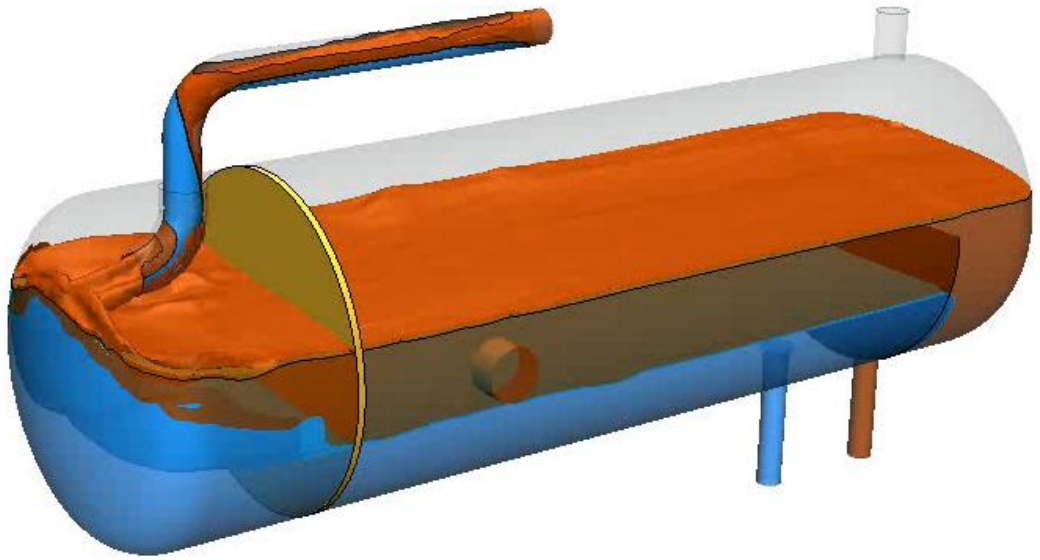
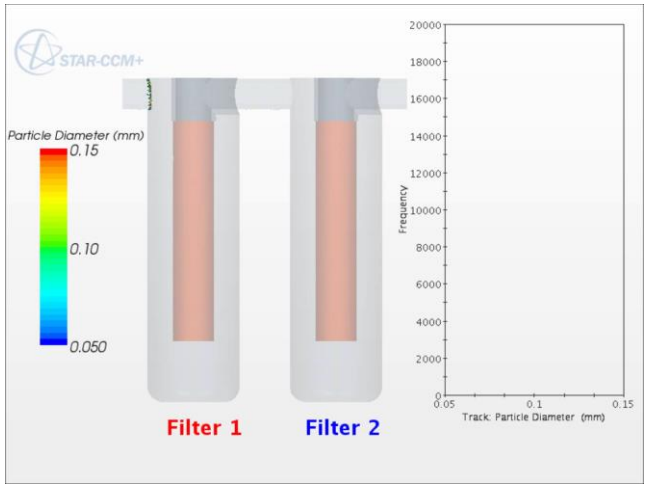
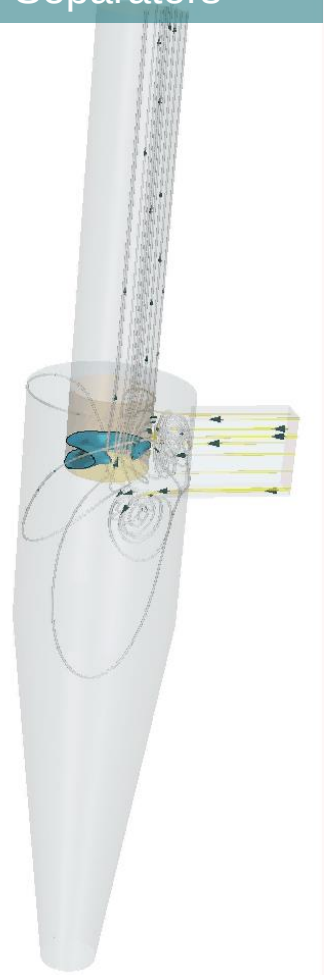




Cyclone Separators



Cyclone Separators	Droplet behavior	Filtration
Electrostatic Separators	Erosion	Particle Tracks
Distillation Columns	Sloshing	Phase distribution

Zeta PDM
Design and innovation in separation technology

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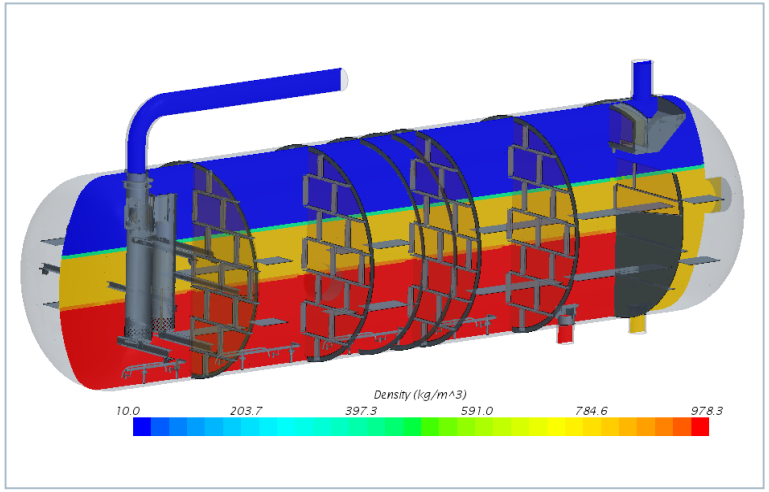
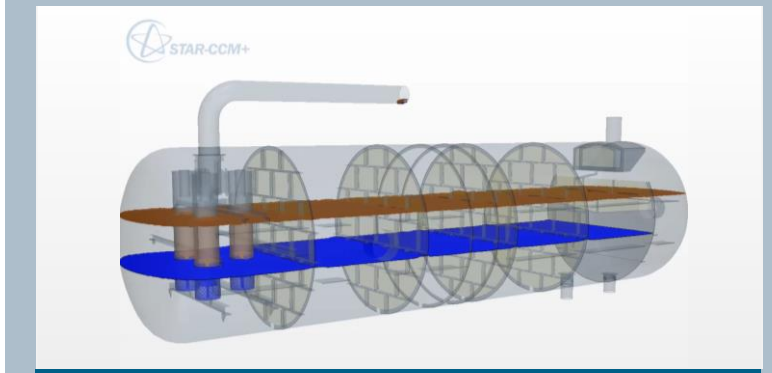
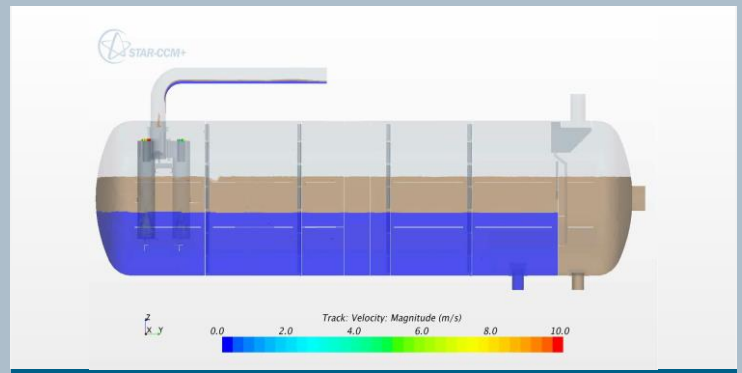


- **Assess separation performance**
- **Full range of operating conditions**
- **Improved design based on assessment by introducing internals**

Predicting separation performance



Multiphase flow behavior



Droplet separation

- 3-phase flow simulation
- Complex flow regimes captured

“Multiphase flow simulation using STAR-CCM+ enables us to optimize our separation technology and demonstrate process performance across the full range of operating conditions”

Stephen Turner, Managing Director, Zeta-pdm

Alternative wind turbine design
Hydro-static power transmission

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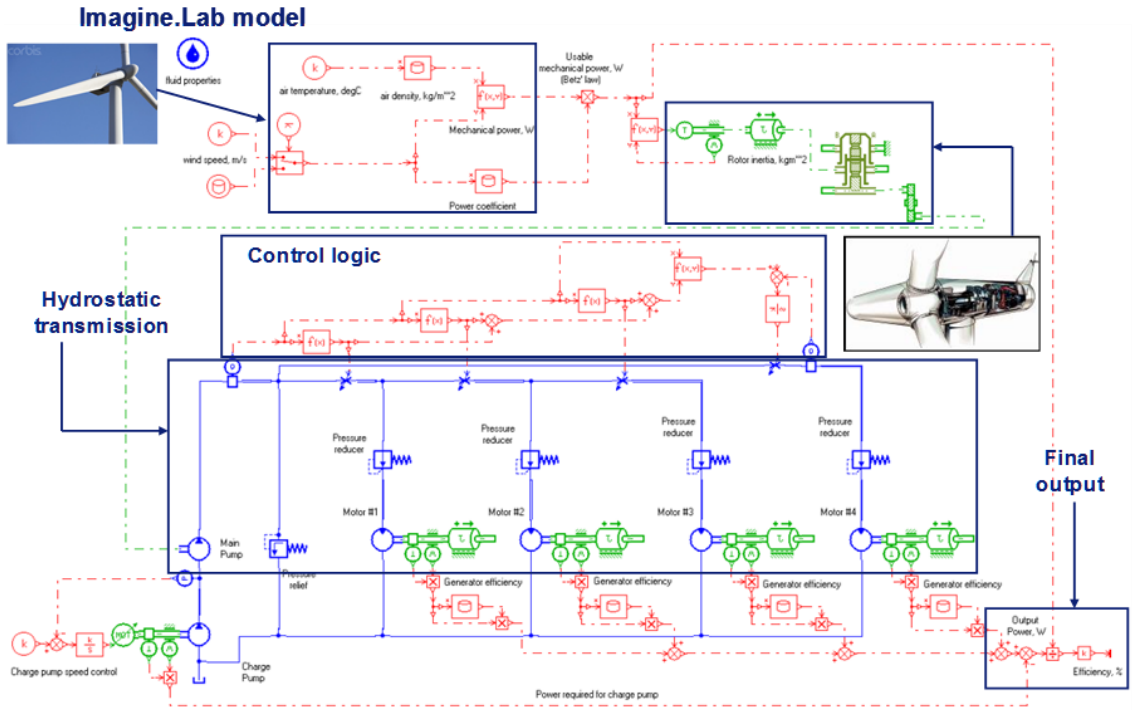
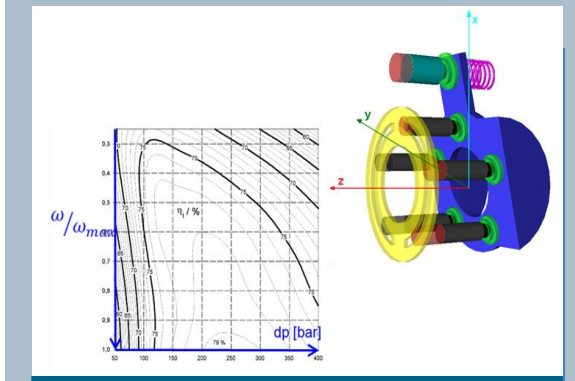


Challenge:
- Evaluation of a hydraulic power transmission concept with multiple generators for electric conversion

Solution:
- Multi-physics 1D simulation

Full system optimization



Pump representation

Physical pump

- System simulation – from wind profiles to electrical power delivered to the grid
- Simultaneously taking into account the aero-dynamic, mechanical, hydraulic, electrical & thermal aspects, governed by the turbine controller

"By system simulation, it has possible to define the most efficient combination of the different subsystems and the optimal control strategy"

Offshore wind farm foundation monitoring
Digital Twin to complement measurement data

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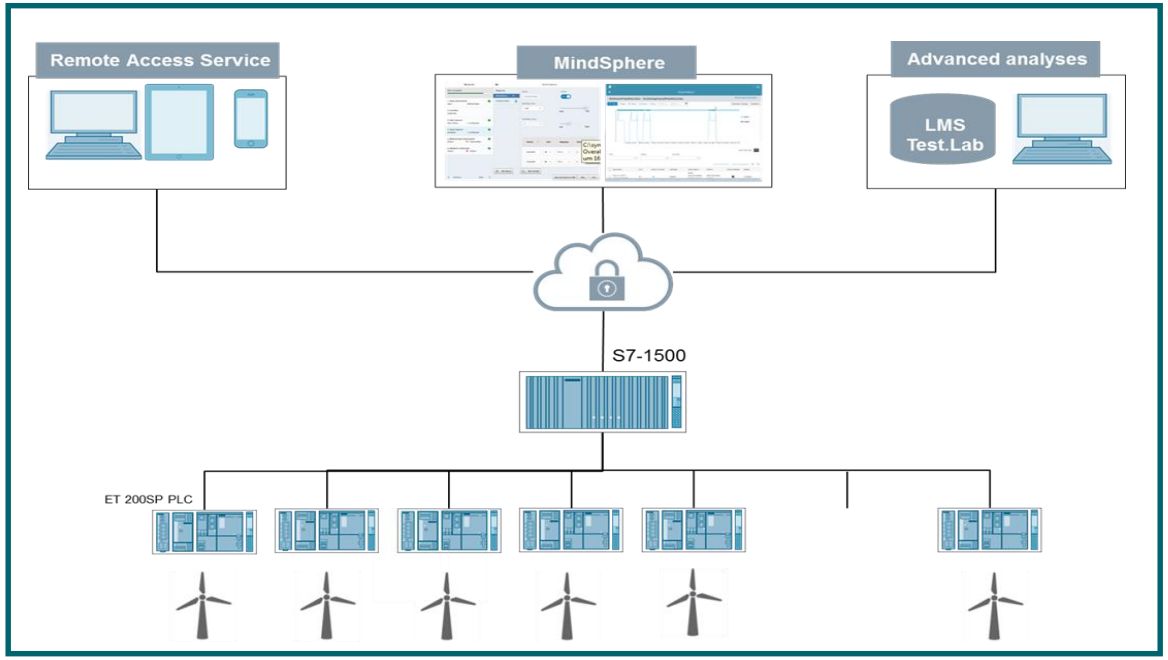
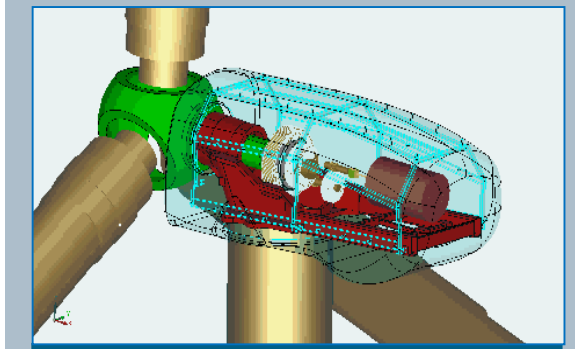
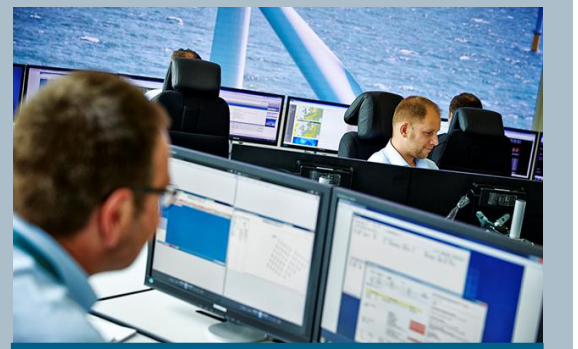


Data Acquisition
- Robust system: Siemens Automation components
- Local PLC based acquisition of sensor signals; complemented with wind turbine controller data (SCADA).
- Central server connected to the cloud for automatic analysis, trending, alarm generation, documentation and data storage.

Model Based Condition monitoring



Validated full turbine model



Control room

- Deeper insight in the global condition by Model Based Condition Monitoring.
- Measurements completed by model-based data.
- Information at locations where no sensors are installed.
- Prerequisite: Turbine model validated by measurements
- Comparison of measurements and predicted values can identify a degrading component.
- Algorithms for ‘Remaining Useful Liffetime’

Operating Exploration: Stirred Vessel Reactor with Mass Transfer

STAR-CCM+

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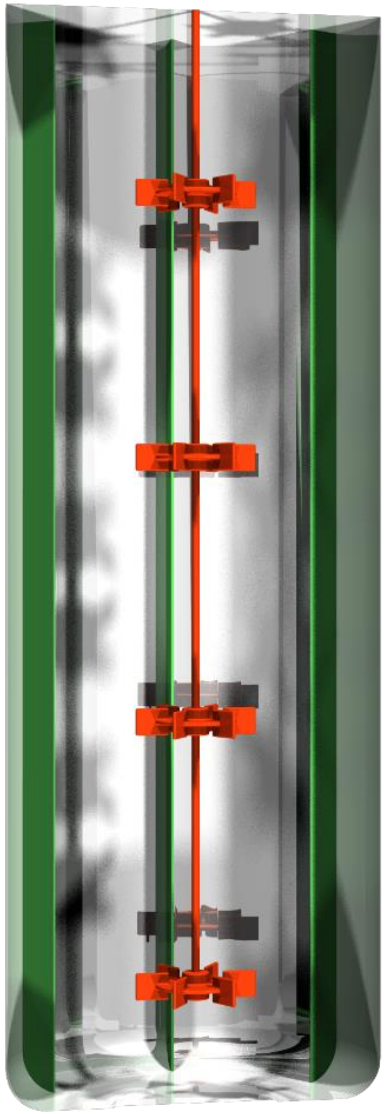
- A 250 liter vessel equiped with 4 Rushton turbines was modeled
- More often than not: DESIGNS are FIXED
- Operating Conditions can be VARIED
- Operating Condition Optimization: OCX

Current Case

- Desired to improve mass transfer from gas to liquid
- Increasing rpm or increasing gassing rate increases motor and compressor power: But not necessarily mass transfer rate
- Optimize operating condition



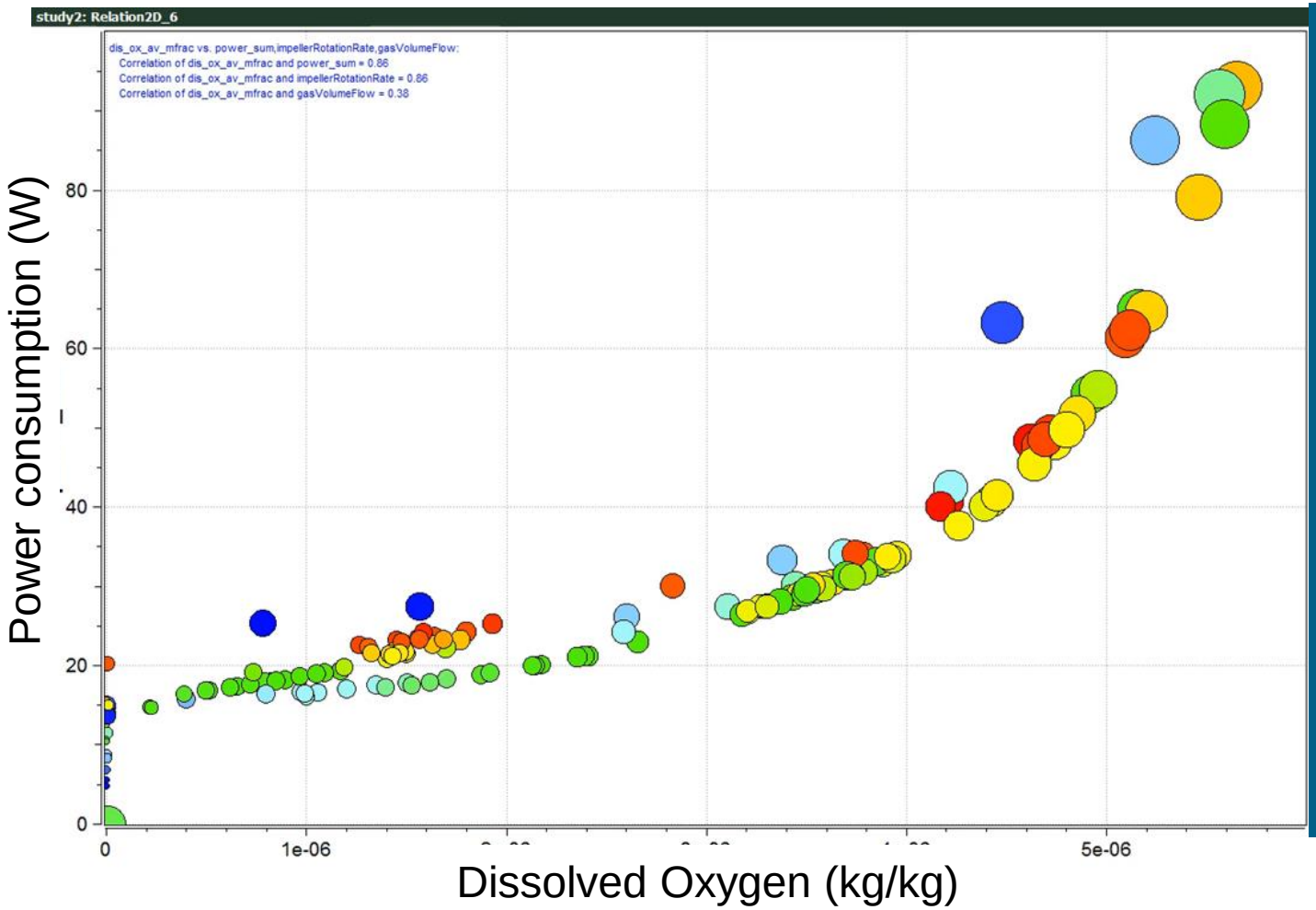
Vessel:
Volume = 250 l
D = 18 in
H = 54 in; H/D = 3

Impeller:
4 Rushton turbines
d = 6 in; D/d = 3
Bottom clearence h=d
6 blades

Baffle:
6 wall baffles
D/b = 12

Perforated plate sparger below lowest impeller

Operating Condition Optimization



1. Operating Parameters:
   - Sparger volume flow :20 – 200 lpm
   - Impeller rotation rate:150 – 450 rpm

   ↓
2. Sherpa optimization

   ↓
3. Objectives:
   - Minimize Power consumption (impeller + compressor power)
   - Maximize Dissolved oxygen (~ kla)
   - Restrict Stress on microbes

Operating Condition Optimization

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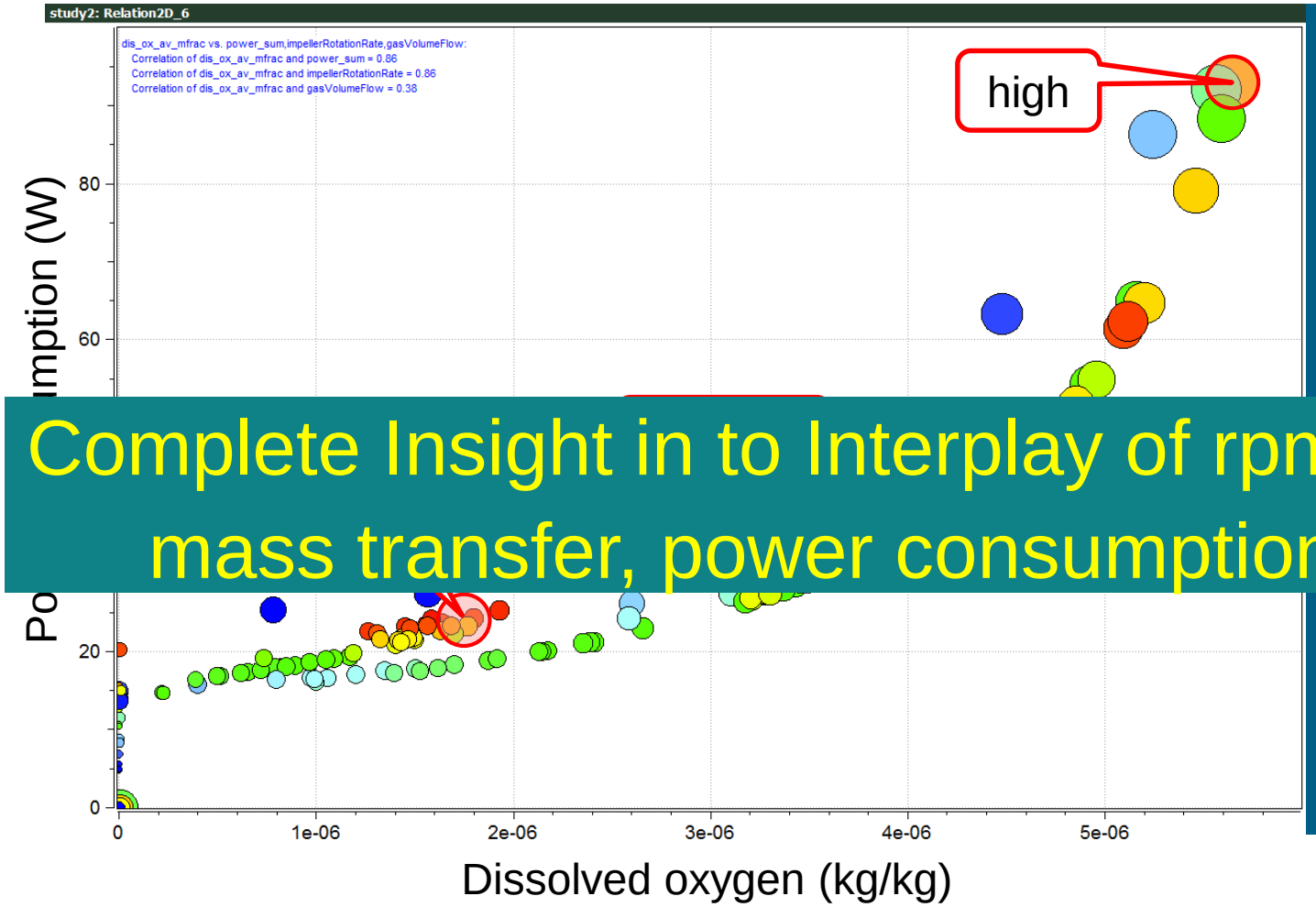

Size: impeller rotation rate ↑

Color: sparger volume flow

- Pareto front consists of good operation conditions
- Trade-off between power consumption and mass transfer

Complete Insight in to Interplay of rpm, gas injection rate with mass transfer, power consumption and shear on liquid

SIEMENS
Ingenuity for life

Need to improve realism, exploration and productivity through simulation, demonstrated on:

- Offshore platform design
- Flow induced vibration
- Thermal fatigue
- Flow distribution
- Wind turbine fatigue
- Operational condition exploration mixing