Debottlenecking Water-Oil Separation with Increasing Water Flow Rates in Mature Oil Fields

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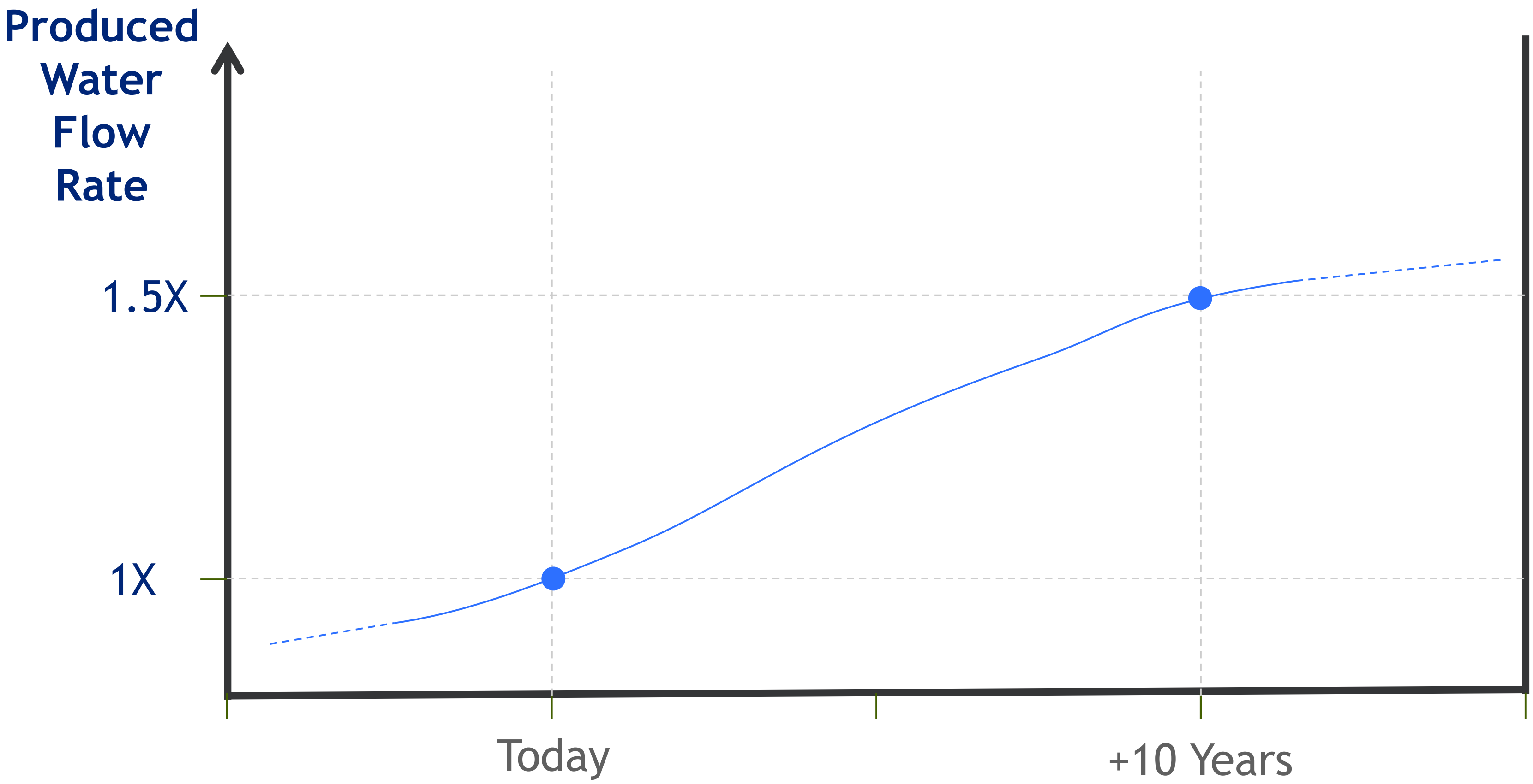
Outline

- Background and Motivation
- Numerical Model and Test Matrix
- Results and Discussion
- Conclusions

Background

- Maturing fields with increasing water flow rates
- For certain GOSPs, water-oil separator (WOSEP) is the bottleneck
- WOSEPs are reaching capacity to process oily produced water
- Need solution to debottleneck gas-oil separation plant for forecast rates
  - Quantify separation performance
  - Apply enhanced internal technology to improve separation at higher throughputs

Produced Water Forecast



Not to scale

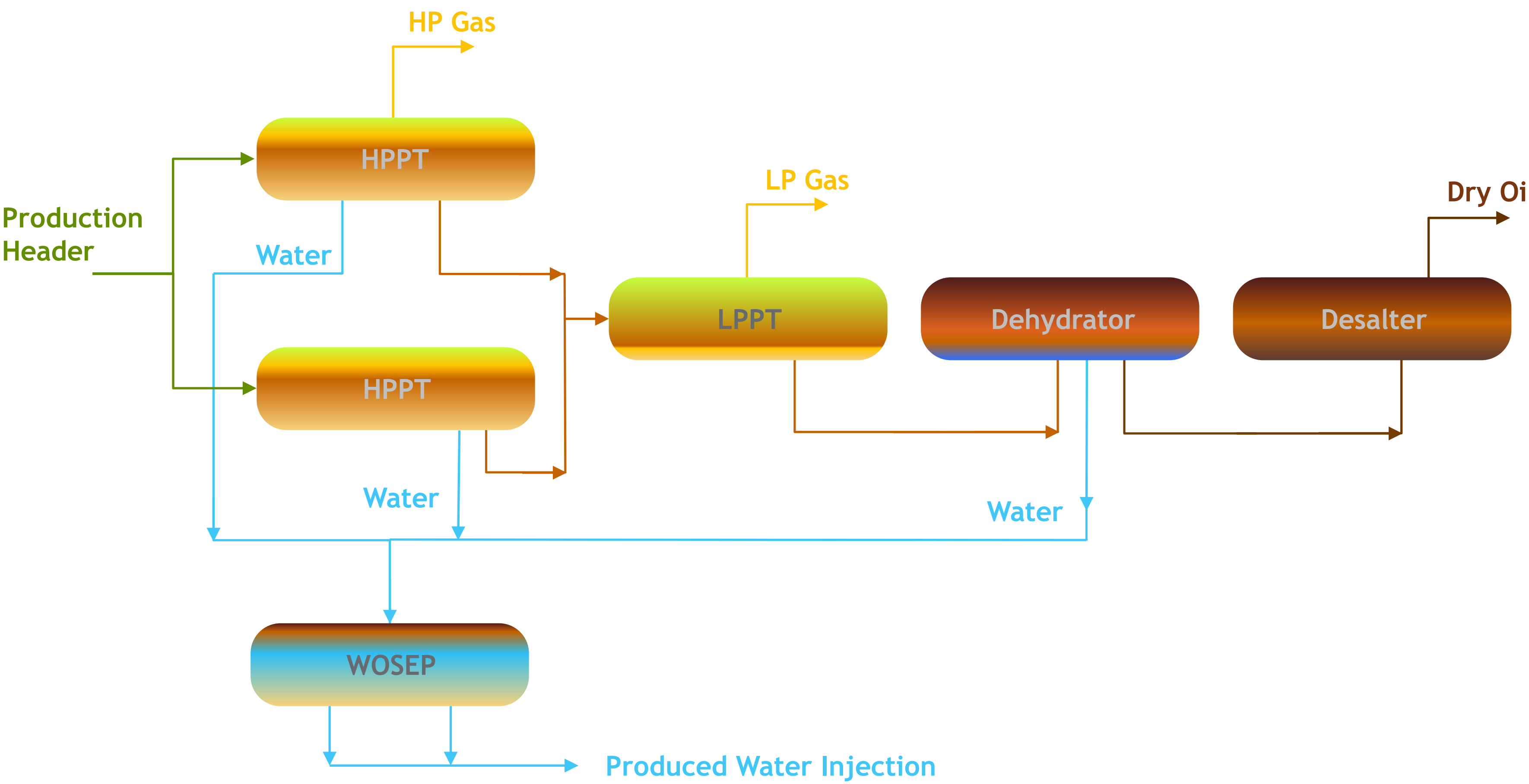
Motivation

- Improving oil separation reduces lost production
- Improved produced water quality prevents formation damage on reinjection to maintain reservoir pressure
- Avoid the need to build additional WOSEPs in the GOSP

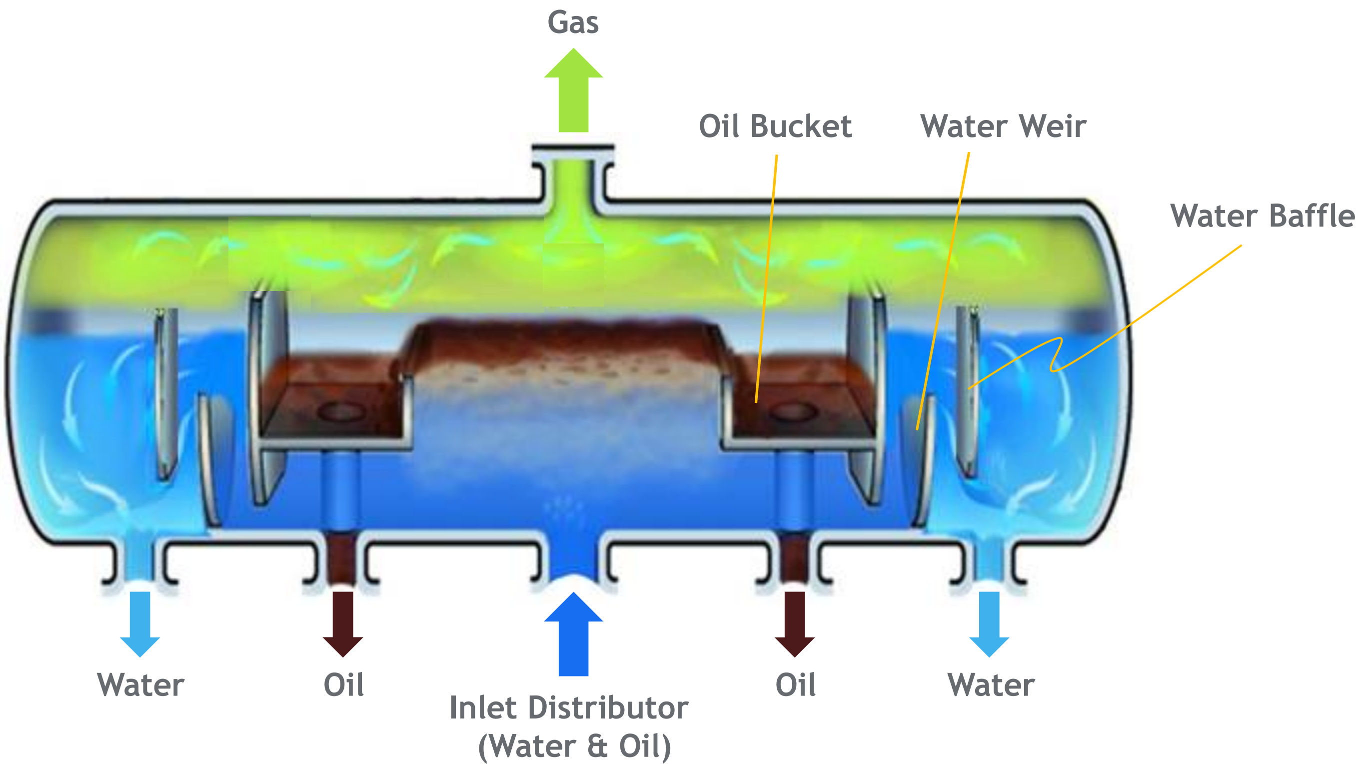
Objectives

- Use state-of-the-art multiphase CFD to model the oil-water flow in the WOSEP vessel
- Develop debottlenecking solutions to increase water handling capacity

Typical GOSP



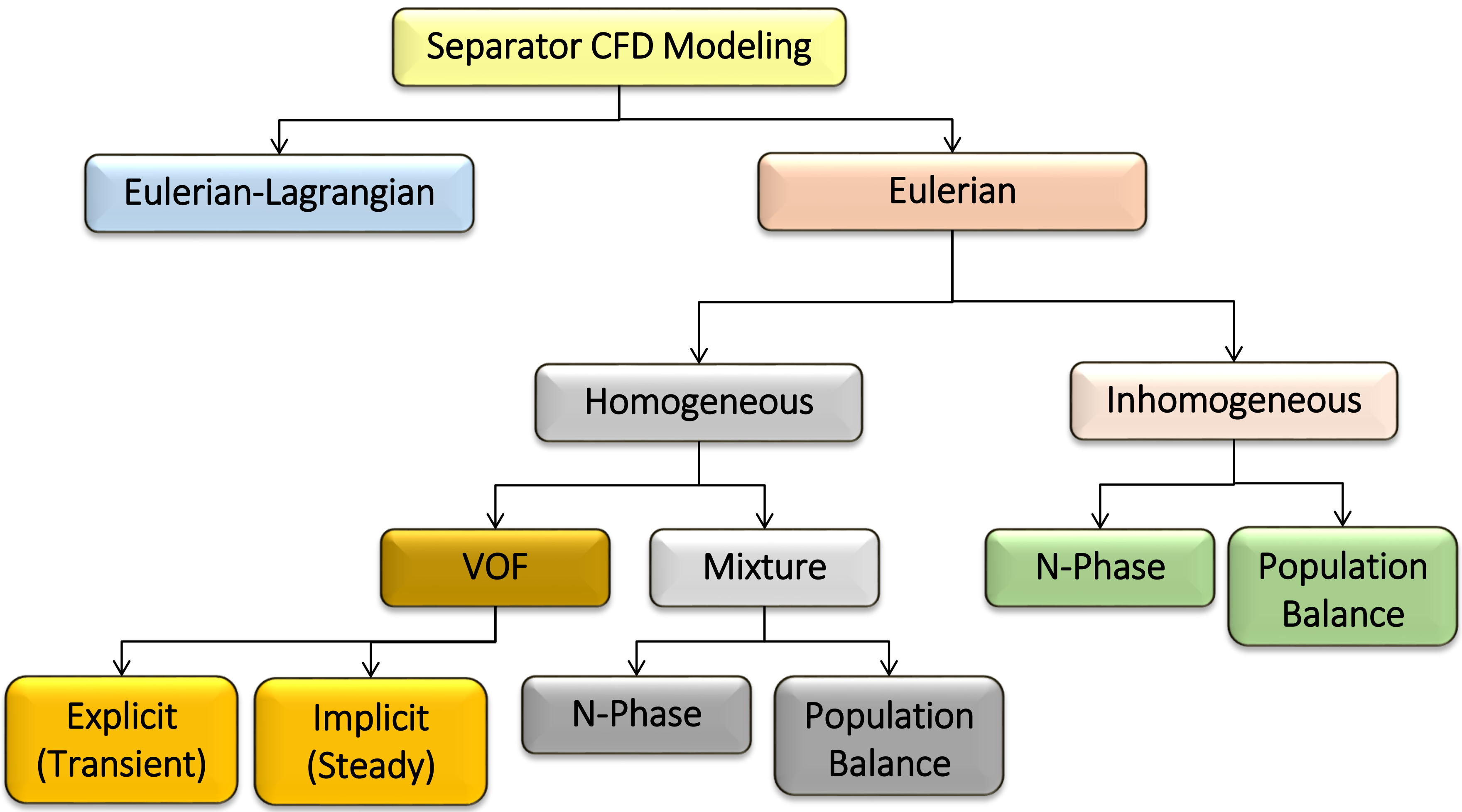
Water Oil Separation Vessel (WOSEP)



Approximate dimensions: 180 ft Length; 14 ft diameter

160 MBD Throughput

Multiphase Modeling



Numerical Methodology

- N-Phase Eulerian multiphase model
  - Water – primary phase
  - Oil and gas – secondary phases
- Phase interaction
  - Schiller-Naumann drag model
- Turbulence
  - Standard $k - \varepsilon$ turbulence model with scalable wall functions
- Steady and incompressible
- High-resolution Computational mesh
  - 2 million polyhedral cells/elements

Solution Platform

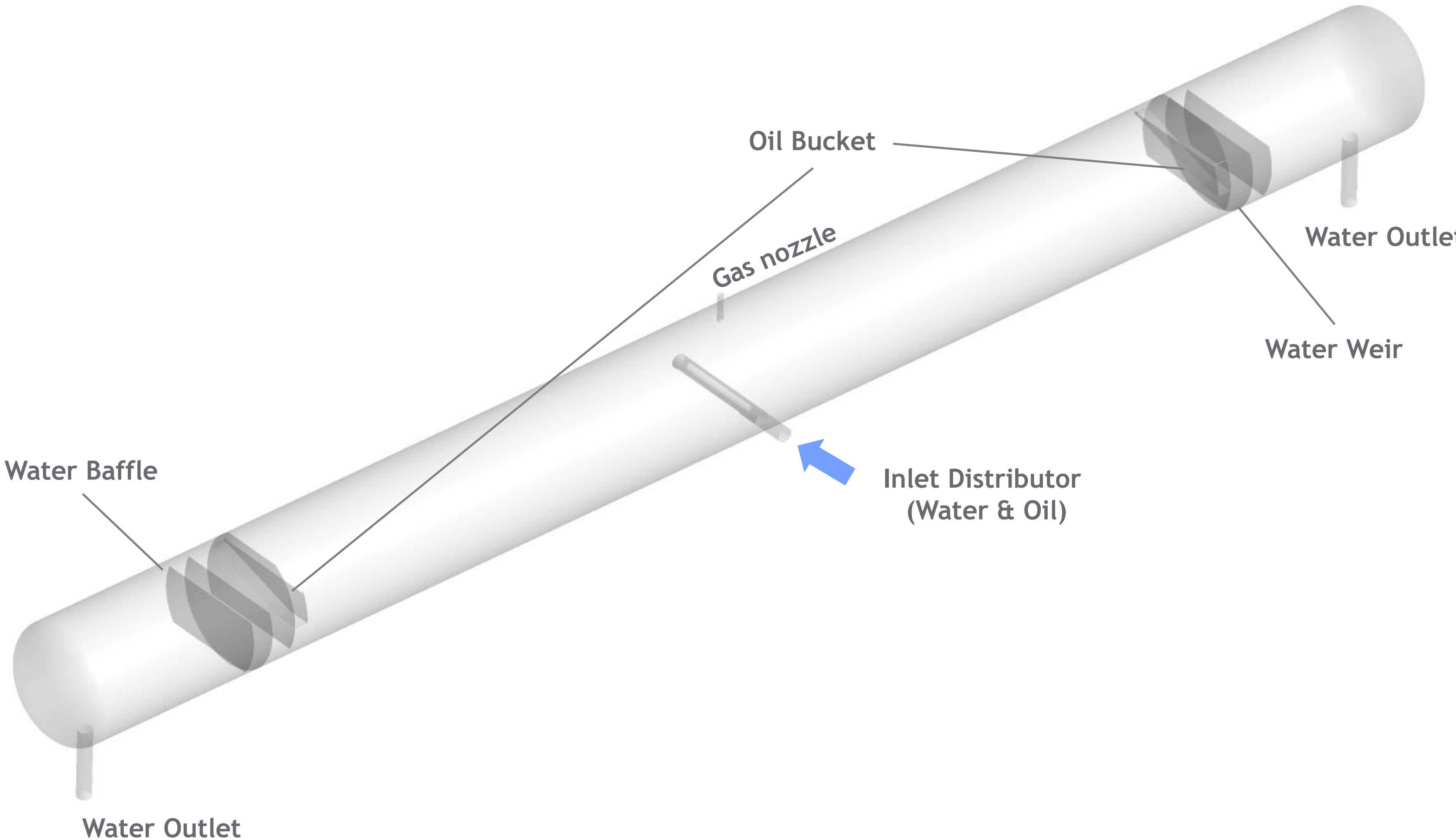
- ANSYS Workbench for Pre-Processing – Geometry and Mesh
- ANSYS Fluent R18.0 for Solution
  - Simulations run in parallel on an HPC cluster with 216 cores
- ANSYS CFD-Post 18.0 for Post-Processing

Numerical Test Matrix

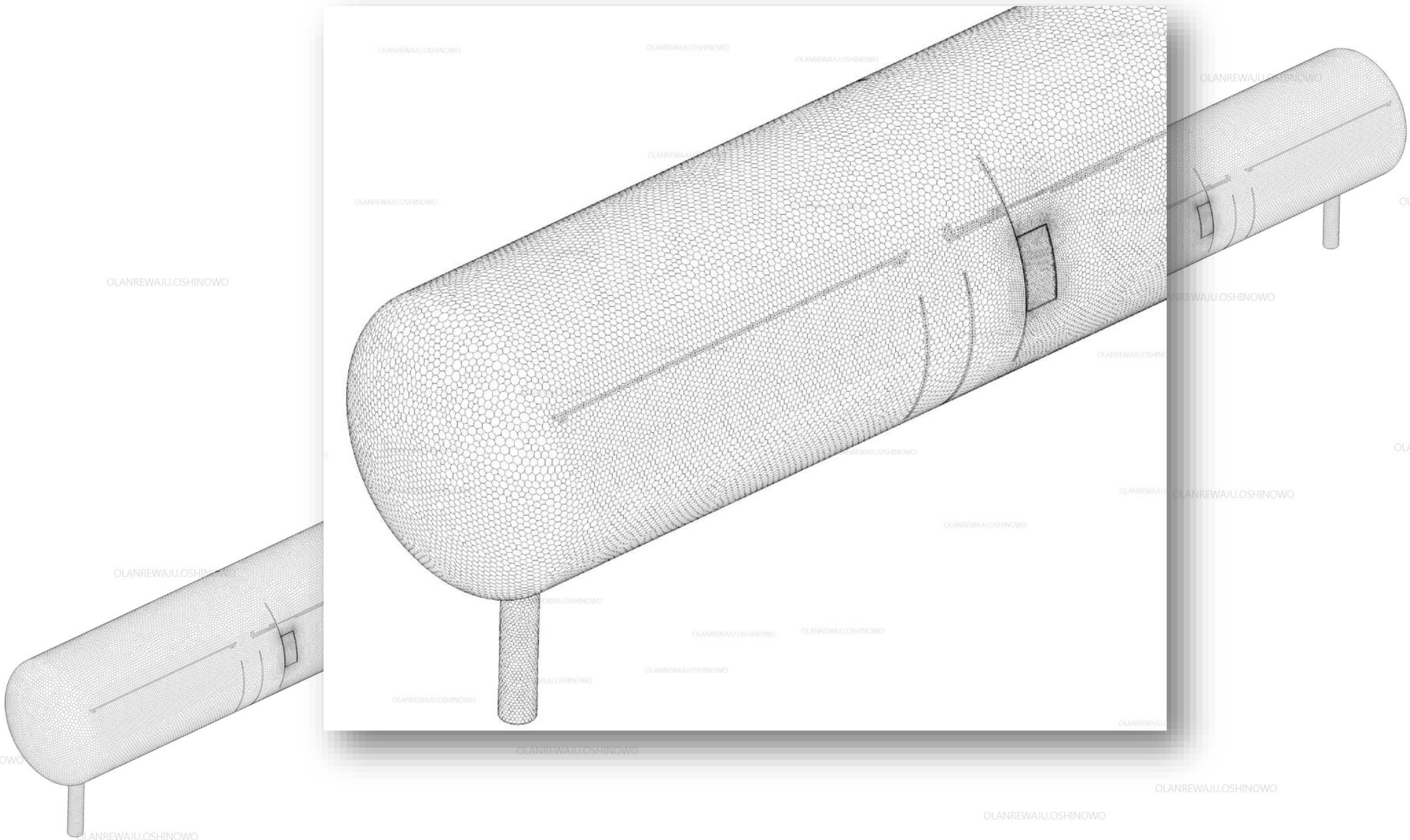
Run	Flow (MBD)	Oil Droplet Diameter (μm)
1	173	10
2	173	50
3	265	10
4	265	50

Inlet Oil Fraction (OF)	0.01

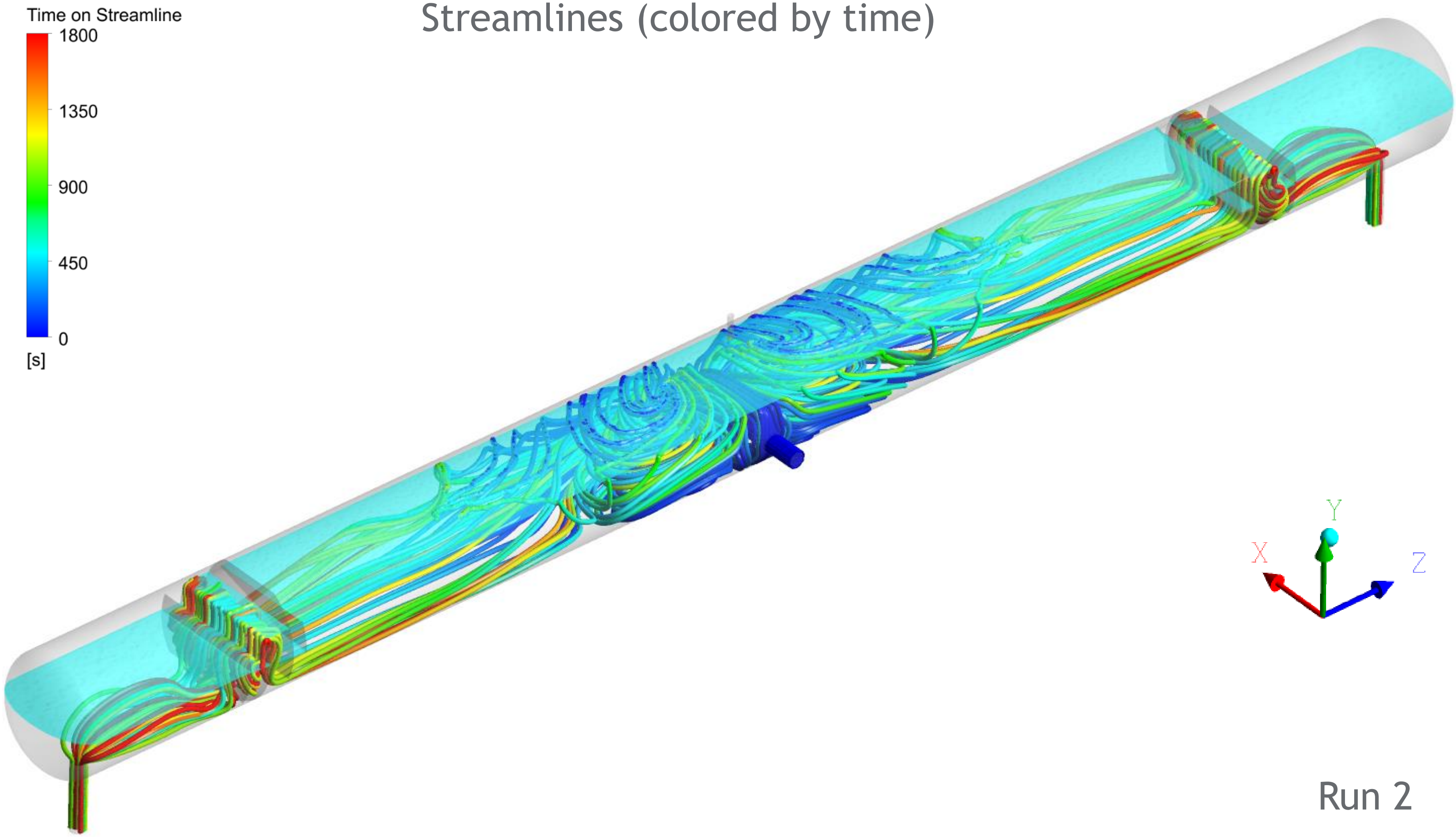
Geometry


Oil Bucket
Gas nozzle
Water Outlet
Water Weir
Water Baffle
Inlet Distributor
(Water & Oil)
Water Outlet

Computational Mesh

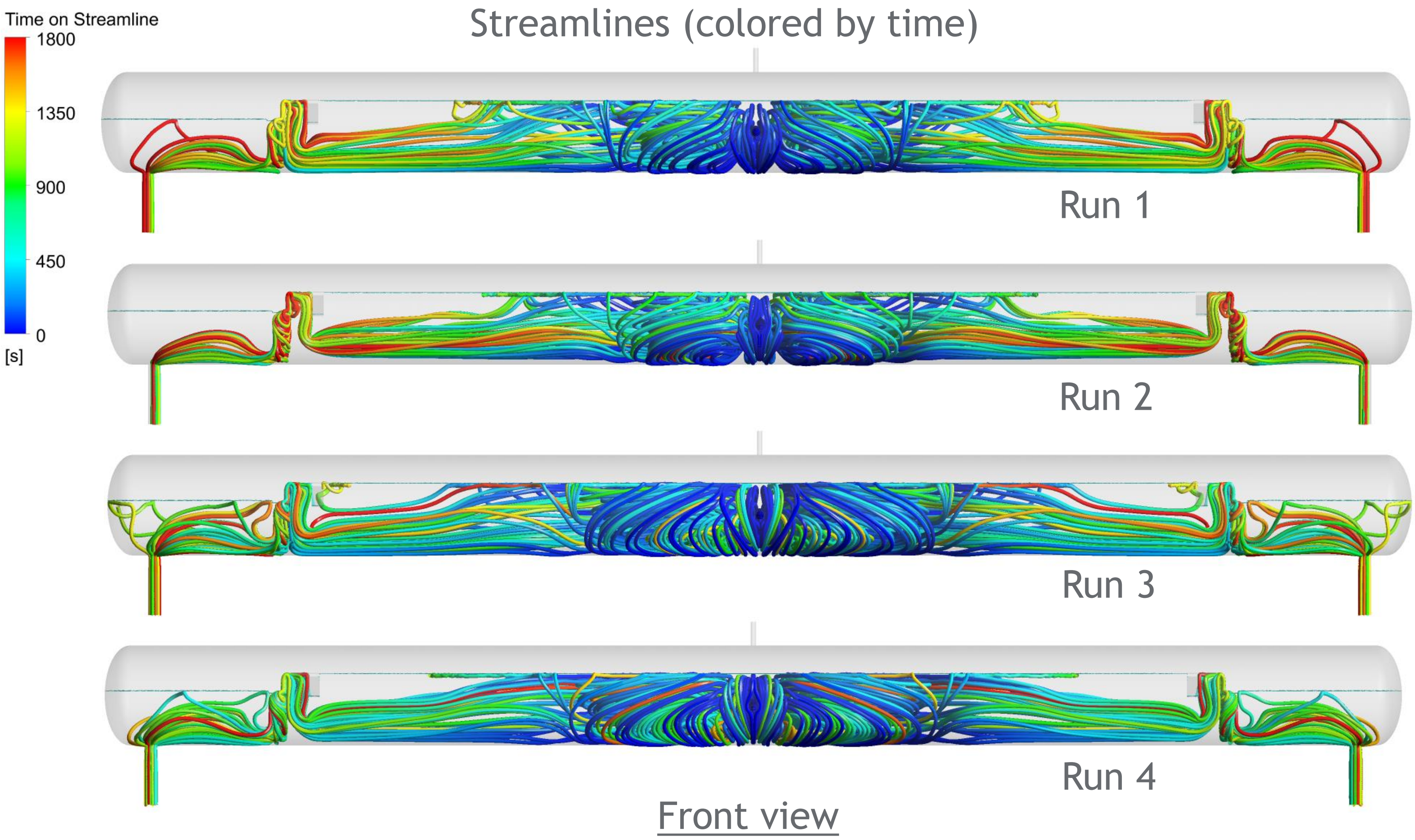


WOSEP Flow Field

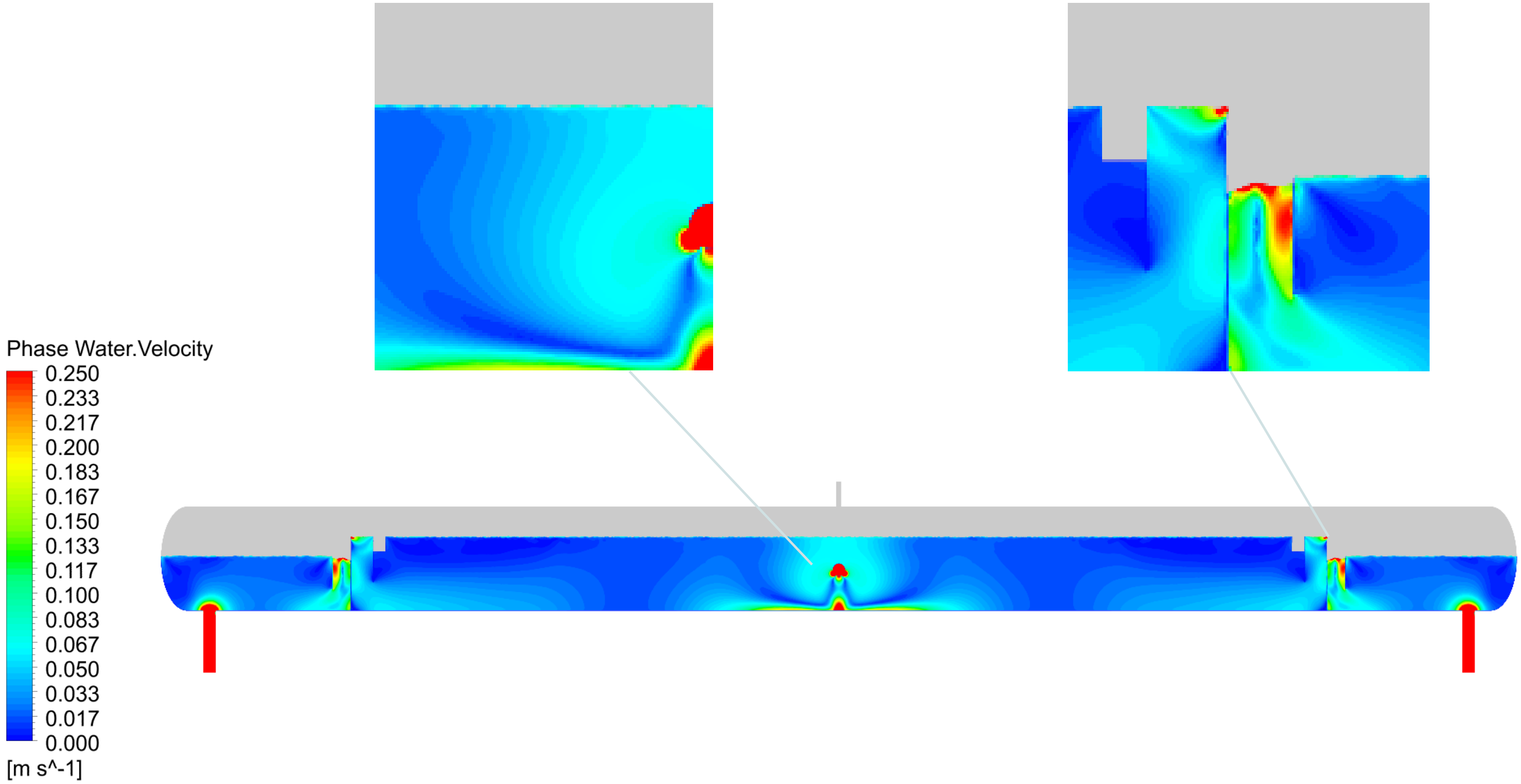


Run 2

WOSEP Flow Field

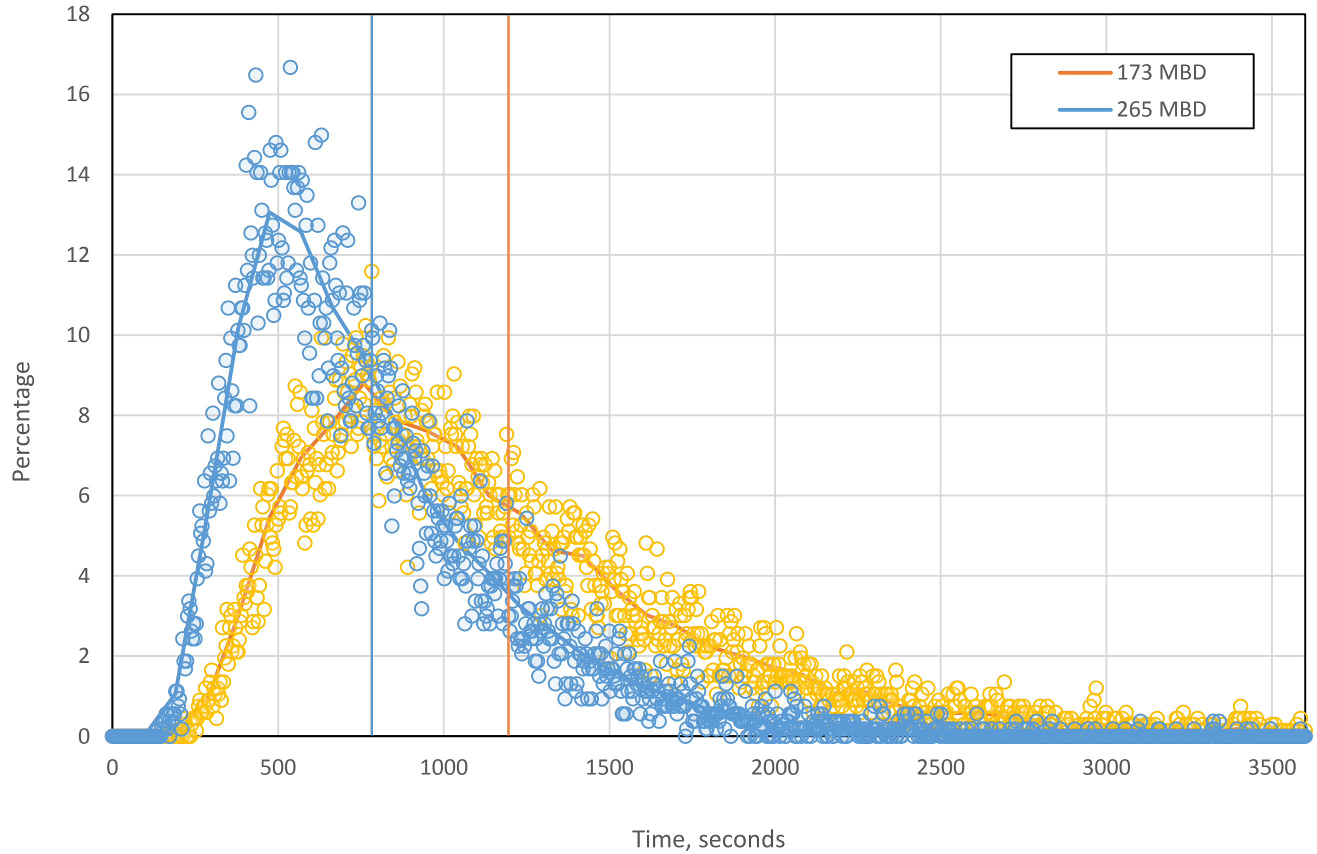


Velocity



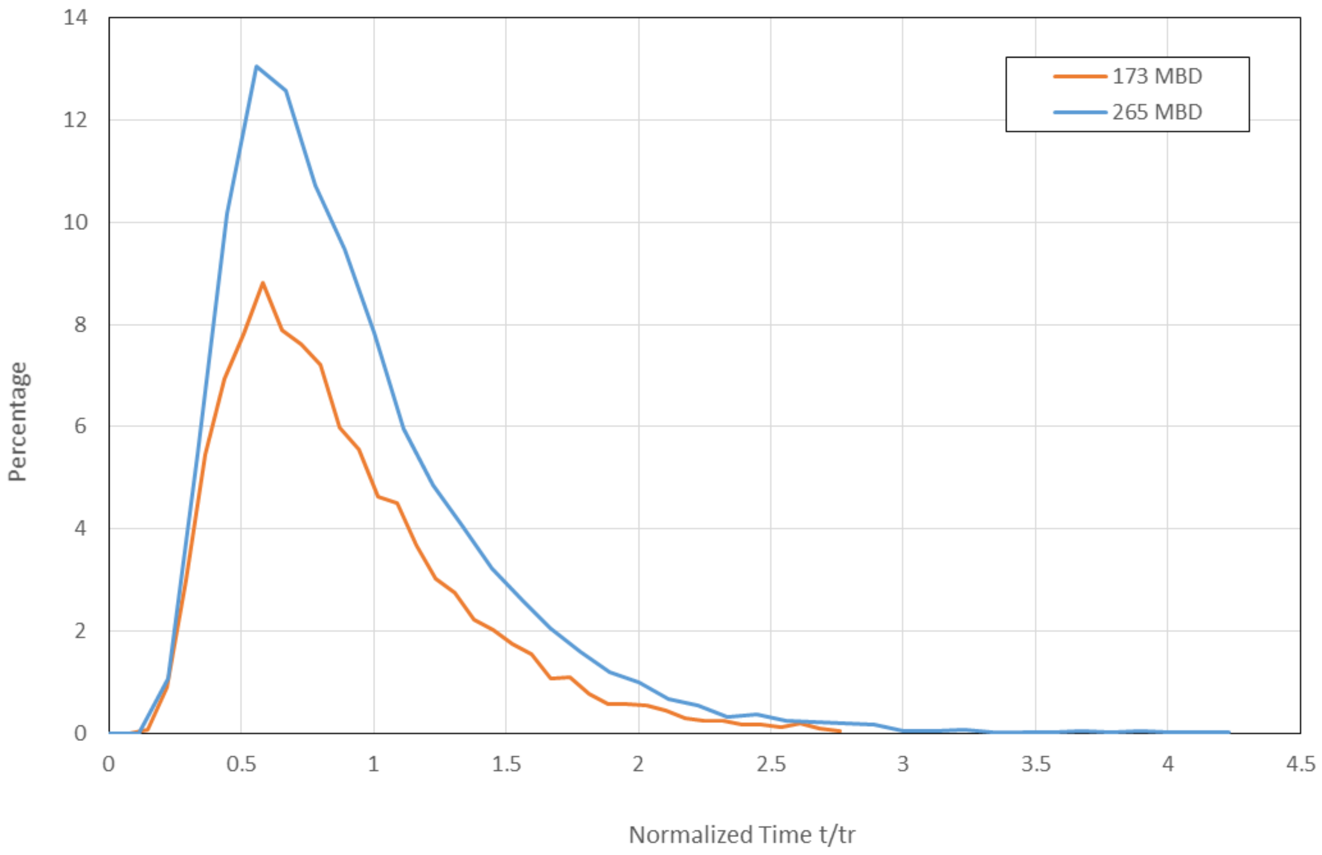
Run 2

Residence Time Distribution

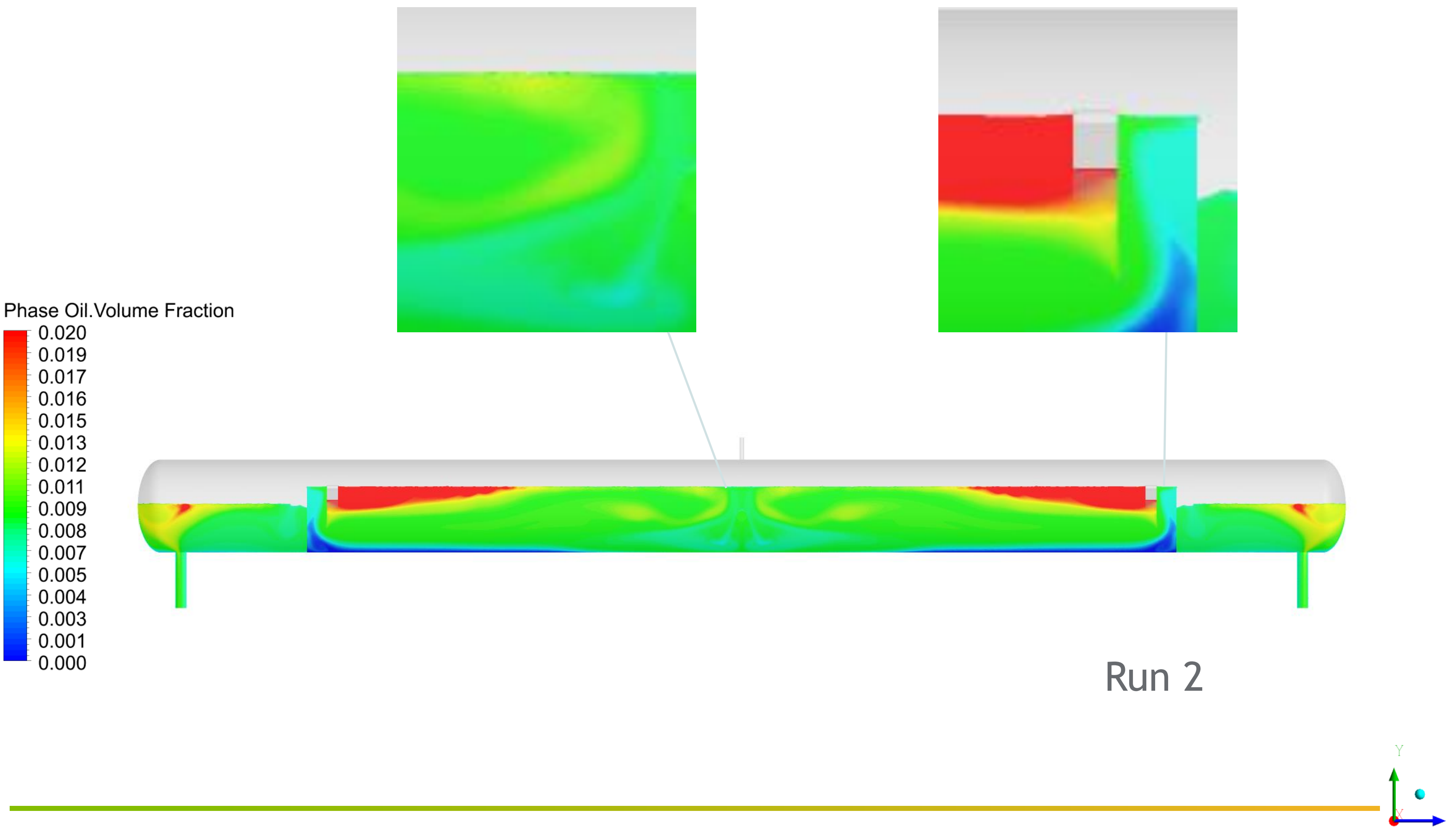


Water Flow Rate {MBD}	Mean of RTD {s}	Retention Time (V_C/Q) {s}
173	1142	1305
265	784	851

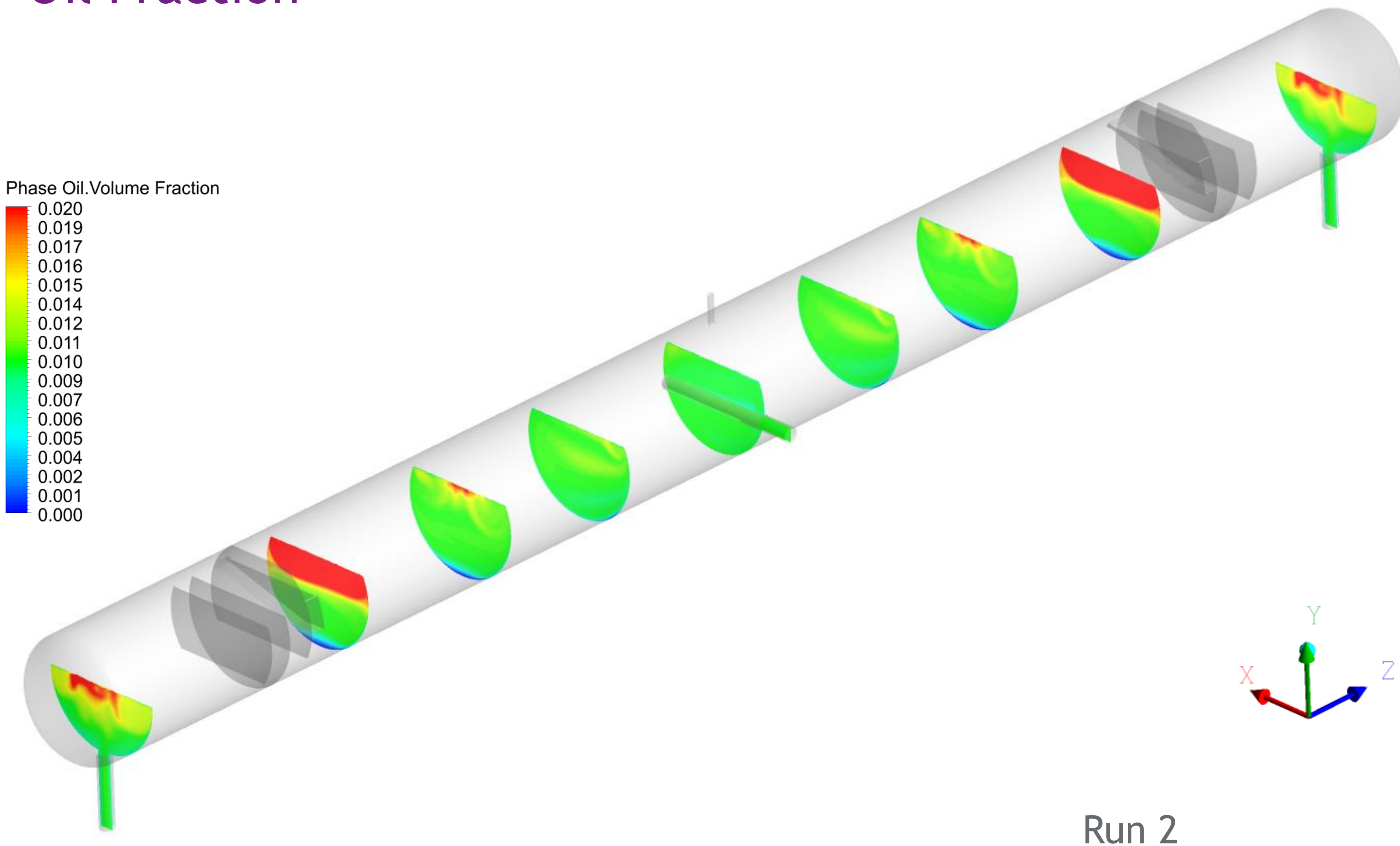
Residence Time Distribution



Oil Fraction



Oil Fraction



Run 2

Effectiveness of Oil Separation

Run	Flow (MBD)	Oil Droplet Diameter (μm)	Oil Removed (%)
1	173	10	<1
2	173	50	9
3	265	10	<1
4	265	50	4

$$Separation\ Efficiency = \frac{Inlet\ Oil\ Fraction\ - Outlet\ Oil\ Fraction}{Inlet\ Oil\ Fraction} \times 100\%$$

Conclusions

- Successful CFD simulations of WOSEP under different conditions
- Flow patterns show adverse vortices induced by the inlet distributor that reduce ability to separate oil from water
- Very low oil separation obtained from separator design for base flow rate
- Increased water throughput further reduces separation performance
- Potential to increase primary stage produced water oil removal through improvements in WOSEP design:
  - Inlet distributor
  - Additional internals (perforated plate baffles or derivatives, coalescing plate packing)
  - Vessel configuration

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Thank You!