Subsea Processing System Integration Engineering

07121-1901

December 3, 2009

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RPSEA
Research Partnership to Secure Energy for America

RPSEA Subsea Processing Simulator

Modeling Update

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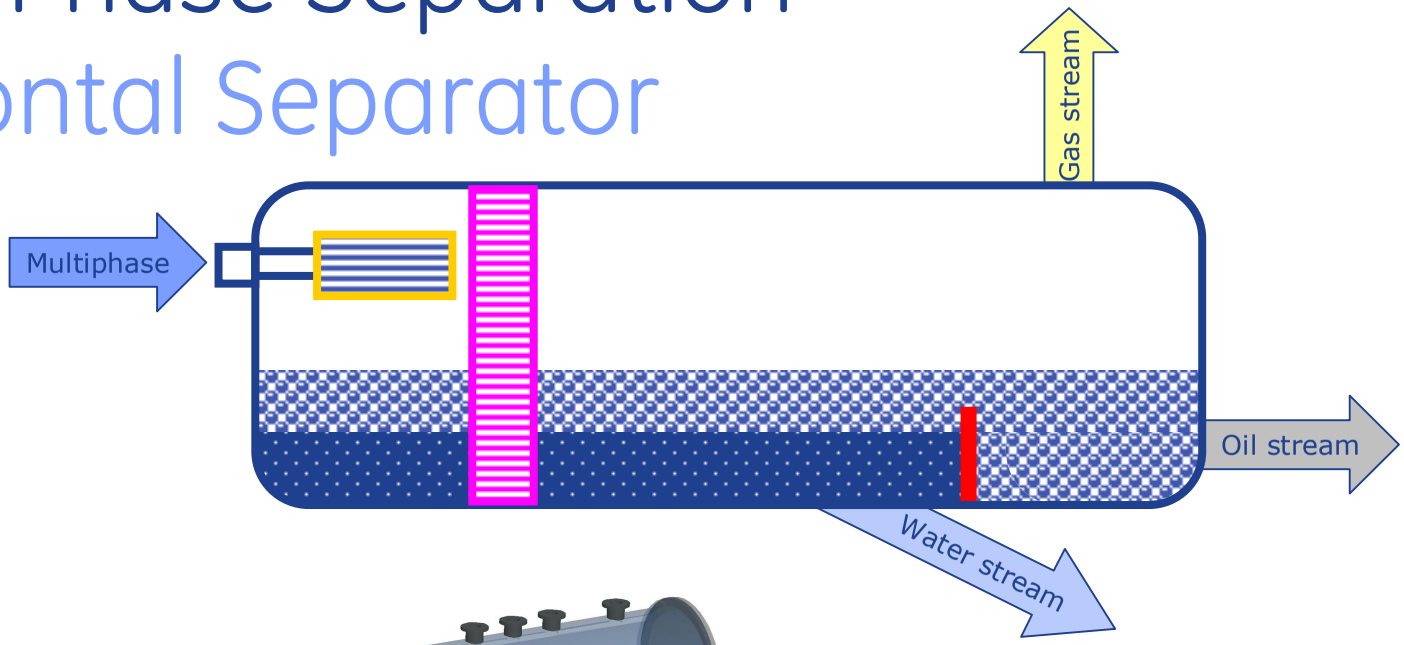
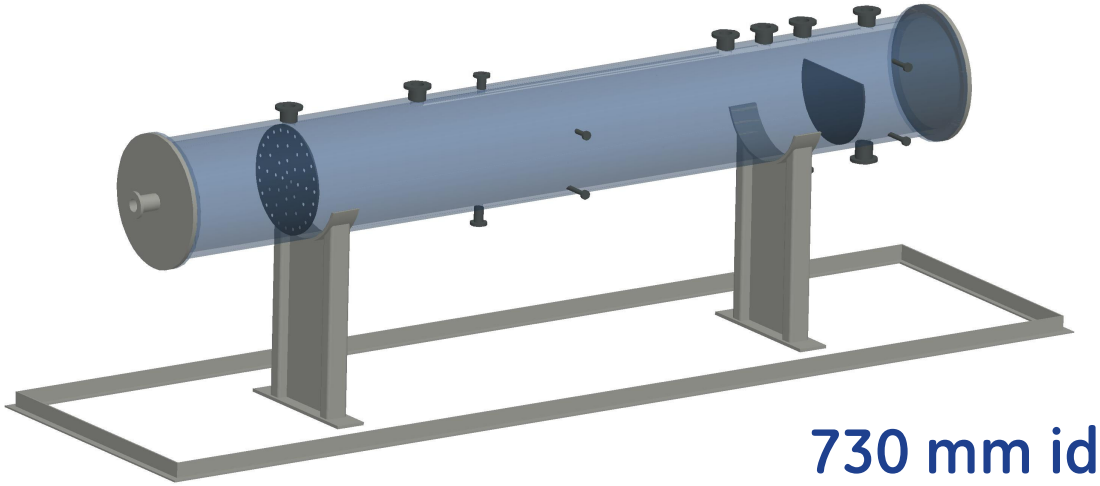
Three Phase Separation
Horizontal Separator



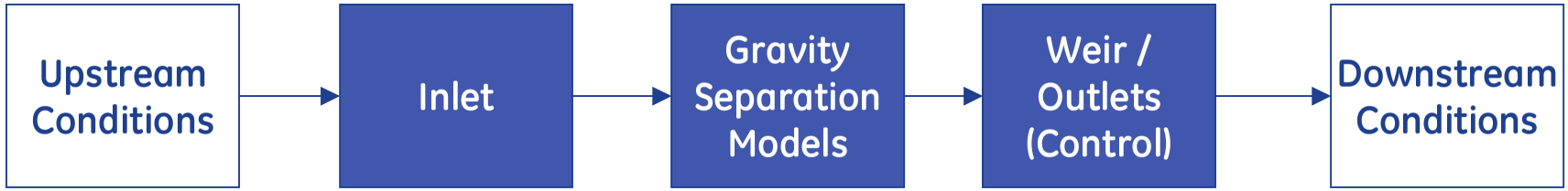


730 mm id
6000 mm overall length

Validation Simulation Breakdown

Objective:

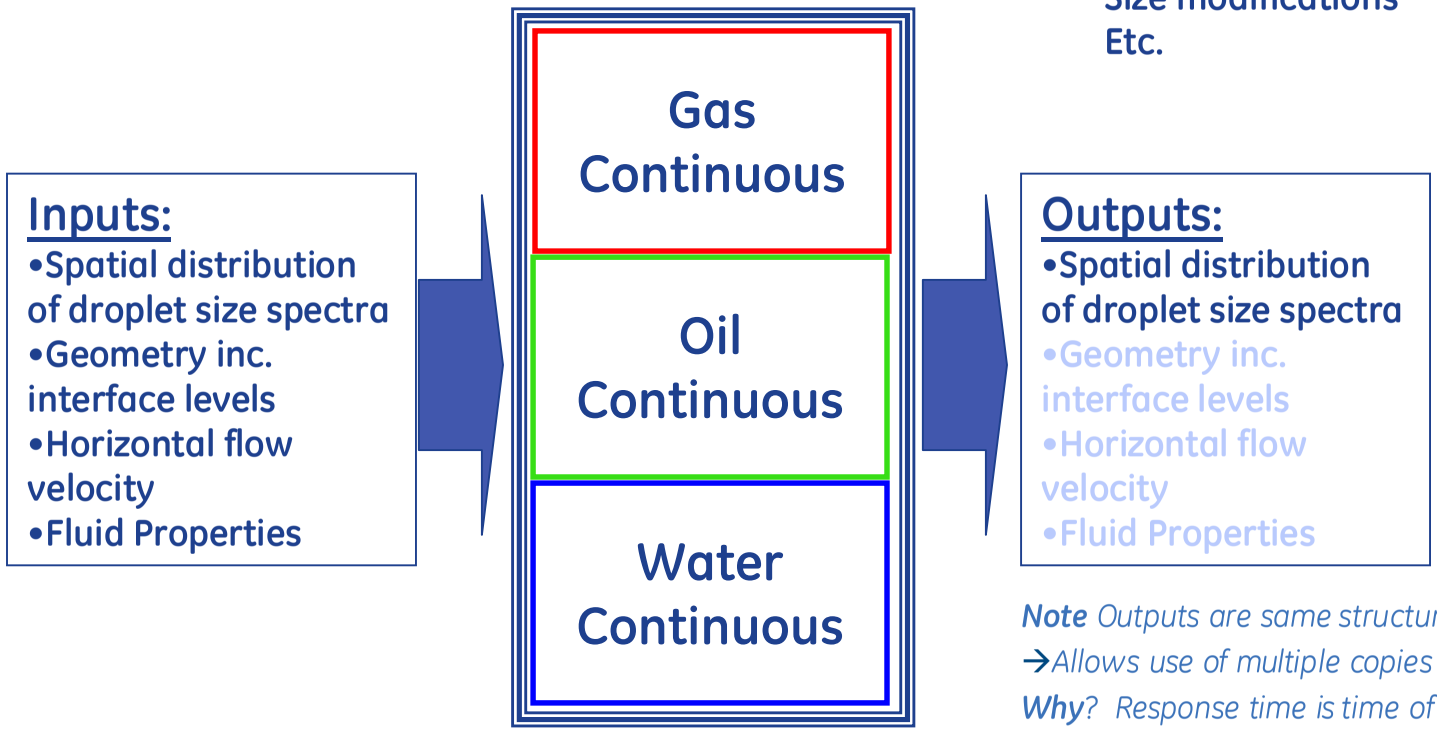
1) Minimize number of tuning parameters (and still get good accuracy)
   - Limited number of runs & instrumentation to tune
   - Too much tuning limits general applicability (Black Box)
2) Ideally, tuning parameters are physics based and orthogonal



Balancing act: simplicity & accuracy

Gravity Separation Model Framework

Submodels
Droplet motions
Axial (plug) flow field
Size modifications
Etc.



Note *Outputs are same structure as inputs.*
→Allows use of multiple copies of the model in series
Why*? Response time is time of fluid transit.*

GSM calculates particle trajectories (zooming opportunities)

GSM Zooming & Tuning

Code structured for easy upgrading and/or zooming

Components: oil & water droplets, gas bubbles → add sand, coated sand, complex droplets, etc.

Continuous fluid horizontal velocity: uniform, linear, arbitrary profile

Droplet motion: Stokes, Newton, add randomness?

Geometry: 2-D → 3-D

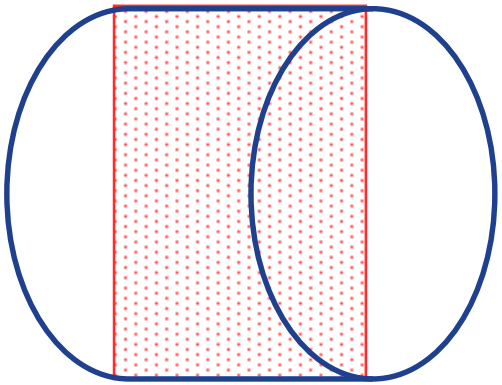
Other: droplet/bubble shapes, coalescence, breakup.
CFD, emulsion / interfaces

Possible Tuning Factors:

✓Effective geometry / velocity scaling

•Effective droplet sizes -- convoluted with inlet model.

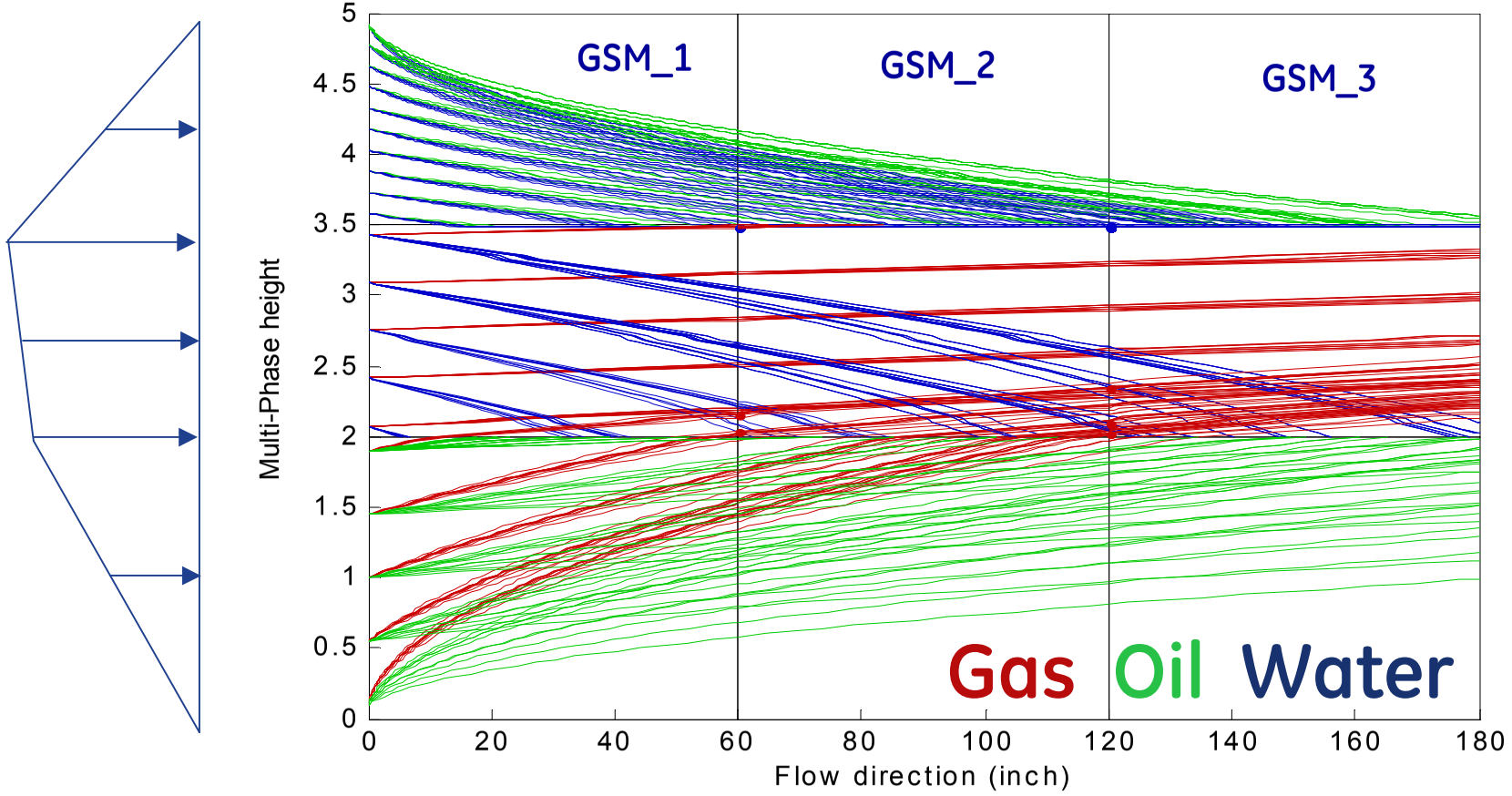
•Effective fluid properties ☹ -- known



2-D model (plane) of 3-D geometry (cylinder)

GSM Simulation (Matlab)

$$V_s = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g\, R^2$$



Weir Model

Grouping of models that

1) Calculates interface levels (incorporating GSMs)
2) Controls the three outlet flow rates

Lab Validation: Steady state, constant levels.

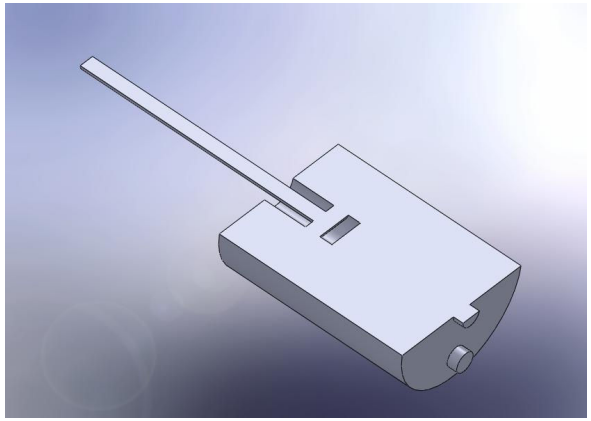
Real world: Control system, valve performance, DP, etc.

Inlet Model

Use CFD to relate upstream conditions to boundary conditions for GSM:

1) Volume Fractions

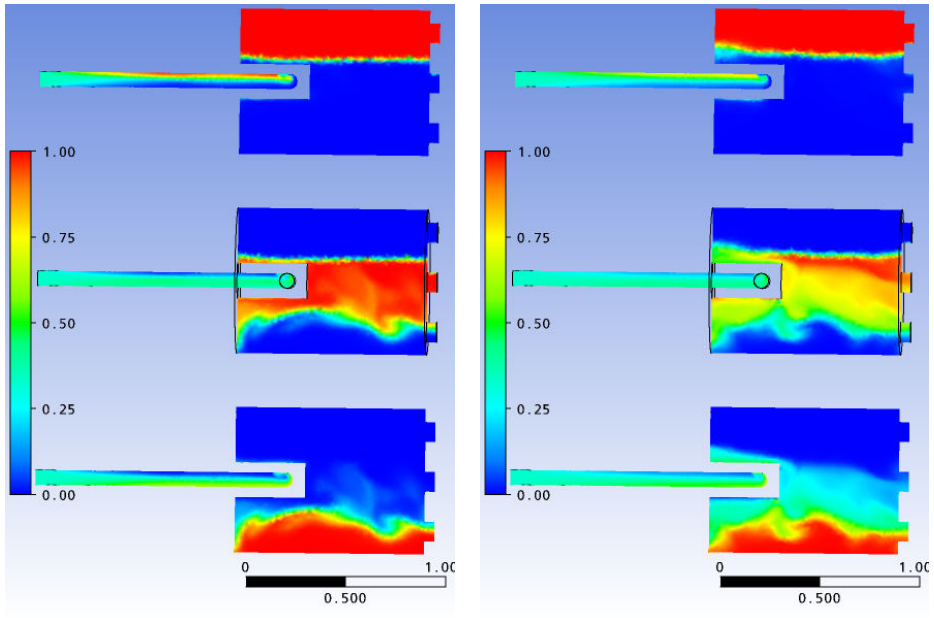
2) Droplet size / spatial distribution



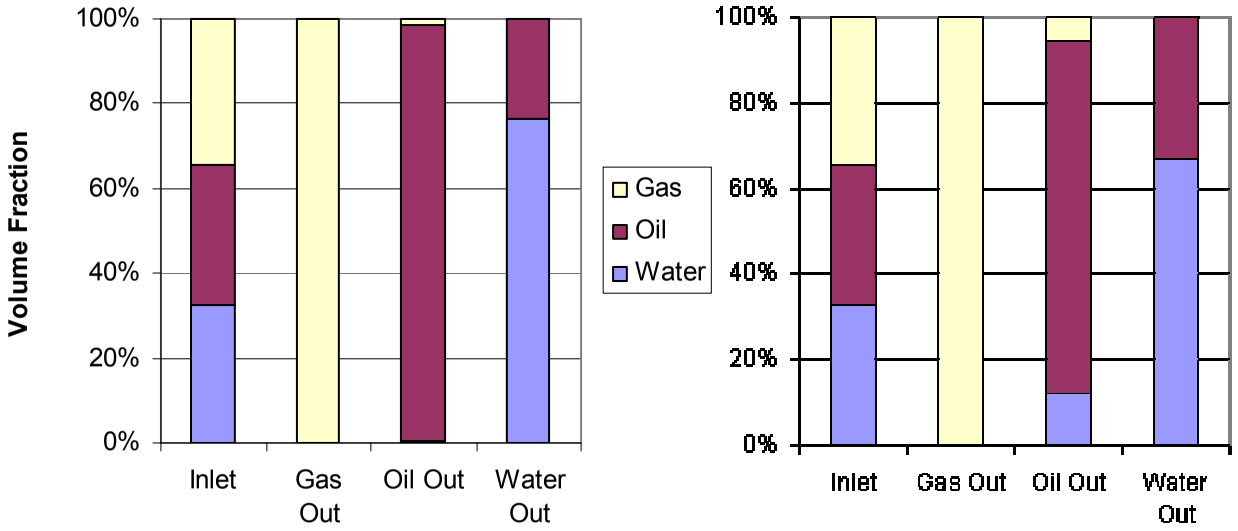
Fluid Domain

Volume Fractions

CFD used to determine phase distribution at baffle plate discharge as function of upstream conditions



10 bar 50 m^3/hr (left), 100 m^3/hr (right)

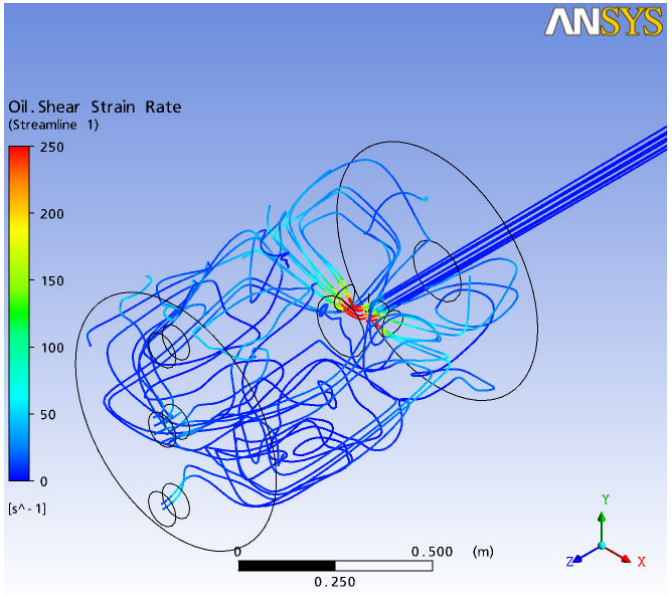


Droplet Sizes

Maximum stable drop size is described by a critical Weber Number

$$We_{crit} = \frac{\rho_c \cdot V^2 \cdot d_{\max}}{\sigma}$$

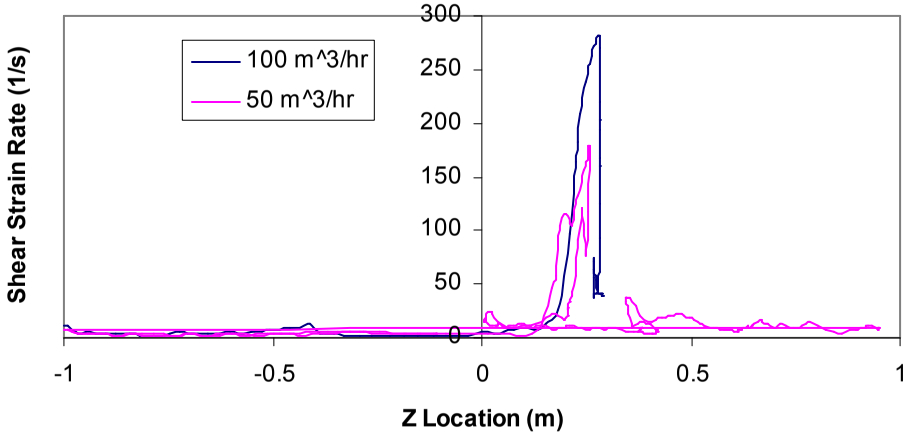
CFD runs to determine shear strain rate along path as function of upstream conditions.



Hinze

$$d_{\max} = \frac{C}{\left(d_N\left(SSR\right)\right)^K} \cdot \left(\frac{\sigma}{\rho_c}\right)^{3/5}$$

(Dimensional Analysis also useful)



Rosin-Rammler distribution used to obtain size distributions from d_{max}.

RPSEA Subsea Processing Simulator

Flow Loop Update

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Operational Capabilities

Pressure: 16 bar design pressure @ 20°C (PN10)

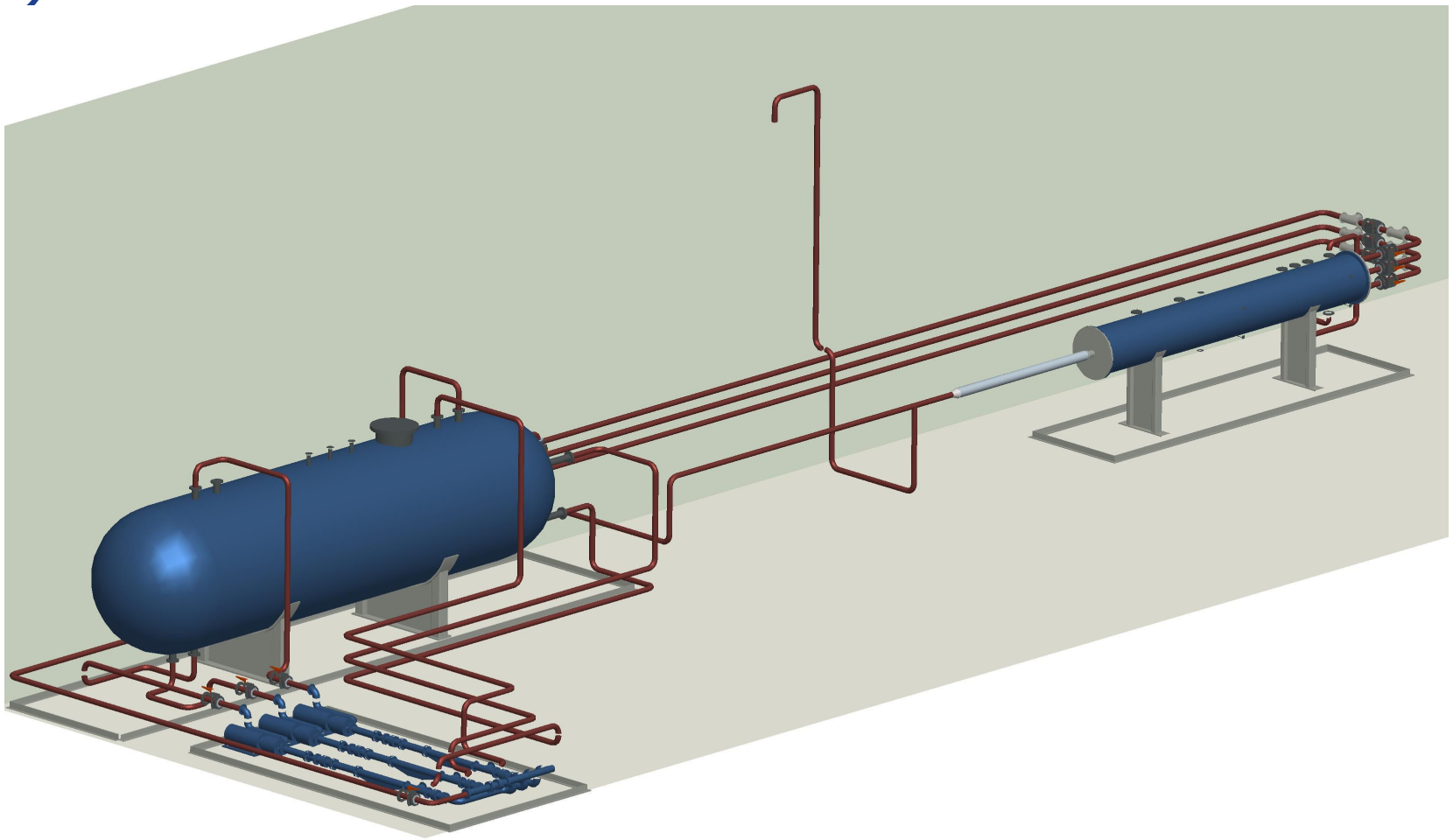
Flowrates:

- Oil: max 70m^3/hr, min 10 m^3/hr
- Water: max 70m^3/hr, min 10 m^3/hr
- Gas: max 270Am^3/hr (@10 bar), min 1 Am^3/hr
- Design Temperature (max/min): 40/4 °C

Fluids:

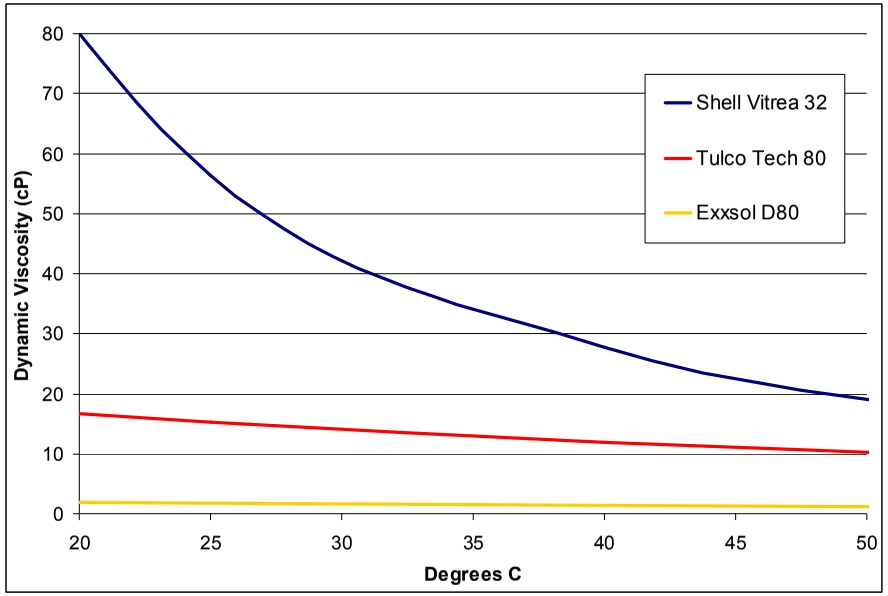
- Salt water; 0-10% of relevant salts (based on city water or distilled water with O_2)
- Model oils, flashed crude oils (no explosive gasses will be allowed in the laboratory)
- Air and N_2

Lay-out



Model Oils

GOM target oils:	**Model oils:**
Lighter Miocene	Exxol D80
SG: 0.6-0.85	SG: 0.79
Viscosity 0.5-2 cP	Viscosity 1.71 cP @ 25 C
Paleogene	Tulco Tech 80
SG: 0.8 to 0.9	SG: 0.86
Viscosities: 1 to 50 cp	Viscosities: 15.3 cP @ 25 C
	Shell Vitrea 32
	SG: 0.87
	Viscosities: 56 cP @ 25 C



Summary

Long lead items on order

- 22 weeks for pumps, May 1 2010 expected delivery

All else in ordering process

Range of GOM viscosities covered by model oils selected

Full GOM pressures and temperatures not achievable in lab setting

- Value of separation increases as separation pressure decreases
- Lab capability relevant to likely first applications

Loop, test separator and test plan design will ensure successful and failed separation operation, outlining performance boundaries

RPSEA Subsea Processing Simulator

Simulator Update

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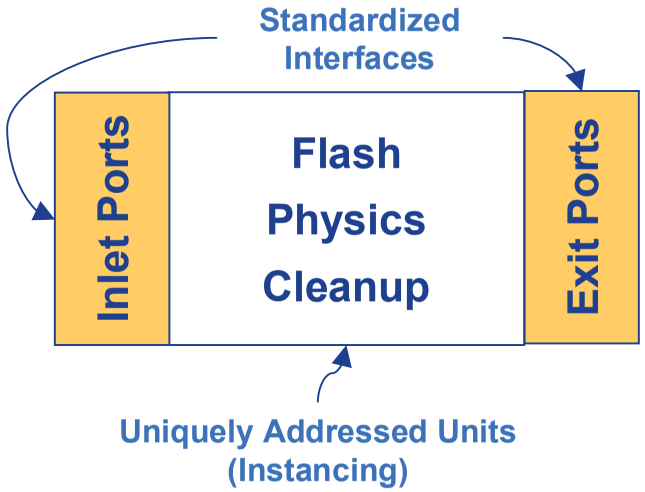
Key Development Fronts



Inner workings:

Translation of **model** library from MATLAB is straightforward

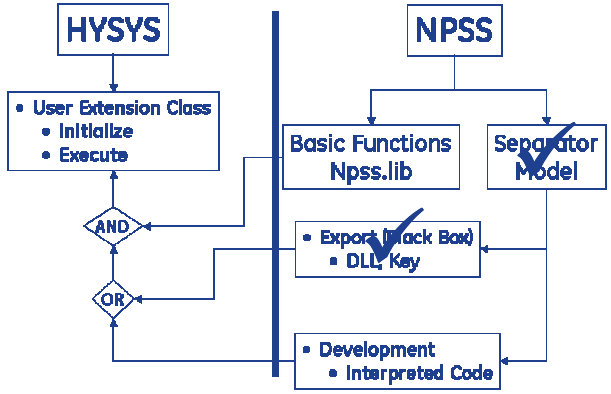
Interfacing:

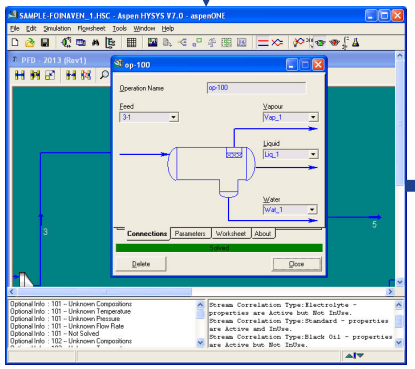
Three NPSS Platform Development Requirements

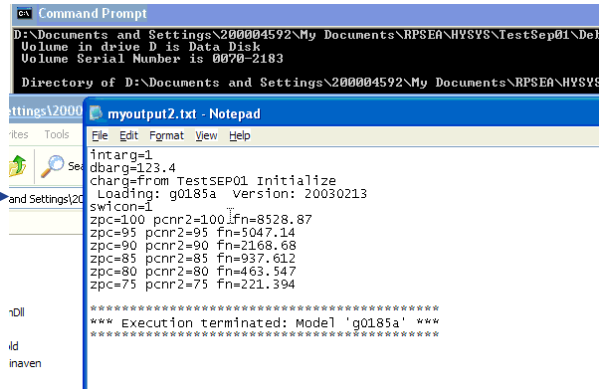
1) Flashing—fluid properties (Demo in Sept meeting)
2) **Interfacing HYSYS with Process Simulator** (Demo today)
3) C++ Implementation into NPSS Syntax / Solvers (in progress)

Interfacing with Process Simulator

HYSYS NPSS Connection (Example)







Recorded Demo of Process