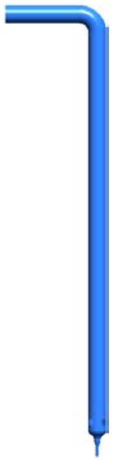
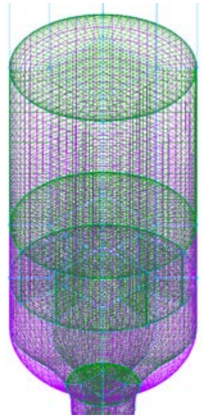
CFD Multiphase Models Application to Predict Pressure Drops in Large Diameter Pipes

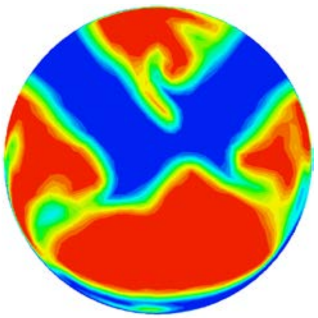
LSU

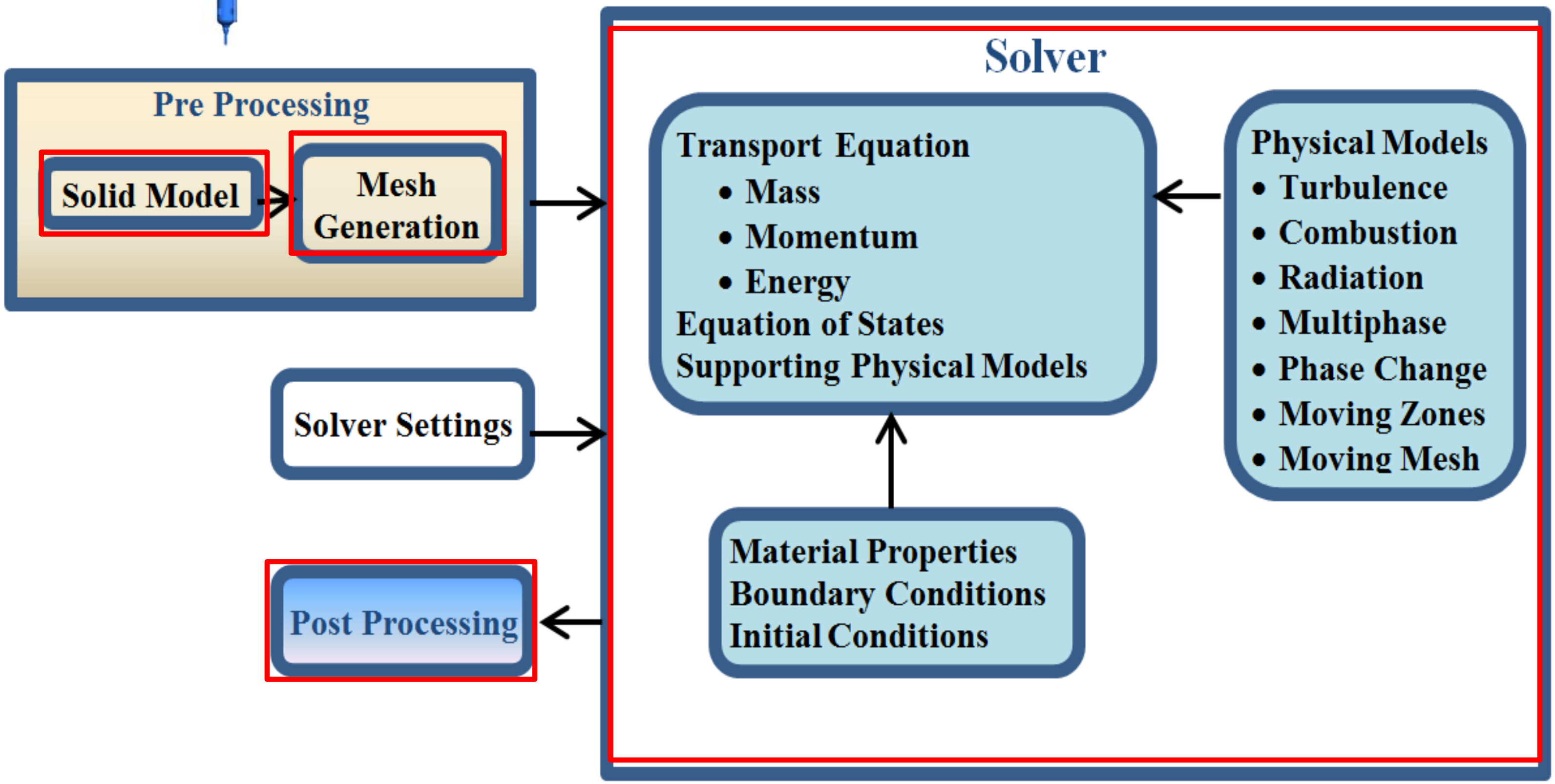
09/28/2016

CFD Modeling Overview









CFD Multiphase Models

Available Models

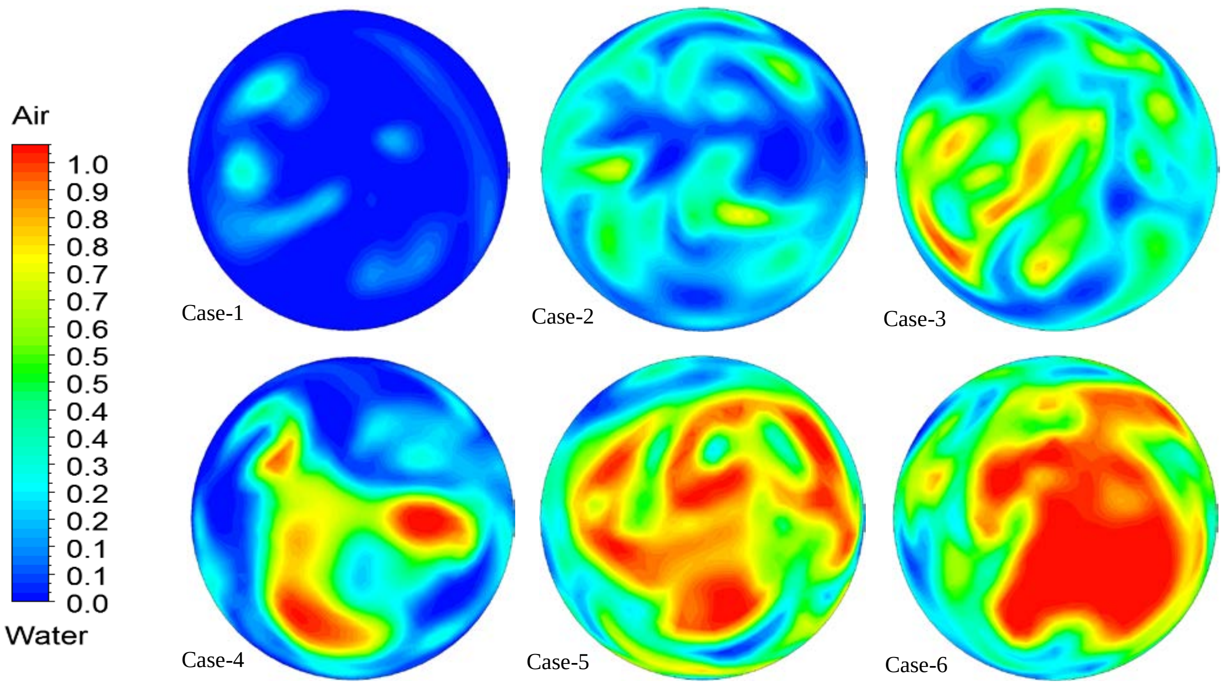
- Volume of Fluid (VOF)
- Mixture Model
- Hybrid Model (Eulerian with VOF as Sub model)
- Discrete Phase Model (DPM)

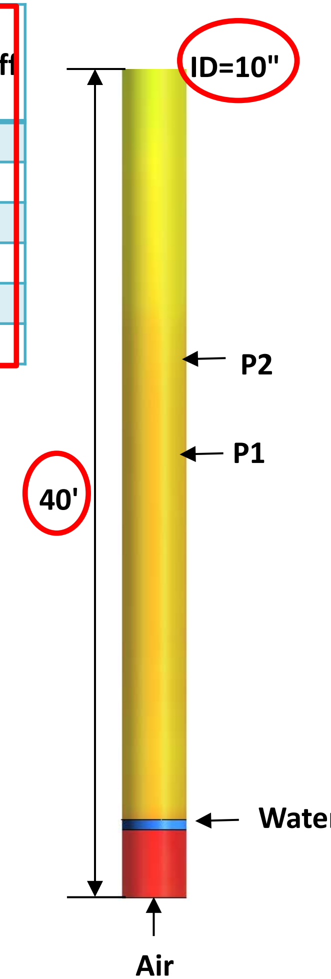
Objectives

- Validate CFD models against available Lab and field data
- Report the advantages and limitations of current CFD multiphase flow models
- Apply these models and predict the pressure drop for WCD conditions

Validation Results-Ali's Data (Air –Water)

Case	Vsl (ft/s)	q_L (bbl/d)	Vsg (ft/s)	q_G (MMSCF/d)	GLR (SCF/STB)	Slip Ratio (Vsg/Vsl)	Exp (dp/dx) psi/ft	CFD (dp/dx) psi/ft	% age Diff
1	3.22	36012	0.31	0.01	1	0.1	0.397	0.414	4.17
2	0.83	9333	2.12	0.10	14	2.5	0.269	0.275	1.91
3	3.40	38071	2.54	0.12	4	0.8	0.311	0.328	5.52
4	3.61	40377	6.91	0.33	11	1.9	0.231	0.242	4.79
5	1.44	16160	7.32	0.35	28	5.1	0.182	0.186	2.17
6	1.02	11415	7.41	0.35	41	7.3	0.166	0.172	3.31

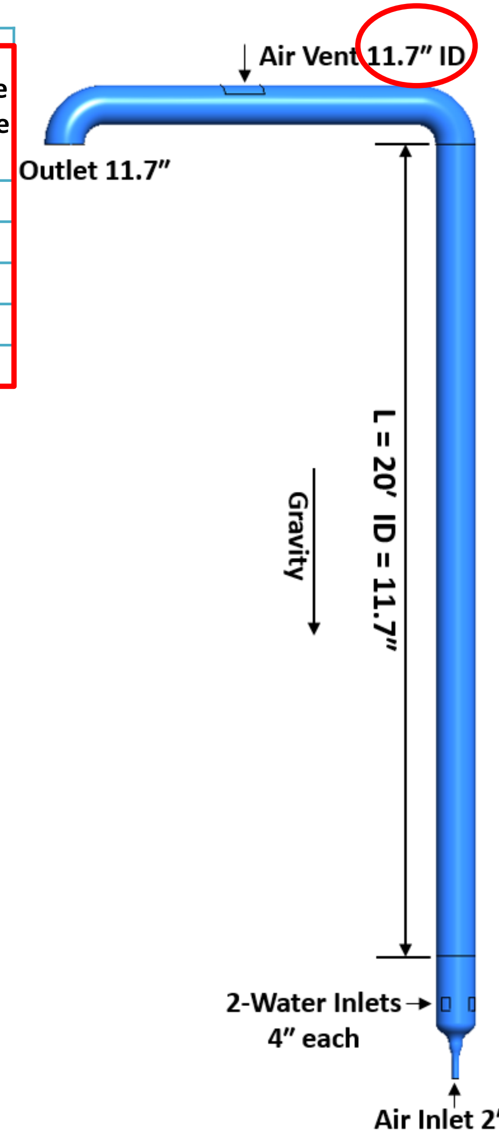


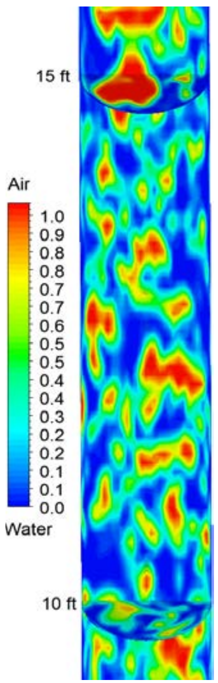


Ali Shazia F. (2009). *Two Phase Flow in Large Diameter Vertical Riser*. PhD Dissertation.: Cranfield University, School of Engineering Department of Process and Systems Engineering.

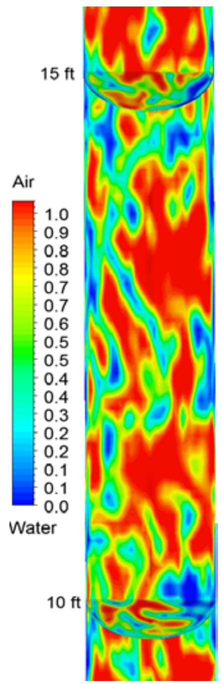
Validation Results LSU-Data (Air –Water)

Case	Vsl (ft/s)	ql (bbl/d)	Vsg (ft/s)	qg (MMSCFD)	GLR (SCF/STB)	Slip Ratio (Vsg/Vsl)	CFD (dp/dx) psi/ft	Exp (dp/dx) psi/ft	Abs % age Difference
1	2.39	27434	2.03	0.1376	5	1	0.33	0.315	5
2	2.4	27614	11.28	0.7655	28	5	0.189	0.178	6
4	2.35	27012	23.69	1.6073	60	10	0.147	0.144	2
5	0.61	7018	12.06	0.8187	117	20	0.146	0.1326	10
3	0.1	1124	12.23	0.8302	738	125	0.128	0.099	28

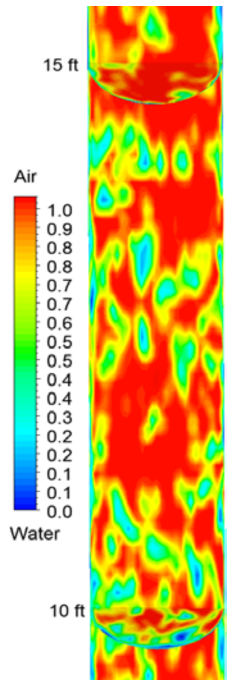




Case (1)



Case (2)



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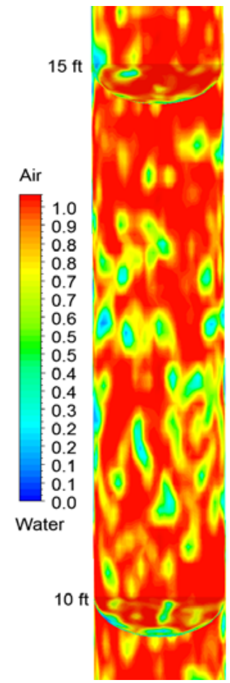
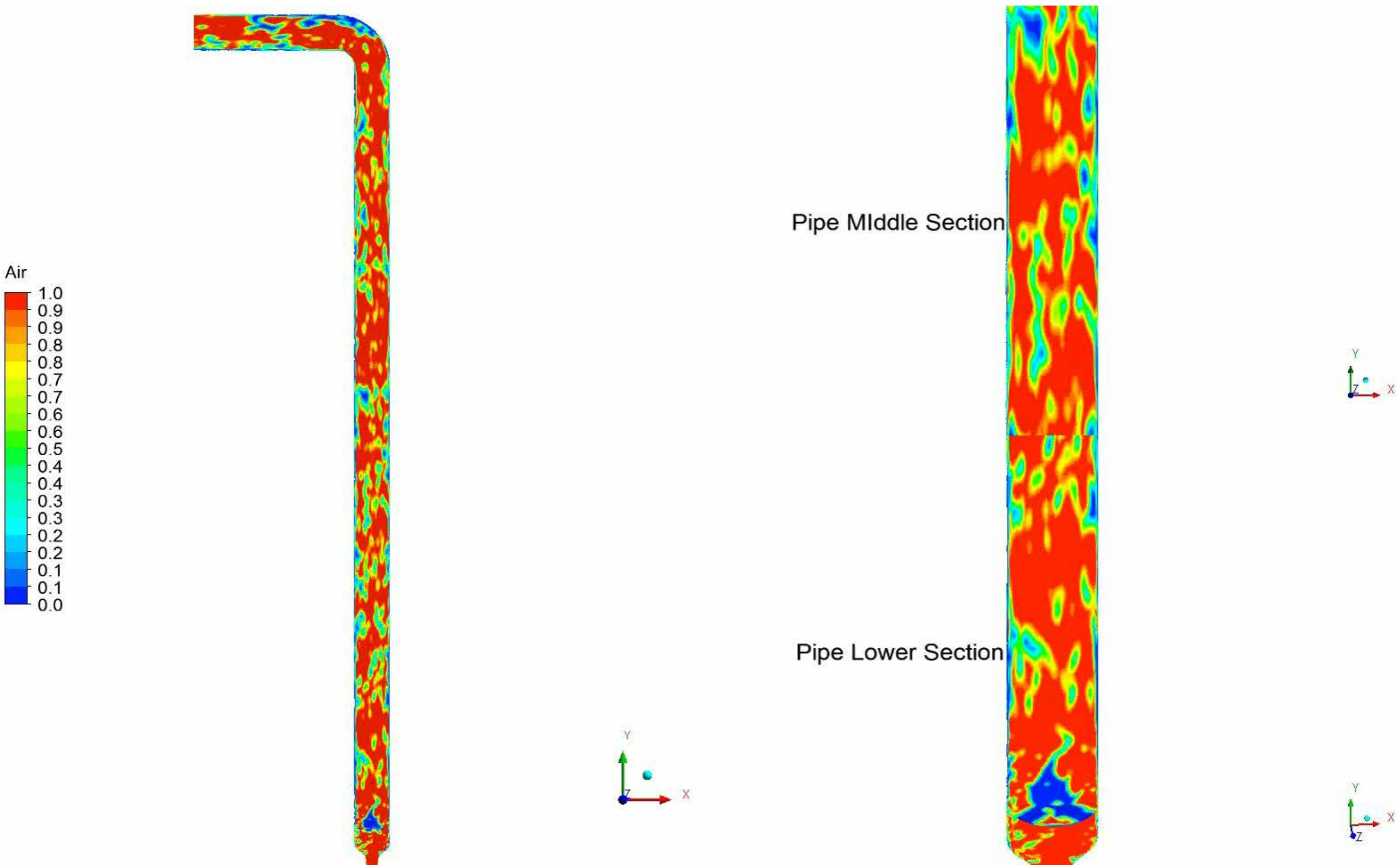


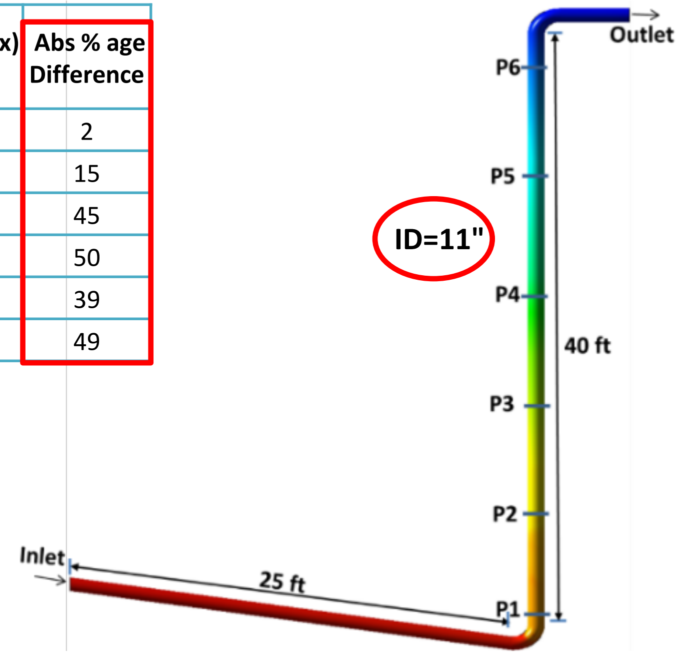
Case (4)

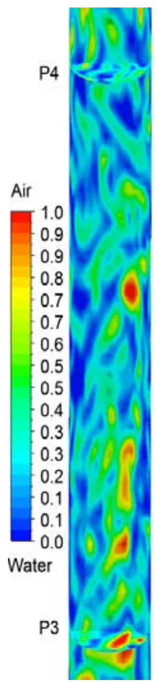
Validation Results LSU-Data (Case 4-Animation)



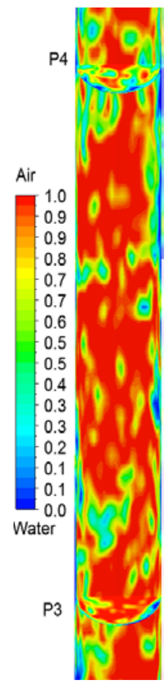
Validation Results-Zabaras-Data (Air –Water)

Case	Vsl (ft/s)	ql (bbl/d)	Vsg (ft/s)	qg (MMSCFD)	GLR (SCF/STB)	Slip Ratio (Vsg/Vsl)	CFD (dp/dx) psi/ft	Exp (dp/dx) psi/ft	Abs % age Difference
1	0.51	5143	1.26	0.0719	14	2	0.3139	0.3202	2
3	0.51	5143	12.31	0.7019	136	24	0.1319	0.1147	15
2	0.17	1714	10.05	0.573	334	60	0.1528	0.1052	45
4	0.51	5143	33.15	1.8902	368	65	0.0302	0.0599	50
5	0.51	5143	48.85	2.7856	542	96	0.0315	0.0514	39
6	0.17	1714	52.08	2.9694	1732	309	0.018	0.0121	49

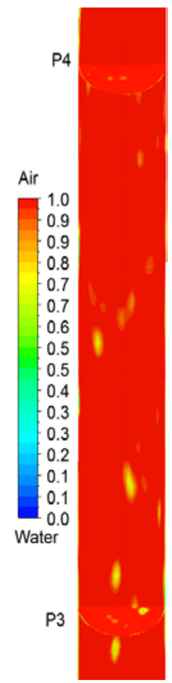




Case (1)



Case (2)



Case (6)

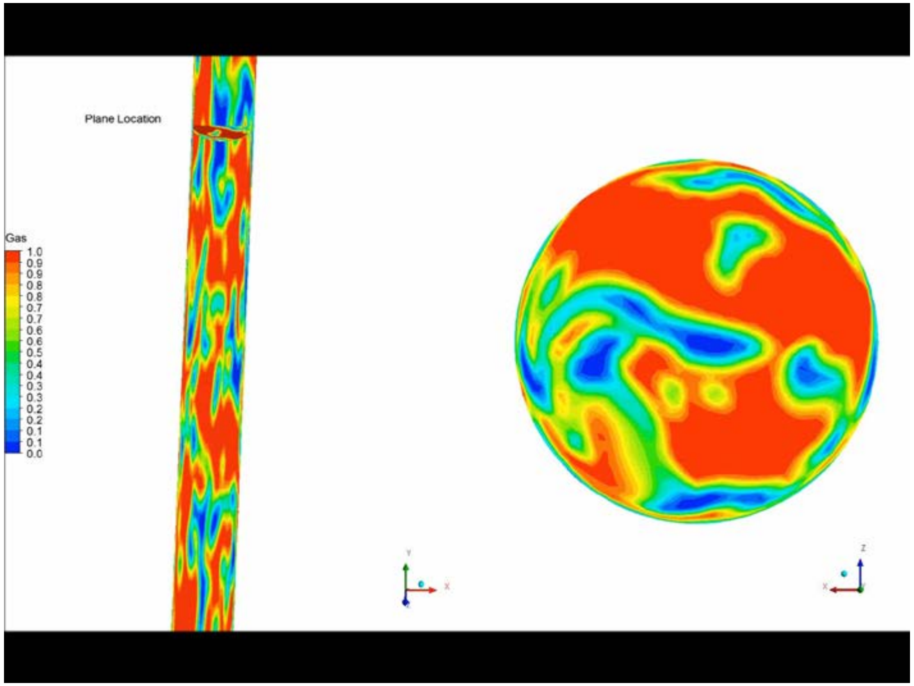
Zabaras, G. J , Schoppa, W.,., Menon, R., & Wicks, M., 2013, May 6. Gaps and Advancements for Deepwater Production and Remote Processing: Large Diameter Riser Laboratory Gas-Lift Tests. Offshore Technology Conference. doi:10.4043/23968-MS. https://www.onepetro.org/conference-paper/OTC-23968-MS

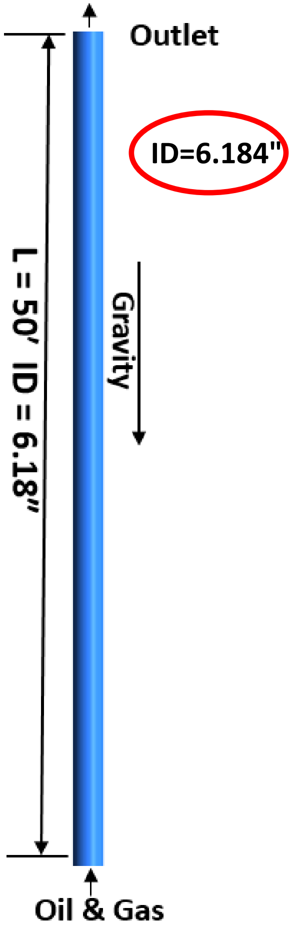
CFD-VOF Model Validation against Forties Field Data

Preliminary Results

ID (in)	qo (STB/D)	qg (MMscf/D)	P inlet (psi)	P outlet (psi)	Avg. Temp (F)	SG (oil)	SG (gas)	Flow Length (ft)	Avg Inclination (degrees)
6.184	26800	9.026	2418	249	188.5	0.842	1.122	7388	1.7

Case	Vsl (ft/s)	ql (bbl/d)	Vsg (ft/s)	qg (MMSCFD)	GLR (SCF/STB)	Slip Ratio (Vsg/Vsl)	CFD (dp/dx) psi/ft	Exp (dp/dx) psi/ft	% age Difference
1	9.17	29436	24.29	6.7432	229	3	0.181	0.1700	7

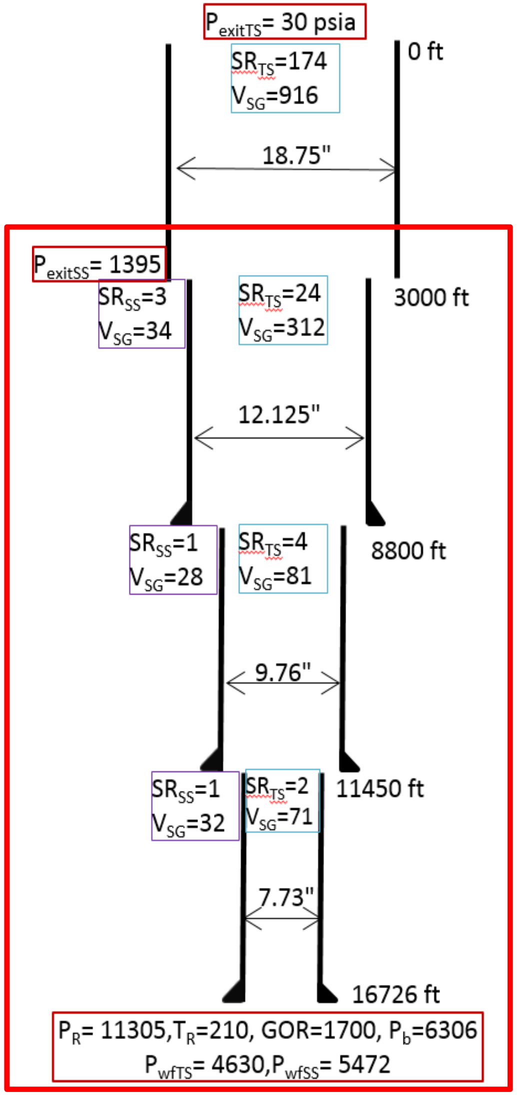




Asheim, H. (1986, May 1). MONA, An Accurate Two-Phase Well Flow Model Based on Phase Slippage. Society of Petroleum Engineers. doi:10.2118/12989-PA

Typical WCD Conditions

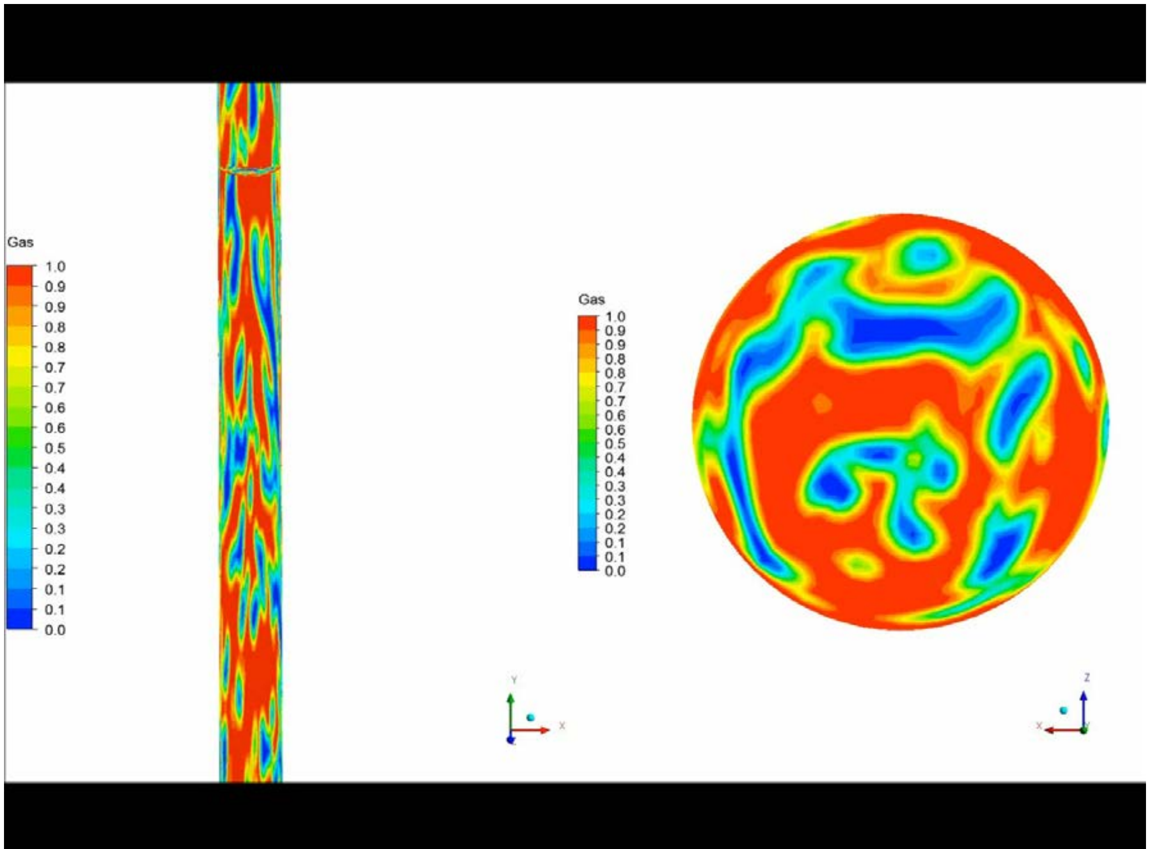
GoM:MC: Black Oil Base-Case

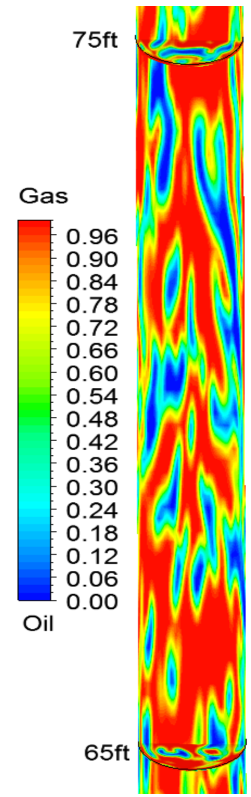


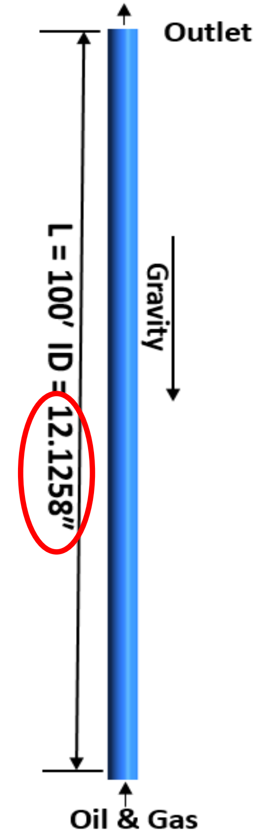
Zulqarnain (2014). "*Deepwater Gulf Of Mexico Oil Spill Scenarios Development and Their Associated Risk Assessment*". PhD Dissertation, Louisiana State University. http://etd.lsu.edu/docs/available/etd-07022015-181918/

CFD-VOF Validation for WCD Conditions

Case	Vsl (ft/s)	ql (bbl/d)	Vsg (ft/s)	qg (MMSCFD)	GLR (SCF/STB)	Slip Ratio (Vsg/Vsl)	CFD (dp/dx) psi/ft
1	10.96	135202	30.06	171.5590	1269	3	0.1600







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Conclusions and Limitations

- **Slip ratio is a critical parameter when analyzing the performance of either 1D techniques or CFD models**
- **CFD-VOF model show promising results for SR<=20, for the fluids and flow conditions tested**
- **Deepwater subsea WCD for the base case is well within the range of CFD-VOF model**
- **CFD provides more flow information, and a greater extent of flow details can be obtained as compared to 1D models**

Future Work

- **Interphase Mass Transfer**
- **Test CFD-Hybrid model for higher slip ratios**