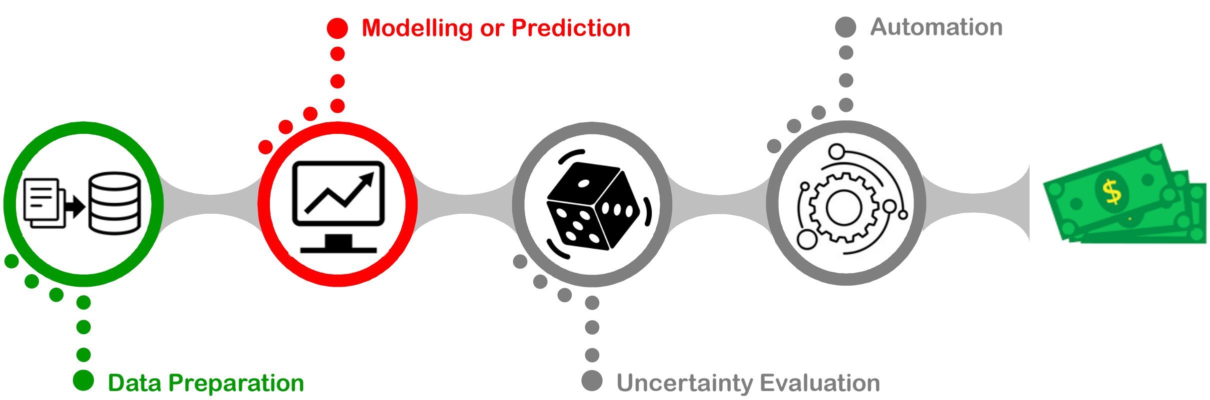
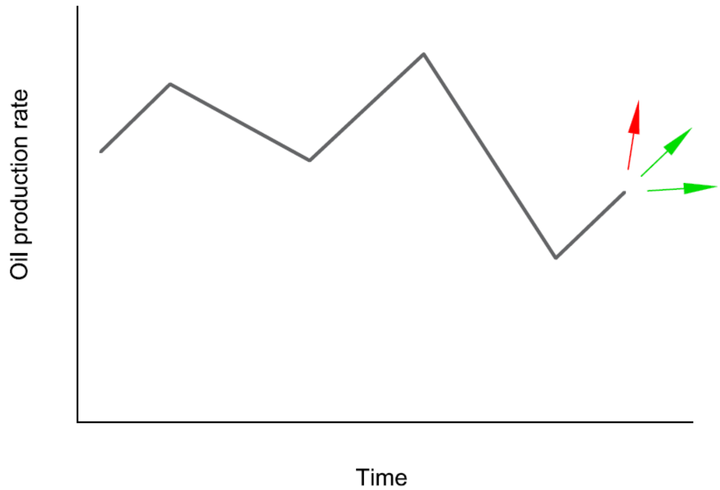
How can we move towards the Digital Field?



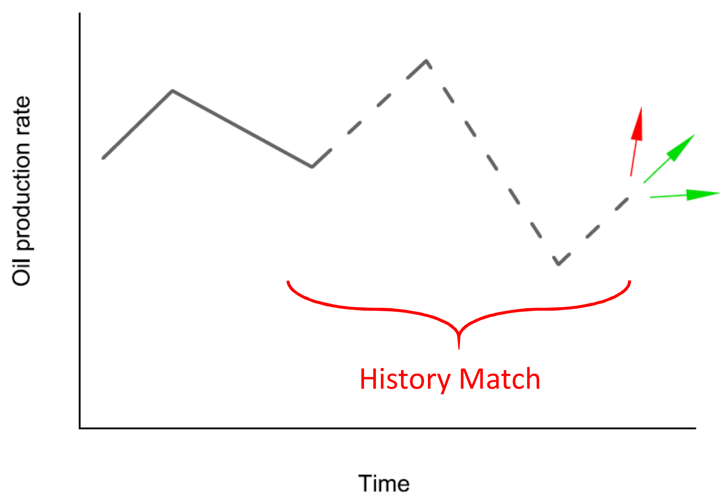
What is important on the Modelling?

The importance of the modelling is to predict future.



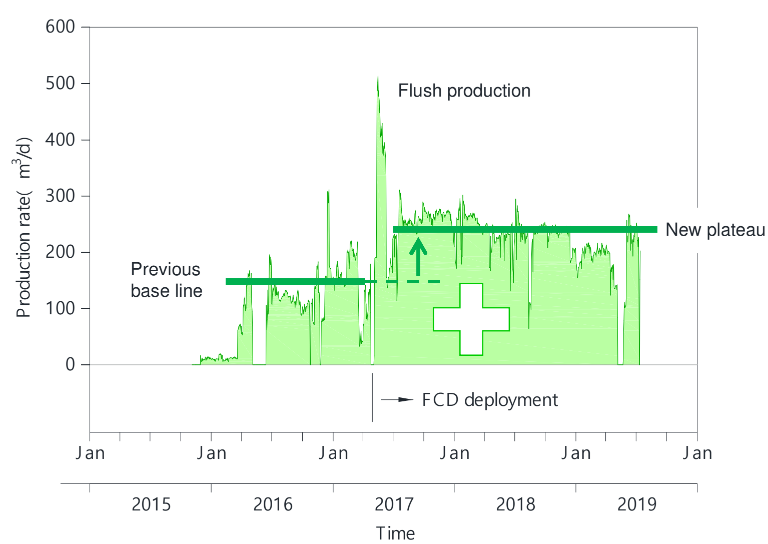
What is important on the Modelling?

The common approach is to history match (or train the data) with current model, and predict the future with current model.

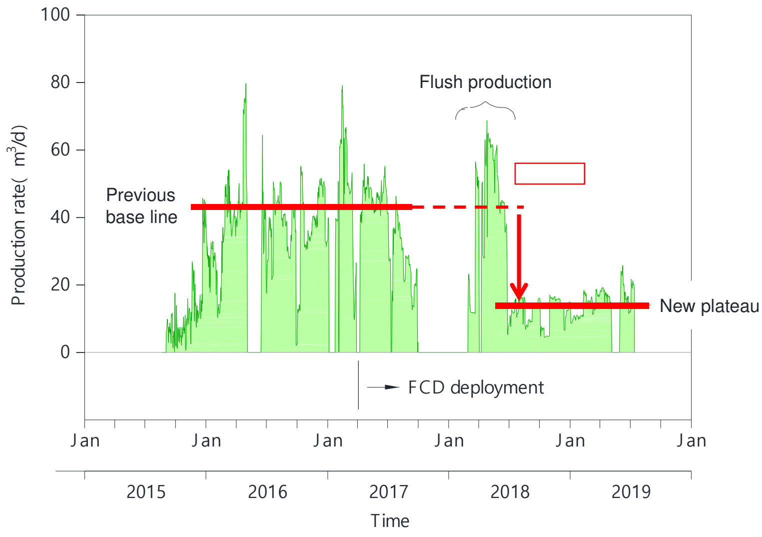


Are we there yet?

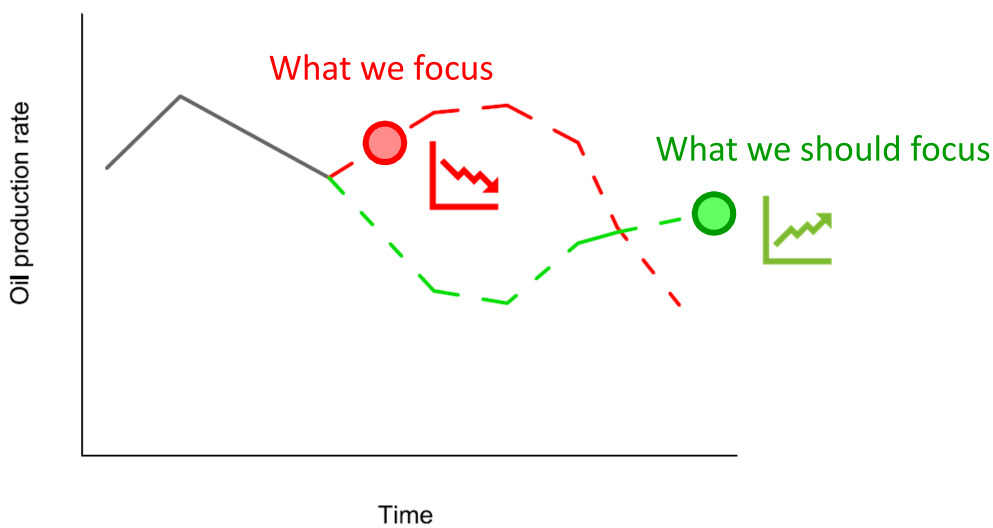
A Good Example of a ICD Design



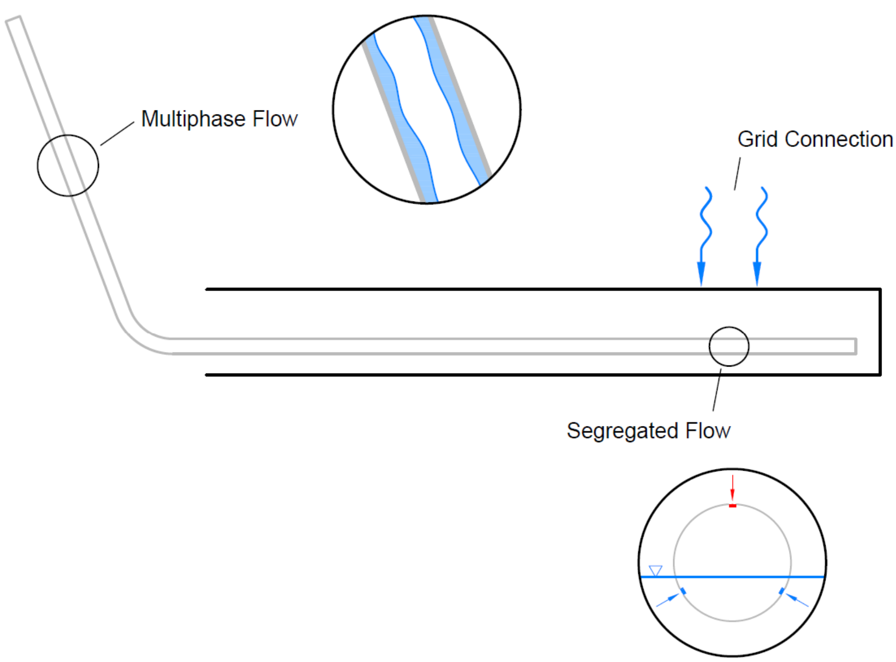
A Bad Example of a ICD Design



If the predictability is questionable then for the optimization we end up reaching a wrong solution

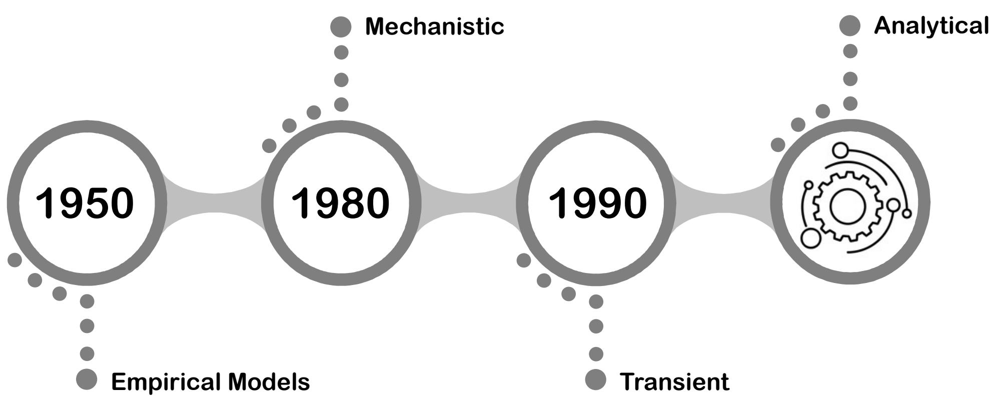


What sections of the Numerical Modeling are the Bottlenecks?



Multiphase Flow in Pipe

Evolution of Multiphase Flow in Pipe: A Modern Approach



What Tulsa says about the Multiphase models?

A Comprehensive Mechanistic Model for Upward Two-Phase Flow in Wellbores

A.M. Ansari, Pakistan Petroleum Ltd.; **N.D. Sylvester,** U. of Akron; and **C. Sarica, O. Shoham,** and **J.P. Brill,** U. of Tulsa

TABLE 2—RELATIVE PERFORMANCE FACTORS

	EDB	VW	DW	VNH	ANH	AB	AS	VS	SNH	VSNH	AAN
n	1712	1086	626	755	1381	29	1052	654	745	387	70
MODEL	0.700	1.121	1.378	**0.081**	**0.000**	0.143	1.295	1.461	**0.112**	**0.142**	**0.000**
HAGBR	**0.585**	**0.600**	**0.919**	0.876	0.774	2.029	**0.386**	**0.485**	0.457	0.939	0.546
AZIZ	1.312	1.108	2.085	0.803	1.062	0.262	1.798	1.764	1.314	1.486	0.214
DUNRS	1.719	1.678	1.678	1.711	1.792	1.128	2.056	2.028	1.852	2.296	1.213
HASKA	1.940	2.005	2.201	1.836	1.780	**0.009**	2.575	2.590	2.044	1.998	1.043
BEGBR	2.982	2.908	3.445	3.321	3.414	2.828	2.883	2.595	3.261	3.282	1.972
ORKIS	4.284	5.273	2.322	5.838	4.688	1.226	3.128	3.318	3.551	4.403	6.000
MUKBR	4.883	4.647	6.000	3.909	4.601	4.463	5.343	5.140	4.977	4.683	1.516

EBD=entire databank; VW=vertical well cases; DW=deviated well cases; VNH=vertical well cases without Hagedorn and Brown data; ANH=all well cases without Hagedorn and Brown data; AB=all well cases with 75% bubble flow; AS=all well cases with 100% slug flow; VS=vertical well cases with 100% slug flow; SNH=all well cases with 100% slug flow without Hagedorn and Brown data; VSNH=vertical well cases with 100% slug flow without Hagedorn and Brown data; AAN=all well cases with 100% annular flow; HAGBR=Hagedorn and Brown correlation; AZIZ=Aziz *et al.* correlation; DUNRS=Duns and Ros correlation; HASKA=Hasan and Kabir mechanistic model; BEGBR=Beggs and Brill correlation; ORKIS=Orkiszewski correlation; MUKBR=Mukherjee and Brill correlation.

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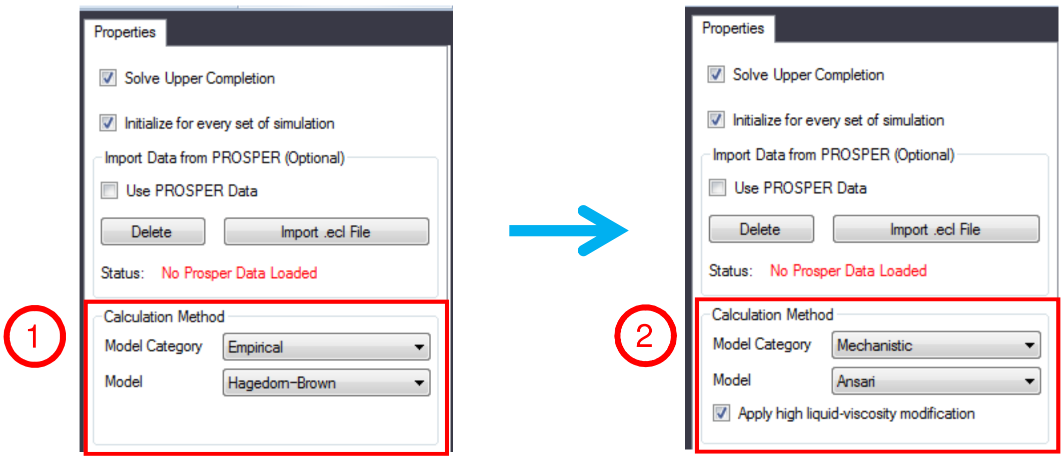
So what we can do?

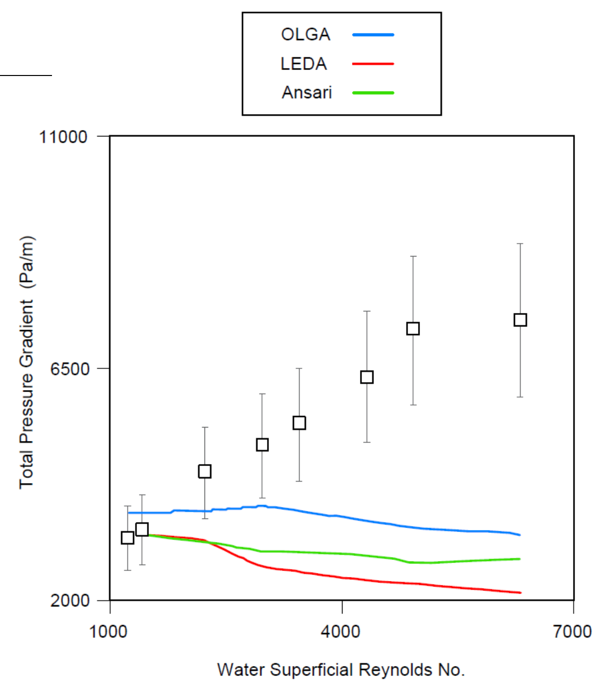
Use an Empirical model (suitable for your system) for initial modeling and then use the Mechanistic models, only if the data is available and we are trying to understand the problem.



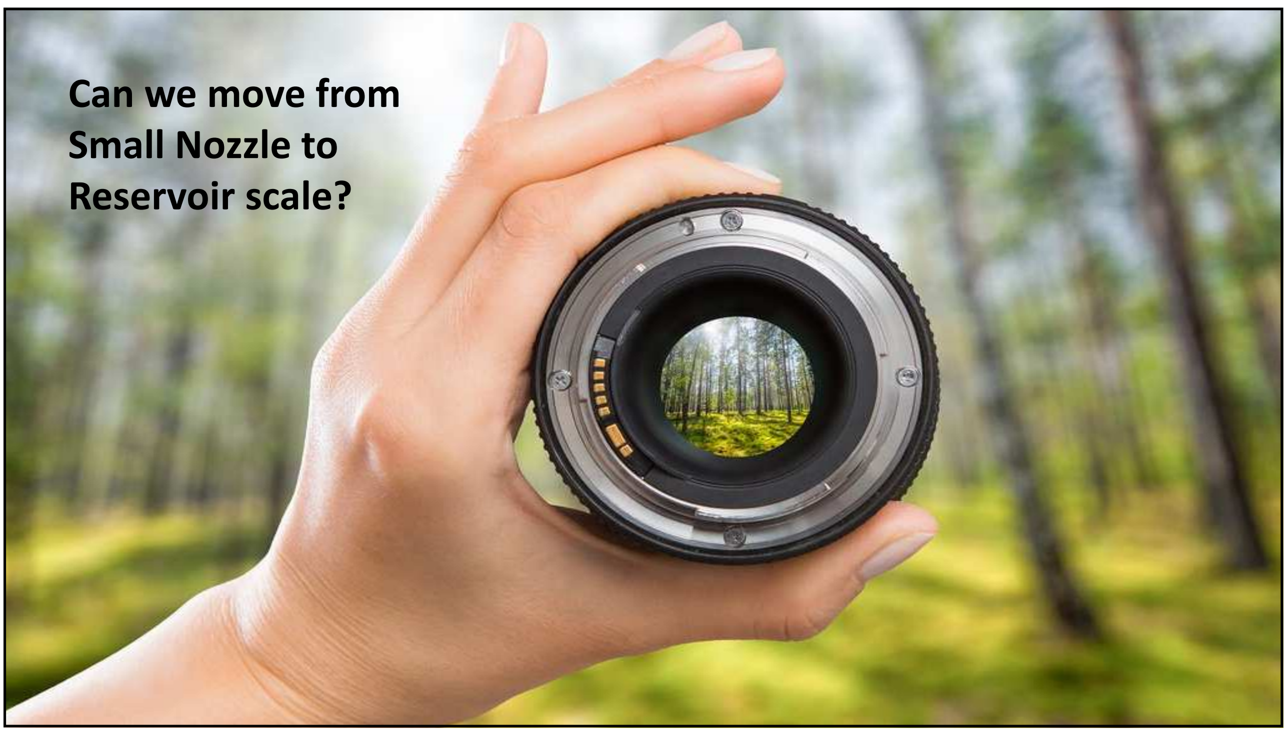
But do not go so complex

Transient models mostly are not providing a good prediction for pressure drop in stead-state cases.

They have so many inputs that most users are not understanding, and some of those creates a non-linear system.



Scale Problem

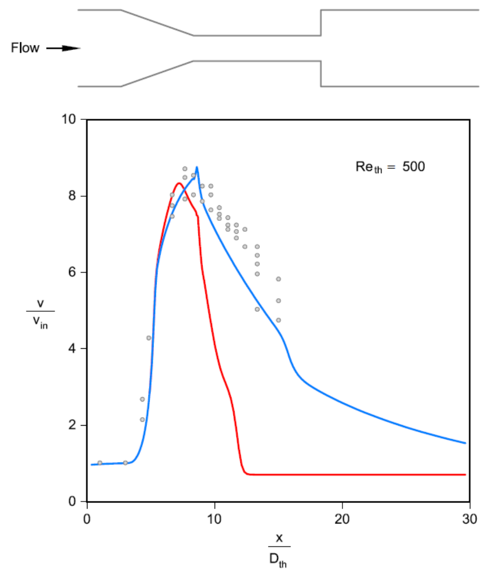


Experiment vs. Model: Laminar Flow

Our industry can model smaller scales with better accuracy, and as we move towards the bigger scale then we start having problems.

The problem is can we move to upper scale?

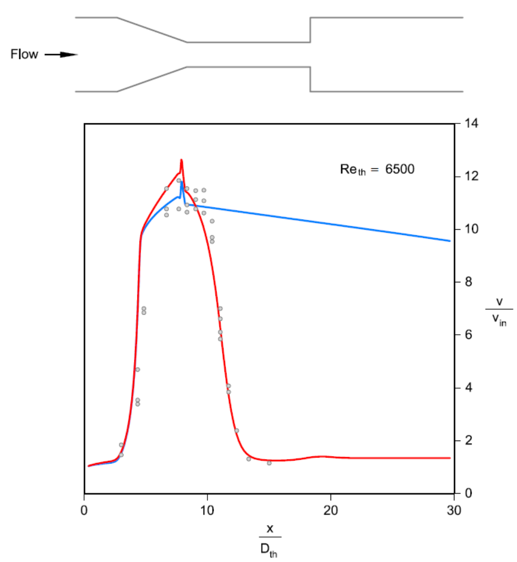
Experimental data
Model: Laminar regime
Model: Turbulent regime



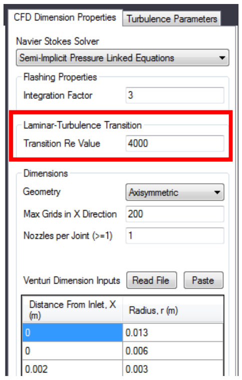
Experiment vs. Model: Turbulent Flow

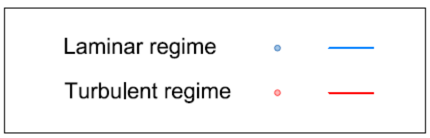
What if we are in the Transition zone (Not fully laminar and not fully turbulent)?

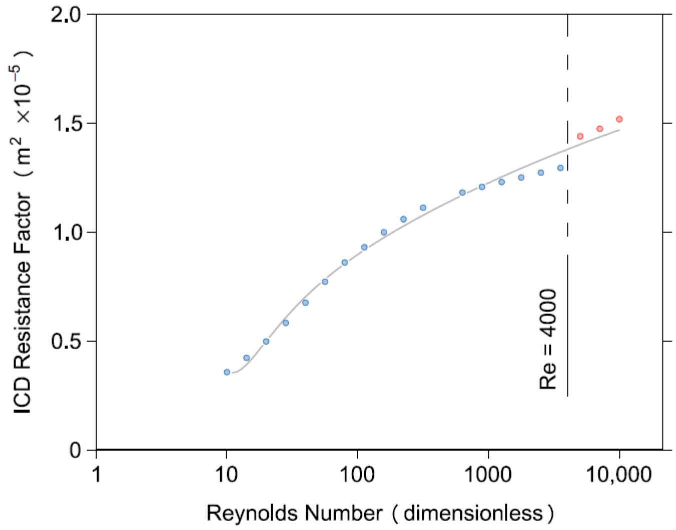
Experimental data
Model: Laminar regime
Model: Turbulent regime

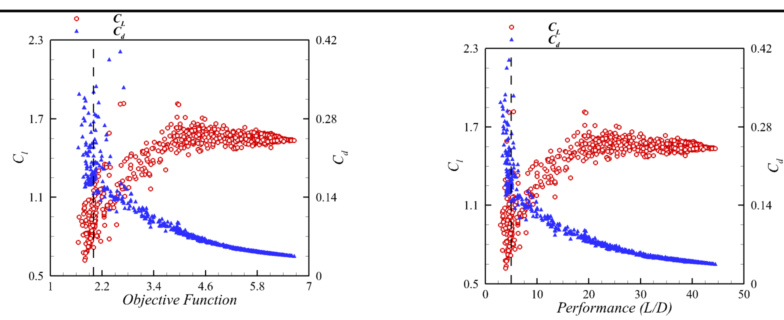


Effect of the transition from laminar to turbulent flow

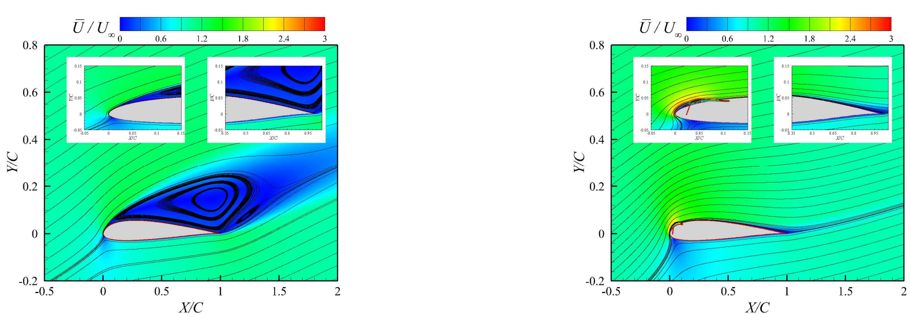






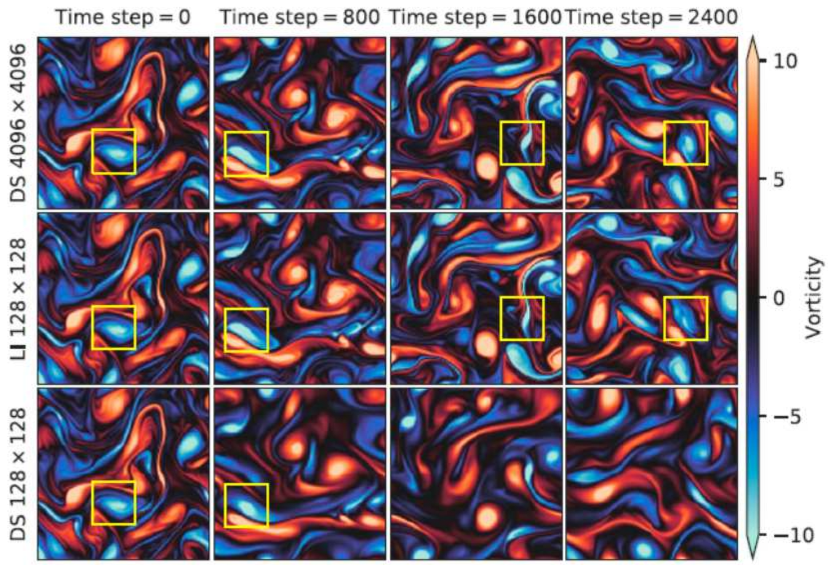


The convergence of the lift and the drag coefficients versus the (*left*) objective function (*right*) Performance (L/D);



The contours of the time-averaged velocity magnitude, (left) Uncontrolled, and (right) Controlled

Effect of the transition from laminar to turbulent flow



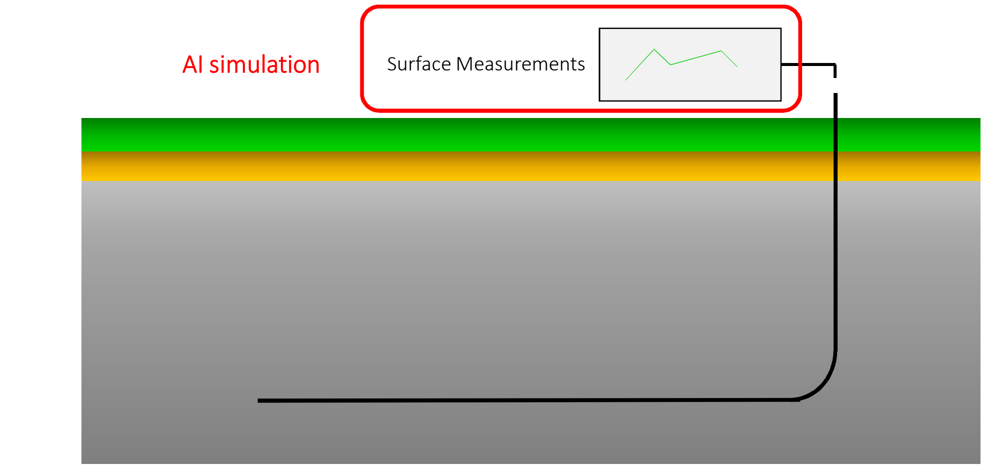
CFD with original resolution

Machine learning

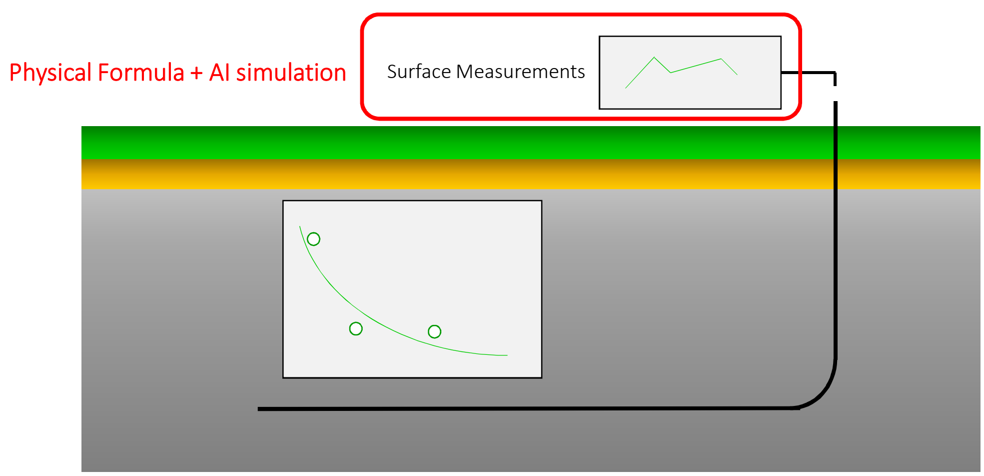
Only CFD with coarse resolution

Using AI in History Matching

What is wrong about Current Practice



What is wrong about Current Practice



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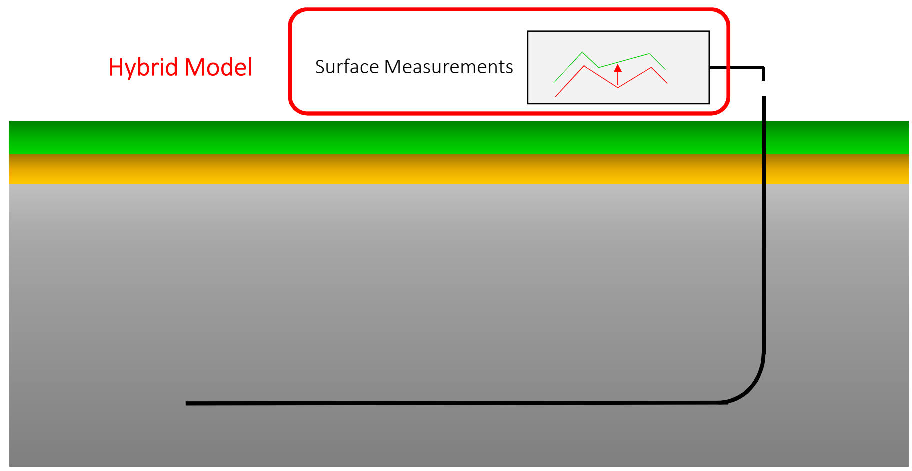
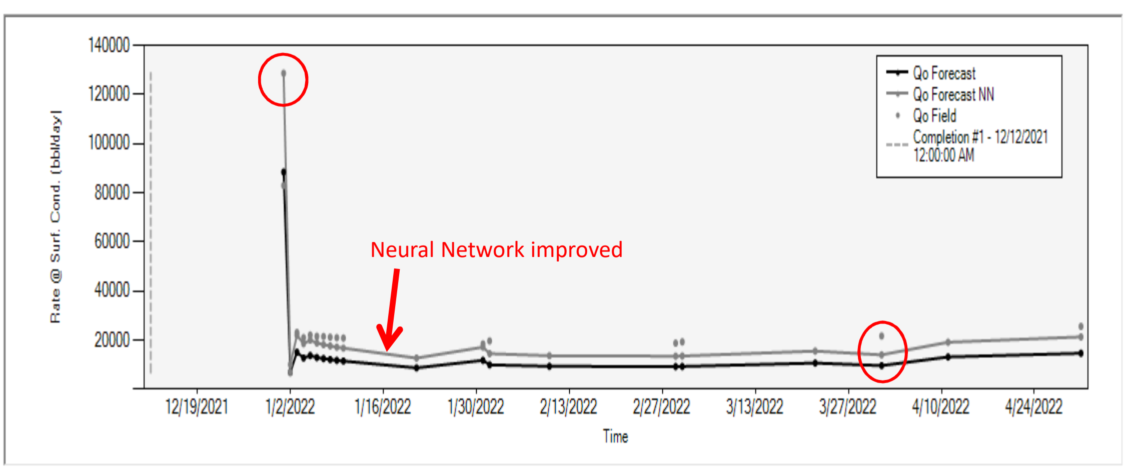
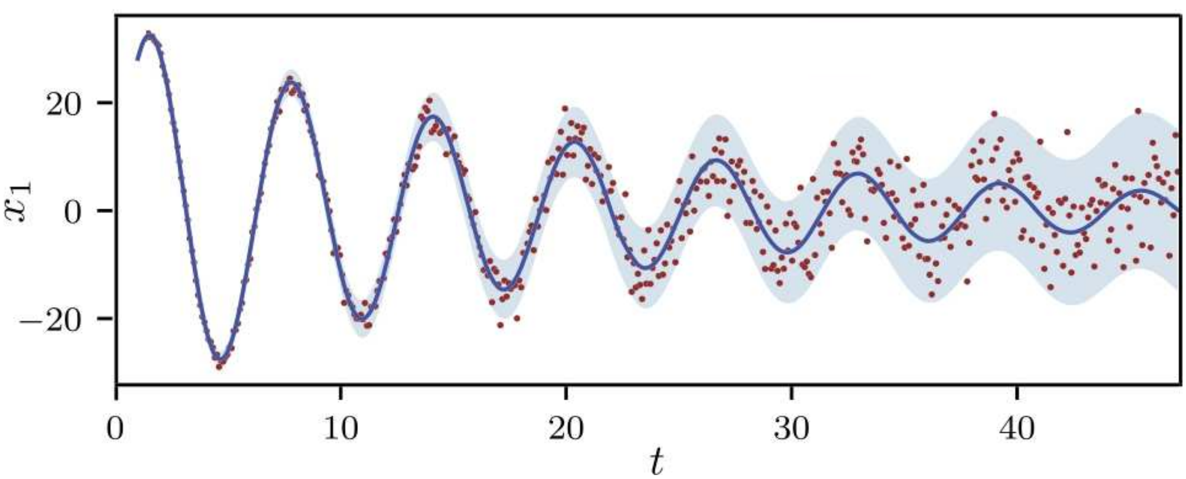


Hybrid Model

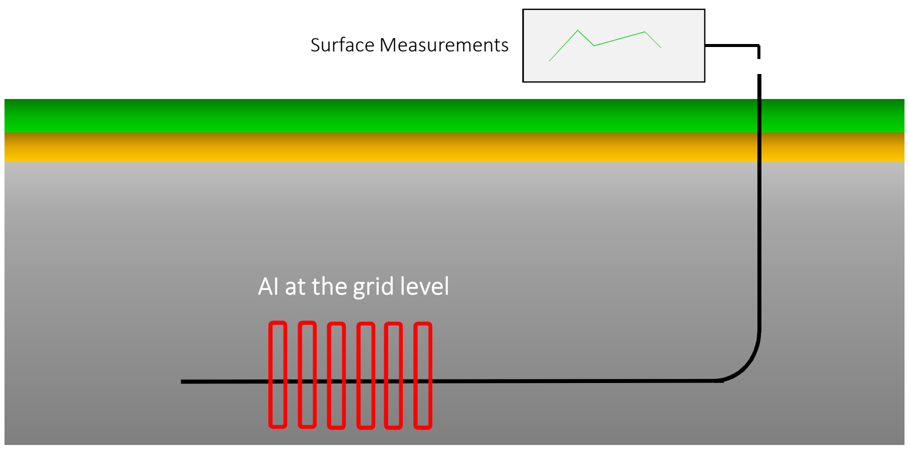
Firstly, the simulation is conducted, and then AI is used to improve the prediction:



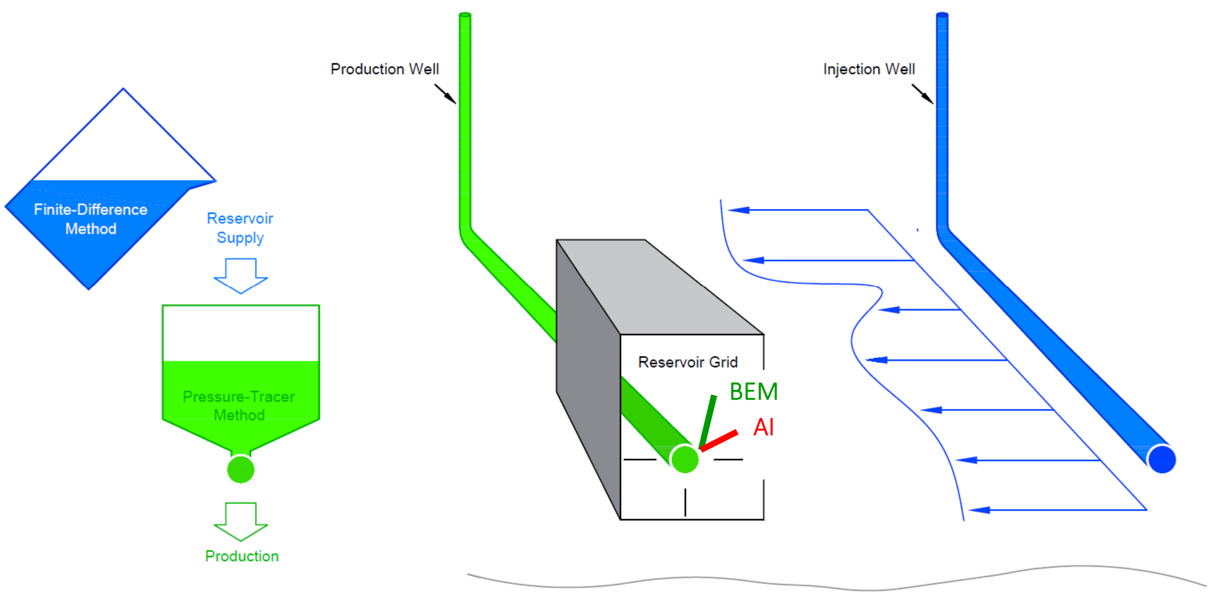
Predicting Uncertainty



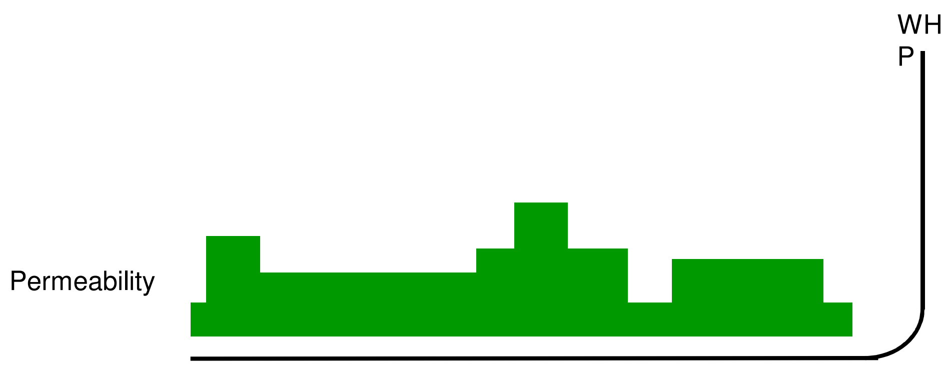
What is wrong about Current Practice



What is the Solution?



What is the stiffness of the numerical simulation



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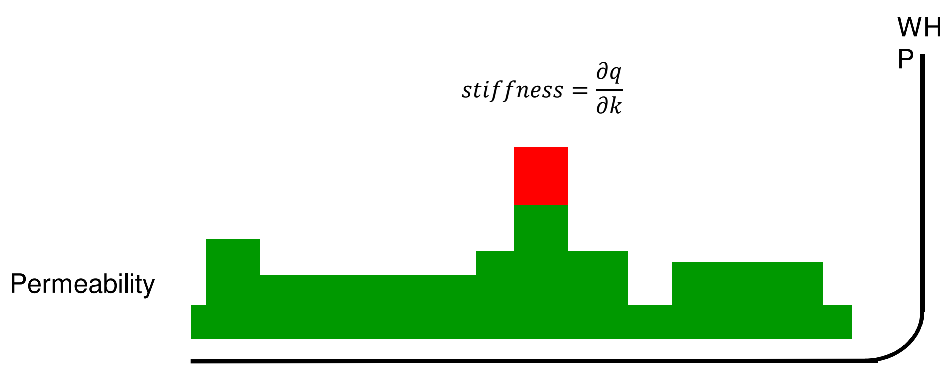
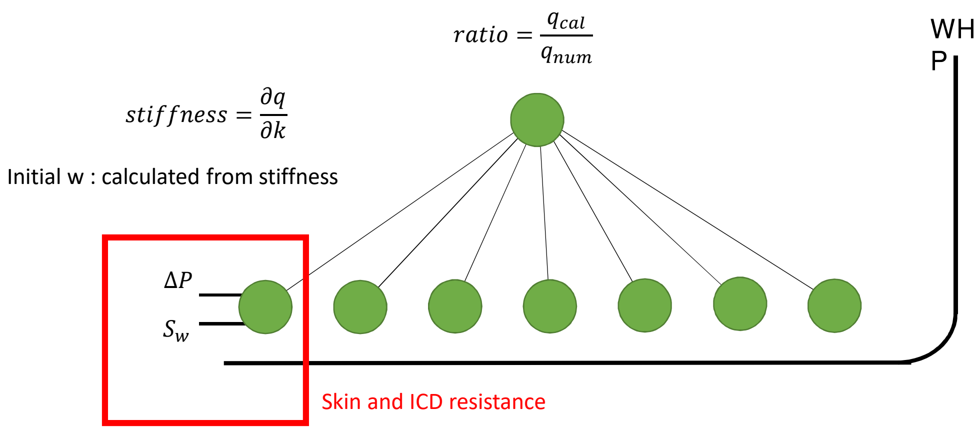


Neural network is designed to cover the difference



Optimization Problems

Why we are not reaching the correct answer?

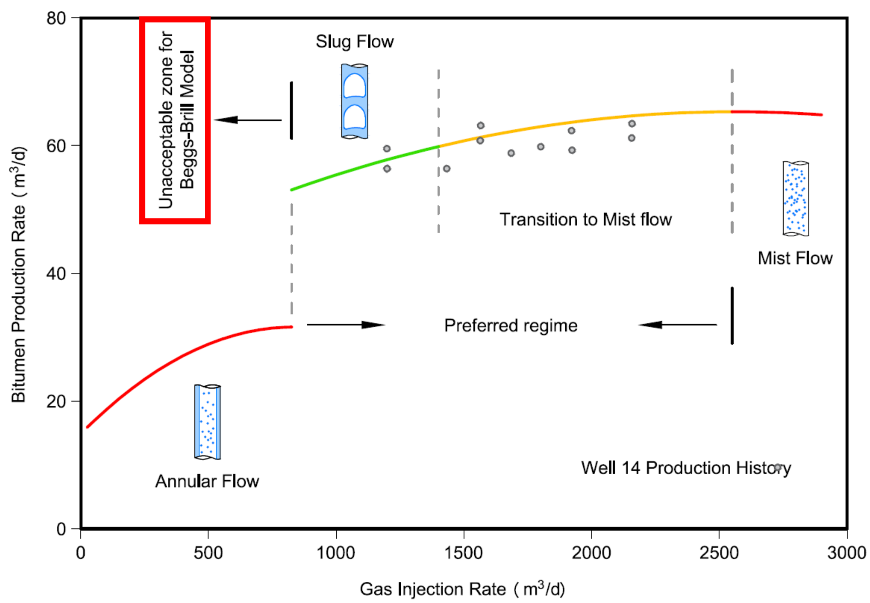
How can we use the general methods such as “Latin Hypercube”? And be sure to reach he answer?

Let’s discuss one simple problem,

We have a single pipeline, with constant rate during the year, and we wont to use this for gas-lift 25 wells, how we allocate the gas-lifting gas to these different wells?

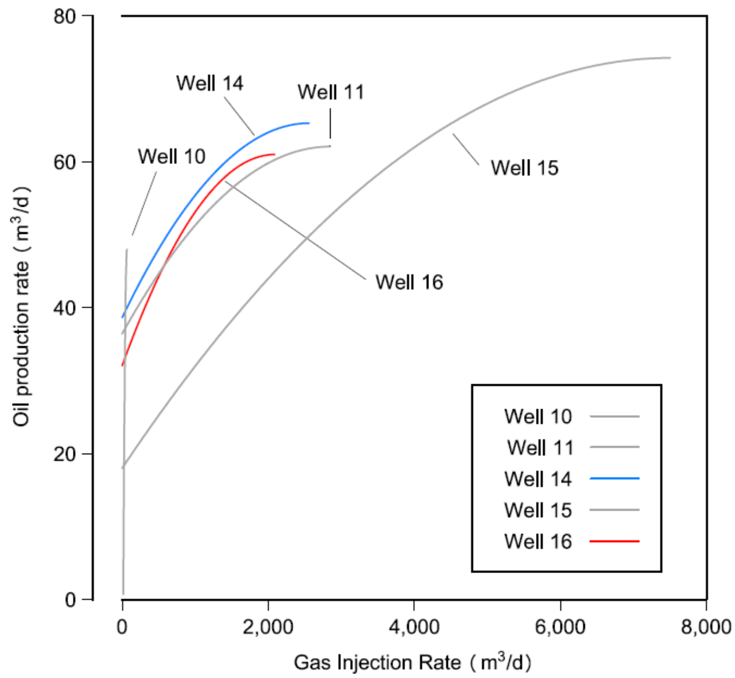
What is the right hole design across the limited-entry screen for acid stimulation?

Gas-lifting effect on the oil rate



What is the right injection rate?

Gradient descent (GD) is an iterative first-order optimization algorithm used to find a local minimum/maximum of a given function.



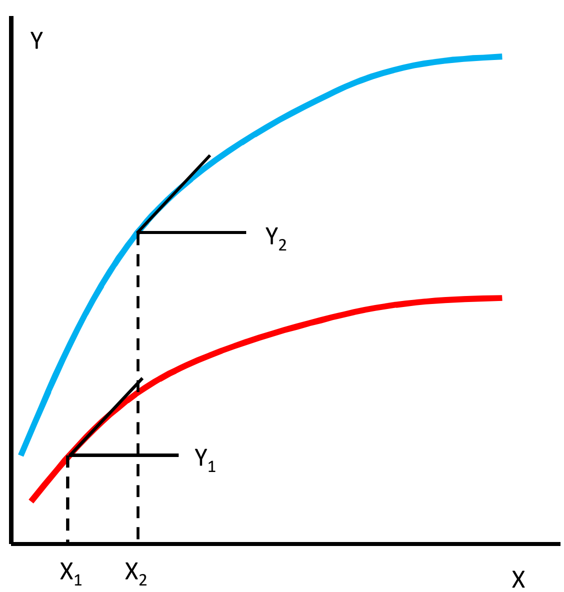
Gradient descent (GD) final outcome

The outcome of the GD is that for keeping the total amount constant, we can add up the Y values at the same derivative (Y').

In the same manner can be applied on X values.

Total rate $= Y_1 + Y_2$

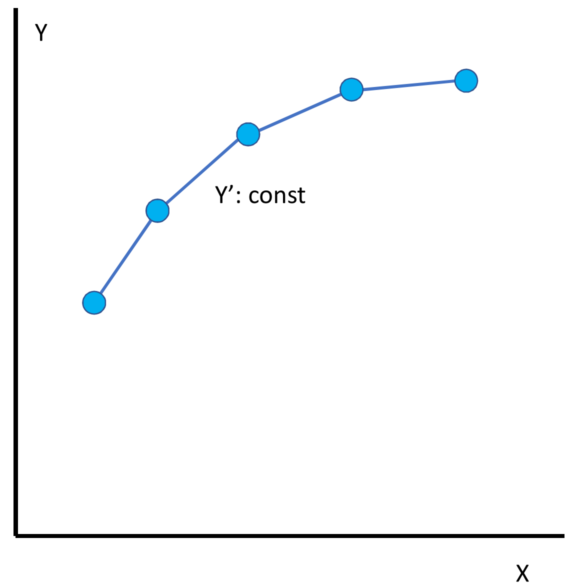
Fraction for well 1 $= \dfrac{X_1}{X_1 + X_2}$



We should make the simulation results smoother

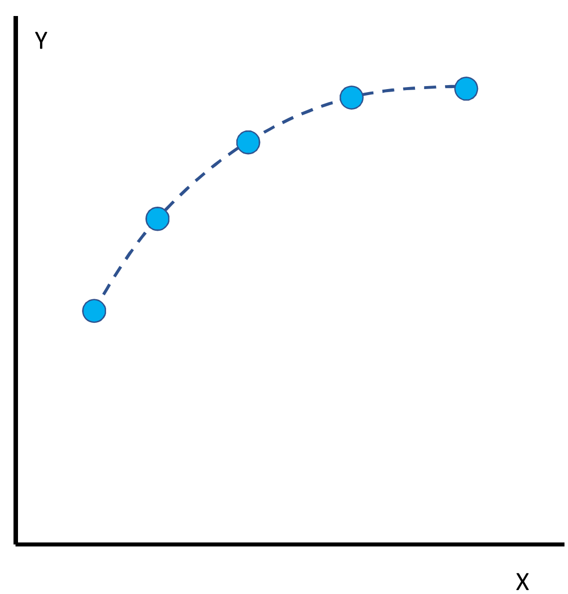
If we try to calculate the actual derivative from the simulation results, it ends to bumpy solution.

For being able to yield to meaningful solution we required the smooth derivative.



We should make the simulation results smoother

The simplest method is to use the polynomial curve fitting and use the analytical formulation to calculate the derivative.

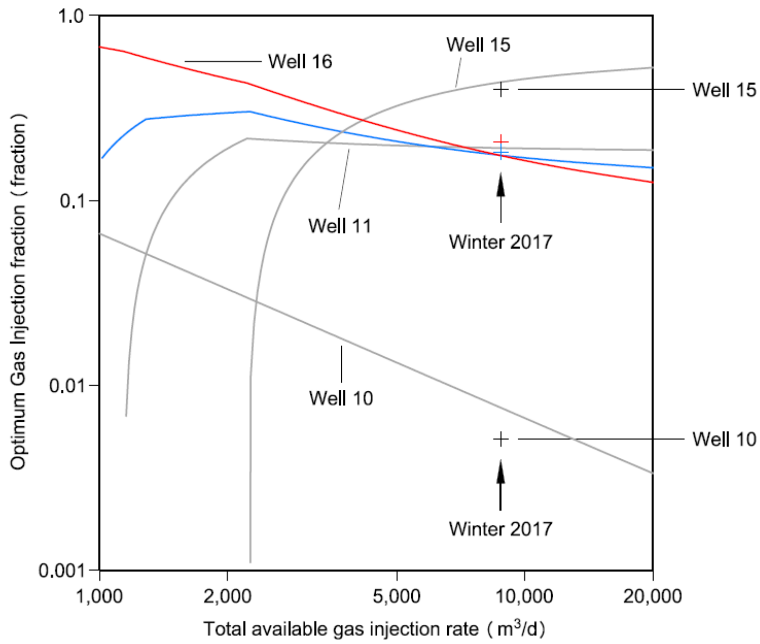


Final Optimization results

The operator in this case were playing with gas-lift for about 10 years, and was pretty sure that they find the optimum fractions.

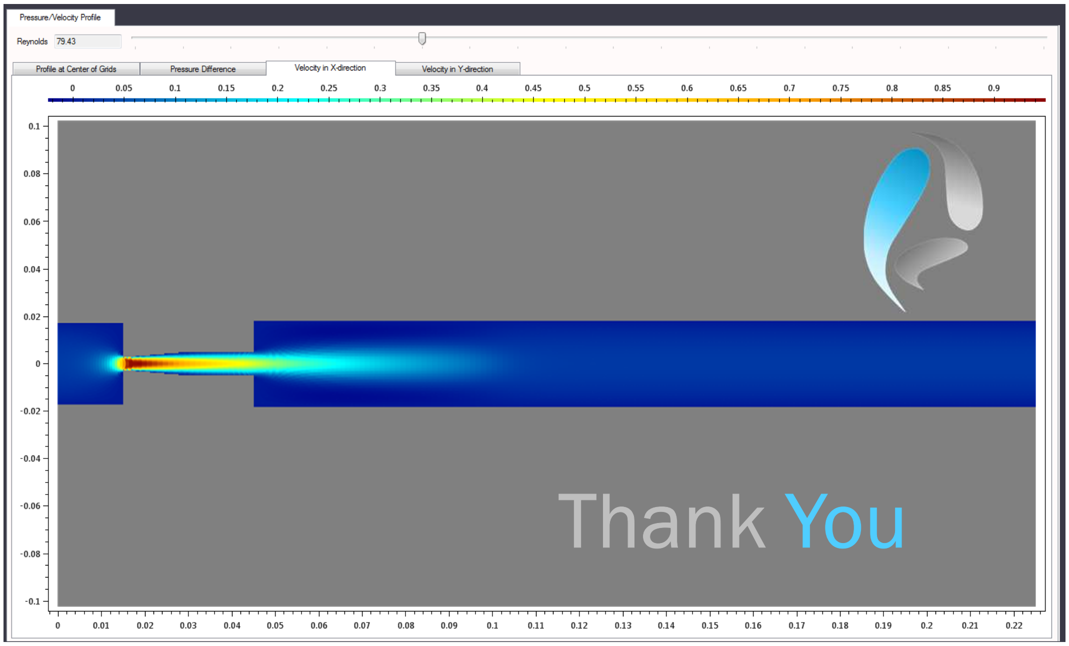
But they were at 85% the optimum production rate for this case.

The human judgement is always based on averaging, and mostly inject less at high producing wells, and higher at low producing wells.



Conclusion

- The main conclusion is that the solution is available, we should only implement it.
- Reaching the digital field concept without fully integrated model is impossible, and we will not get there through “short-cuts”.


Pressure/Velocity Profile
Reynolds 79.43
Profile at Center of Grids
Pressure Difference
Velocity in X-direction
Velocity in Y-direction
Thank You