

SPE-212000-MS
**Hydrate Risk Management and Evaluation for
Gas-Dominated Systems Using Machine
Learning**

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Outline



Background & Introduction



Research Objective



Explore Methodology



Data Analysis and Model Development



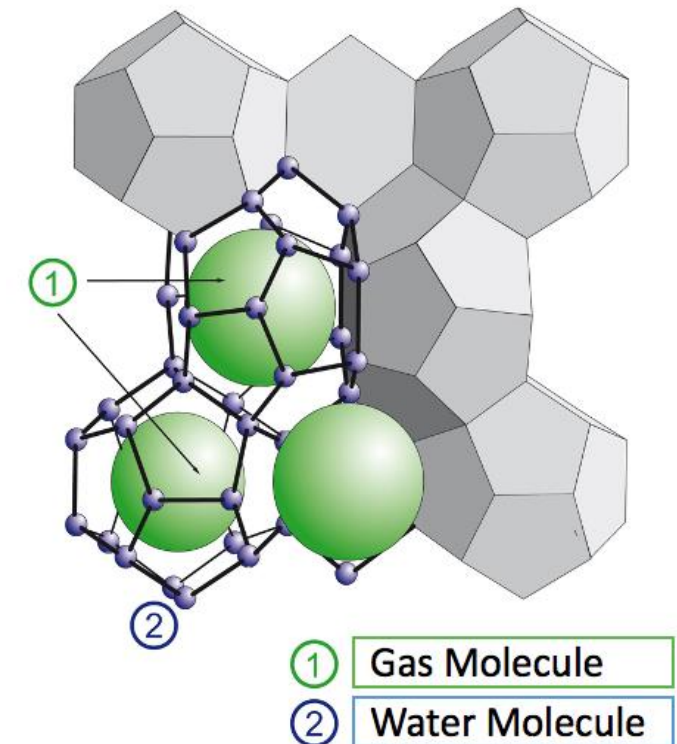
Results



Conclusion

Gas Hydrates

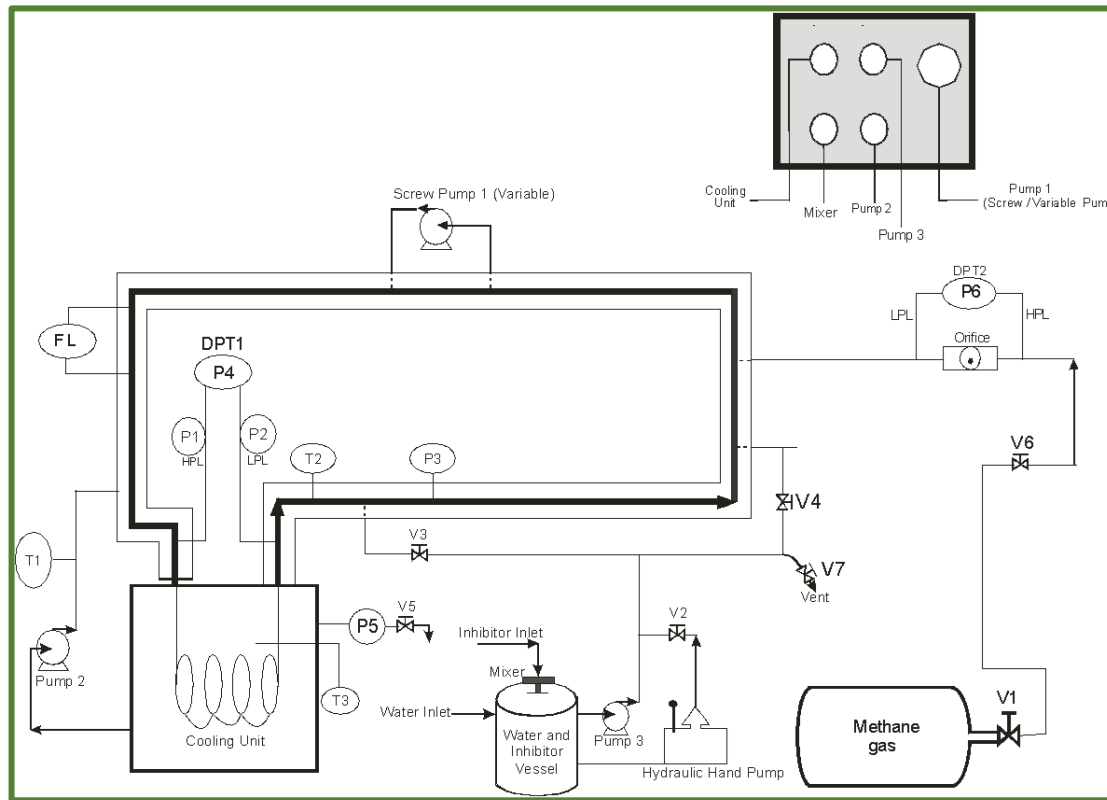
- ✓ Ice-like clathrates composed of gases, trapped in water molecules.
- ✓ They form in conditions of high pressure and low temperature.
- ✓ Can cause flow restrictions and increased pumping pressure



Research Purpose

Develop a model that goes beyond prediction of thermodynamic conditions but also determines the risk level associated with hydrate formation for flow management.

Hydrate Flow Loop



- Hydrate formation in a flowline was simulated in the laboratory using a flow loop developed by (Odutola et al., 2017)
- Description of flow loop is also published in (Odutola et al., 2017)
- Data Generated from the experiment was used to develop predictive models

Risk Management and Evaluation

- During the experiment, there was always a difference in volume between effluent and influent of the fluid used on the flow loop
- This difference accounted for the volume of hydrate formed
- We assumed the rate of hydrate growth (and thus x_h) was constant through the experiment run time

$$x_h = \frac{v_1 - v_2}{v_2}$$

x_h = Fraction of hydrate formed from the fluid

V_1 = Volume of influent fluid at the start of runtime

V_2 = Volume of effluent obtained at end of runtime

Data Obtained From Flow loop

- Experiment runtime (mins)
- 1st, 2nd, and 3rd loop thermometer values (deg.C)
- 1st, 2nd, 3rd, 5th and 6th Pressure gauge values (Psi)
- 4th Pressure gauge value (Bar)
- Hydrate Formation State.
- Flowrate
- Percentage fraction of hydrate formed ($x_{h\%} = \frac{v_1 - v_2}{v_2} * 100$)

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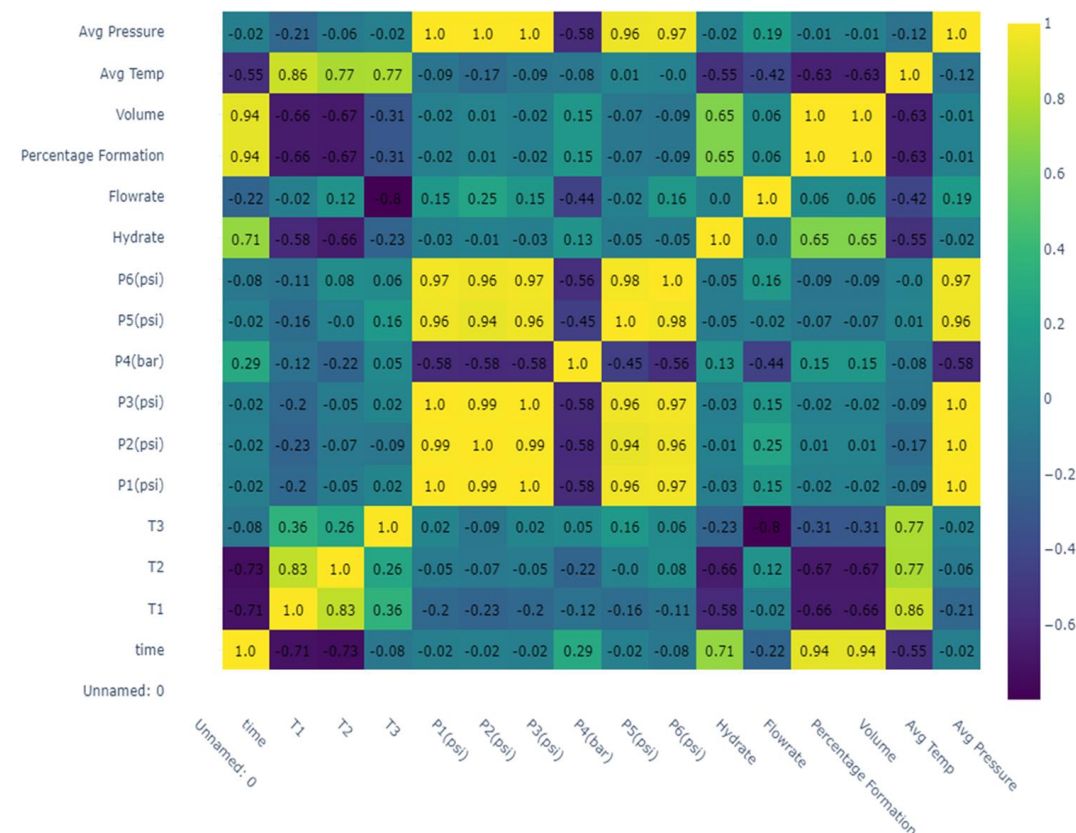
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Data Analysis

	count	min	max
time	305	0	120
T1	305	-2	27
T2	305	6	31
T3	304	20	34
P1(psi)	305	95	150
P2(psi)	305	112	170
P3(psi)	304	95	150
P5(psi)	305	104	150
P6(psi)	305	106	150
Hydrate	305	0	1
Flowrate	305.0	135	155



Correlation Plot Before Data Exploration



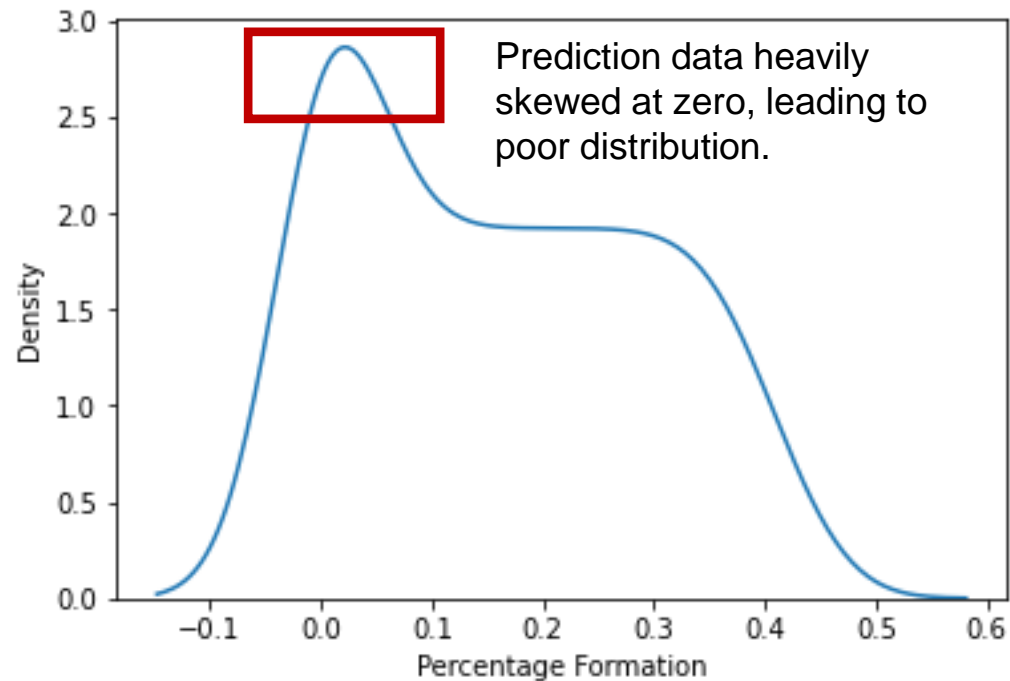
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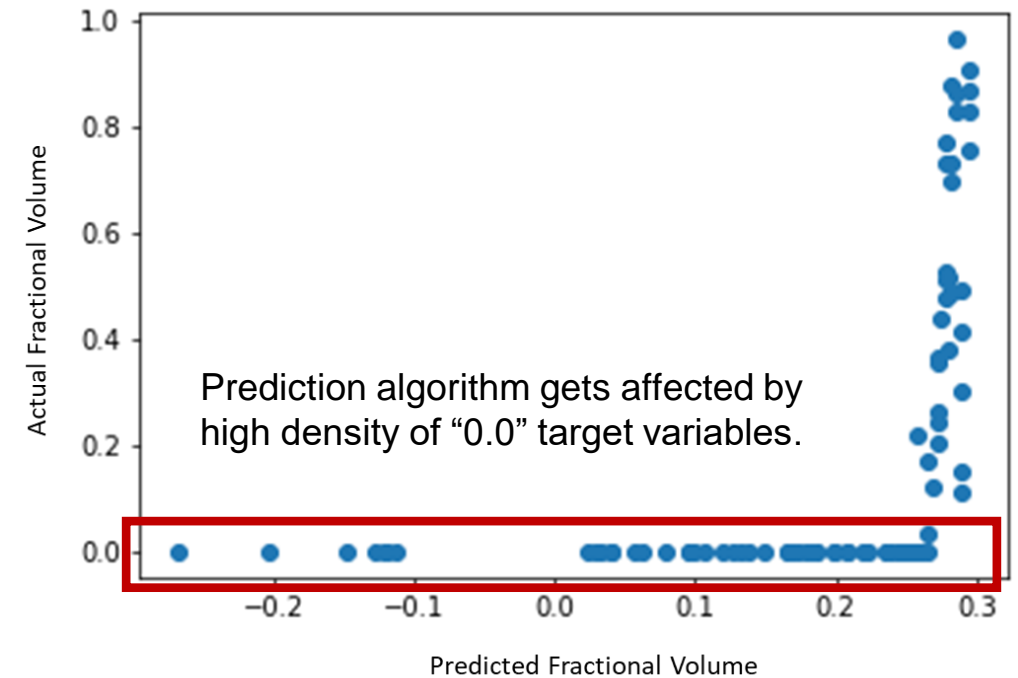
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Data Analysis

Density Plot of Target Variable to Check Distribution



Prediction Check on Poorly Distributed Data

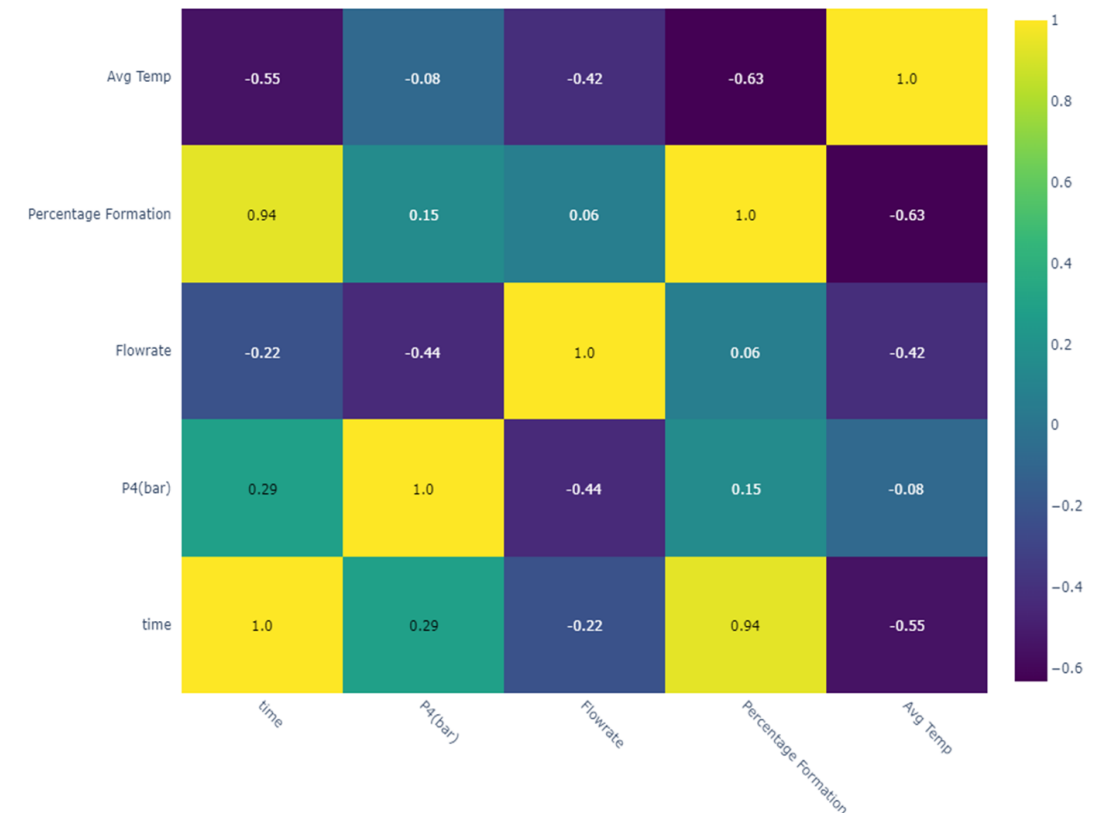


Data Analysis

Further exploration involved dropping multicollinear features and standardization

	count	std	min	max
Time	156	1.003221	-2.42657	1.598309
Flowrate	156	1.003221	-1.50543	1.257475
Avg temp	156	1.003221	-1.27806	2.913054
P4(bar)	156	1.003221	-1.38376	1.505536
Percentage formation	156	1.003221	-1.19216	2.019396

Correlation Plot after Data Exploration



Predictive model Development

3 regression algorithms were employed in the development of predictive models:

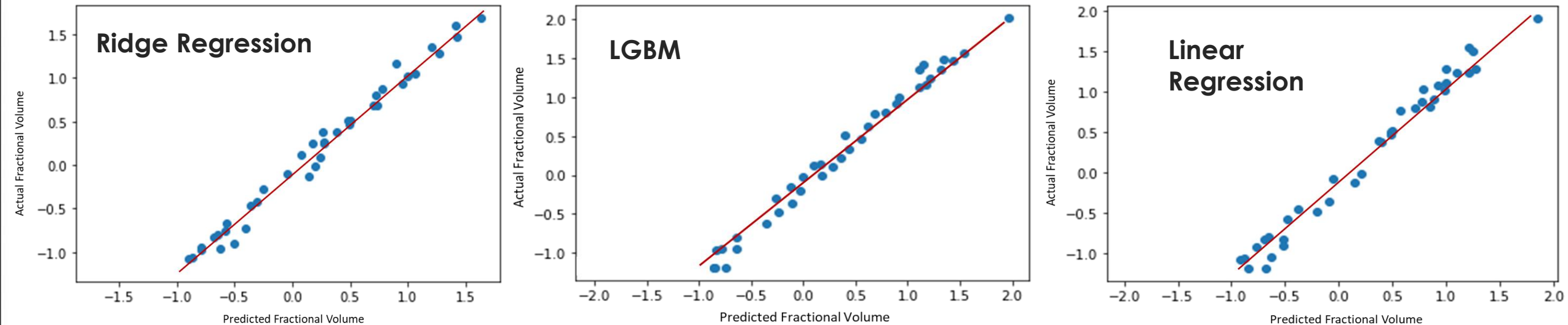
- ✓ Linear Regression (Multivariate)
- ✓ Ridge Regression
- ✓ Light Gradient Boosting Machine (LGBM)



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Results



	Ridge Regression	LGBM	Linear Regression
RMSE	0.1682	0.2343	0.232
R-Squared	0.9595	0.9354	0.9376

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Conclusion

- ❑ The Implementation of data-drive technologies, undoubtedly lead to an increase in process efficiency.
- ❑ In this work, a hydrate risk level analysis model based on the fractional hydrate formation volume was developed with flowrate, temperature, and pressure as independent variables to the model.
- ❑ The Ridge Regression with an RMSE of **0.1682**, and a correlation coefficient of 0.9595 gave the best model and the algorithm. This primary idea behind this work can be scaled-up for more robust applications



THANK YOU!