Modeling Cake Fouling for AnMBR

Colby Cash, David Ladner | Clemson University, Department of Environmental Engineering and Earth Science

2019 Membrane Technology CONFERENCE & EXPOSITION

Introduction

Anaerobic Membrane Bioreactor's (AnMBR's) have the potential to revolutionize municipal wastewater treatment.

Advantages

- Effective COD removal
- Eliminates aeration costs
- Methane production
- Minimal sludge generation

Disadvantages

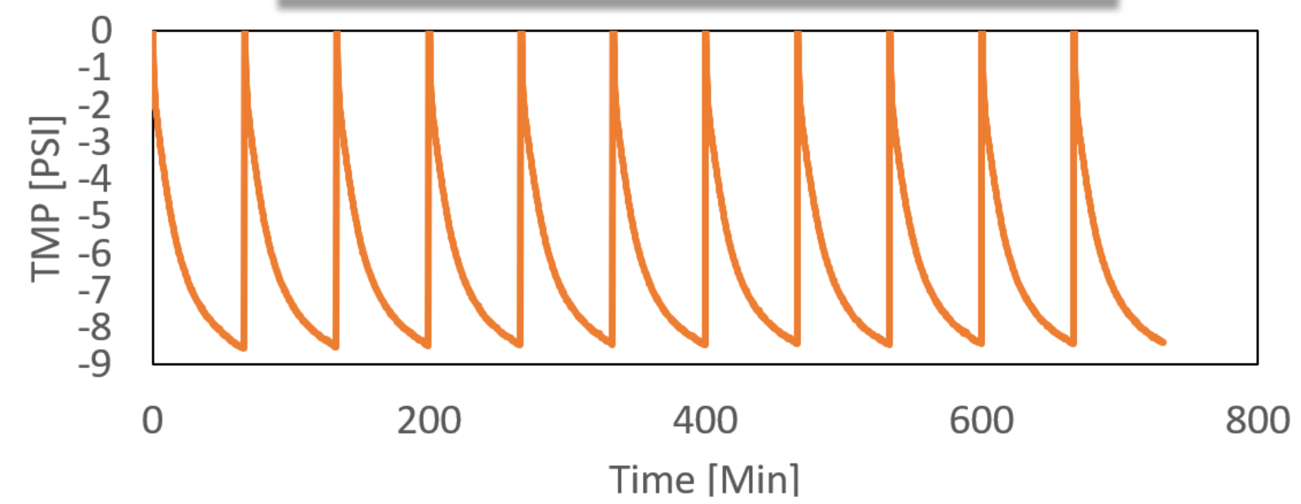
- Lack of nutrient recovery/removal
- Increased membrane fouling

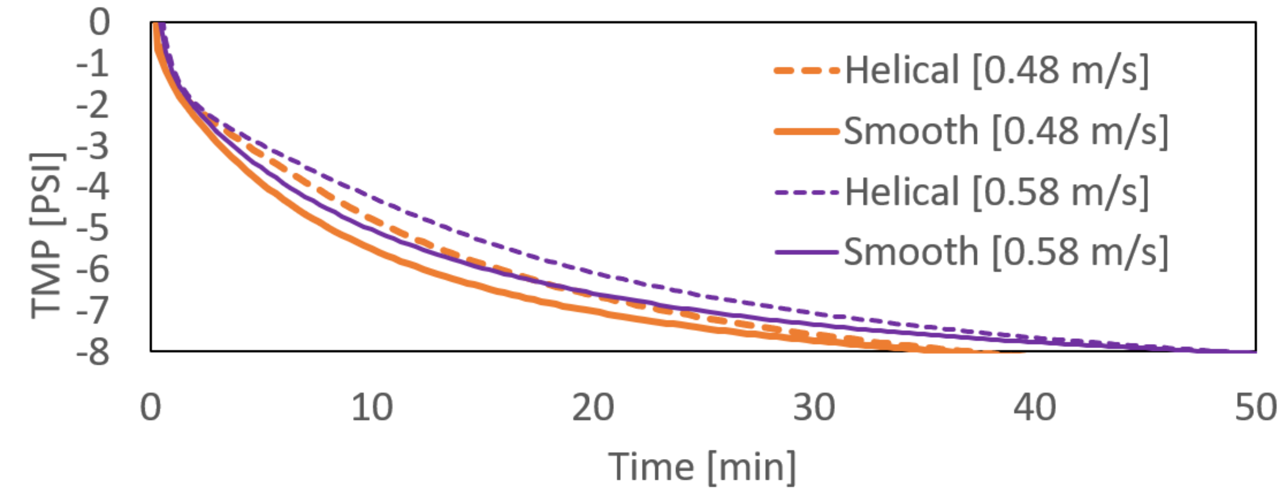
The issue of membrane fouling can be better understood when the AnMBR foulants are compared to traditional MBR foulants.

WW Characteristics[1]	MBR	AnMBR
TSS	Moderate	High
OLR	Low	High
SMP	Low	High

The goal of this research is to create a computational fouling model to describe foulant buildup on the membrane in an AnMBR, and to validate that model using lab-scale experiments.

Lab Data





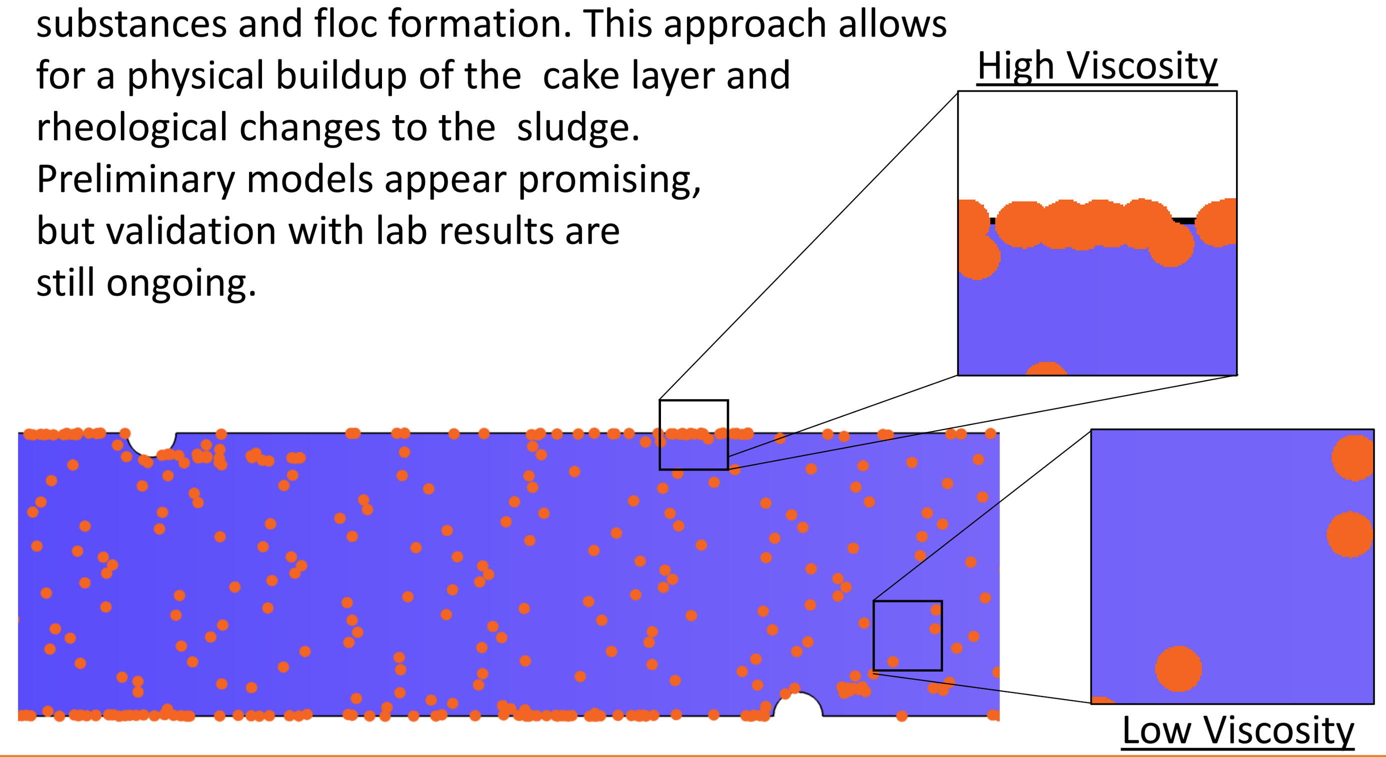
Results from experiments (top) were averaged (bottom) to determine fouling rates at different crossflow velocities.

Fouling Model

In an effort to better understand foulant behavior for AnMBR, it would be invaluable to have an accurate time dependent CFD fouling model. This model would be able to predict foulant deposition, cake layer development, and cake reduction due to shear forces.

The proposed model uses scaling fluid viscosity[2] based on local particle concentration. As particles deposit on the membrane and the concentration increases, the local viscosity increases to mimic extracellular polymeric substances and floc formation. This approach allows for a physical buildup of the cake layer and rheological changes to the sludge.

Preliminary models appear promising, but validation with lab results are still ongoing.



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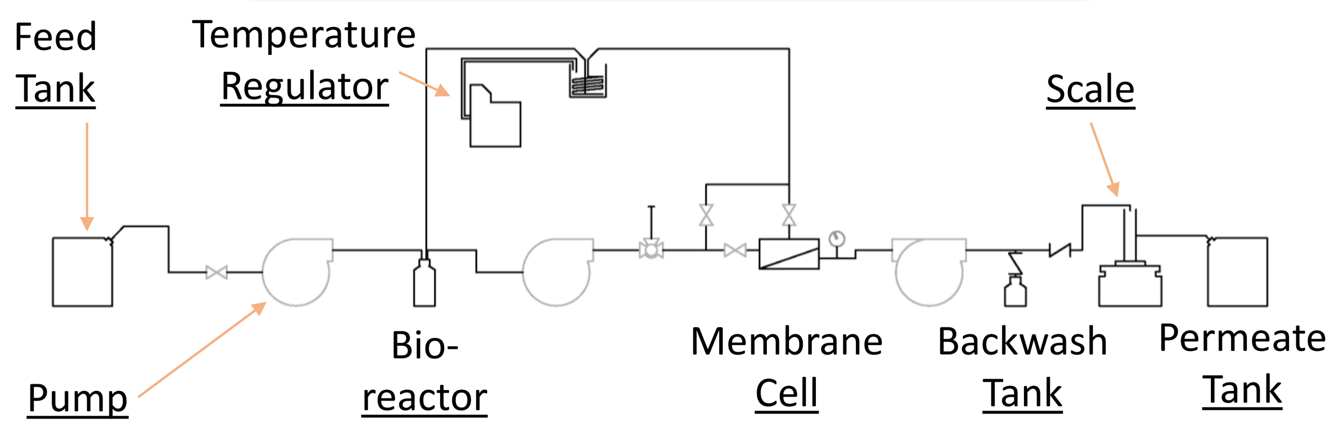

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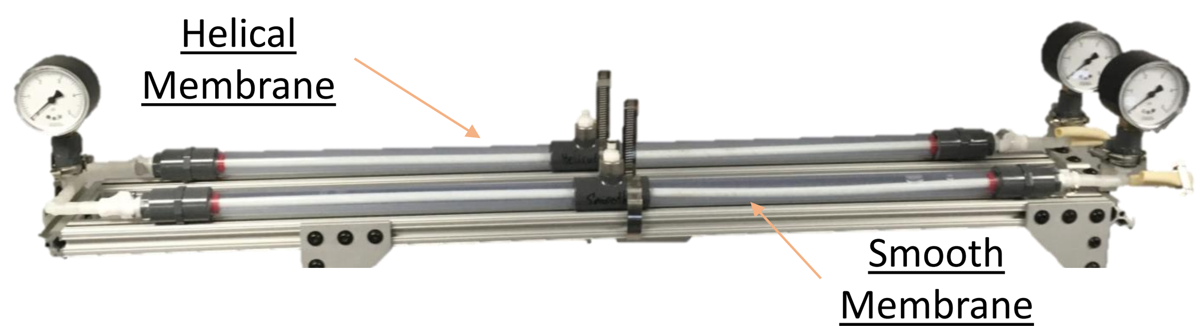

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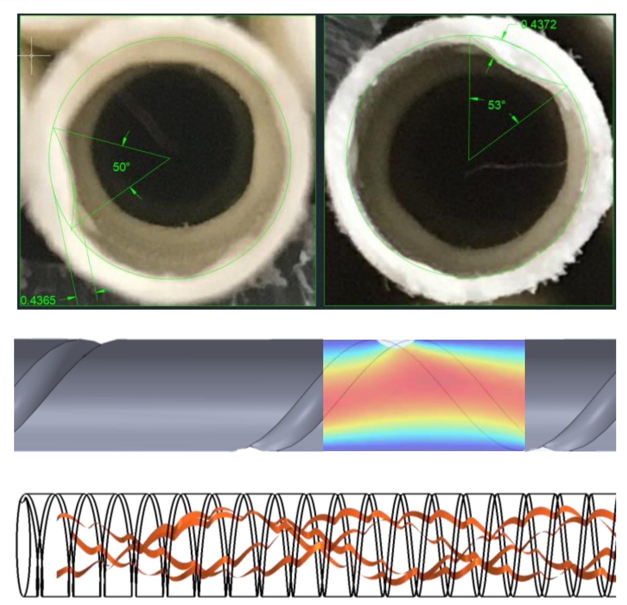
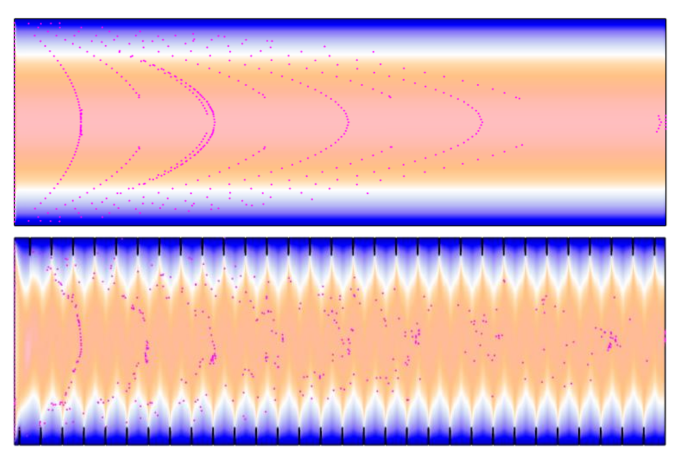
Computational models were created to characterize the crossflow and flux for both membranes. The simulations utilize k-e turbulence models, both 3D and 2D simulations were used. The head loss along the helical membrane is double that of the smooth membrane, which agrees with experimental results. According to the model though, the shear delivered to the membrane surface is not significantly different between the two membranes.





The velocity profile for the helical membrane is significantly disrupted by the pattern, and it is possible that the additional turbulence contributes to keeping particles in suspension. This behavior could explain the superiority of the helical membrane as seen in the lab results above.

Ongoing Work

- Further lab experiments at higher crossflow velocities.
- Further development of viscosity scaling fouling model.
- Validation of model through rheological testing of cake layer.
- Modeling the increase of TMP based on cake characteristics.
- Introduction of multi-phase components such as gas bubbles or GAC.
- Developing viscosity relationship based on biological parameters.
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Cited Works

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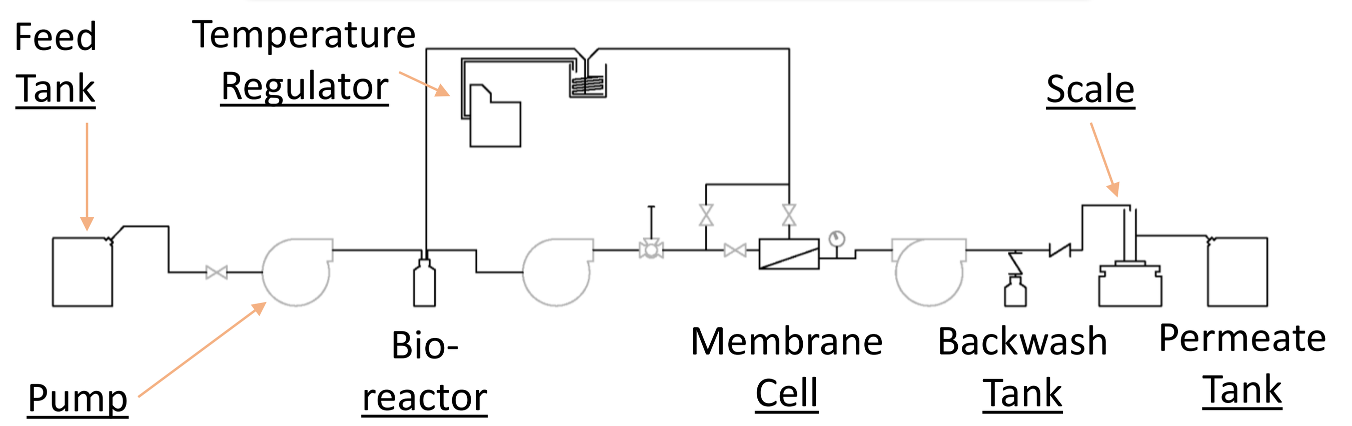

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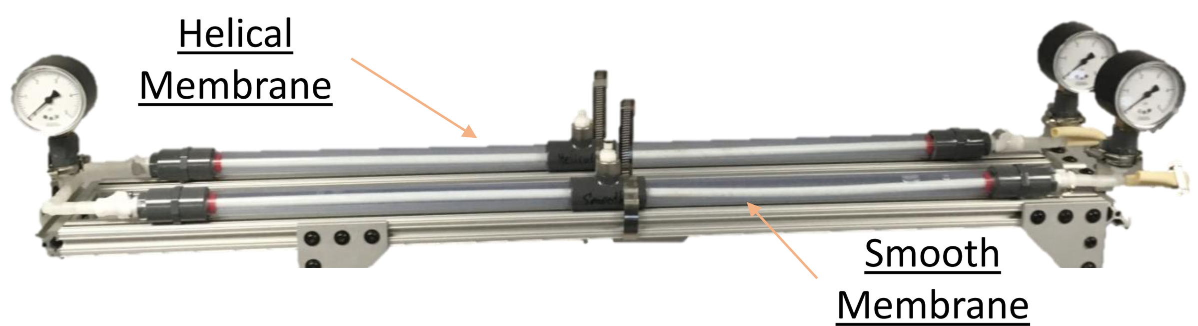

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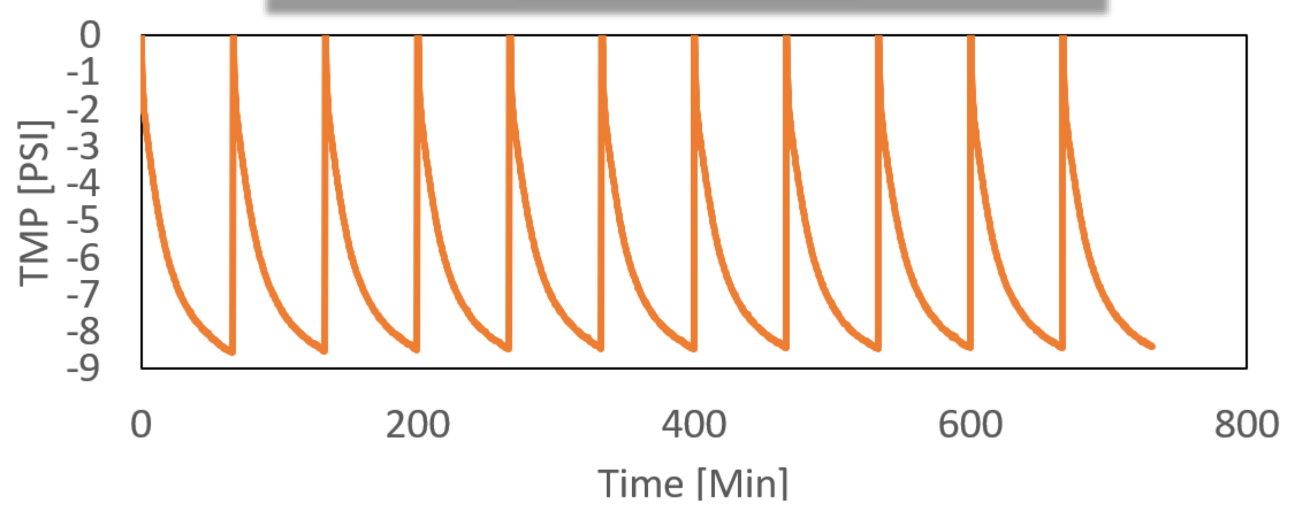

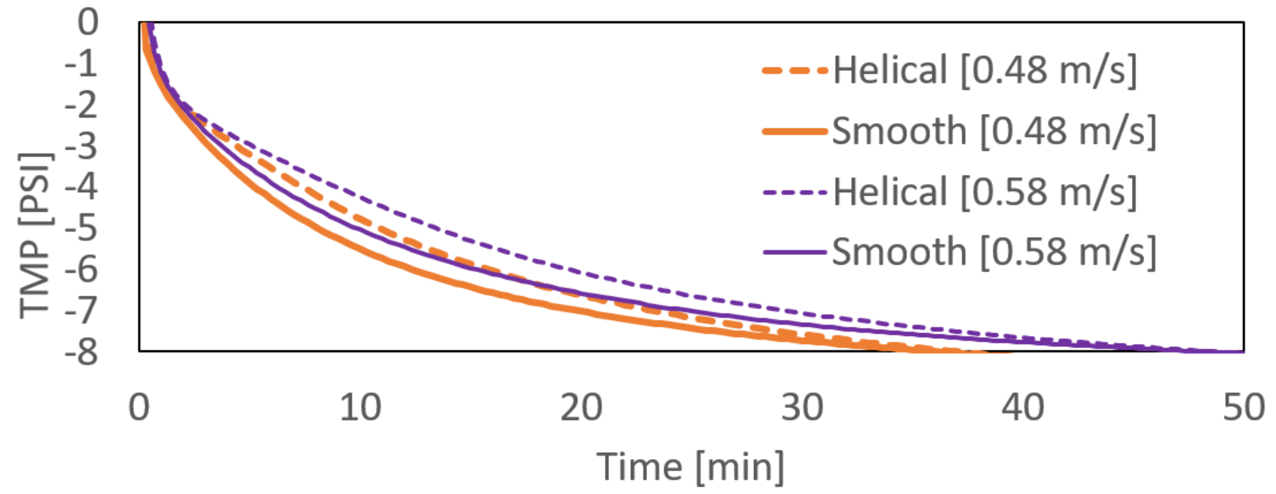

Results from experiments (top) were averaged (bottom) to determine fouling rates at different crossflow velocities.

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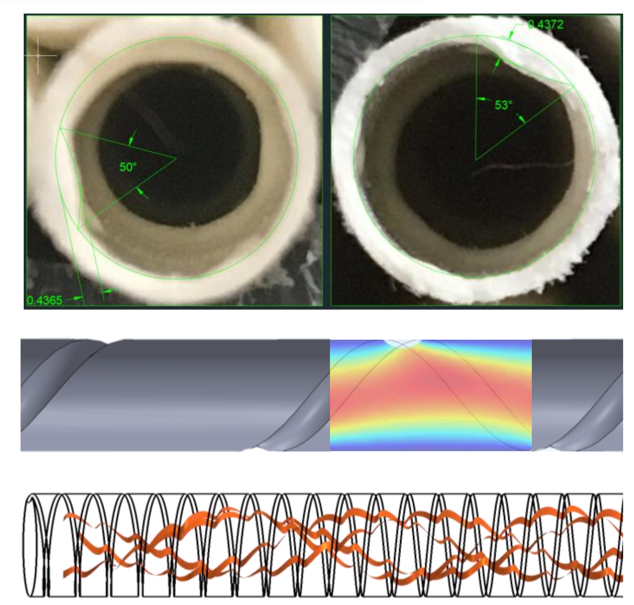

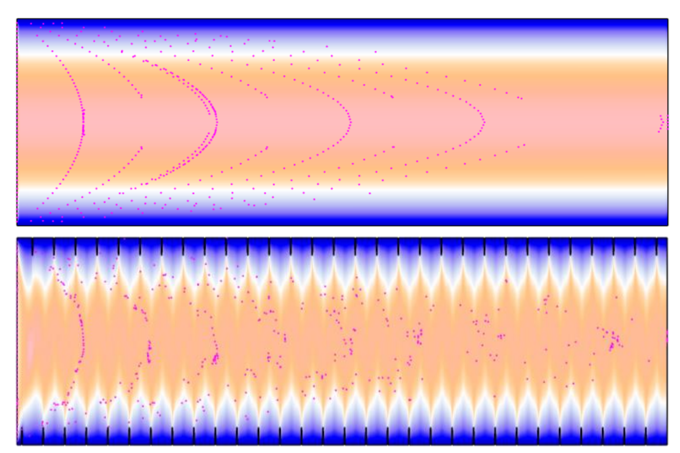

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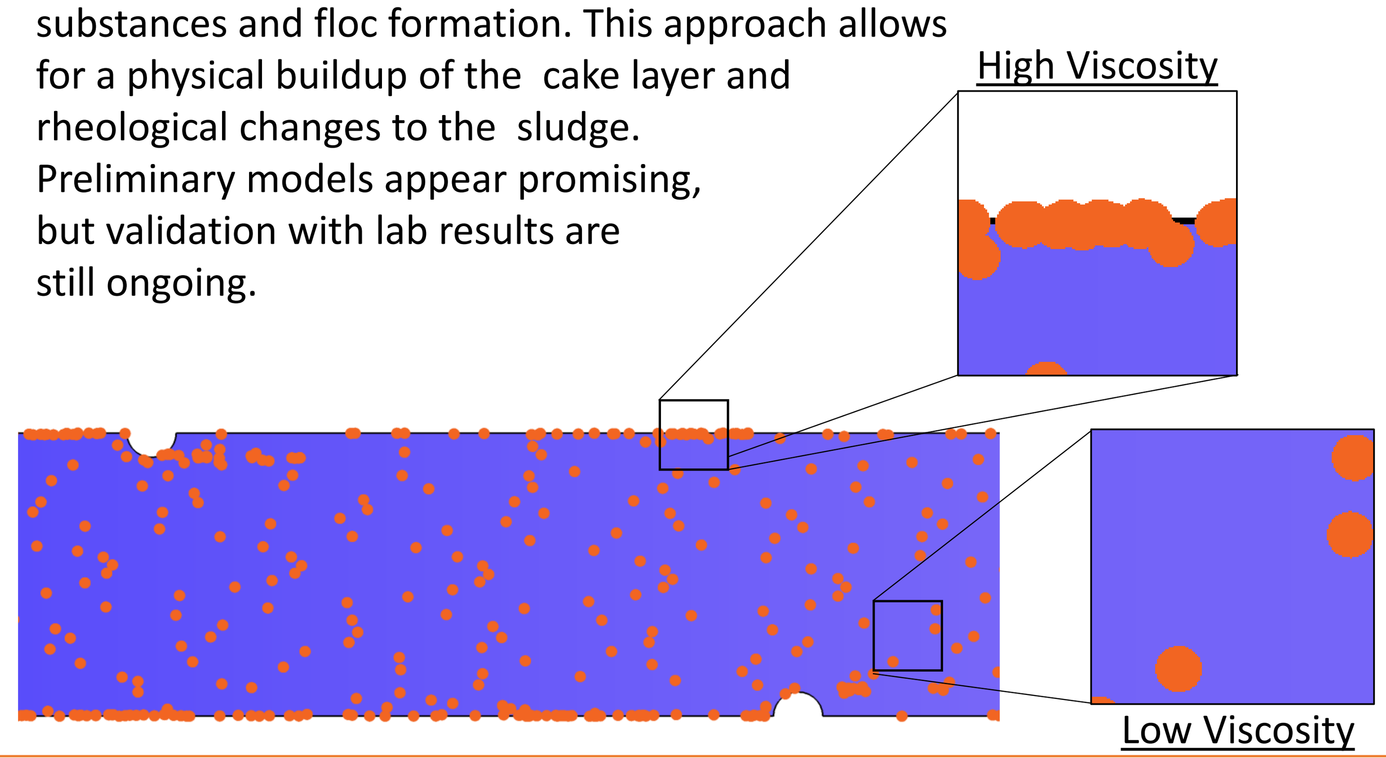

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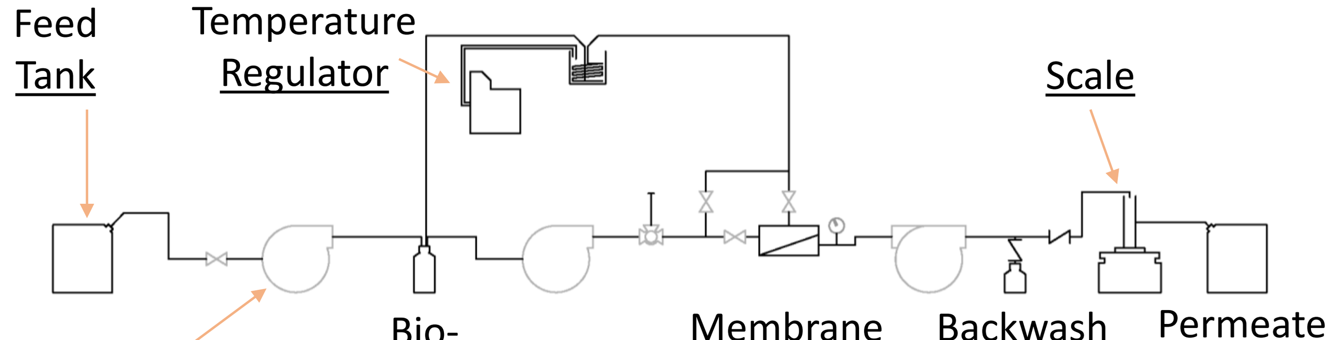

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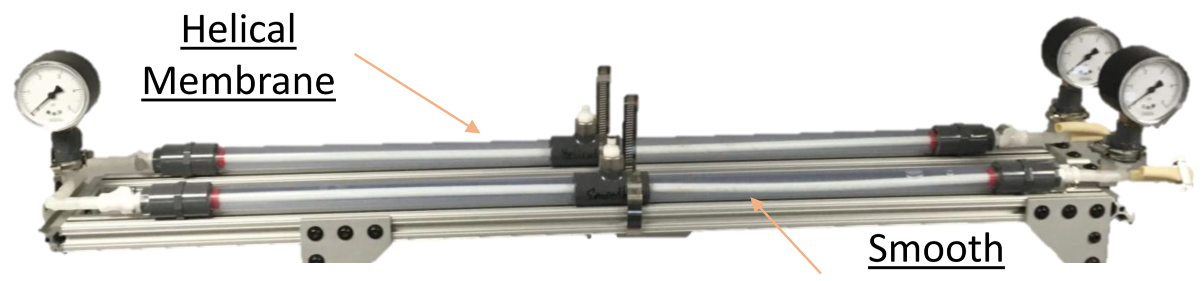

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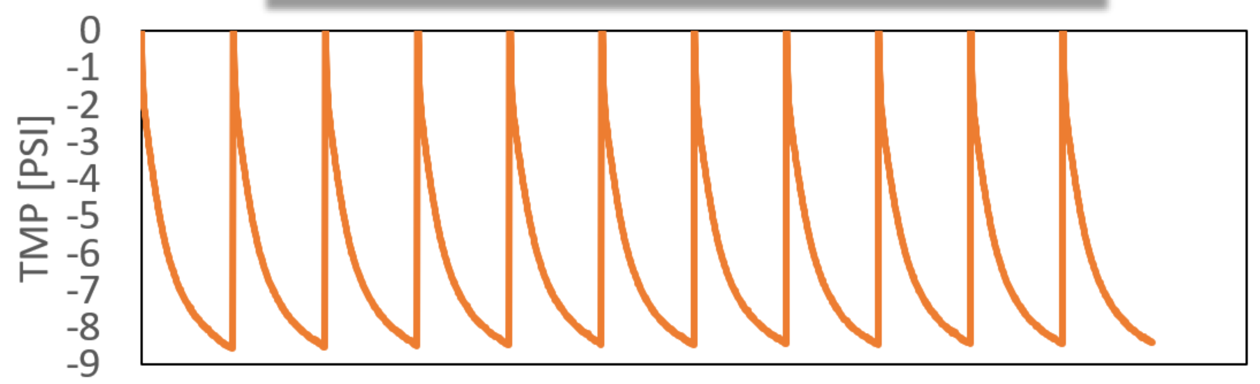

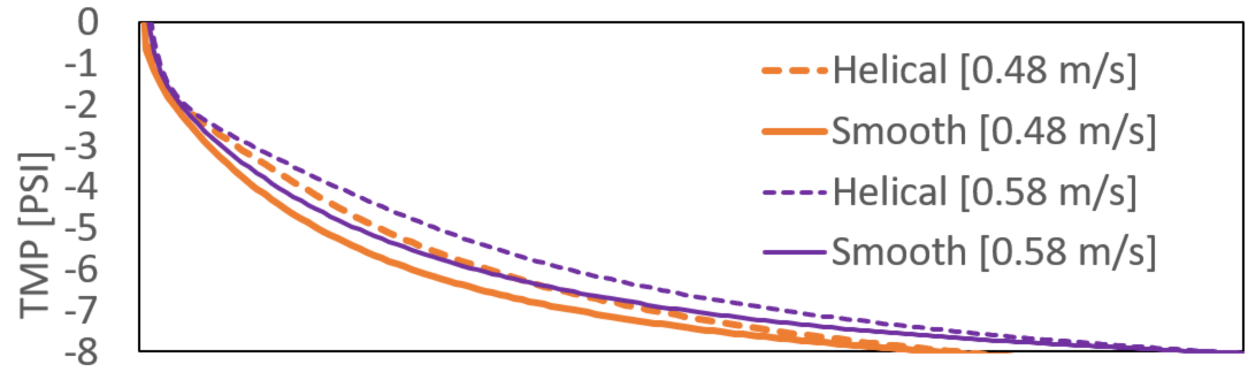

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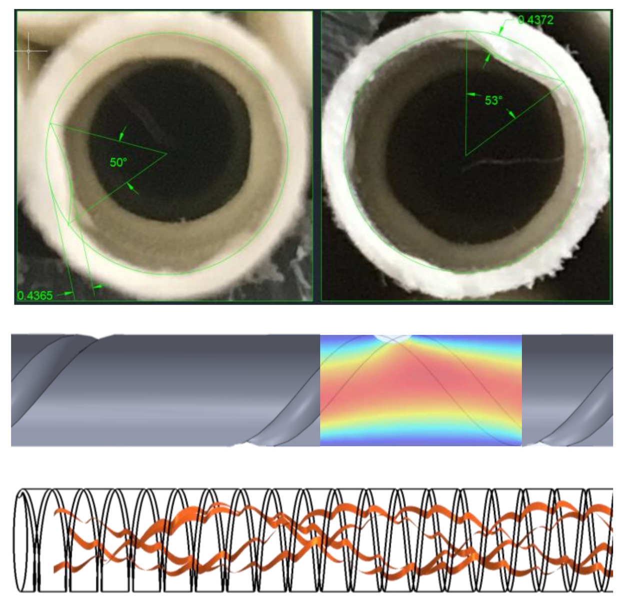

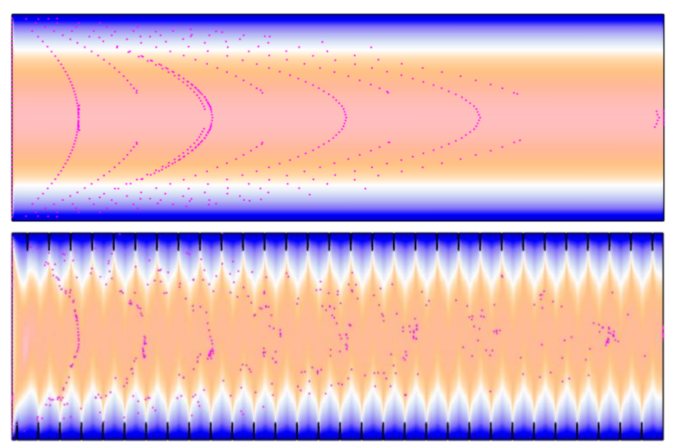

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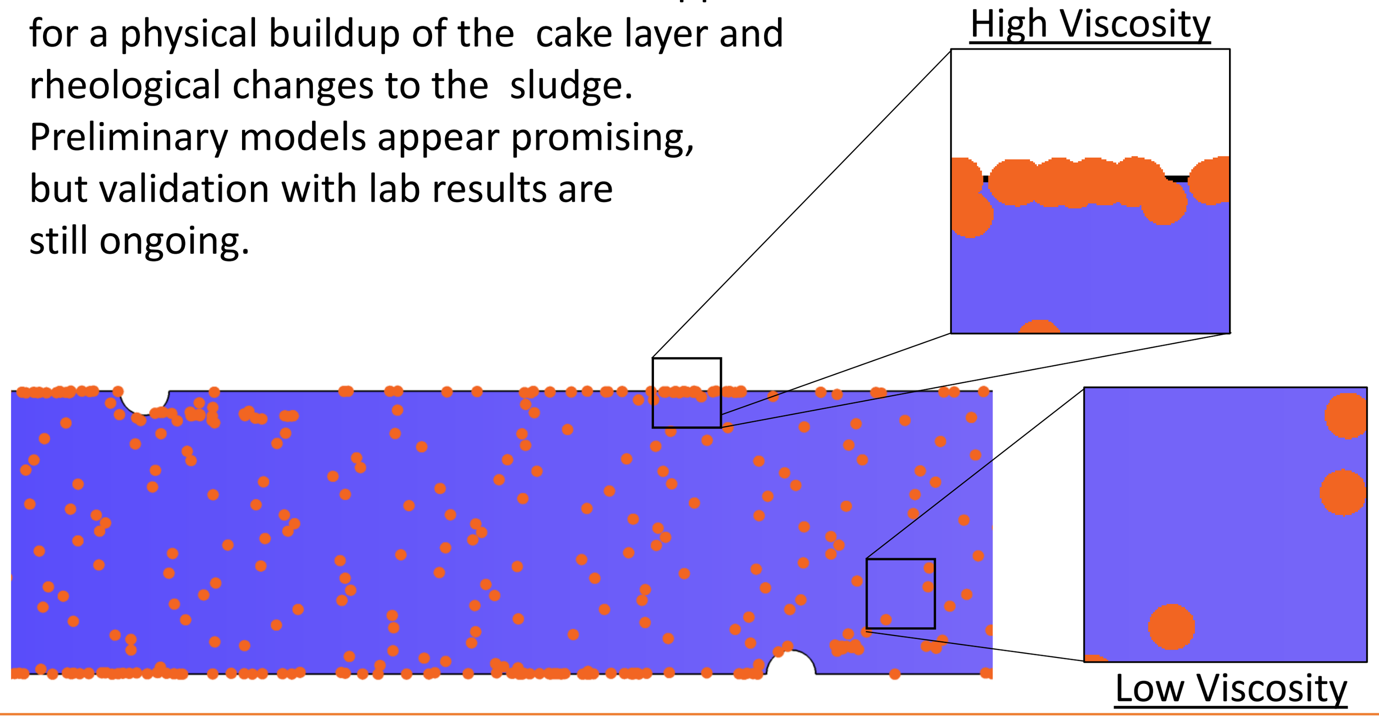

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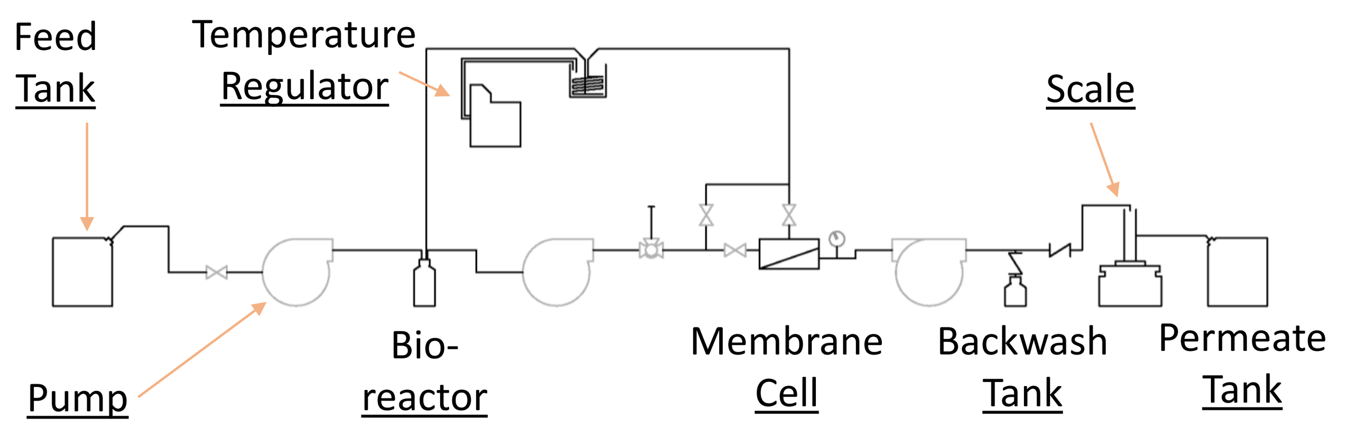

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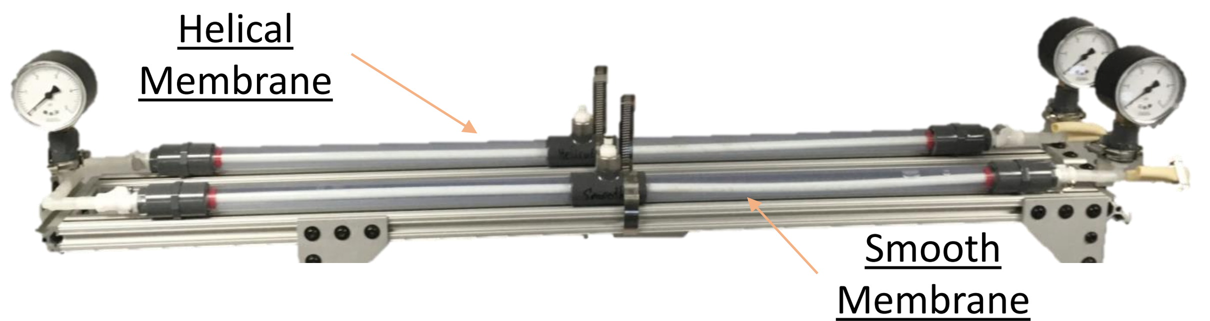

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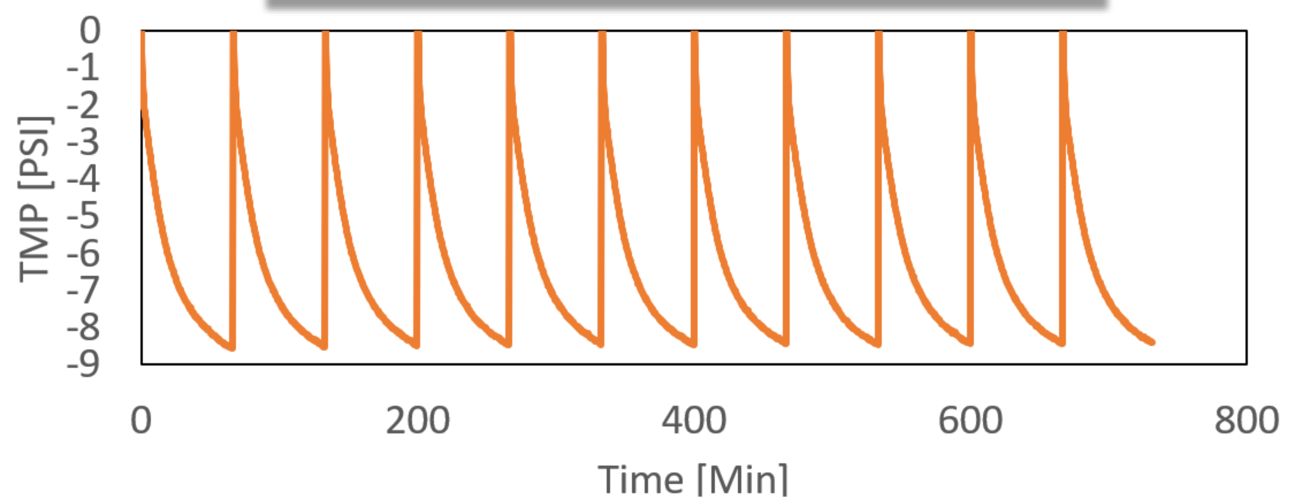

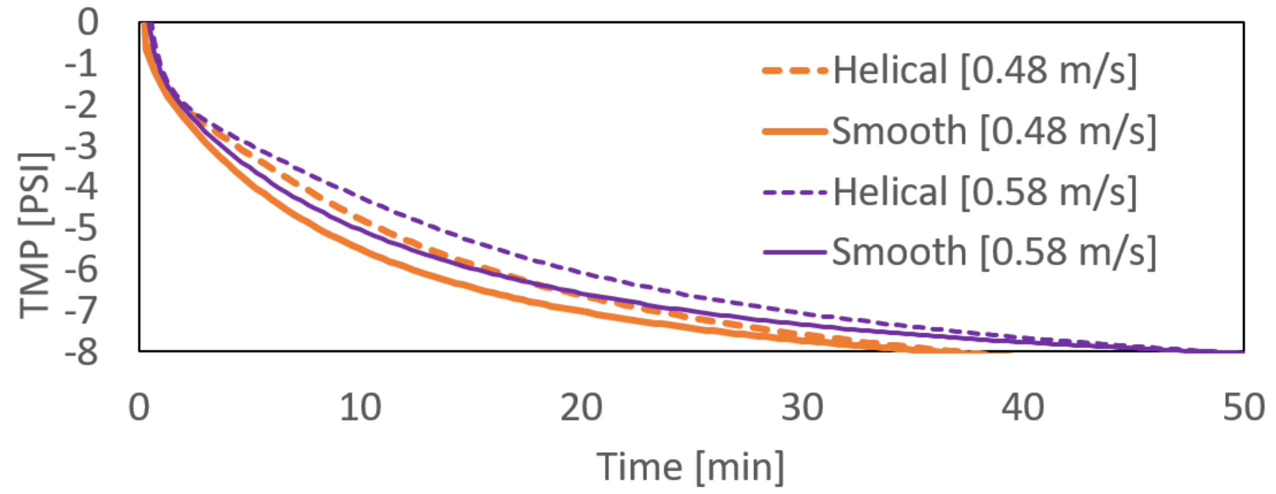

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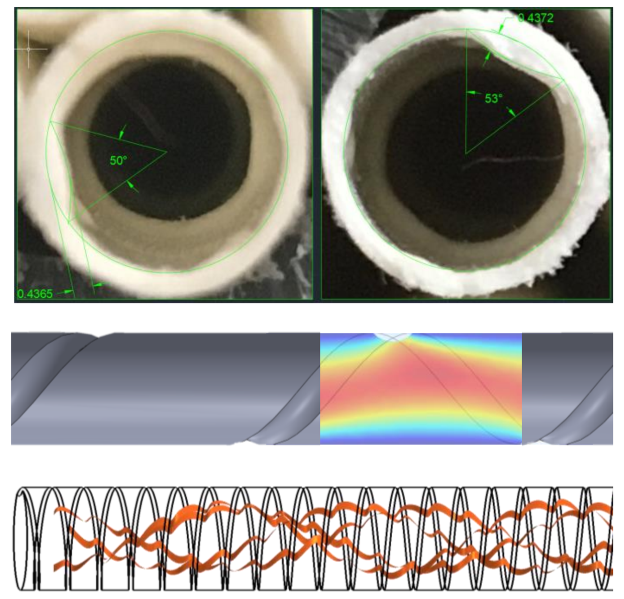

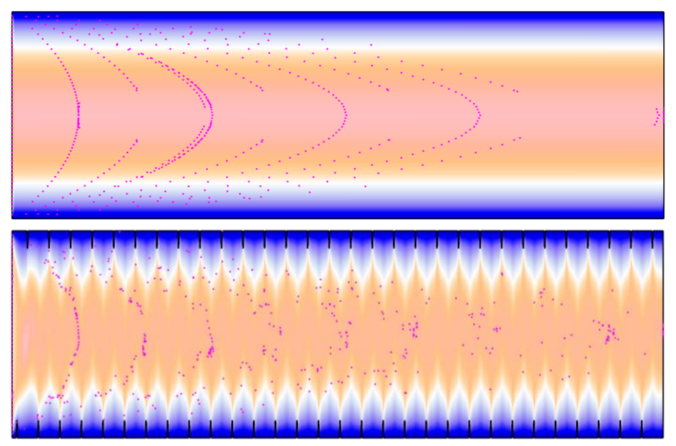

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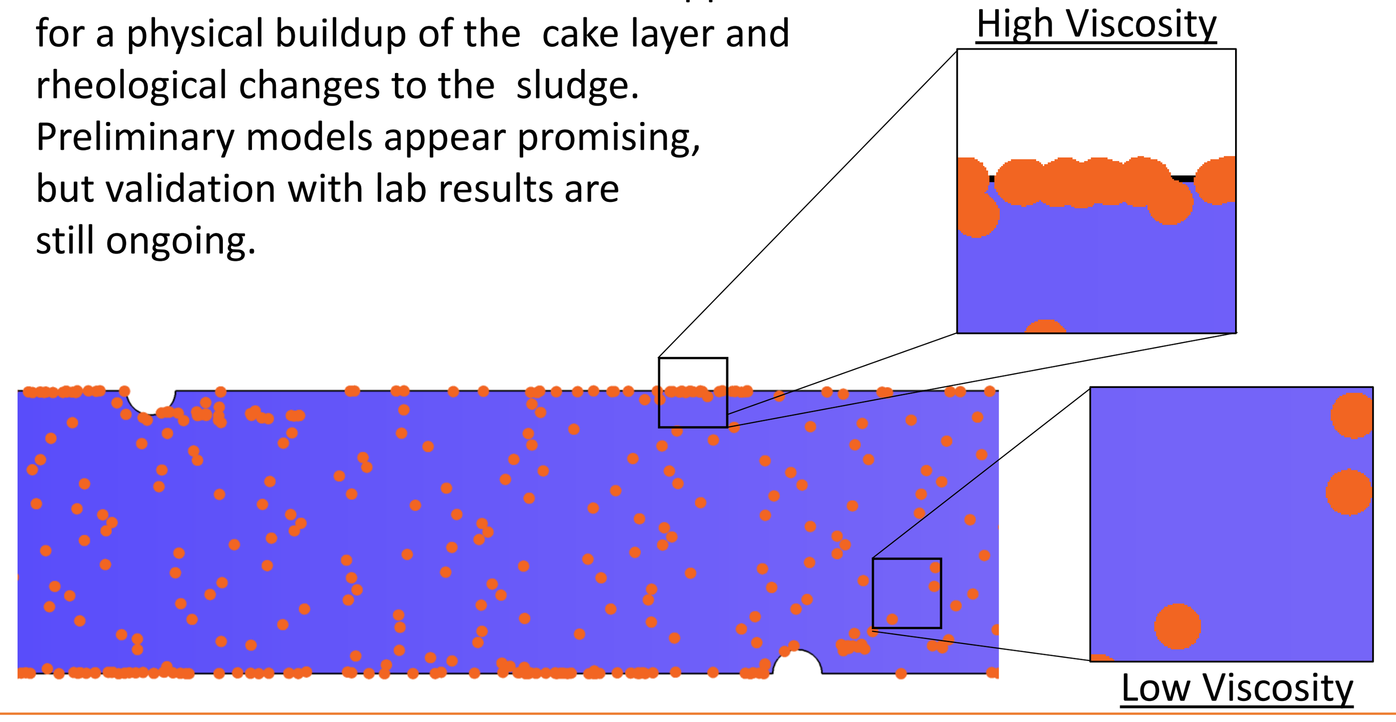

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