Niedner - Sanexen Visualization Tool Manual

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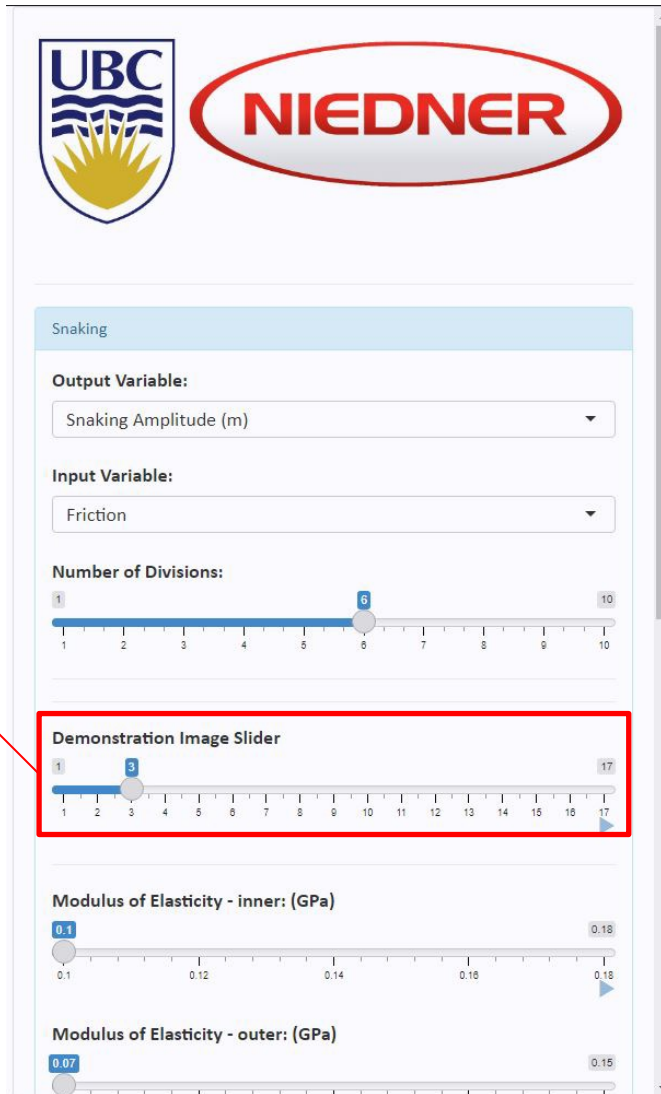
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Visualization tool manual

Visualization tool manual

A separate tab is allocated to each defect case study: Snaking, Bunching and Assembly

Each tab contains 4 drop-down buttons containing additional information specific to each task

Finite element simulation results (csv files) can be downloaded from here

Additional images can be uploaded by the user into the tool

Visualization tool manual

Documentation provides an overview of the case study and details regarding the model variables and statistical analysis

You can use this slider to change the documentation page

Visualization tool manual

The Plot tab summarizes the statistical info regarding the FE simulation data used for each case study. Input/output variables and the number of histogram bins can be selected from the menu on the left.

Visualization tool manual

Can be used to specify the input variables of the FE simulation

The FE simulation results including the simulation image and output variable values are displayed under "Images" and "Table" tabs. The result is generated based on the input values specified by the user from the menu on the left (shown with the red box.)

FE Models' Output Specification and ML Models Results

Samples' deformation After stress relaxation test
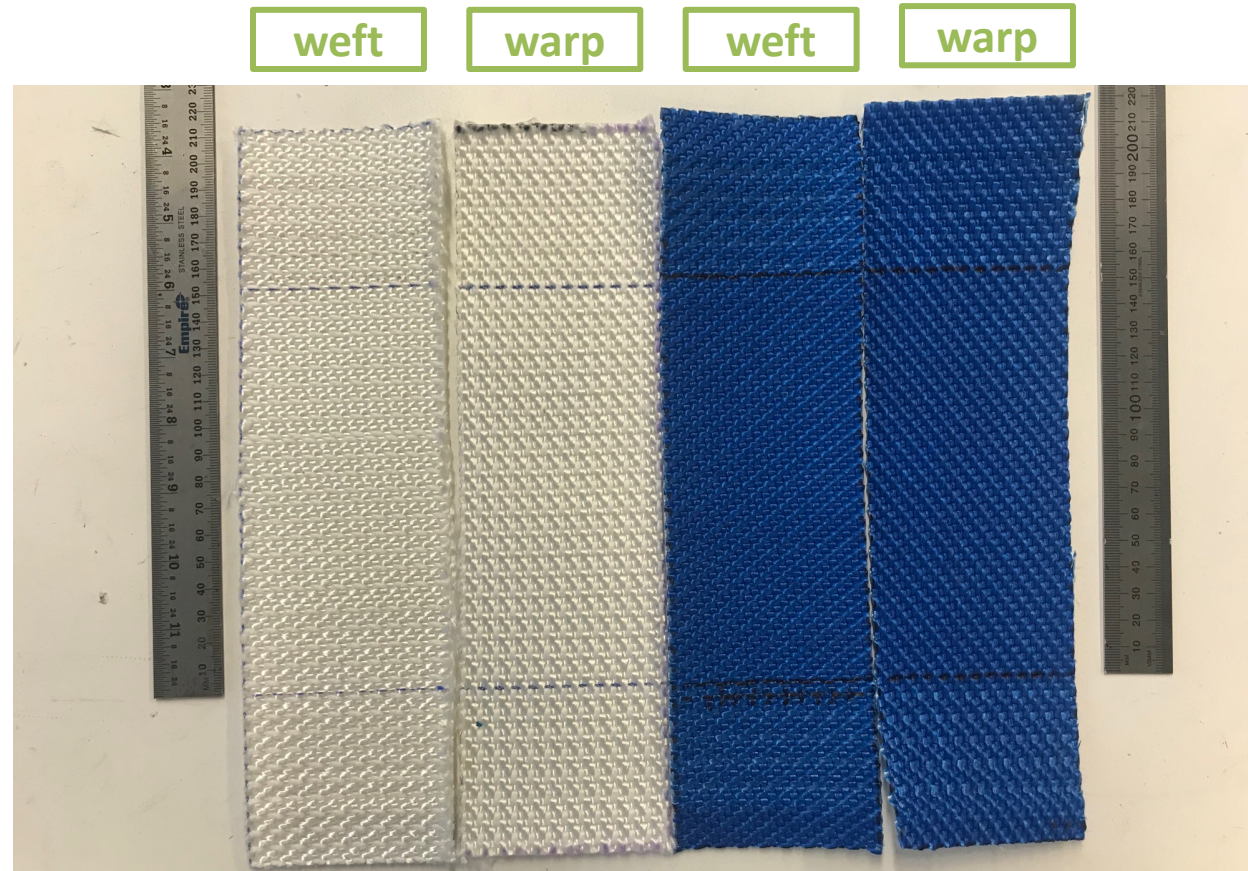
Inner layer   Outer layer

Schematic of Inputs

Modulus of elasticity Warp (E1)

Outer layer   Inner layer
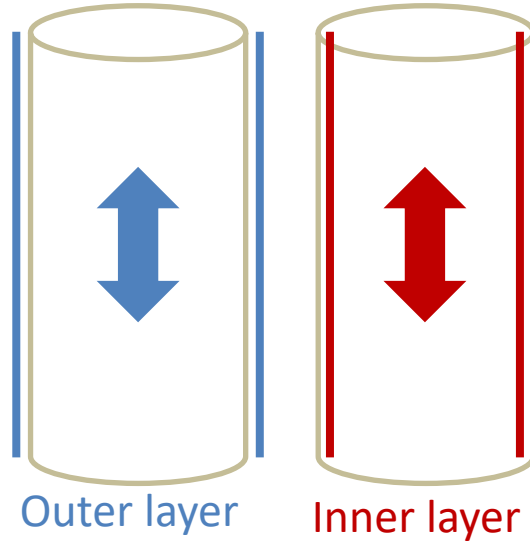
Modulus of elasticity Weft (E1)

Outer layer   Inner layer
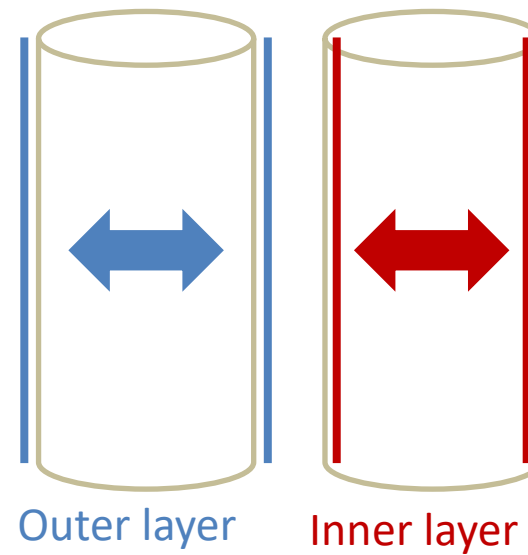
Coefficient of friction   Load

Shear modulus

Outer layer   Inner layer

9
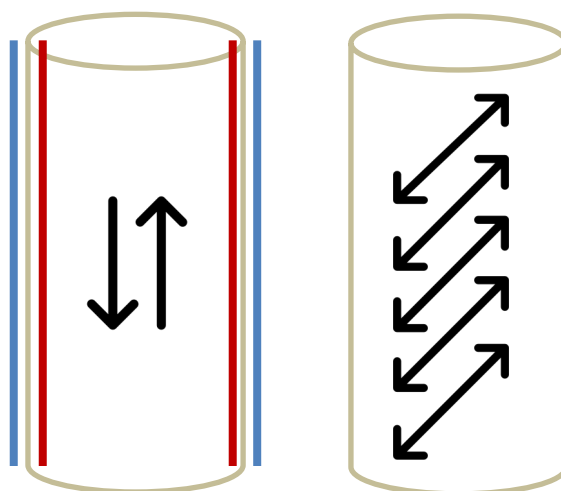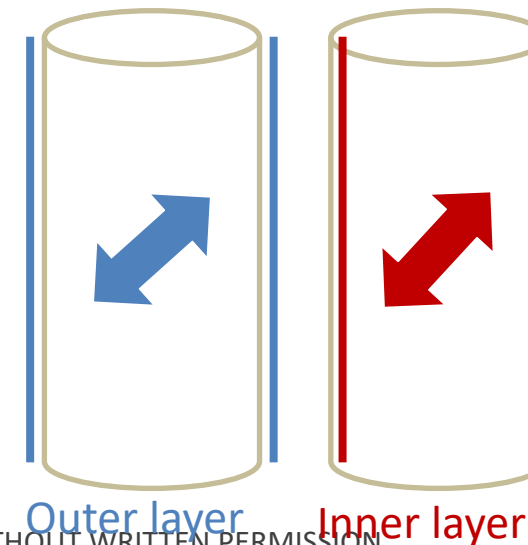
Snaking - Data summary

Parameter Name	Units	Input Variables Min-Max (Levels)
Inner Modulus	GPa	0.10-0.18 (5)
Outer Modulus	GPa	0.07-0.15 (5)
Axial Load	kN	6-14(5)
Friction Coefficient	-	$0.01 - 45$ (10)

U, U1
+3.929e-01
+3.232e-01
+2.535e-01
+1.838e-01
+1.141e-01
+4.444e-02
-2.525e-02
-9.494e-02
-1.646e-01
-2.343e-01
-3.040e-01
-3.737e-01
-4.434e-01

Outputs:

1 → # of snaking occurrence

2
3
4
5
6

} Global snaking length (m)

7 → Maximum snaking amplitude
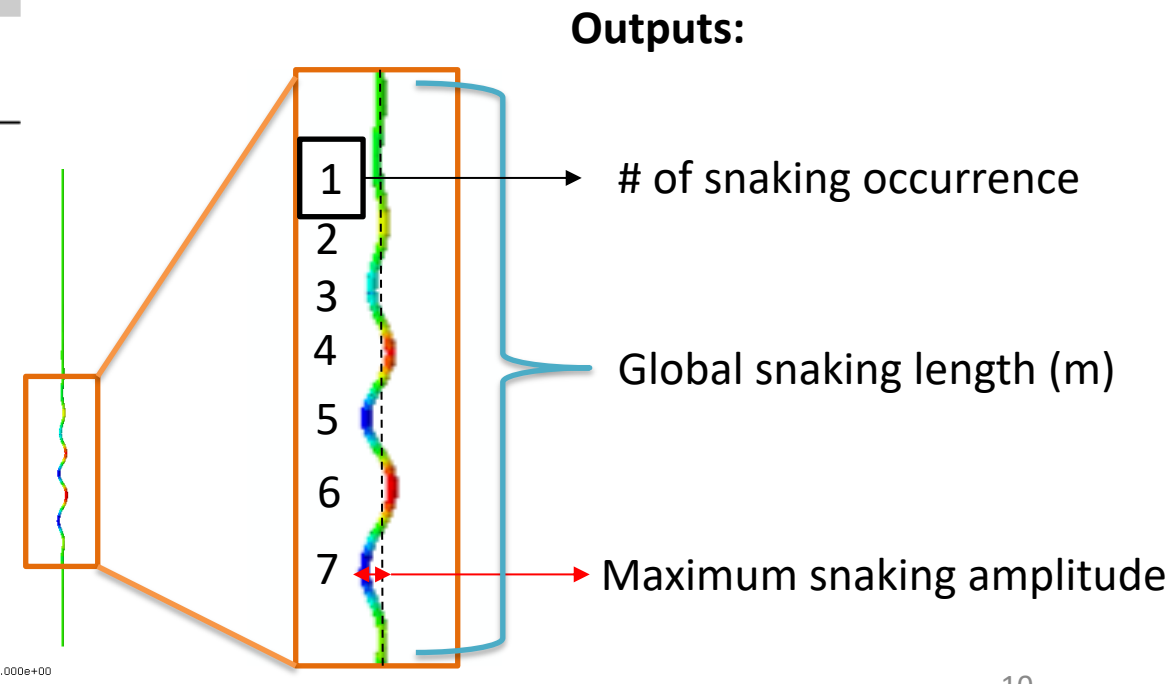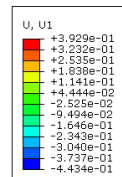
Step: Step-1
Increment   875: Step Time =   1.000
Primary Var: U, U1
Deformed Var: U   Deformation Scale Factor: +1.000e+00

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Model selection

Model	Interpretability	R² Coefficient of Determination (Highest)	MSE	Training Speed
Number of Snaking				
Linear Regression	High	0.321	4.268	High
SVR	Low	0.545	2.856	Low
Decision Tree(*)	High	0.600	2.508	High
XGBoost(**)	Low	0.602	2.500	Low
Global Length of Snaking				
Linear Regression	High	0.764	41.78	High
SVR	Low	0.873	23.32	Low
Decision Tree (*)	High	0.880	21.24	High
XGBoost (**)	Low	0.881	21.22	Low
Snaking Amplitude				
Linear Regression(*)	High	0.708	0.495	High
SVR	Low	0.712	0.483	Low
Decision Tree	High	0.711	0.490	High
XGBoost(**)	Low	0.723	0.460	Low

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Pareto Charts for Best Models
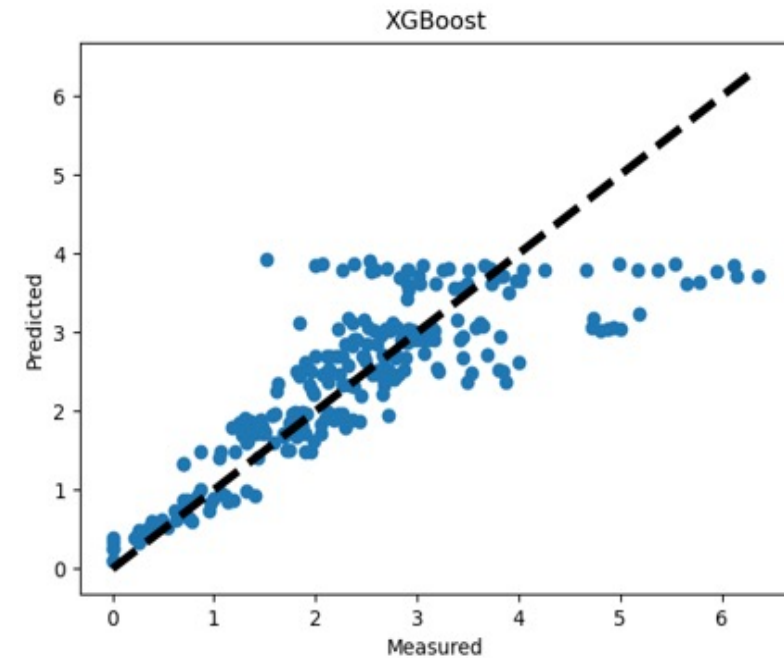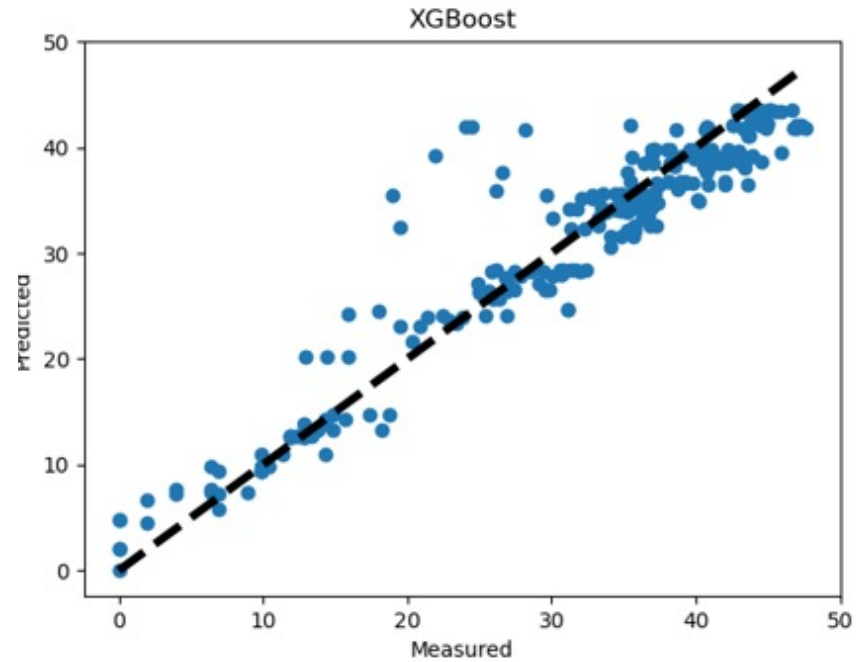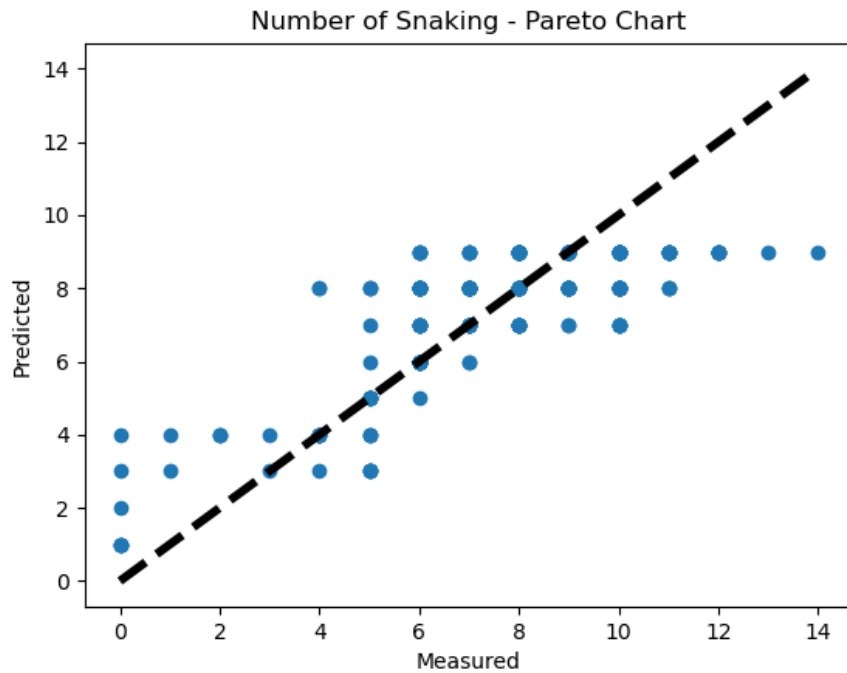
Bunching - Inputs

Variable	Unit	Levels[*]
Modulus of elasticity – inner – warp	GPa	0.1, **0.14**, 0.18
Modulus of elasticity – inner – weft	GPa	0.18, **0.26**, 0.34
Modulus of elasticity – outer – warp	GPa	0.07, 0.09, 0.15
Modulus of elasticity – outer – weft	GPa	0.07, 0.103, 0.25
Shear modulus - inner	MPa	3.128, **3.87**
Shear modulus - outer	MPa	0.48, 1.79
Friction coefficient (**between inner and outer layers**)	-	**0.14**, 0.2
Axial load (water pressure drop)	$\frac{N}{mm^2}$	3e-5, 6.6e-5
Pre-strain	%	Inside jacket 1.6%, Inside jacket 0.44%, Outside jacket 0.5%

Bunching - Outputs

Maximum bunching amplitude (m)

Reference path

Location of maximum bunching amplitude on the hose (m)
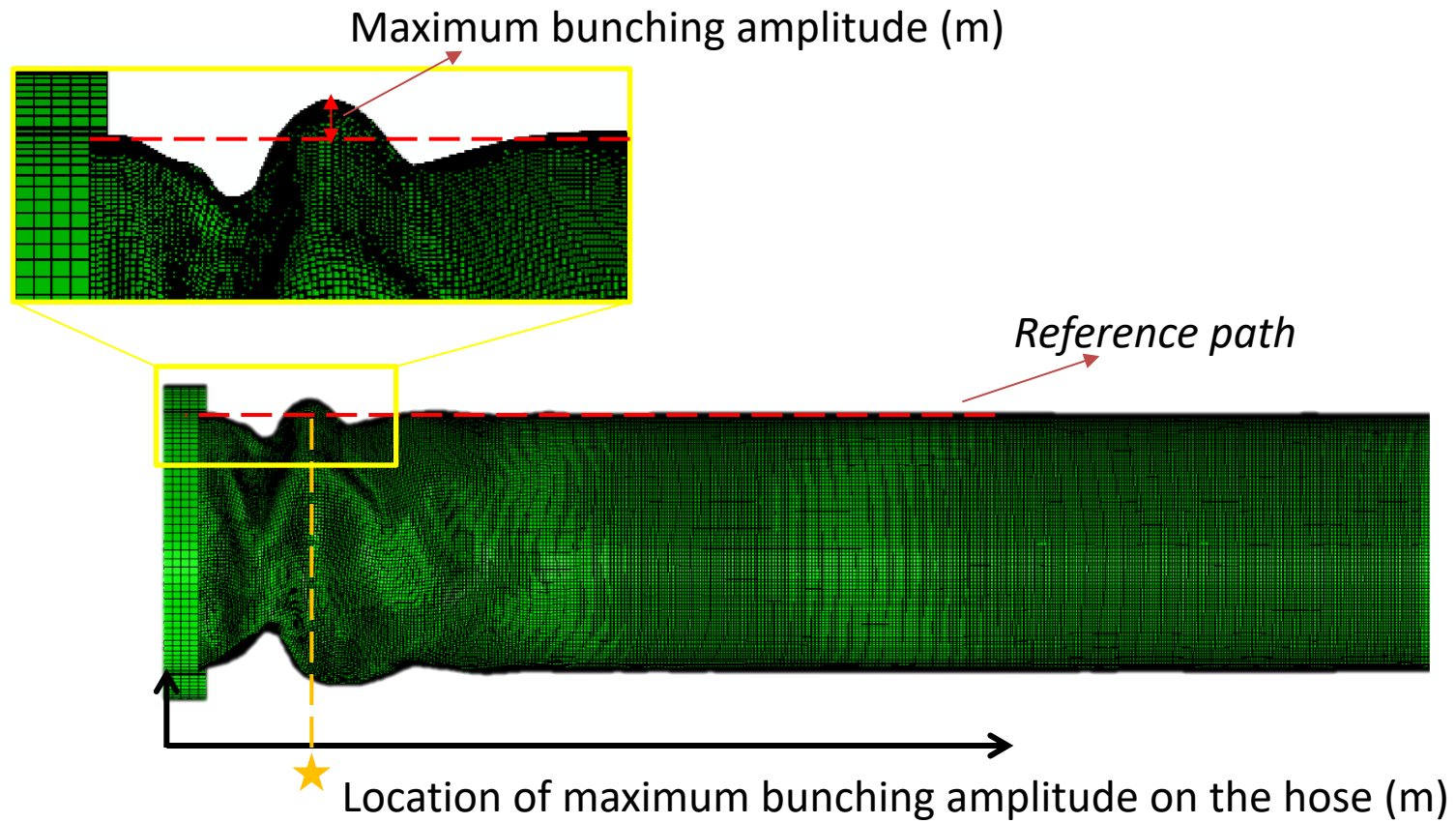
Bunching – ML model performance

Model	R-squared
Linear regression	0.66
Ridge regression	0.67
Random forest	**0.91**
Gradient boosting	0.83
SVM - RBF kernel	0.84
SVM - Linear	0.6

Random forest

SVM – RBF kernel
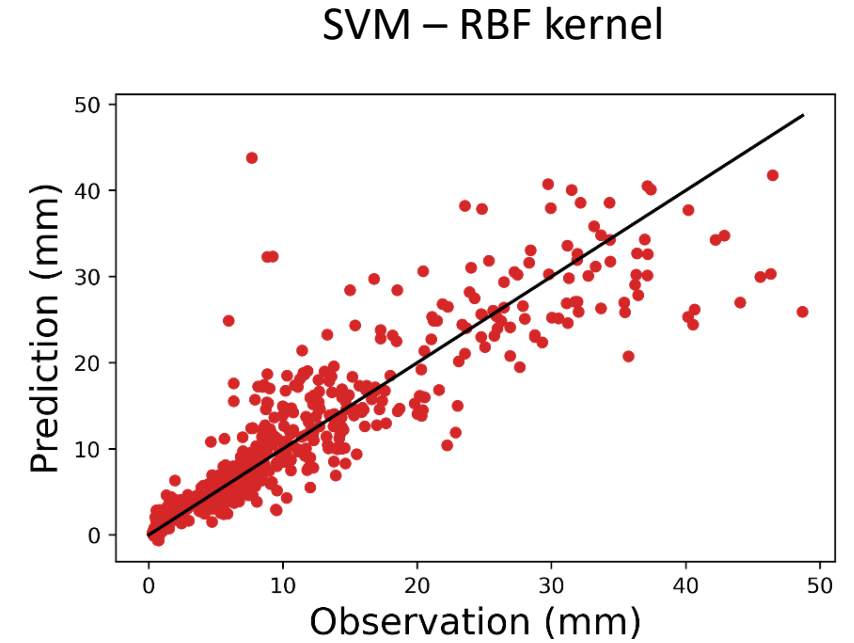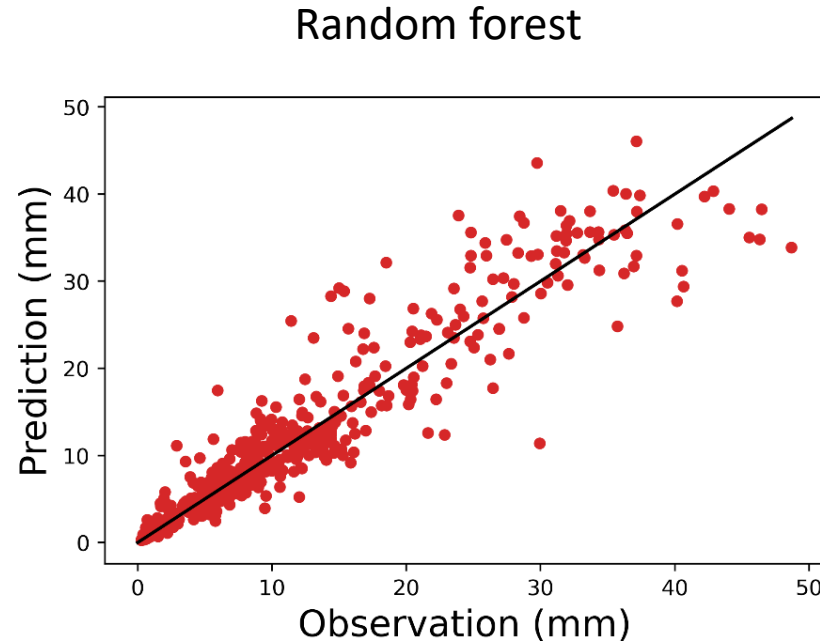
Assembly - Inputs

Variable	Unit	Levels*
Modulus of elasticity – inner – warp	GPa	0.1, **0.14**, 0.18
Modulus of elasticity – inner – weft	GPa	0.18, **0.26**, 0.34
Modulus of elasticity – outer – warp	GPa	0.07, **0.09**, **0.15**, 0.18
Modulus of elasticity – outer – weft	GPa	0.07, **0.103**, **0.25**, 0.3
Shear modulus - inner	MPa	2.8, **3.87**, 4.8
Shear modulus - outer	MPa	1.3, **1.79**, **6.62**, 8
Friction coefficient (**between inner and outer layers**)	-	0.1, 0.2

* The level at the center for each variable was derived from characterization experiments.

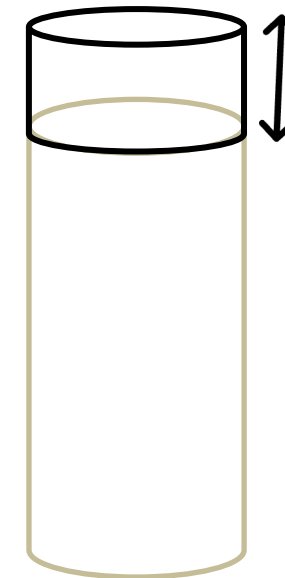Outer layer **with** TPU ■
Outer layer **without** TPU ■

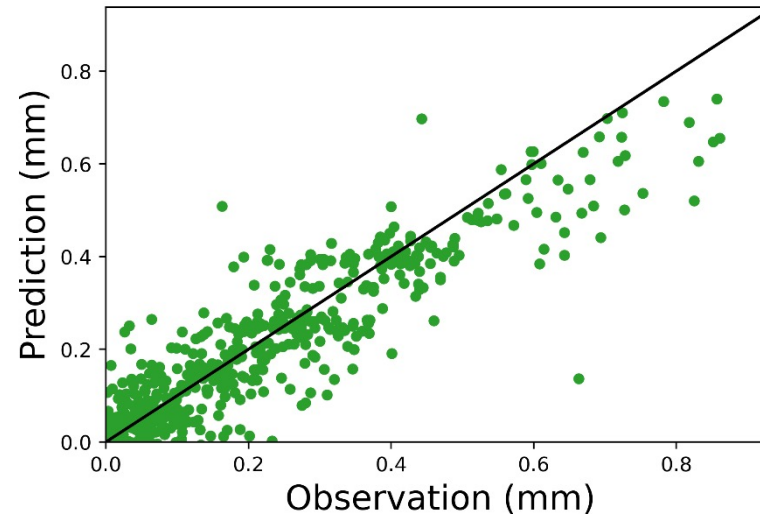# Assembly - Outputs

Excessive length (Deformation in the assembly direction)
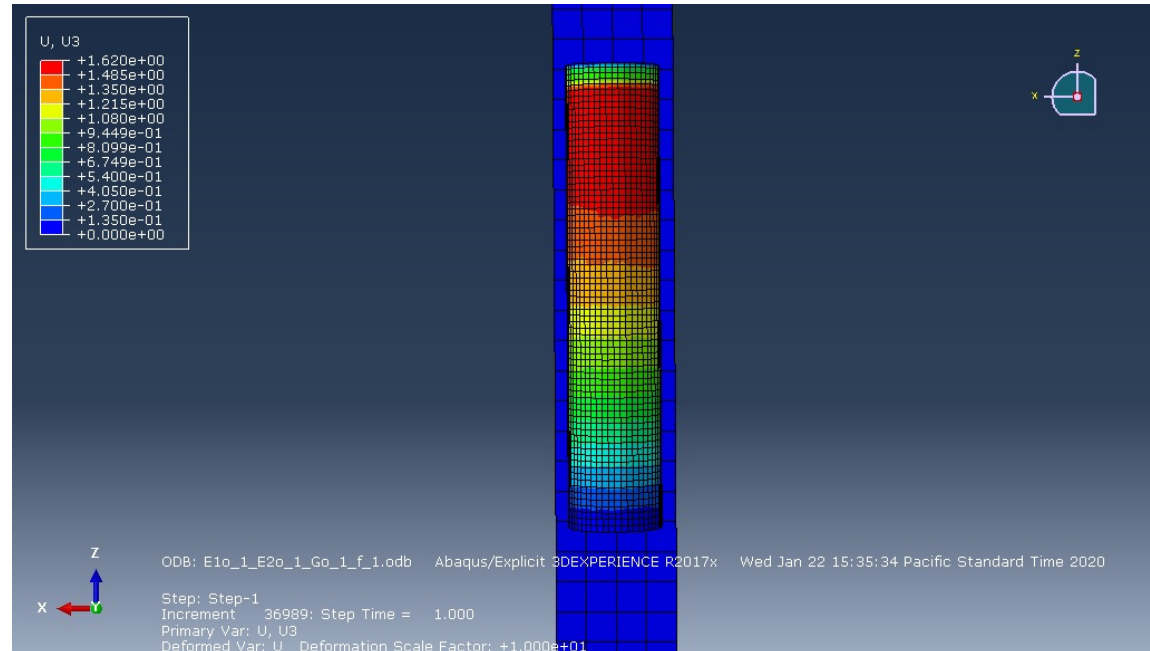
Excessive length

Assembly – ML model performance

Model	R-squared
Linear regression	0.63
Ridge regression	0.63
Random forest	0.83
Gradient boosting	**0.85**
SVM - RBF kernel	**0.85**
SVM - Linear	0.1

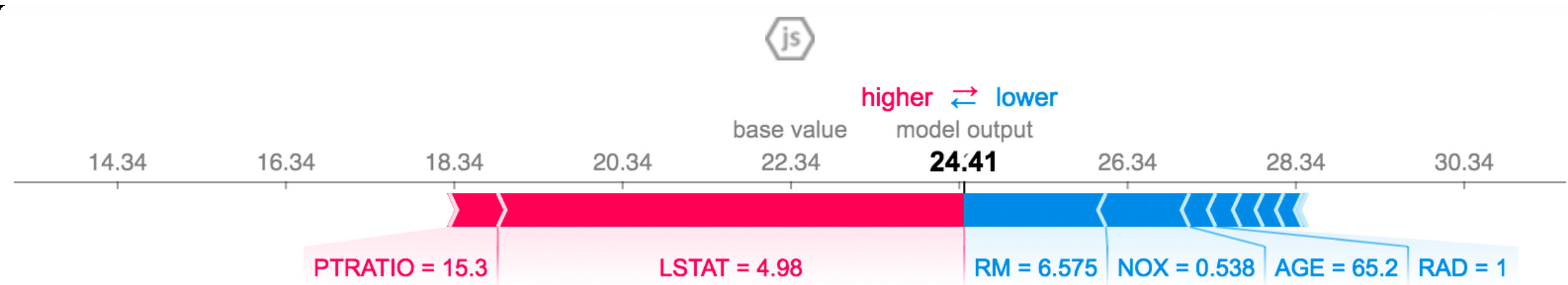

Gradient boosting

SVM – RBF kernel
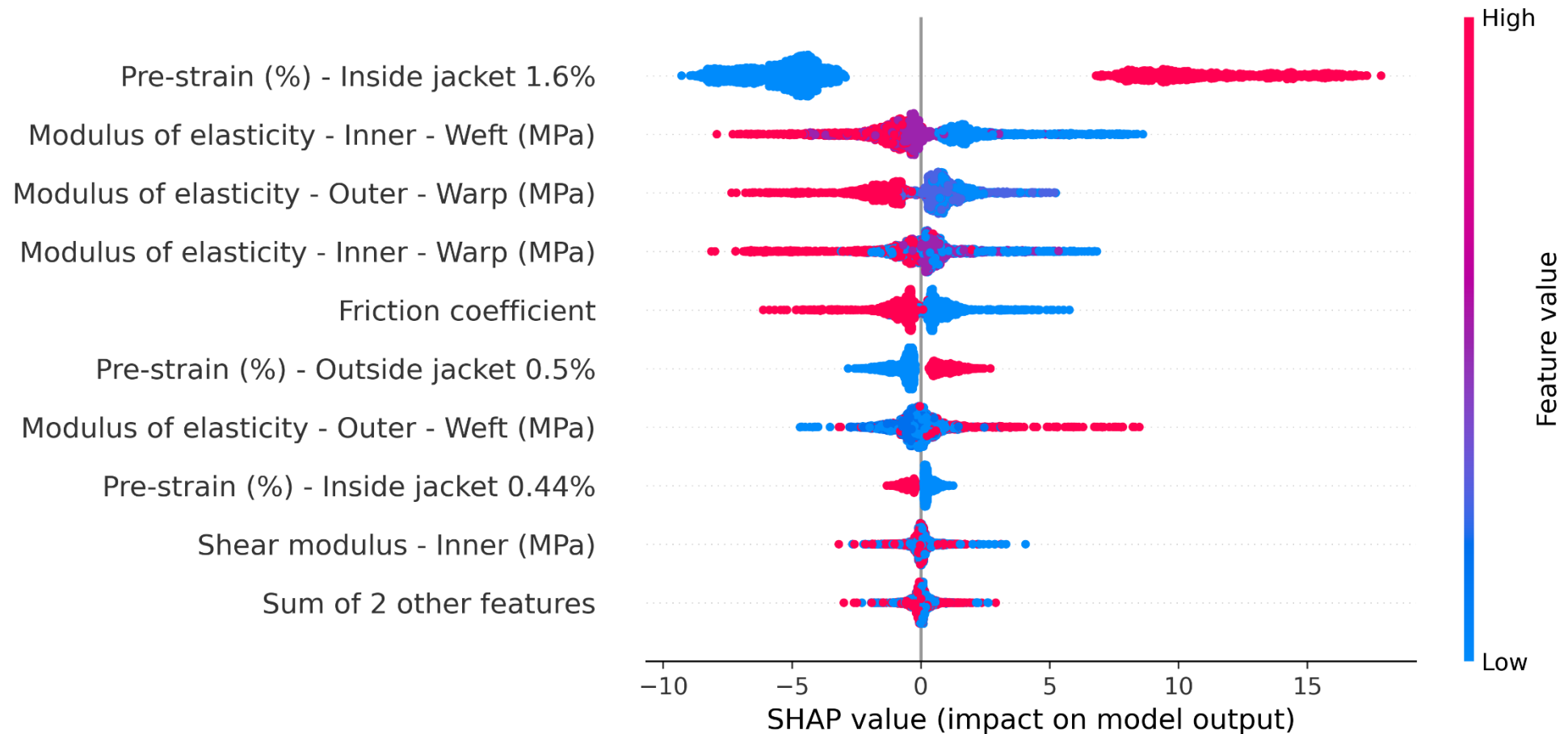
ML Interpretability Analysis
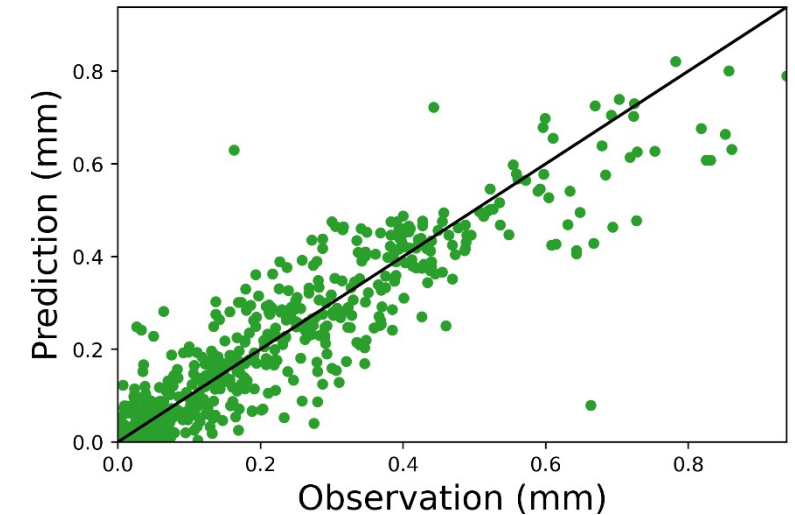
SHAP

- **Shapley additive explanations (SHAP)** is an additive feature attribution approach based on game theory.
- SHAP identifies the **contribution of each feature** to the model's prediction in an attempt to understand the underlying **decision rules** learned by the model.
- It interprets the model by assigning importance (SHAP) value to each feature in the prediction of any particular instance.

higher ⇄ lower					
	base value	model output			
14.34	16.34	18.34	20.34	22.34	**24.41**	26.34	28.34	30.34

PTRATIO = 15.3   LSTAT = 4.98   RM = 6.575 | NOX = 0.538 | AGE = 65.2 | RAD = 1

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Model explainability analysis - Bunching

Model explainability analysis - Assembly