Observations of the Experimental Study of Fluid-Structure-Interactions of Plate-Type-Fuel

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Introduction

- Supporting US Fuel Qualification of UMo monolithic fuel
- Flow testing needed to support requirements for geometric stability within fuel qualification report
- Flow testing three materials
  - Aluminum 6061 T0
  - Aluminum clad with Aluminum Dispersed with SS particles
  - Aluminum clad with DUMo monolithic fuel
- Goal to observe the bias in geometric stability across all three materials

Experiment Description

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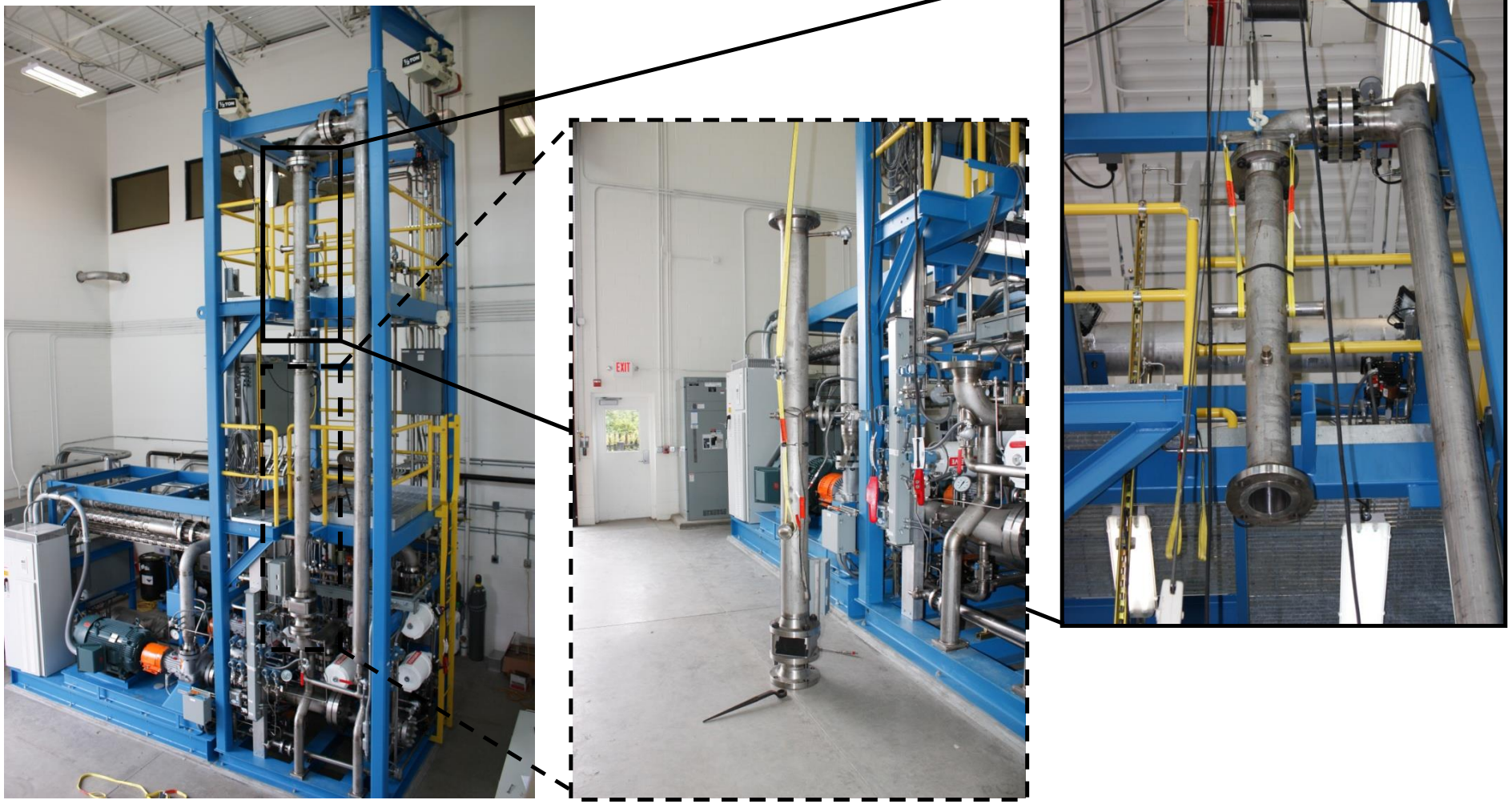
- Hydro-Mechanical Fuel Test Facility



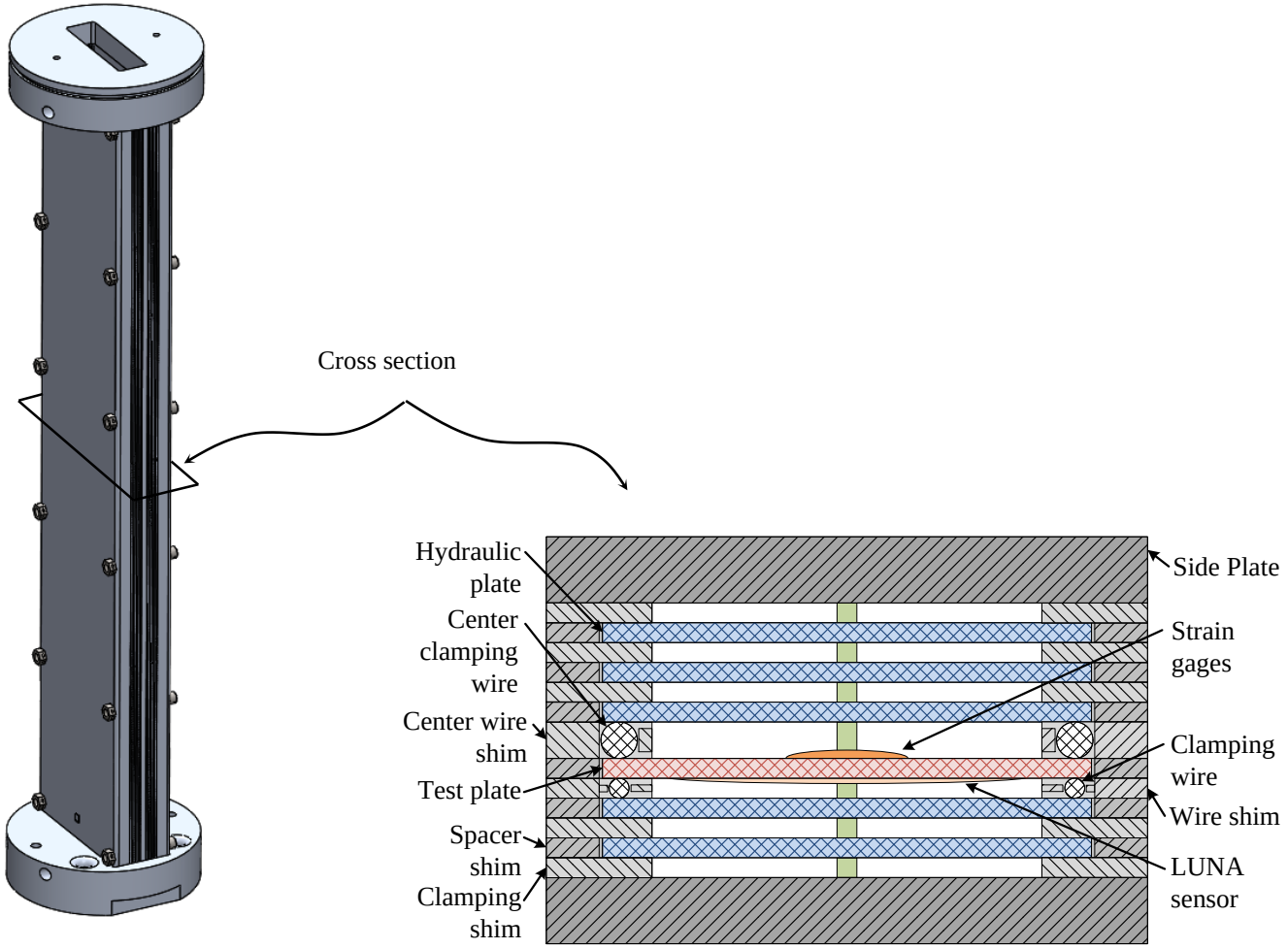
Experiment Description

- Hydro-Mechanical Fuel Test Facility
  - Isothermal Loop
  - Subcooled
  - Full-Bundle Flow Testing Capacity

Parameter	Value
Flow Rate Range [liters/sec]	0 – 100.94
Pressure Range [MPa]	0.101 – 4.137
Fluid Temperature Range [°C]	20 – 238
Conductivity Range [micromhos]	1 – 3
pH Range	4 – 8

Experiment Description

- Generic Test Plate Assembly



Experiment Description

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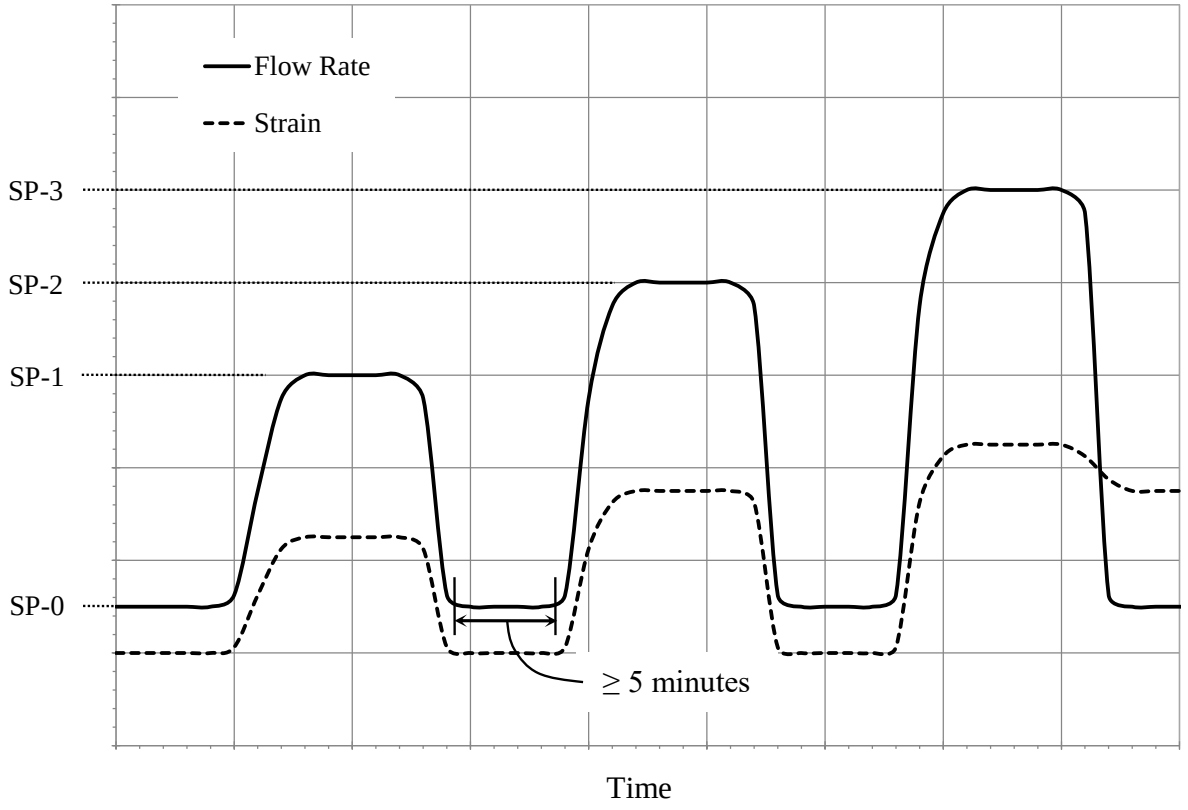
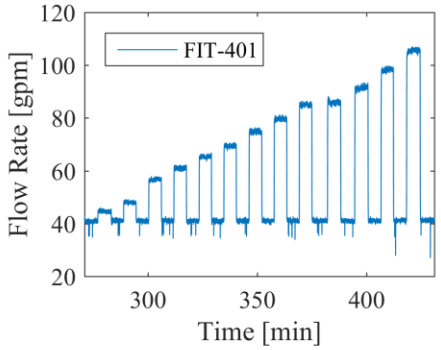
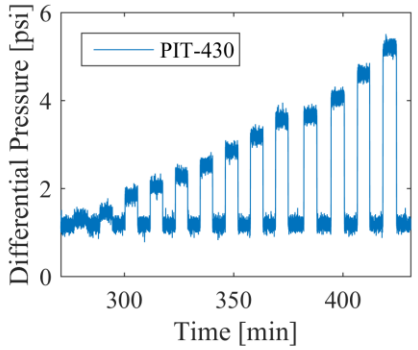
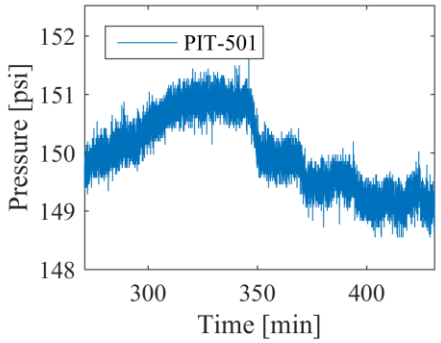
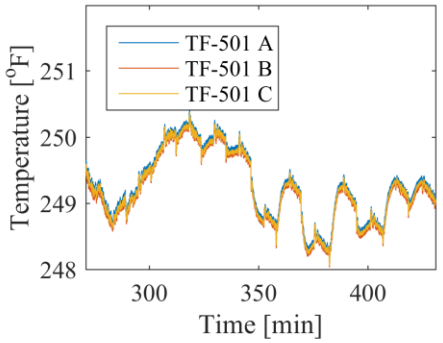


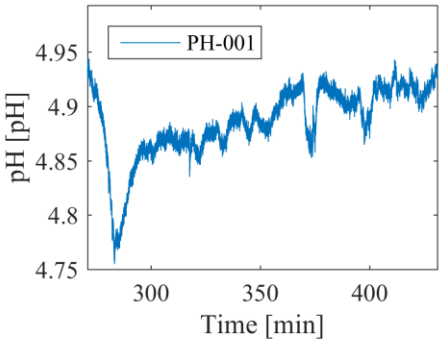
Results

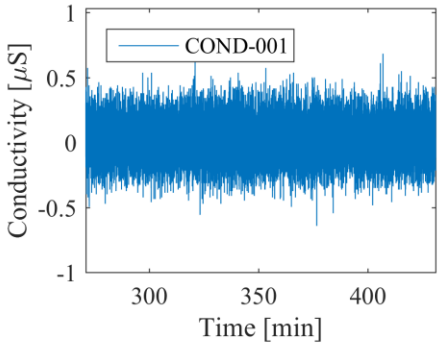

FIT-401
Flow Rate [gpm]
120
100
80
60
40
20
300
350
400
Time [min]


PIT-430
Differential Pressure [psi]
6
4
2
0
300
350
400
Time [min]


PIT-501
Pressure [psi]
152
151
150
149
148
300
350
400
Time [min]


TF-501 A
TF-501 B
TF-501 C
Temperature [°F]
251
250
249
248
300
350
400
Time [min]


PH-001
pH [pH]
4.95
4.9
4.85
4.8
4.75
300
350
400
Time [min]


COND-001
Conductivity [μS]
1
0.5
0
-0.5
-1
300
350
400
Time [min]

Results

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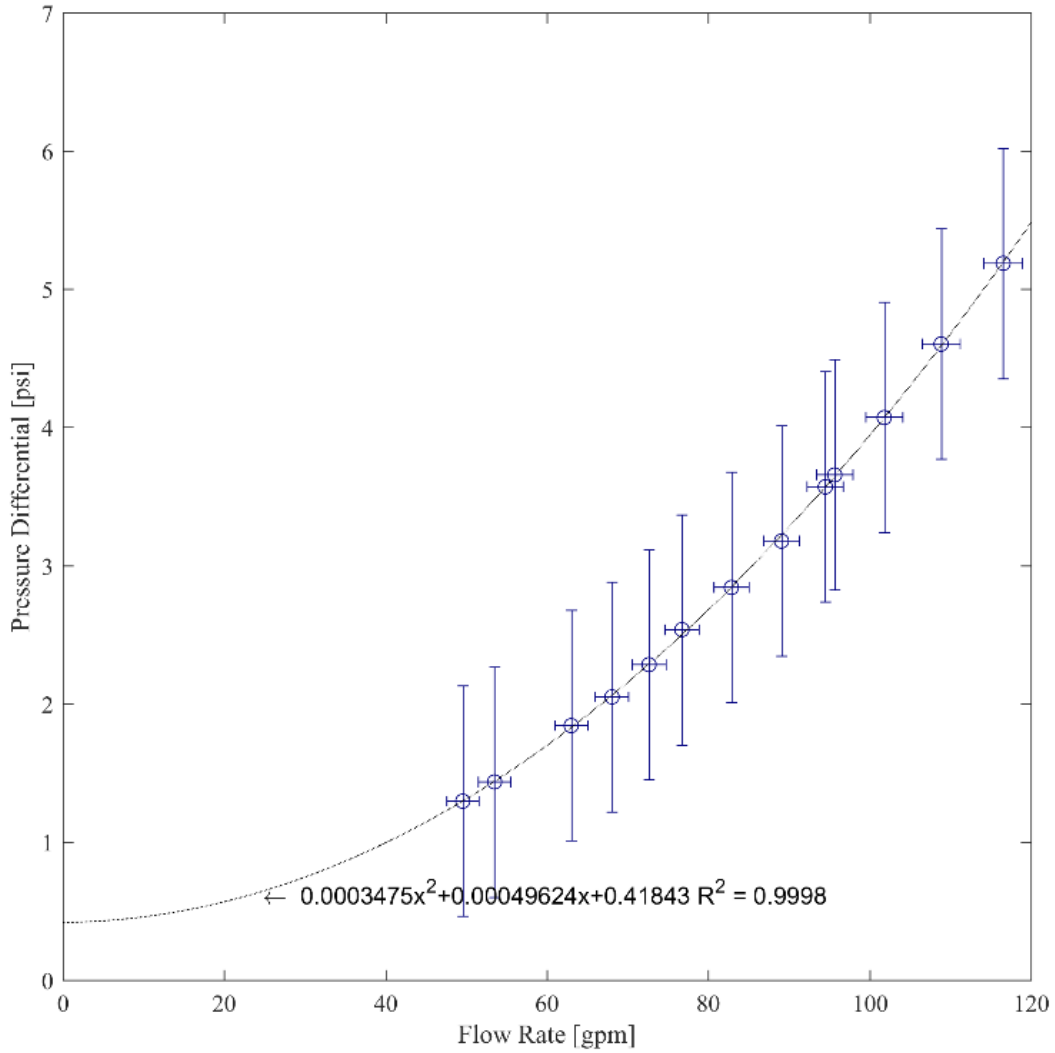

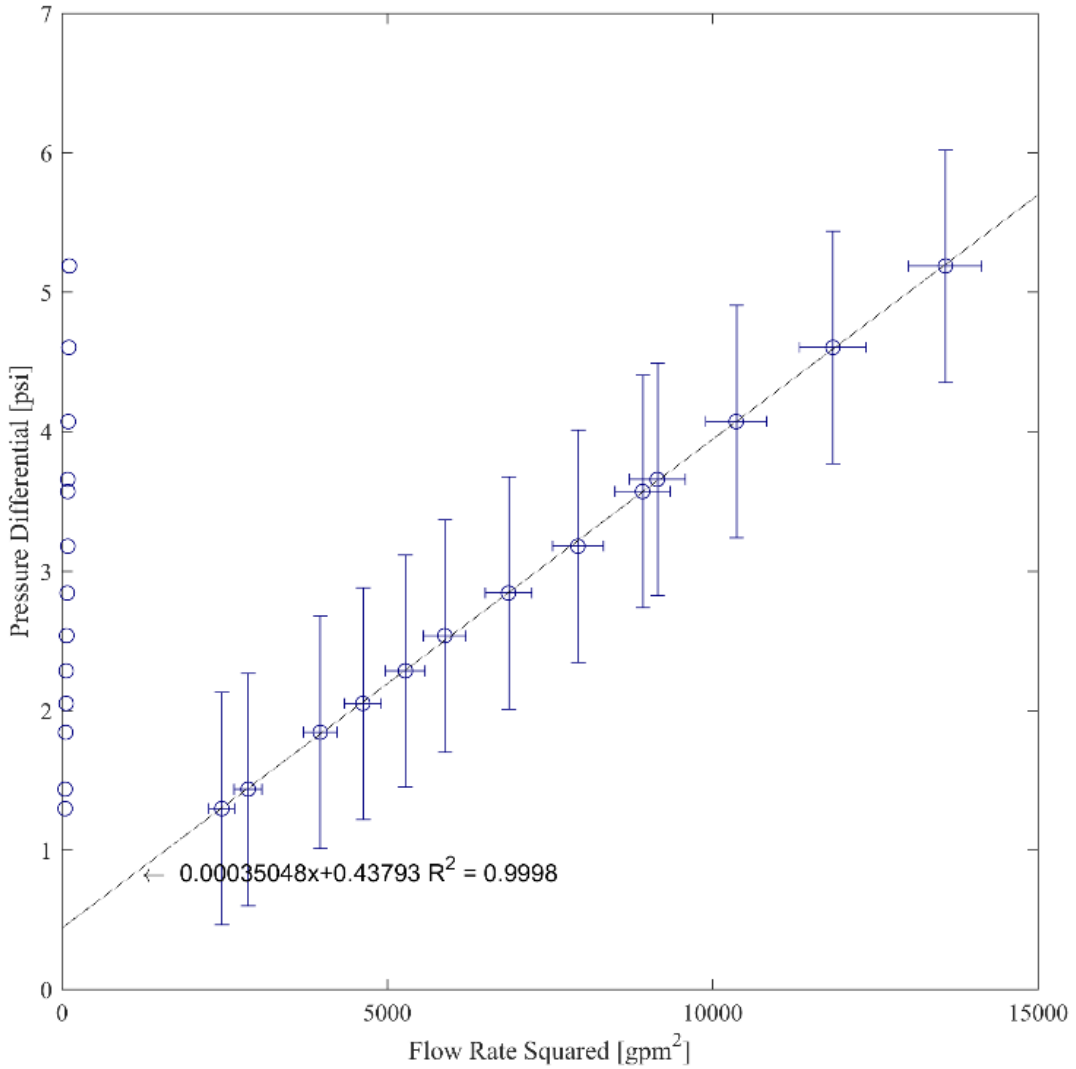

Results

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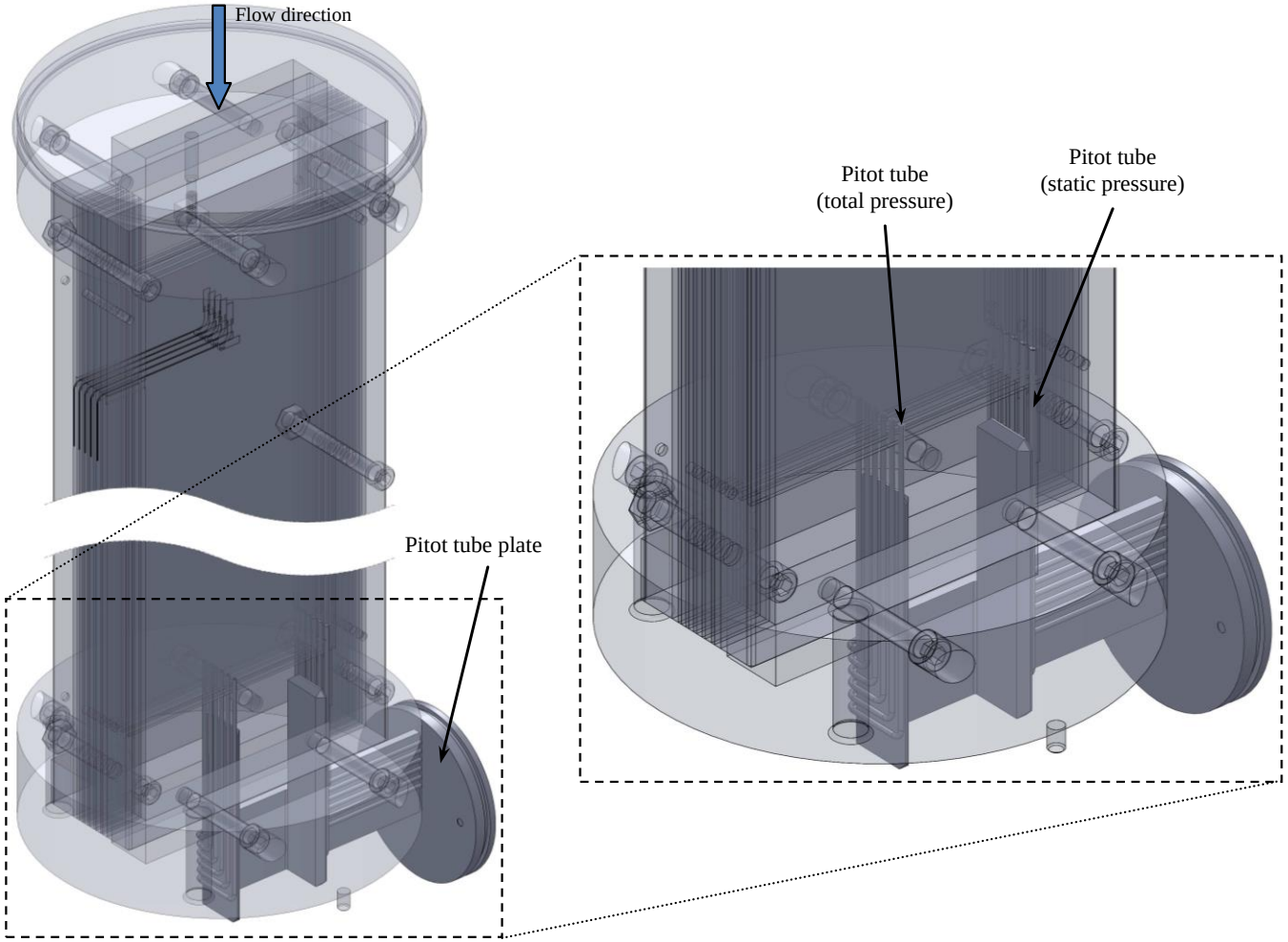

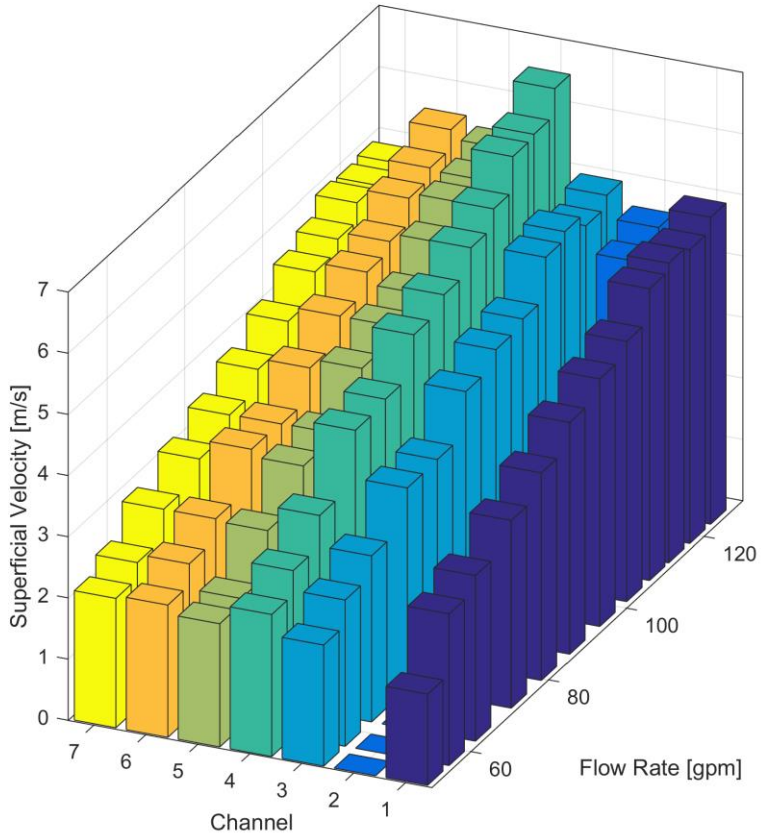

Results

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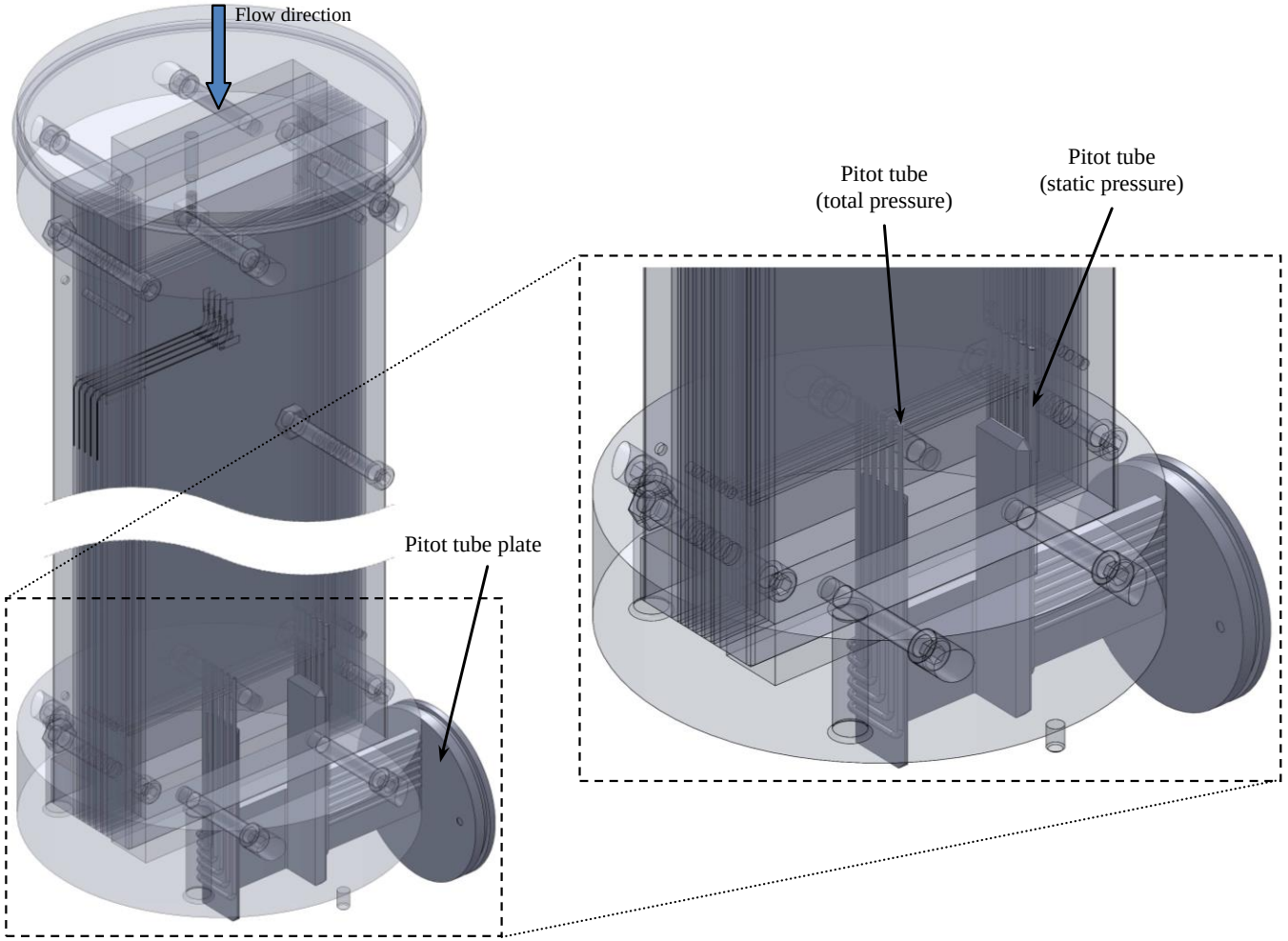
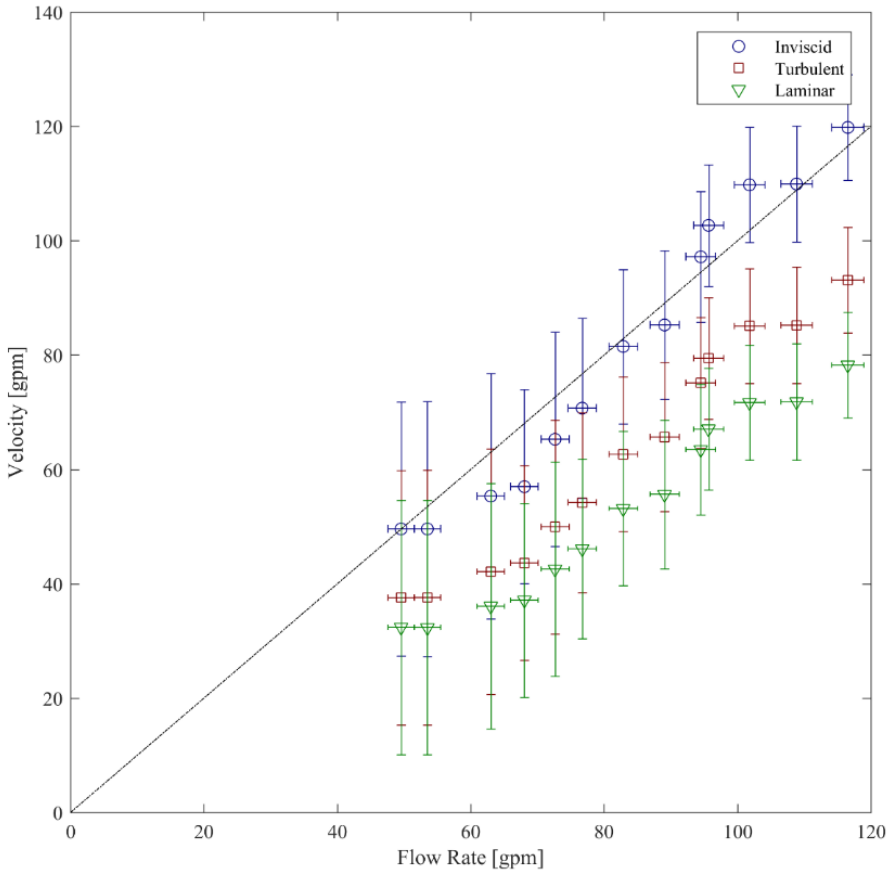
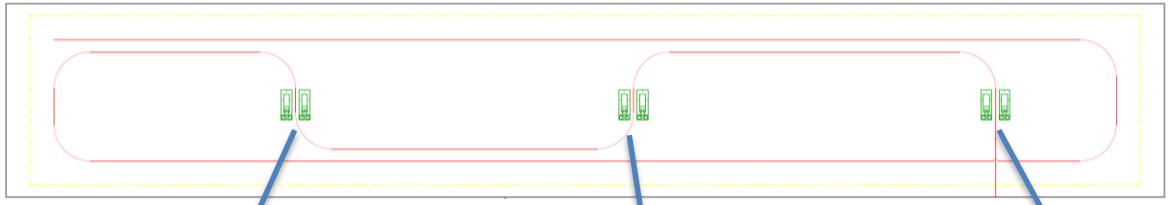




Results

Flow



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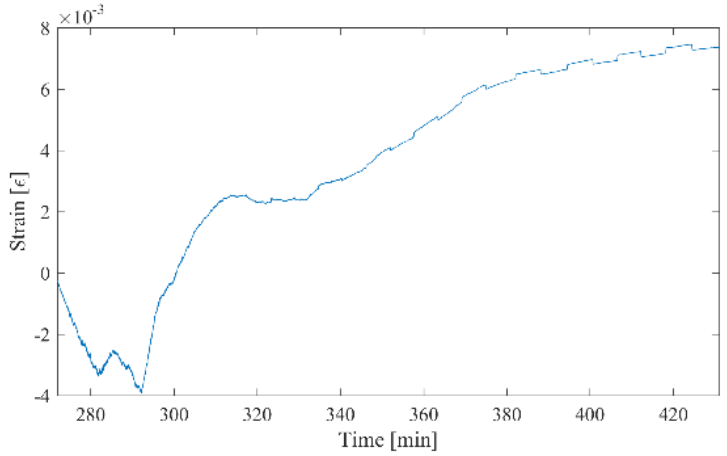
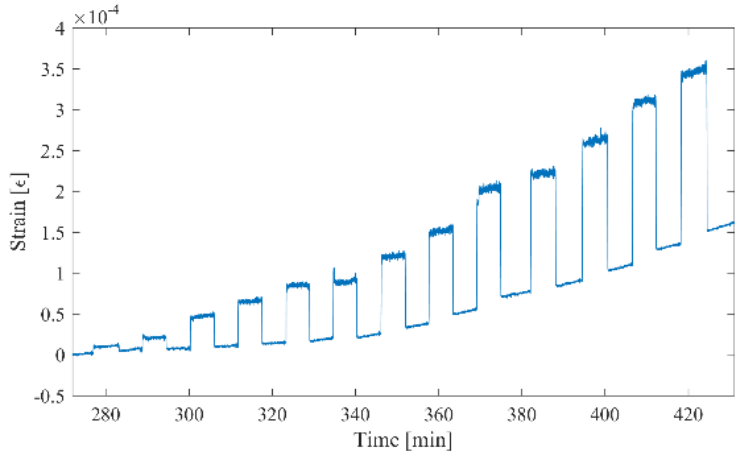
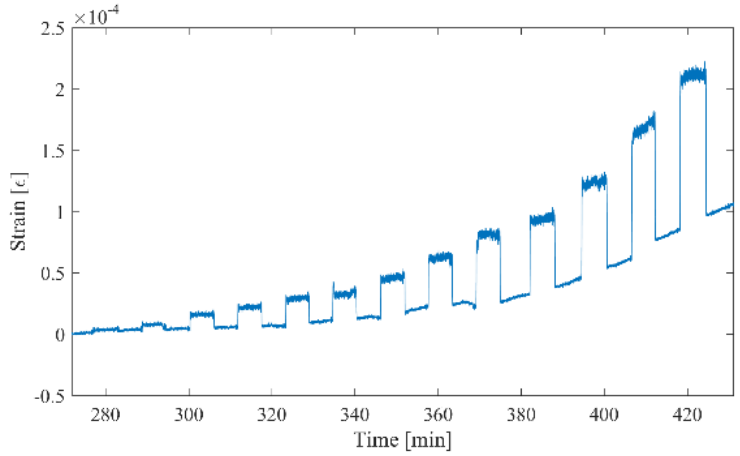
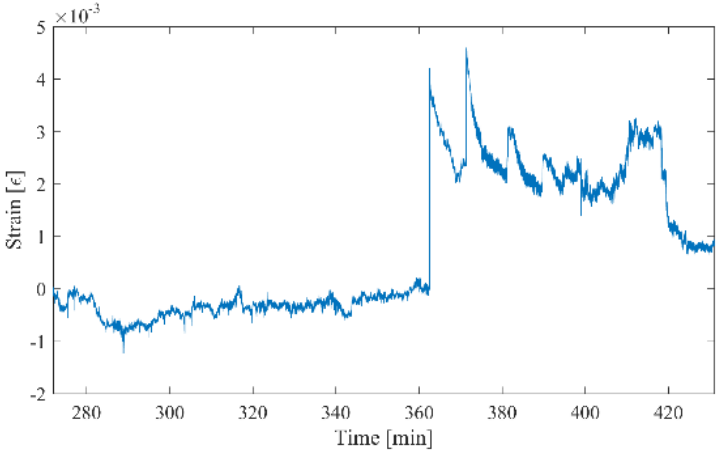
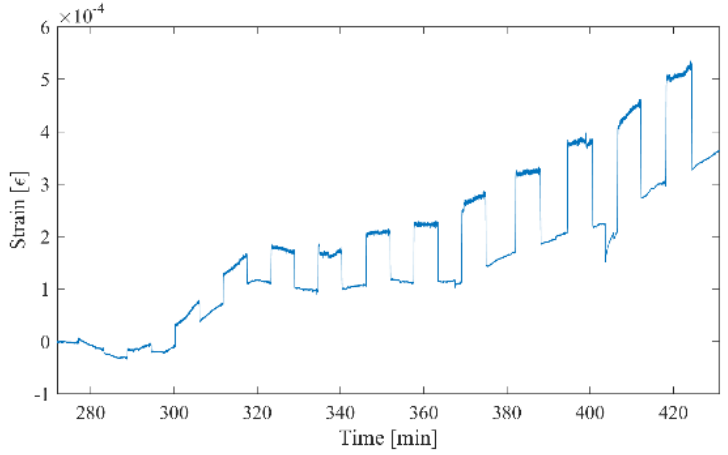
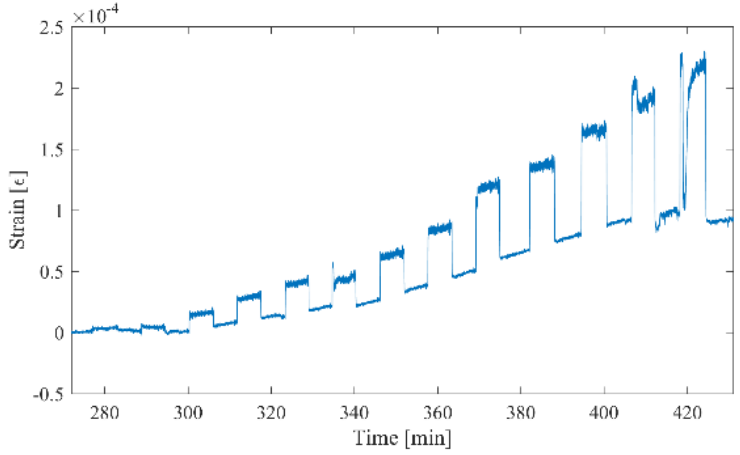






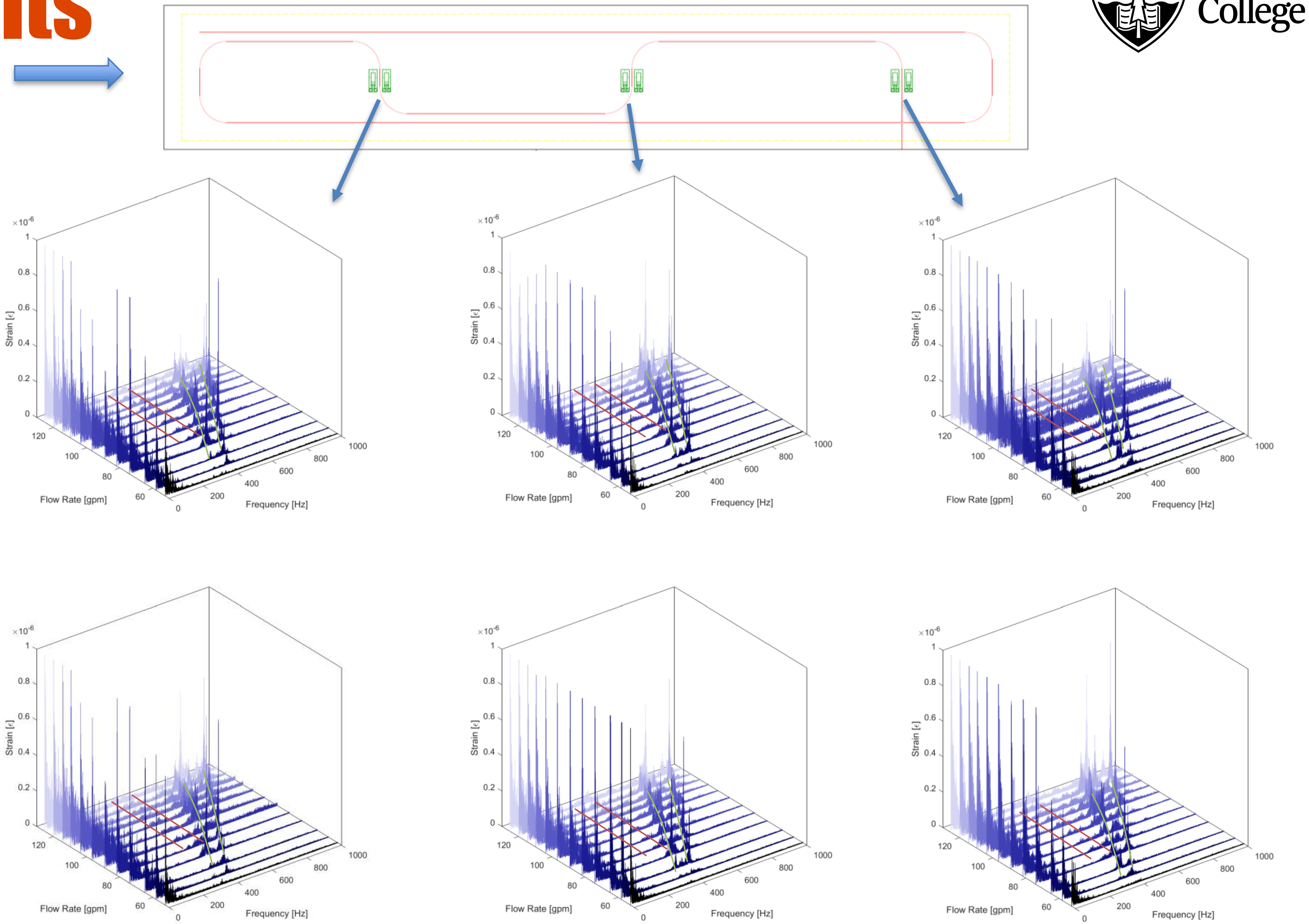






Results

Flow



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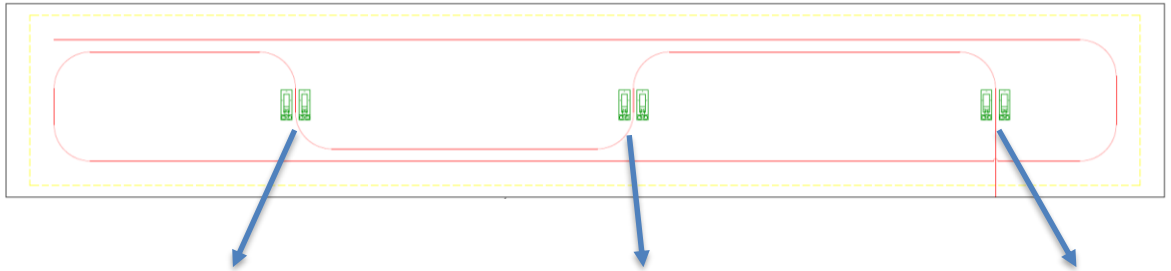
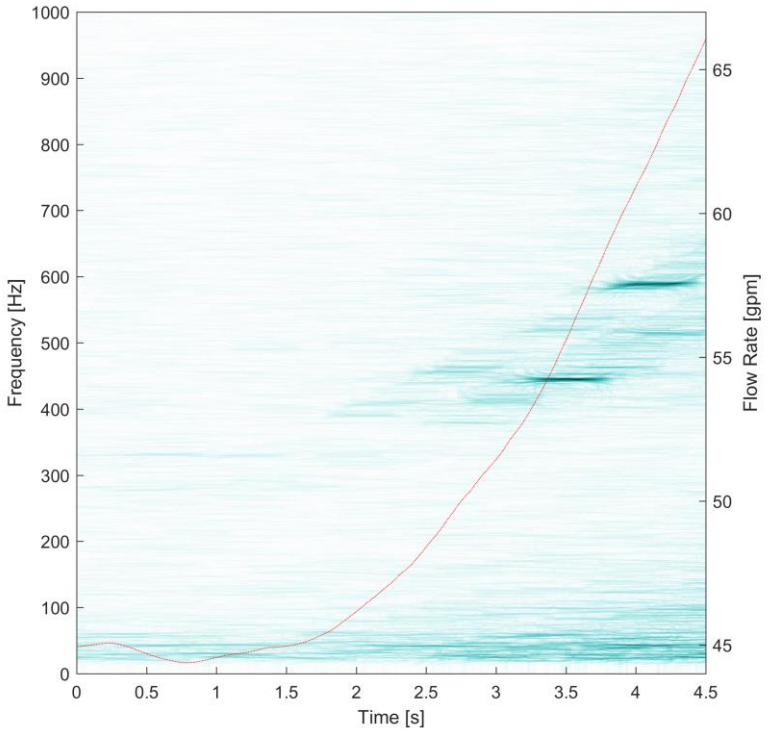
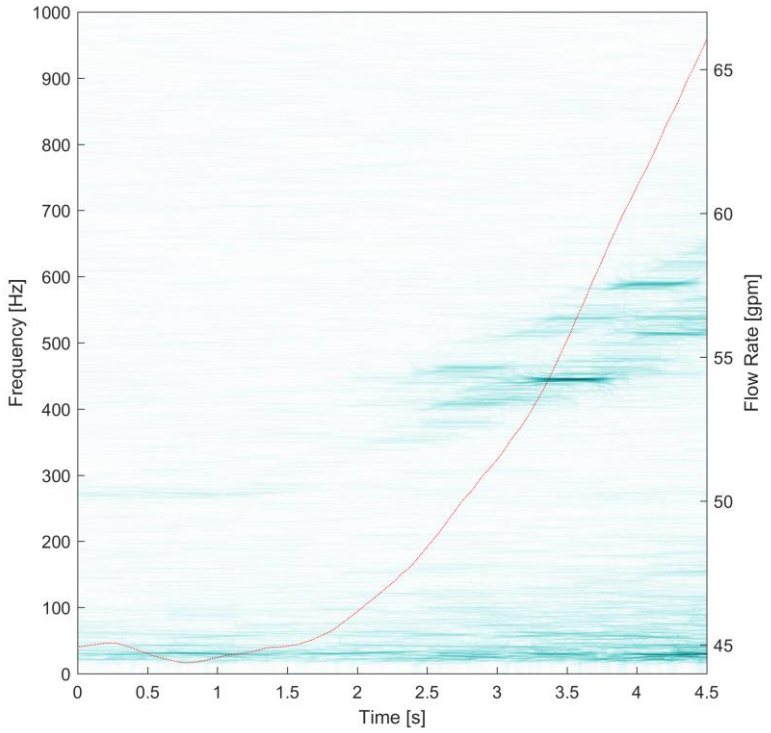
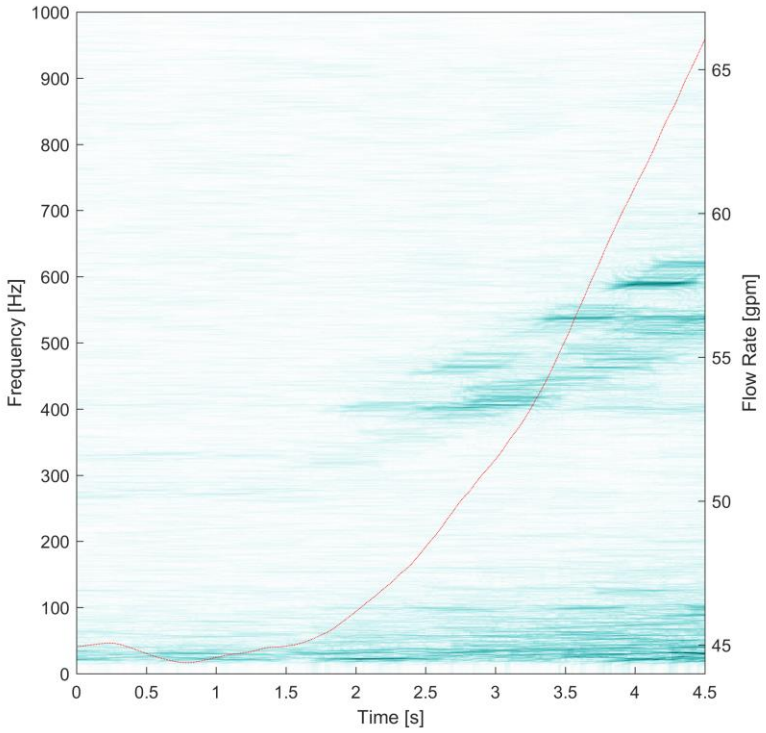
Results

Flow









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Conclusions

- As plates increase in aspect ratio from a square to long rectangular forms (such as those tested within this study), the most fundamental mode must produce provide the ability to absorb the largest quantity of kinetic energy burdened by the fluid domain, in the case of large aspect ratio plates this may result in the third, forth, or n-th mode shape in order to satisfy this criterion.

Conclusions

- The plastic deformation profile of a flat plate under hydraulic loading is not always consistent as may be initially hypothesized. The mechanical instability of thin plates and shells is highly susceptible to perturbations imposed by boundary conditions. In early tests it was observed that the ramp-rate from one flow rate to the next (or the varying of this ramp rate) may impact the deformation shape or the buckling mode that a plate undergoes as a result of the varying of the acoustic pressure imposed on the plate as that flow rate is increased.

Conclusions

- While it was initially hypothesized that plastic failure (static buckling) of a plate would occur before any dynamic failure (flutter, etc.) this hypothesize was disproven. When increasing flow rate, dynamic instability was found occur first, at flow rates where flutter was observed, often after a period of time the plate would self-stabilize and find a ‘new equilibrium geometry’, after further investigation previous researchers too had made these observations.

Thank You

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