

DTU



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Nordic Process Control Workshop 2026

Discrete-Continuous Dynamic Modeling of a Batch Process Flowsheet Using MATLAB Simulink and Stateflow

Motivation

Hybrid dynamics concept:

- Real systems combine continuous evolution with discrete events.

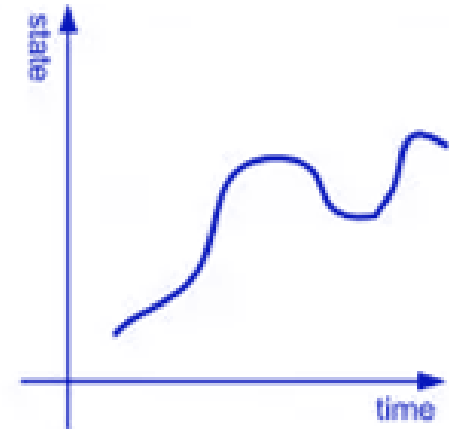
Challenges in modelling:

- Hybrid systems introduce discontinuities and state-dependent switching complication simulation and control.

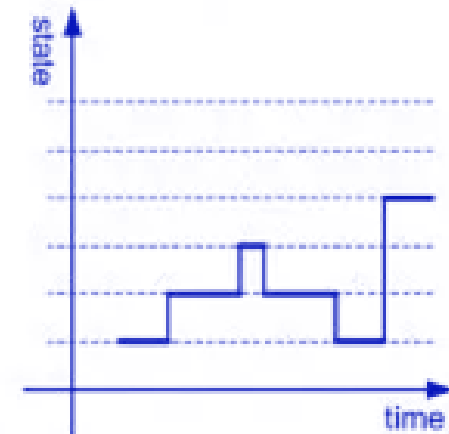
Modeling Approach

- Tools such as MATLAB Simulink combined with the Stateflow toolbox provide a practical framework for representing hybrid systems.

Continuous dynamics



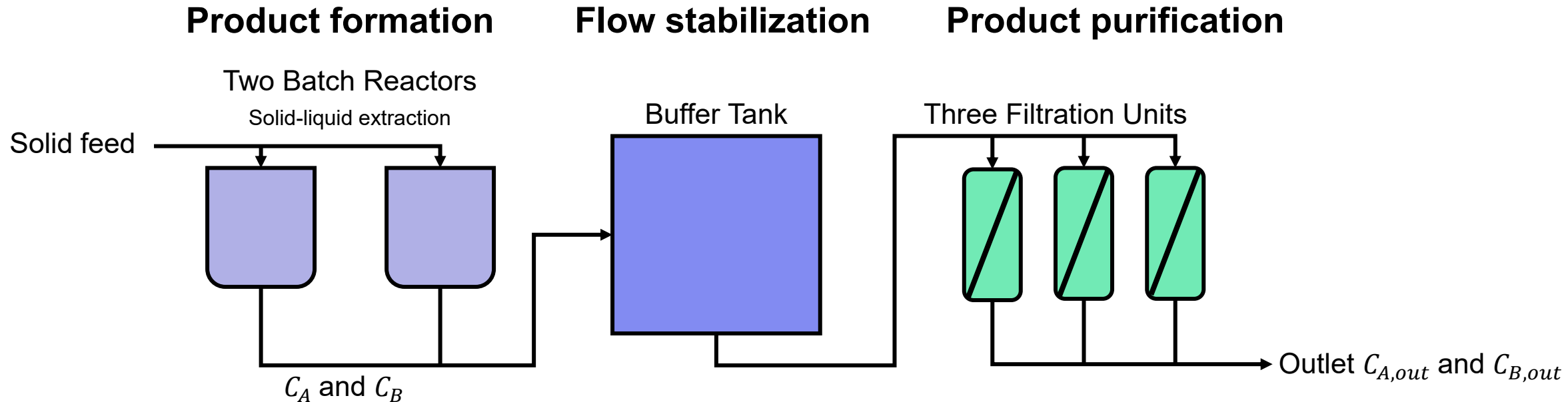
Discrete dynamics



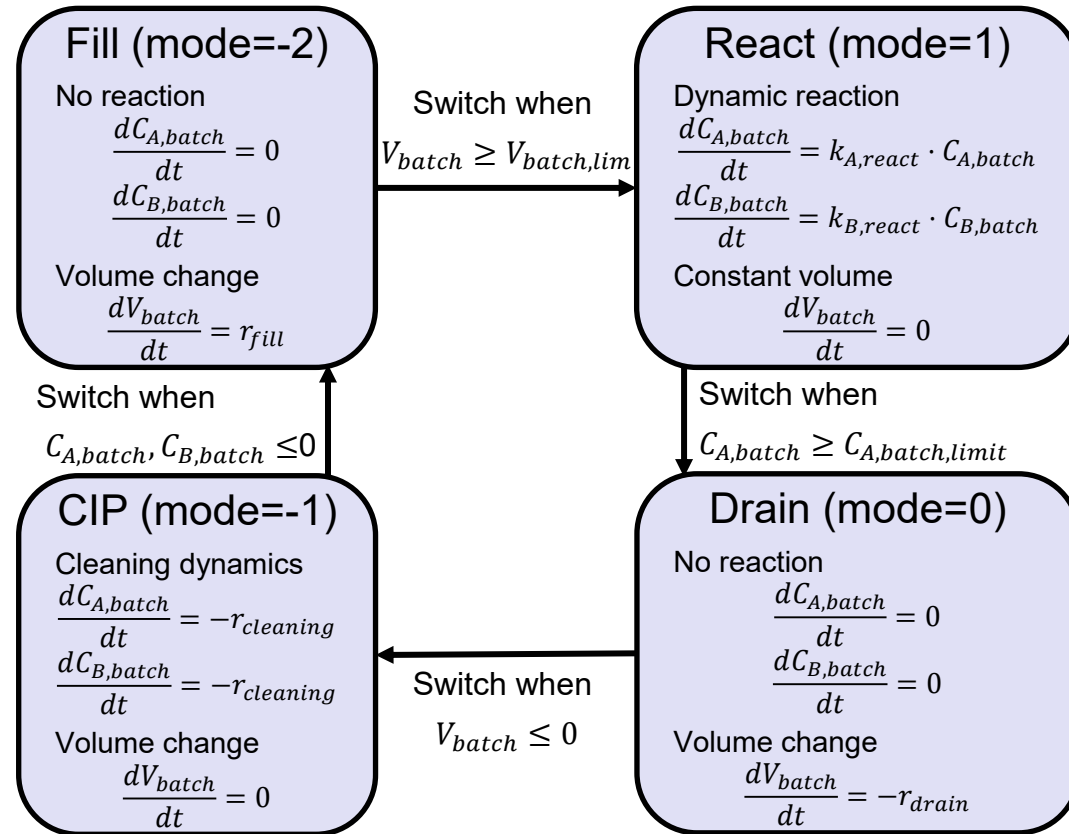
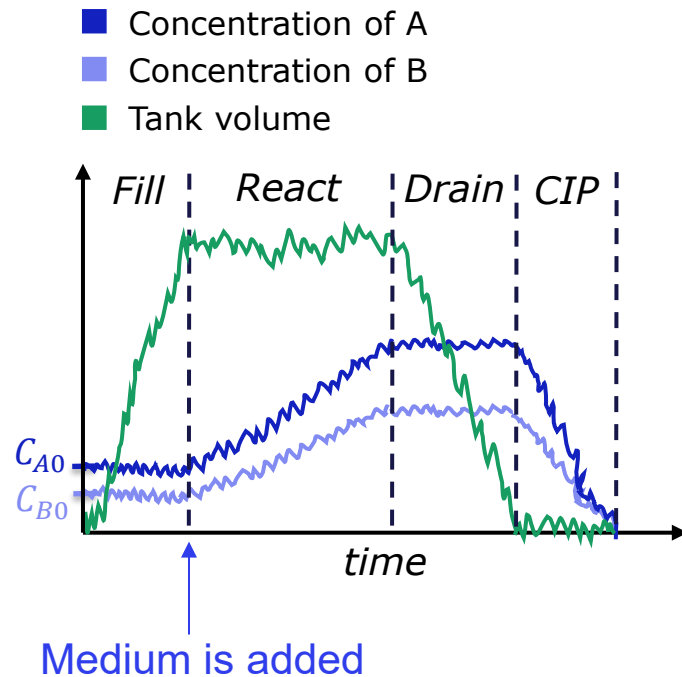
Generic flowsheet

Product A

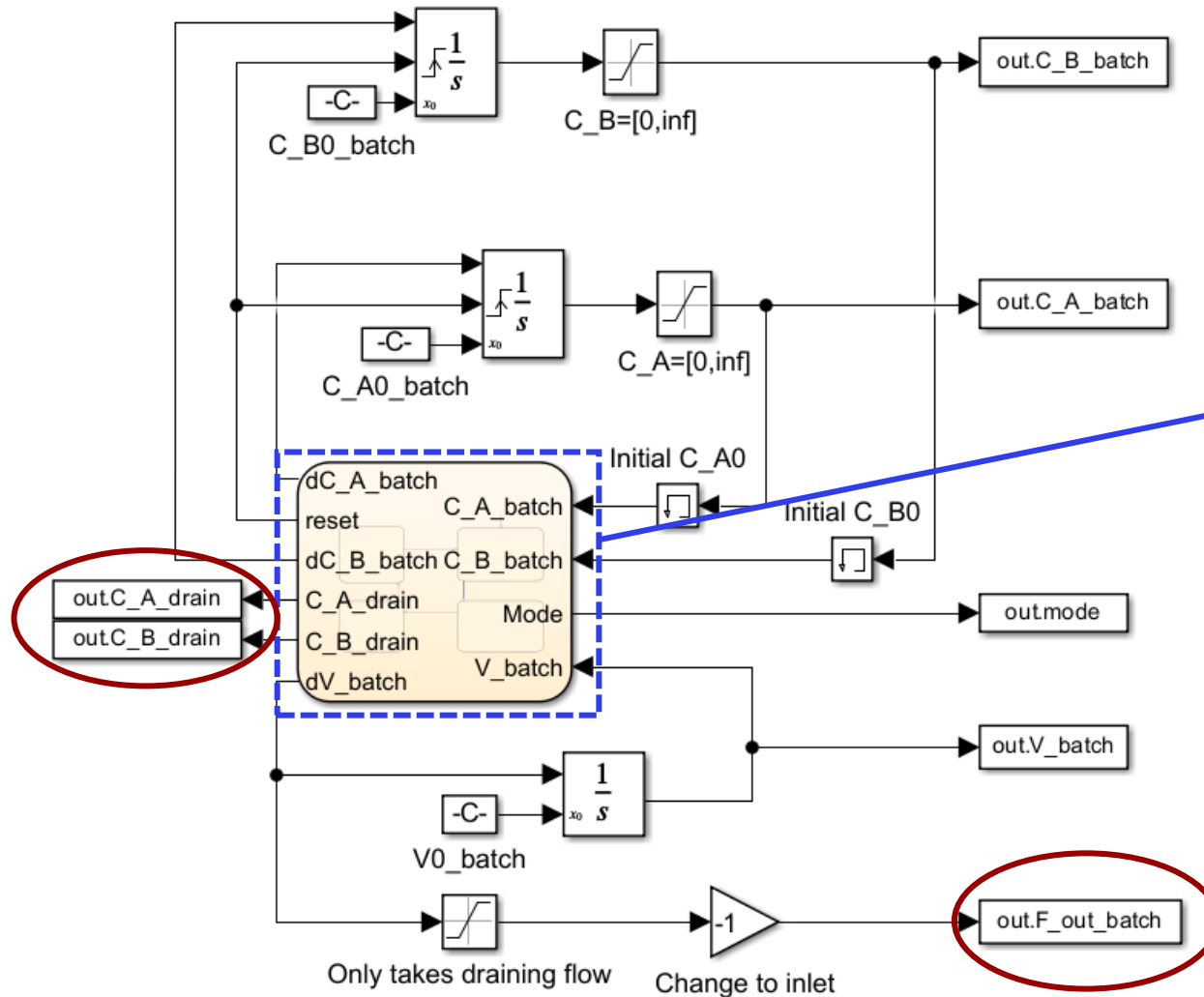
Suspended particles B



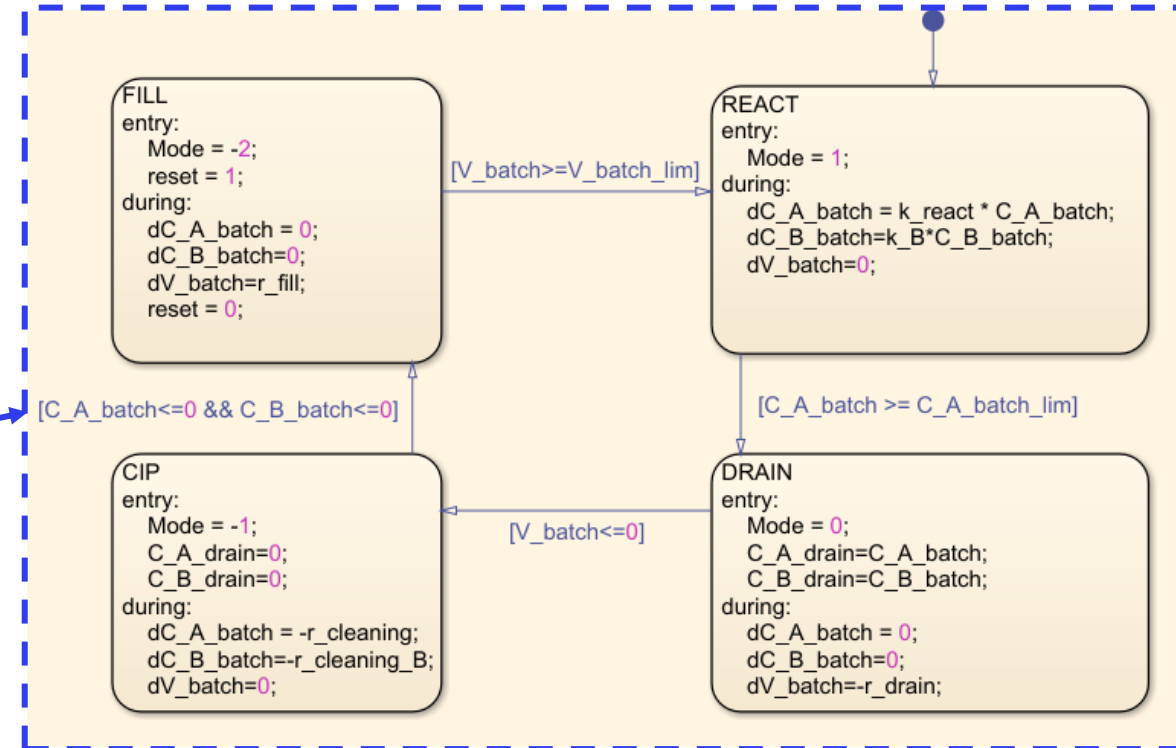
Batch reactor dynamics



Batch reactor in Simulink



Stateflow



Buffer tank dynamics

Simple continuous dynamics for a tank with **perfect mixing**:

Volume:
$$\frac{dV_{buf}}{dt} = F_{in,buf} - F_{out,buf}$$

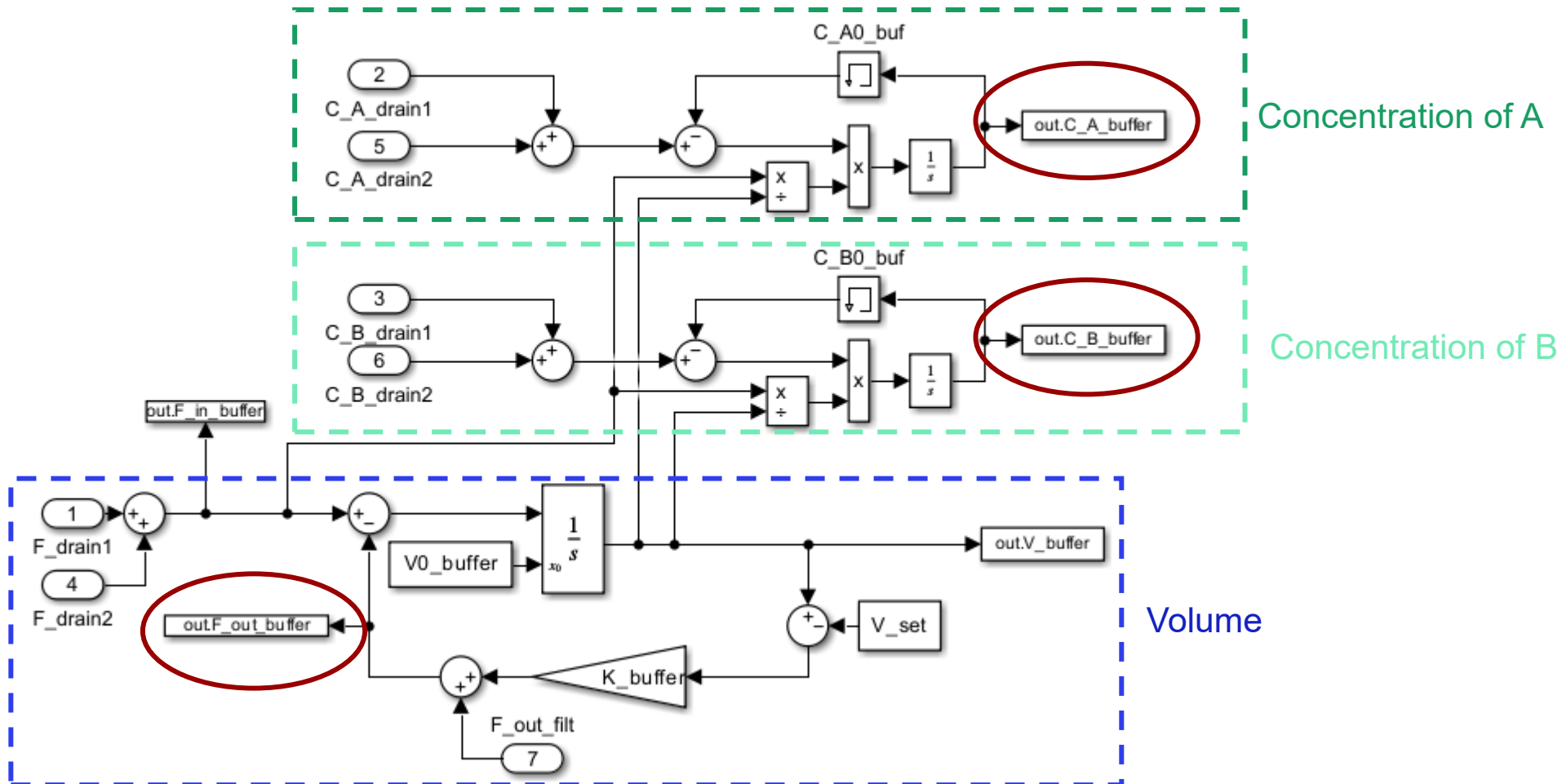
Product concentration:
$$\frac{dC_{A,buf}}{dt} = \frac{F_{in,buf}}{V_{buf}} \cdot (C_{A,batch,drain} - C_{A,buf})$$

Solids concentration:
$$\frac{dC_{B,buf}}{dt} = \frac{F_{in,buf}}{V_{buf}} \cdot (C_{B,batch,drain} - C_{B,buf})$$

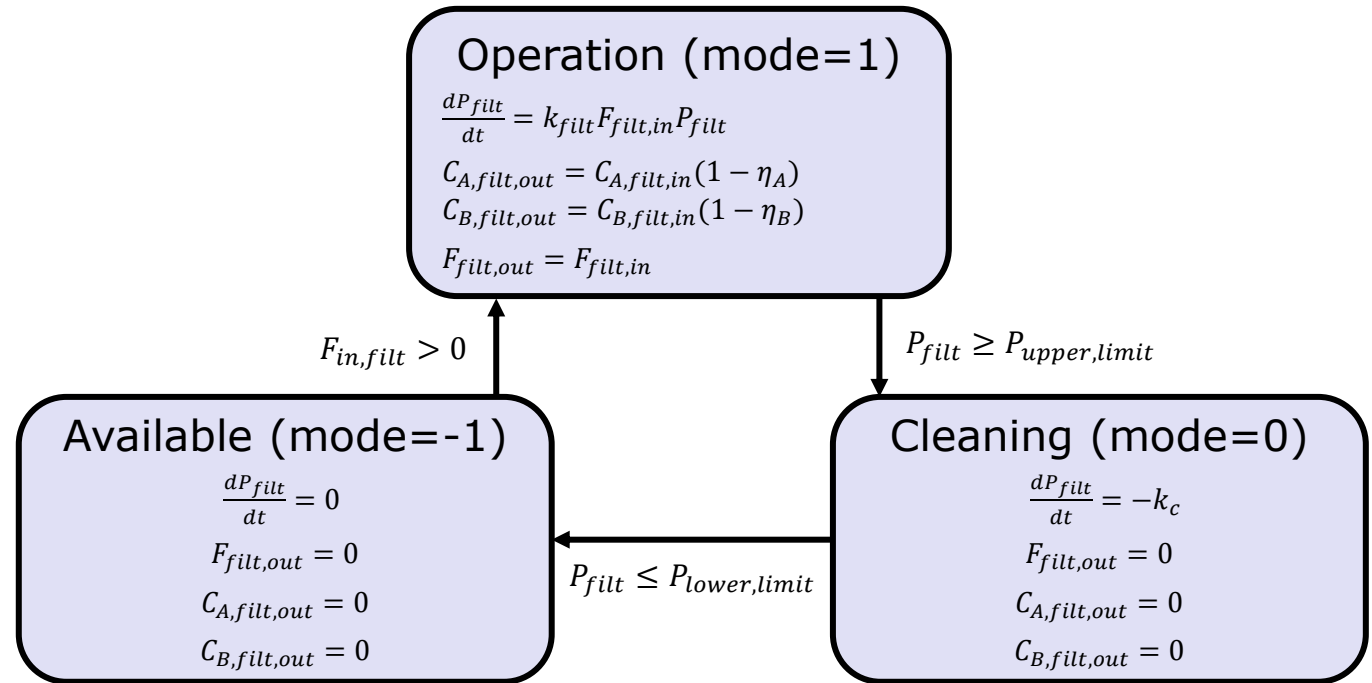
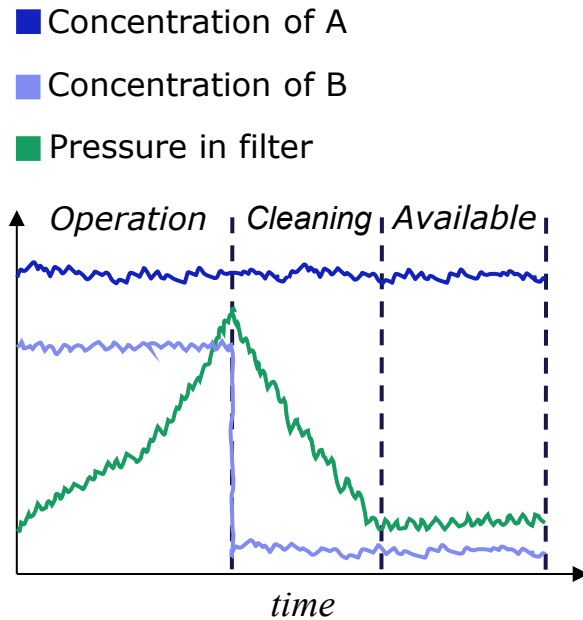
Control of volume:
$$F_{out,buf}(t + \Delta t) = F_{out,buf}(t) + K_{buffer} \cdot (V_{buf}(t) - V_{set\ point})$$

Proportional control

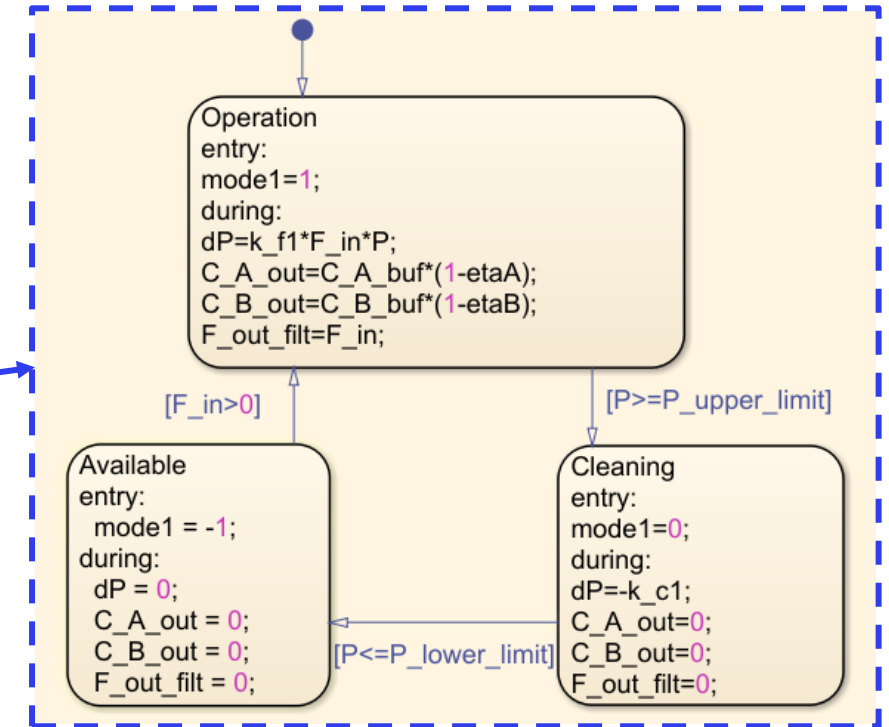
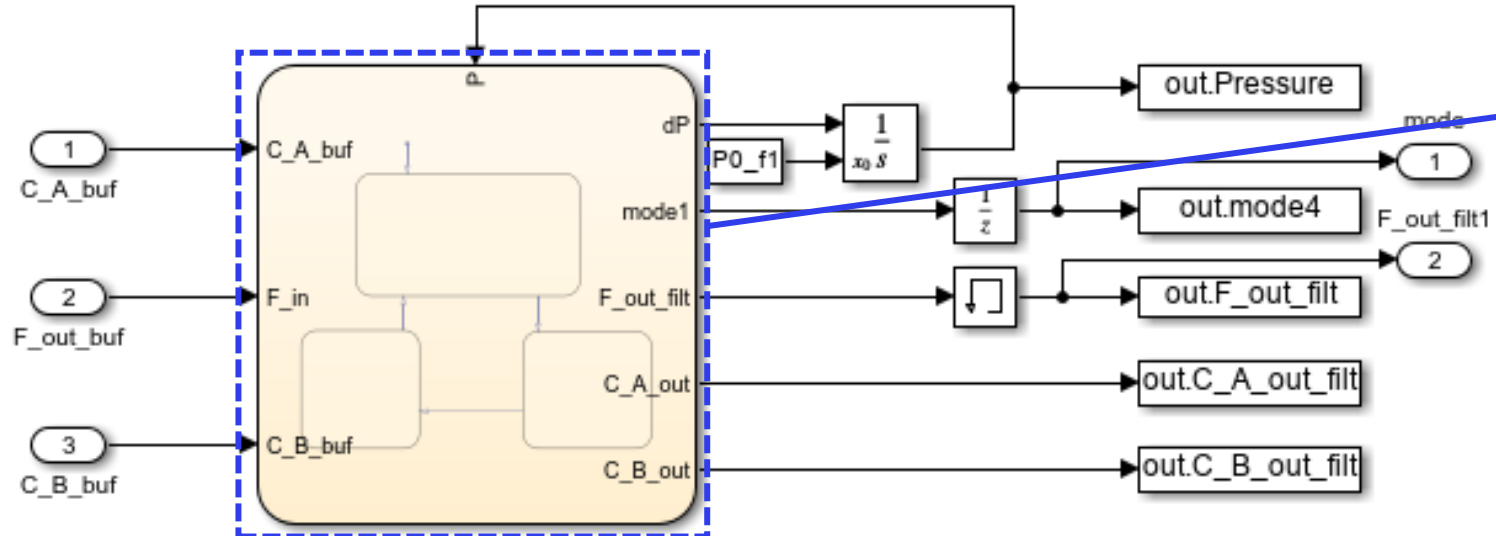
Buffer tank in Simulink



Filtration unit dynamics

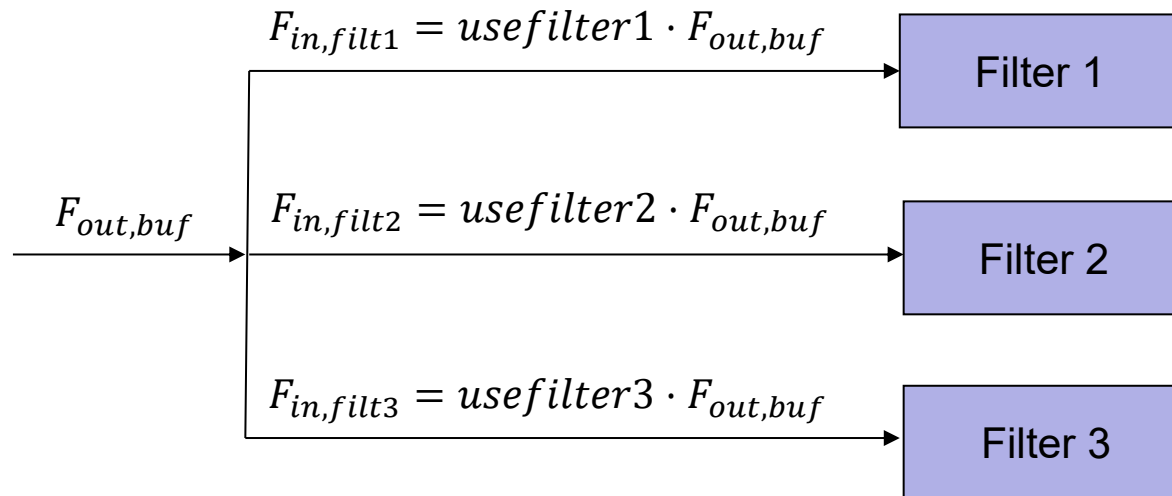


Filtration unit in Simulink



Supervisor state controlling the active filters

Assumption: Two filters operate simultaneously while one cleans



Cleaning filter 1

$usefilter1 = 0$
$usefilter2 = a$
$usefilter3 = 1 - a$

Cleaning filter 2

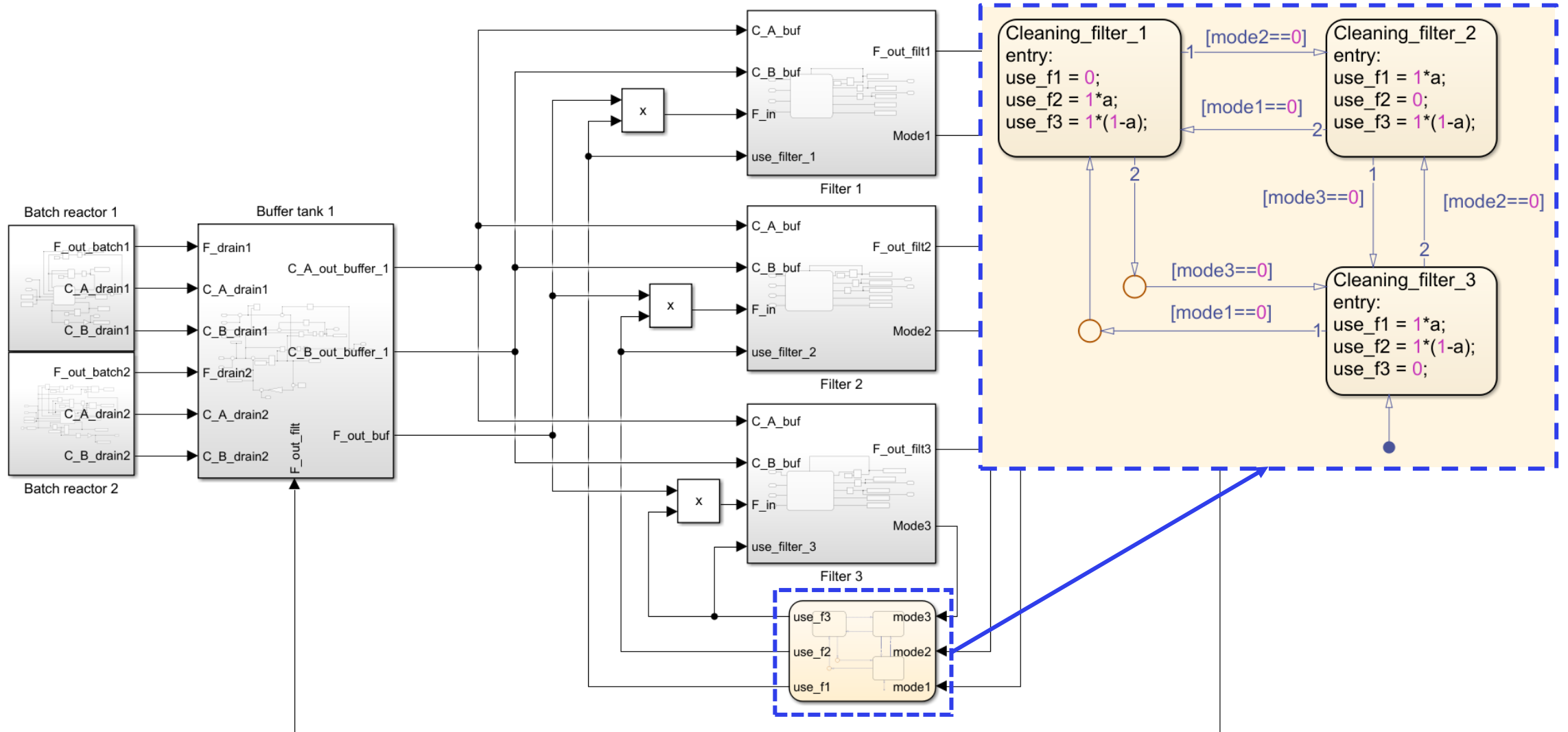
$usefilter1 = a$
$usefilter2 = 0$
$usefilter3 = 1 - a$

Cleaning filter 3

$usefilter1 = a$
$usefilter2 = 1 - a$
$usefilter3 = 0$

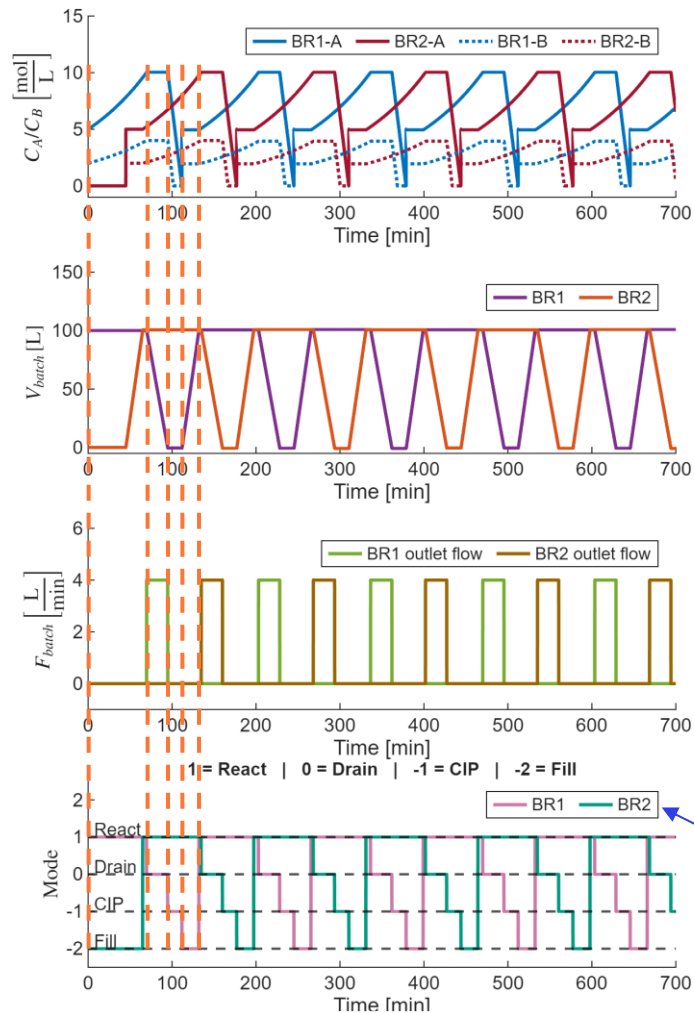
Makes sure 100% of $F_{out,buf}$ is divided between the operating filters

Full flowsheet



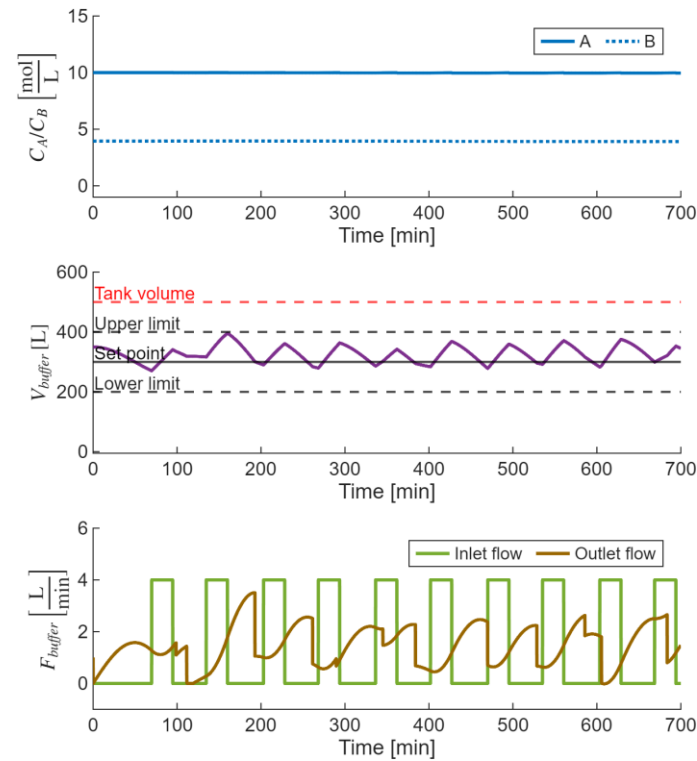
Simulation results

Two batch reactors running off-set



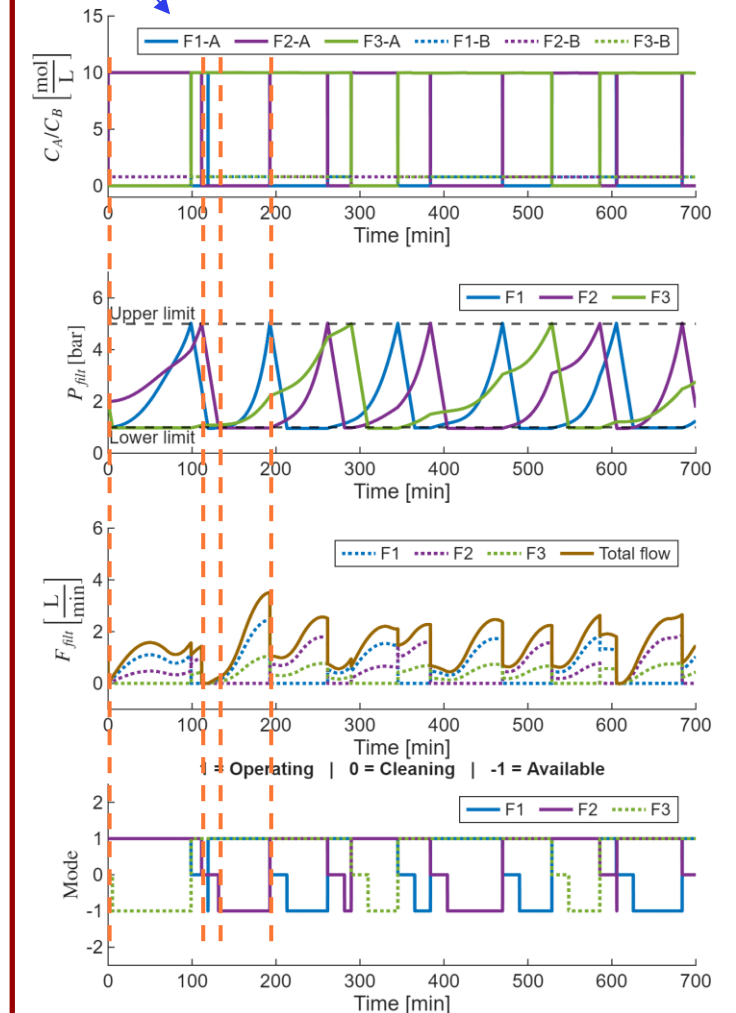
BR=Batch reactor

Buffer tank



F=Filter

Three filtration units

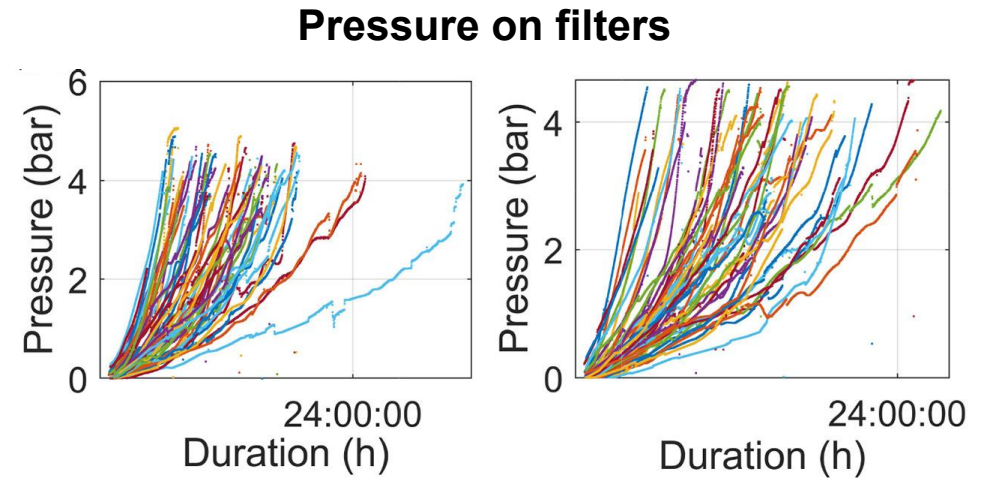


Conclusions

- Full flowsheet implemented in a single simulation environment
- Continuous and discrete process behavior successfully integrated

Outlook

- More realistic dynamics
 - Parameter values
 - Feed concentration effects
 - Constant flow through filters



**Thank you for you
attention!**