Mess- und Regelungstechnik
Univ.-Prof. Dr.-Ing. Andreas Kroll

Master Thesis

Application of Model Predictive Control for Stiff Systems in the Process Island 2 of the muPlant

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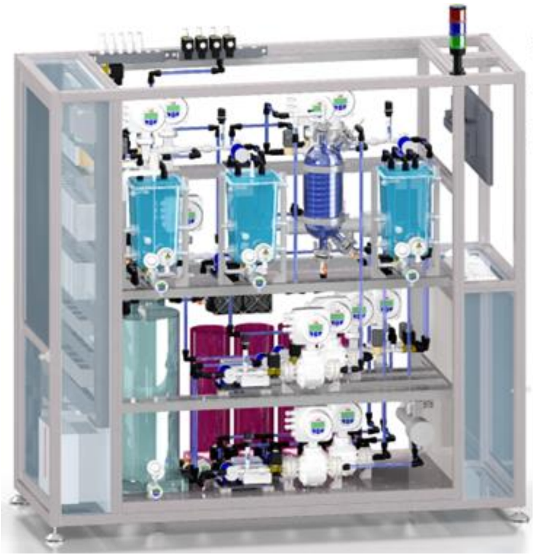

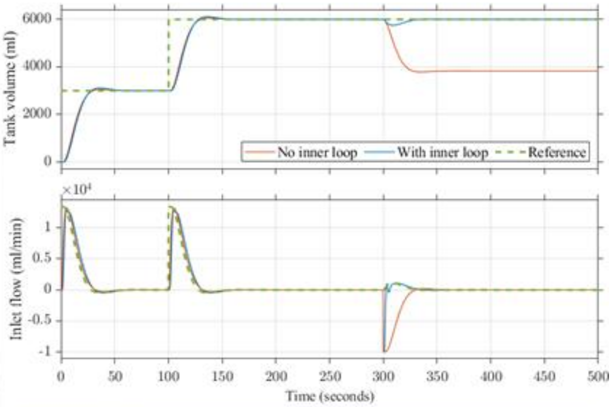

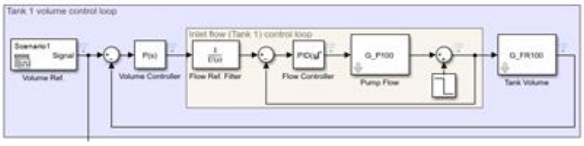

Stiff or multi-timescale systems are characterized by having components that change at vastly different rates, due to the great disparity between the time constants of the individual transmission links. Consequently, the overall system evolves not on a single, but rather on multiple time scales [1]. One of the fundamental issues is the presence of widely separated clusters of eigenvalues, leading to system matrices that are ill-conditioned, which are sensitive to numerical errors and can end in poor controller performance or even instability [2], [3].

Model predictive control (MPC) is a popular control strategy due to its ability to predict future behavior and handle constraints, like actuator saturation, physical or safety limitations [4]. However, model-based control becomes difficult when the model or its inverse is ill-conditioned [2]. Furthermore, the presence of multiple timescales usually ensues prediction horizons with a big number of timesteps, increasing the computational demands during real-time operation. All this makes the implementation of MPC for stiff systems challenging [5].

Multi-level control strategies allow to manage systems that operate on multiple timescales [6], but can struggle in ensuring all constraints are satisfied, and the decoupling of decision-making can result in suboptimal solutions [7]. To address these issues, some works propose single-layer MPC strategies with non-uniform prediction horizon to handle the timescale multiplicity [5], [7] or use multi-timescale models in the MPC [2].

In this work, an existing single-layer MPC strategy for stiff systems is to be researched and used to control the various flow rates, tank levels and tank temperatures in the Process Island 2 of the muPlant at the department.

This work includes the following tasks:

- Familiarization with the topic and report problems in past works.
- Choose, implement and document operation modes in the facility to be addressed in this work.
- Identification of models for the flow rates, level and temperature of the tanks.
- Research about MPC methods for stiff systems.
- Implementation, test and fine tuning of a chosen MPC method via model simulation.
- Implementation of the fine-tuned MPC in the facility and evaluation of the results.
- Documentation of the work and colloquium presentation.

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Duration: October 2024 – March 2025

Literature:

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