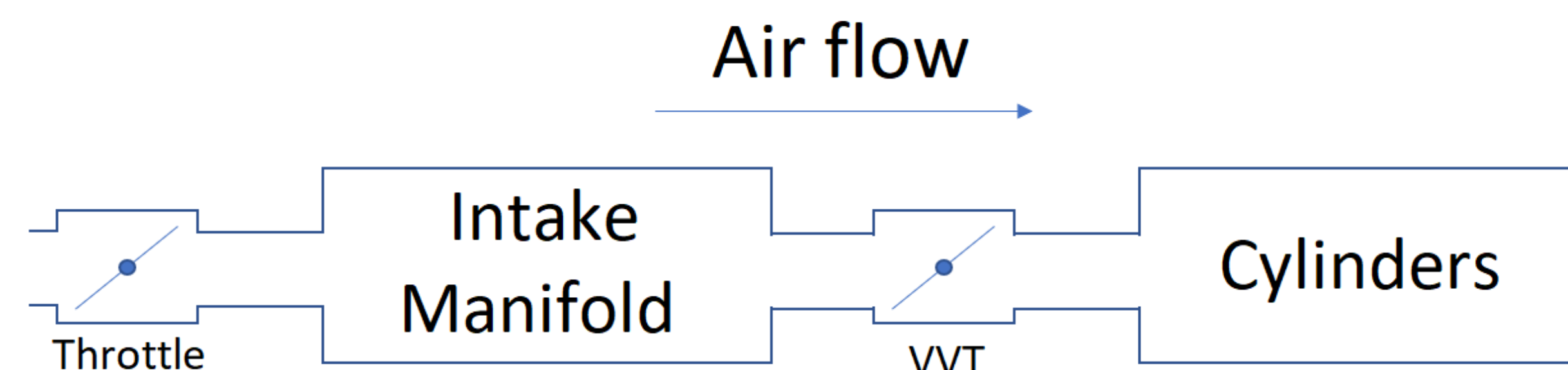


Multivariable engine control

Robin Holmbom

Background

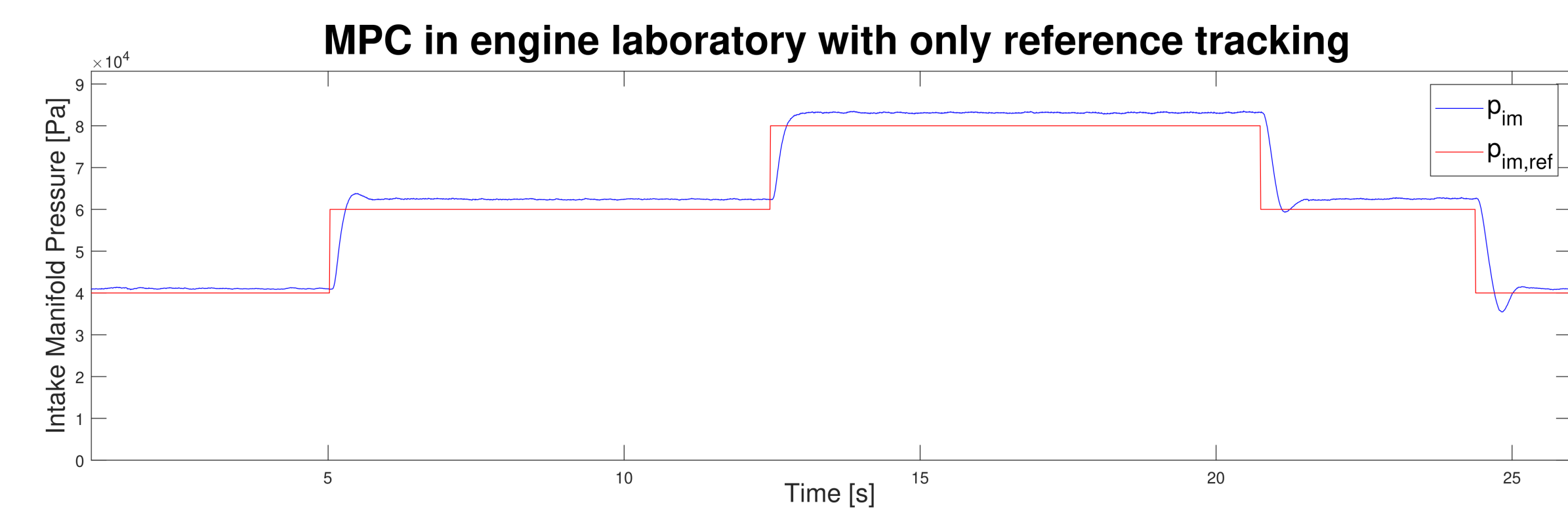


The Figure above show two actuators that affect the air flow in an SI Engine, the throttle and Variable Valve Timing, (VVT). An often used strategy in engine control is to create decoupled SISO systems with the help of look-up tables. The VVT and throttle is no different, a common strategy is to let the throttle control the intake manifold pressure, and the VVT is controlled to predefined actuator positions to reach a certain objective, eg. fuel efficiency. These predefined positions are determined for different engine speeds, intake pressures, etc. However, cross-coupling can cause unwanted behaviour during transients, which then is handled via extensive calibration. The ongoing work is to use Model Predictive Control, (MPC), to handle these types of problems and also demonstrate it in our engine test cell.

Ongoing work

✖ Student Projects

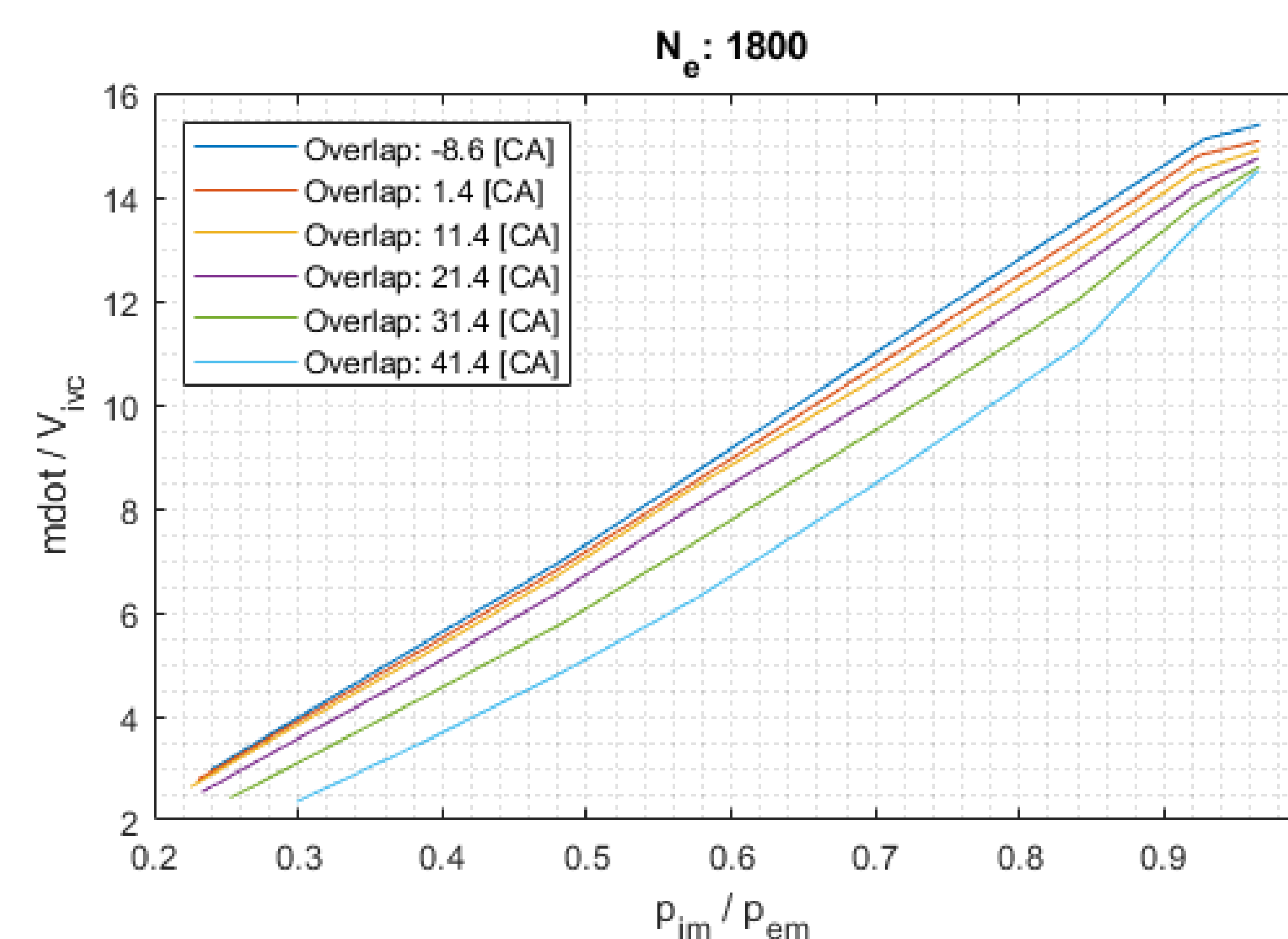
For the third year, a project in the course: Automatic Control - Project Course, TSRT10, a MPC project involving engine control is offered. The Figure at the top middle is from [2] and show a real-time MPC running in our engine test cell by the student project last year. It controlled the intake manifold pressure by actuating the throttle.



However, in this implementation it does not handle model errors which results in steady-state error. This year's student project involves handling these model errors and also the implementation of controlling the VVT actuator as well.

✖ Mass Flow Modelling of Variable Valve Timing

Parallel to the student project this autumn my research is centred around the development of a mass flow model for the intake valves. The model's goal is supposed to be of a complexity that works with real-time MPC. This work is right now being summarized in a paper that is going to be sent in for review in the upcoming weeks.



In the Figure above the mass flow is seen to be affected by the overlap created by the phase shift of the inlet cam shaft.

Where a large pressure difference between intake and exhaust manifold results in more back flow of residual gases.

Future

Investigate and demonstrate the possibilities multivariable control design offers. By

- ✖ Demonstration of a multivariable MPC controller in engine test cell using throttle and VVT as actuators.
- ✖ Investigation of different control formulations for different strategies: fuel efficiency, performance, etc.
- ✖ Investigation of the possibilities to fulfill constraints.
- ✖ Demonstration of the integration of more actuators, for example exhaust cam actuation, and turbo control.

Student Project Homepages

- [1] *Multi Variable Control of Combustion Engine*, Student Project 2018
http://www.isy.liu.se/edu/projekt/tsrt10/2018/engine_ctrl/
Accessed: 2020-10-30
- [2] *MPC for Real Time Engine Applications*, Student Project 2019
<http://www.isy.liu.se/edu/projekt/tsrt10/2019/volvo/>
Accessed: 2020-10-30