1 Control Design

1. Study the system (plant) to be controlled and obtain initial information about the control objectives
2. Model the system and simplify the model, if necessary
   (a) Identification of the input and output variables of the process
   (b) Identify the dependencies of each variable, starting with the output, until the system only depends on input variables
   (c) Identify the transmission behaviour between the signals
3. Scale the variables and analyze the resulting model; determine its properties
4. Decide which variables are to be controlled (controlled outputs)
5. Decide on the measurements and manipulated variables: what sensors and actuators will be used and where will they be placed?
6. Select the control configuration
7. Decide on the type of controller to be used
8. Decide on performance specifications, based on the overall control objectives
9. Design a controller
10. Analyze the resulting controlled system to see if the specifications are satisfied; and if they are not satisfied modify the specificiations or the type of controller
11. Simulate the resulting controlled system, either on a computer or a pilot plant
12. Repeat from step 2, if necessary
13. Choose hardware and software and implement the controller
14. Test and validate the control system, and tune the controller on-line, if necessary

2 Control Design - Application

2.1 Control Objectives

1. Engine has to output torque requested by driver. Integral over pressure trace depends on chosen boundaries: how to chose?

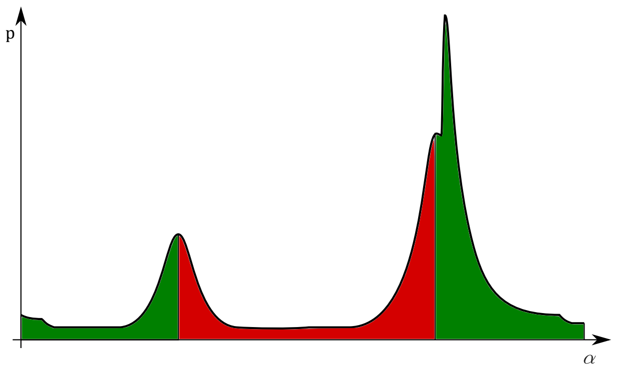

Figure 1: Control objective 1 - Output requested torque

Torque → IMEP via newton on piston

2. Minimal fuel consumption. Efficiency characterized by CA50

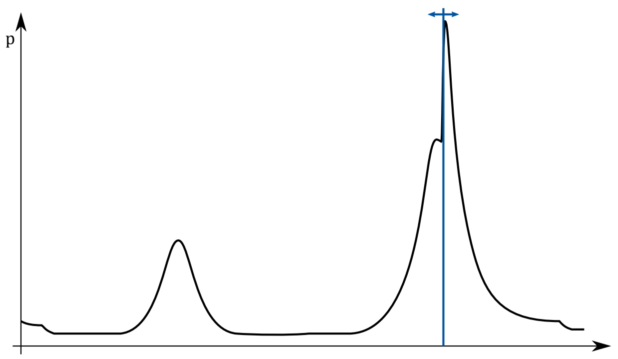

Figure 2: Control objective 2 - Output requested torque

Efficiency → CA50 via thermodynamic cycle analysis. Müsste eig. laut idealem Kreisprozess genau bei OT sein?

3. Product life cycle → Limit pressure rise gradient

4. Comfort → Limit pressure rise gradient
Comfort → ...

2.2 System Model

- Wie viele Speicher besitzt das modellierte System? Welche Ordnung hat die Zustandsraumdarstellung?
- Welche technischen Systeme können ausreichend genau durch eine Linearisierungen dargestellt werden? Warum?

2.3 Model Analysis

2.4 Controlled Outputs

2.5 Measured and Manipulated Variables

2.6 Control Configuration

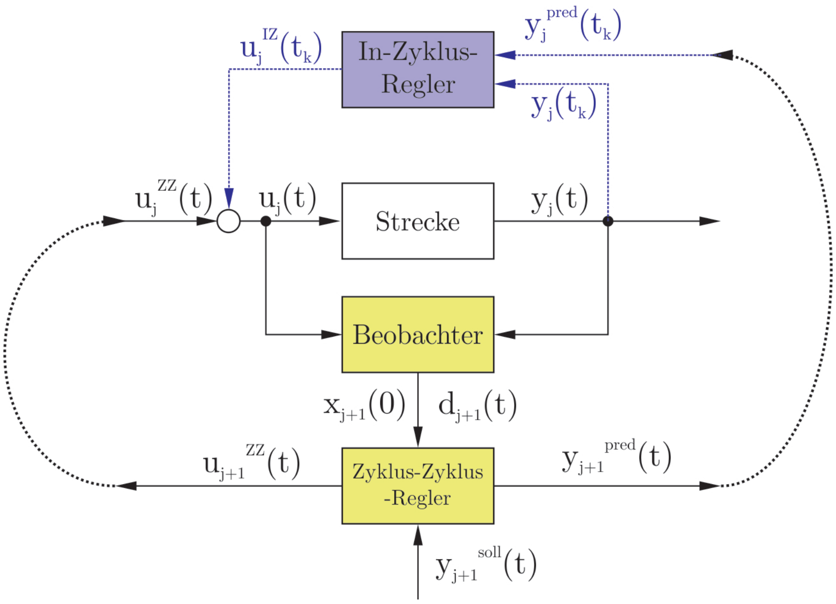

Figure 3: Control configuration - Multiscale Control

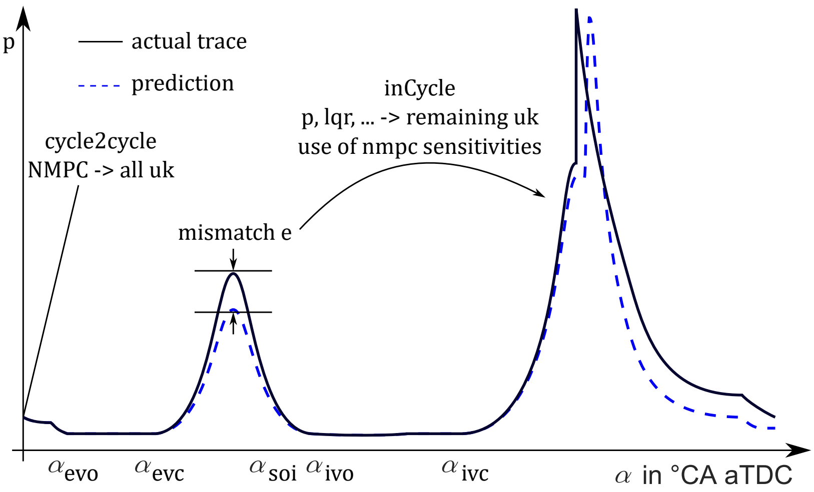

Figure 4: Control configuration - Multiscale Control

2.7 Controller Type

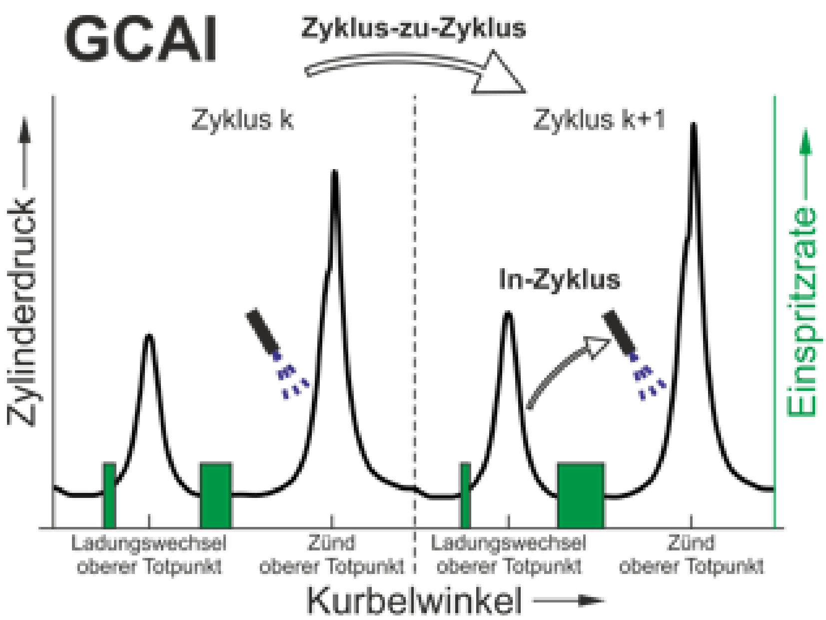

Figure 5: Control type - Multiscale Control

2.8 Performance Specification

Define test objective. As being part of research investigation usefulness unrealistic to set control goals.

2.9 Controller

Cycle-to-Cycle: NMPC

$$
\begin{align}
p_{pred}(\alpha) \tag{1}\\
\frac{\mathtt{d}}{\mathtt{d}water} CA50 \tag{2}\\
\frac{\mathtt{d}}{\mathtt{d}p_k} CA50 \tag{3}\\
\tag{4}
\end{align}
$$

In-Cycle: P

$$\Rightarrow u_p = k_P \cdot e \cdot sign(CA50_{p_k}) \cdot sign(CA50_{water}) \tag{5}$$

In-Cycle: LQR

$$\Rightarrow u_{lqr} = ... \tag{6}$$

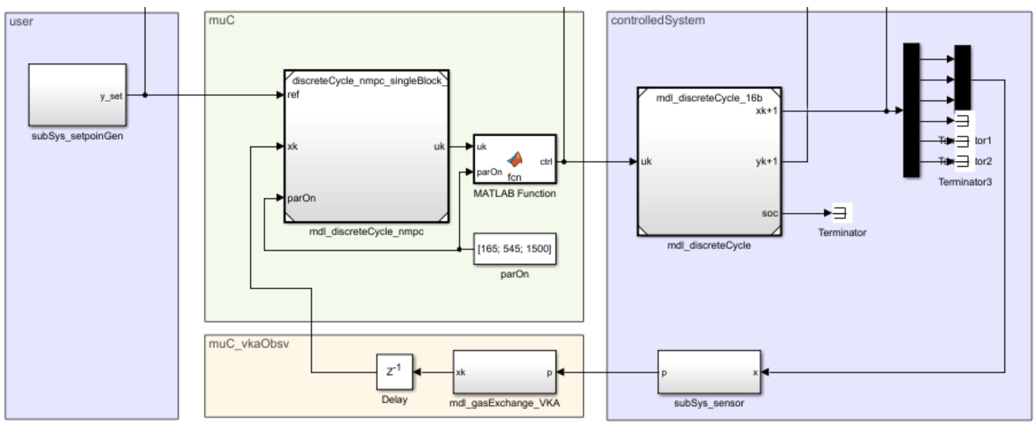

Figure 6: Developed Control - Multiscale