Part III

Simulation & Optimization Studies

Introduction

In this part the main achievements of this thesis are presented. They are the dynamic real-time substrate feed optimization scheme for biogas plants and the state estimation method, which is a necessary part of the former.

As the dynamic real-time substrate feed optimization scheme uses the biogas plant simulation model presented in Section 7.4 for prediction, it needs the state vector of the biogas plant in each control sampling time. Unfortunately most of the state vector components of this model cannot be or are not measured on full-scale biogas plants.[3] Therefore, the state estimator is needed, which estimates the state of the plant given past and present measurement data, see Section 4.1.

The developed dynamic real-time optimization scheme has a two-layer architecture (Adetola and Guay, 2010, Würth et al., 2011). The upper layer solves the optimization problem and proposes an optimal setpoint that the lower layer has to track. This structure has traditionally been used for economic optimization of chemical processes (Ellis and Christofides, 2014). Next to the two-layer architecture also an one-layer (De Souza et al., 2010) and a three-layer layout (Alves et al., 2010) are used for process optimization. The main advantage of the two-layer approach is that the real-time optimization problem and the setpoint tracking task can be solved in different time-scales. This allows to use very large models in the RTO and furthermore a two-layer architecture is more transparent for the plant operators, cf. Würth et al. (2011). A disadvantage of the two-layer approach is that the upper and lower layer often do not use the same model (here, the lower layer does not use a model at all) and therefore inconsistencies may arise (De Souza et al., 2010).

This third part of the thesis contains two chapters. In Chapter 8 estimation results of the state estimator developed in Chapter 4 applied to the simulation model out of Section 7.4 are presented.

In Chapter 9 numerous simulation and optimization experiments are performed for the dynamic RTO scheme. In these experiments the biogas plant model of Section 7.4 is optimally controlled. In some tests the state estimator from Chapter 8 is used. In all others an ideal state estimator is used instead.

[3] See Table 7.1 for the definition of the state vector of the ADM1.