387b Parameter Estimation and Output Feedback Nonlinear Model Predictive Control of an Industrial Batch Polymerization System

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Nowadays chemical and related processing industries are faced with the need of increasingly precise control of product properties to meet specific demands. It is recognized that nonlinear model predictive control (NMPC) is an excellent candidate as a key enabling technology for the continued success of the chemical industries. However, NMPC has found successful application in a limited number of mainly academic example cases to date [1]. The main objective of the presented project is to fill the gap between the academic results and the industrial potential of NMPC, and to provide a balanced assessment of the advantages and difficulties related to the implementation of this control strategy in an industrial framework. Of particular interest will be on finite time processes since they play a significant role in the production of most modern high-value added products [2,3], and represent specific control problems.

The presentation illustrates the benefits of nonlinear model predictive control for batch processes. The control challenges typical for finite-time processes are highlighted. The application of NMPC for the setpoint tracking and end-point property control of an industrial batch reactor is illustrated, with special emphasis related to challenges in the practical application. An industrially feasible batch NMPC approach is described, which can serve as a generic algorithm for the control of the class of non-isothermal batch processes. A real-time formulation of the NMPC that takes computational delay into account is described. Real-time feasibility of the on-line optimization problem from the NMPC is achieved using an efficient multiple shooting algorithm [4,5,6]. A user friendly software package is presented which can serve for the fast prototyping of NMPC algorithms in a typical industrial environment [7]. A two step approach is proposed to derive the control relevant model used in the NMPC from the complex first principles model. The reduced model is fitted to the experimental data from the real plant using maximum likelihood estimation. A comparison between using moving horizon estimation and parameter adaptive extended Kalman filter (PAEKF) for state estimation and on-line model adaptation is presented. A practical approach is proposed for tuning the estimator, based on the parameter uncertainty description resulted from the model identification. The performance of the NMPC implementation is assessed via simulation and experimental results in the case of an industrial batch polymerization system.

References

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