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Advanced Model Based Control of Chemical Systems

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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. The talk will present several exemplary applications of NMPC technologies applied for complex chemical processes, with special focus on fine and pharmaceutical systems, that exhibit challenging control problems due to process nonlinearity and strong interactions and where the application of advanced control technologies can bring significant economic benefits with increased product quality and process operability. An evaluation study of the implementation of a nonlinear model predictive control strategy for the temperature setpoint tracking of a pilot-scale industrial batch polymerization reactor will be described as an illustrative example of the benefits that advanced control technologies can bring in an industrial environment. The study was performed in collaboration with BASF and ABB, Germany. In the NMPC implementation real-time feasibility of the on-line optimization problem is achieved using an efficient multiple shooting algorithm. A real-time formulation of the NMPC that takes computational delay into account will be presented. The control relevant model for the NMPC is derived from the complex first principles model and is fitted to the experimental data using maximum likelihood estimation. A parameter adaptive extended Kalman filter (PAEKF) is used for state estimation and on-line model adaptation. The performance of the NMPC implementation is assessed via simulation and experimental results, in comparison to cascade PID and linear MPC. A second example that illustrates the use of NMPC technology in continuous pharmaceutical crystallization processes will also be presented.