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ORIGINAL PAPER

Model predictive control-based robust stabilization of a chemical reactor‡

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The paper addresses an approach to robust stabilization of chemical continuous stirred tank reactors. State feedback was used for the stabilization and the feedback controller was designed using the robust model-based predictive control algorithm in which the symmetric constraints on input and output variables are taken into account. The known strategy was modified by adding integral action to the controller. Parameters of robust feedback controllers with and without integral action were found as solutions of a constrained optimization problem solved on the infinite prediction horizon. The possibility to stabilize chemical reactors with uncertainty using the robust model-based predictive control has been verified by simulations and compared with the optimal linear quadratic control and the model-based predictive control. The obtained results confirm that the robust model-based predictive control provides better results than other approaches.

Keywords: chemical reactor, multiple steady states, uncertainty, robust stabilization, model-based predictive control, linear matrix inequality

Introduction

Continuous stirred tank reactors (CSTRs) are unquestionably very important equipments in chemical, pharmaceutical, and food industries. From the control viewpoint, CSTRs are very complicated equipments due to their nonlinearity, potential safety problems, and the possibility of multiple steady states occurrence, see e.g. Molnár et al. (2002), Graichen et al. (2009), and Favache and Dochain (2010). When an unstable steady state coincides with the operating point with the maximum reaction rate, it is necessary to stabilize the CSTR in the unstable steady state (Alvarez-Ramirez & Femat, 1999; Bakošová et al., 2009).

Model-based control strategies are mostly used for the control design of chemical reactors, but there are usually differences between the dynamics of the process and the model. The model inaccuracies can be considered as uncertainties; they complicate the controller design and deteriorate the quality of control. Using a robust control strategy can lead to a significant improvement of CSTR control quality, as it is shown e.g. in Ding (2010), Gerhard et al. (2004), Bakošová et al. (2009), Flores-Tlacuahuac et al. (2005), etc.

The importance of a good performance of chemical reactors causes great interest of control specialists and many recent papers are devoted to CSTR control. Sarhadi et al. (2012) proposed a robust two-degree-of-freedom configuration of a generalized predictive control (GPC) design for single-input and single-output (SISO) linear systems verified by simulations on a CSTR model. In comparison to the other heuristic GPC tuning rules, this strategy allows handling the

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