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Fuzzy Model-based Predictive Control of a Chemical Reactor

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1. Summary

Model-based predictive control (MBPC) refers to a class of control algorithms, which are based on a process model. MBPC can be applied to such systems as e.g. multivariable, non-minimum-phase, open-loop unstable, non-linear, or systems with a long time delay.
In this paper a comparison of different MBPC has been presented as a case study for a continuous-time stirred reactor with two first-order irreversible parallel exothermic reactions. The focus is given to the fuzzy predictive contrd approach.
Chemical reactors with exothermic reactions represent the most dangerous operational units in the chemical industry. The temperature control is a real problem for conventional PID controllers in this case, and fuzzy MBPC is one of the possibilities how to solve it. In this approach, a fuzzy model gives a prediction of the plant output. Simulation results show that fuzzy predictive control gives promising results.

Keywords: chemical reactor, fuzzy identification, predictive contrd

2. Abstract

Predictive control has become popular over the past years as a powerful tool in feedback control for solving many problems for which other control approaches have been proved to be ineffective.
MBPC is a name of a several different control techniques. All are associated with the same idea. The prediction is based on the model of the process.
The target of the model-based predictive control is to predict the future behaviour of the process over a certain horizon using the dynamic model and obtaining the control actions to minimize a certain criterion, generally

$$J(k,u(k))=\sum_{j=N_1}^{N_2}(y_m(k+j)-y_r(k+j))^2+\lambda\sum_{j=1}^{N_u}(u(k+j-1))^2 \qquad (1)$$

Signals $y_m(k+j)$, $y_r(k+j)$, $u(k+j)$ are j-step ahead predictions of the process output, the reference trajektory and the control signal, respectively. The values N_1 and N_2 are minimal and maximal prediction horizon and N_u is prediction horizon of control signal. The parameter λ represents the weight of the control signal.

The controller consists of the plant model and the optimization block. The optimization block determines the value of u' that minimize J, and then the optimal u is input to the plant. Equation (1) is used in combination with input and output constraints:

$$
\begin{aligned}
u_{min} &\leqslant u \leqslant u_{max} \\
\Delta u_{min} &\leqslant \Delta u \leqslant \Delta u_{max} \\
y_{min} &\leqslant y \leqslant y_{max} \\
\Delta y_{min} &\leqslant \Delta y \leqslant \Delta y_{max}
\end{aligned}
$$

Nonlinear model based predictive control, fuzzy model based predictive control and linear based model predictive control have been simulated and compared with same conditions. Finally, the comparison with a PID controller was made. In Figure the responses of the process and the reference trajectory are shown. Simulation results show that fuzzy predictive control gives promising results.

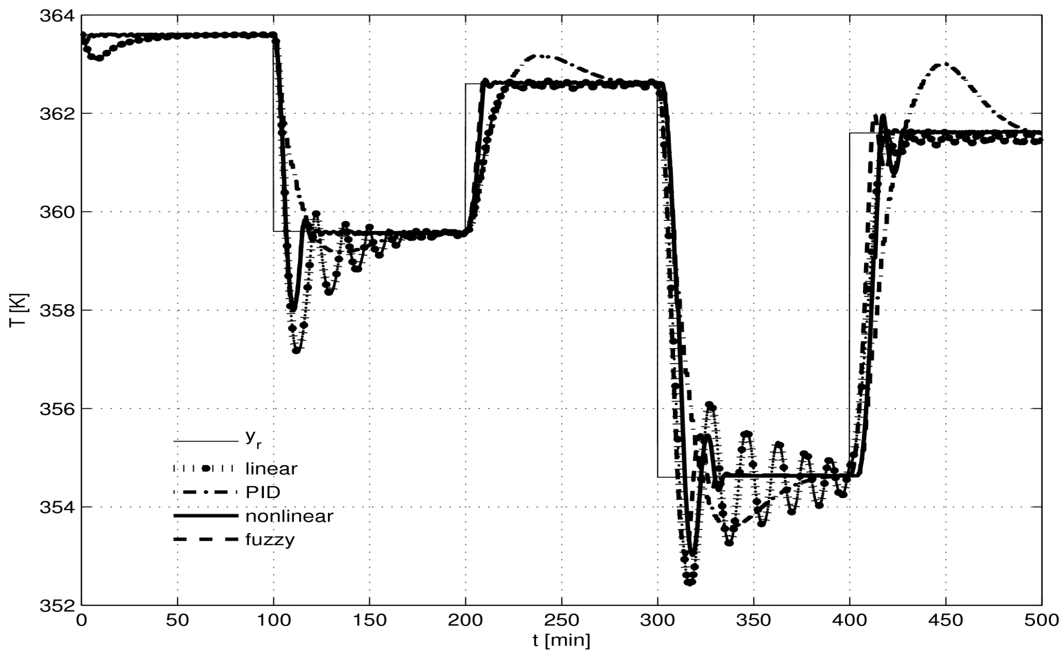

Figure: Comparison chosen model based predictive control simulations with PID controller.

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