Robust Model-based Predictive Control of Heat Exchanger Network in the Presence of Fouling

J. Oravec*, M. Trafczynski2, M. Bakošová1, M. Markowski3, A. Mészáros1, K. Urbaniec4

1Slovak University of Technology in Bratislava, Slovakia
2Institute of Mechanical Engineering, Faculty of Civil Engineering, Mechanics and Petrochemistry, Warsaw University of Technology, Poland
3Warsaw University of Technology - Plock Campus, Poland
4Warsaw University of Technology, Poland

Abstract

Heat exchangers belong to the devices most widely used in industrial production systems. The control performance of heat exchanger operation can be impaired by fouling which builds up on the heat-exchange surface. Fouling leads to burning of extra fuel to compensate for reduced heat recovery and requires increased costs caused by cleaning interventions, etc. In this work, a real-life benchmark system is considered. The controlled system represents a heat exchanger network coupled with a crude distillation unit (CDU). The mathematical model was built and validated based on the data recorded in three years of the plant operation. This paper directly extends the results of the work [1], where the detail model was derived and the PID controllers were designed to reduce the impact of fouling.

Model-based predictive control (MPC) represents current state-of-art in model-based control. The receding horizon strategy enables optimizing of the control action in each step taking into account various requirements and constraints, see, e.g., [2]. As the heat exchangers are highly affected by various uncertain parameters, robust MPC is able to optimize the control performance subject to the uncertainties. Linear matrix inequalities (LMIs) serve to formulate the convex optimization problem in the form of semidefinite programming (SDP) that is solved efficiently in polynomial time.

Various alternative robust MPC strategies [3] were introduced to optimize the control performance of the complex benchmark, i.e., shell-and-tube heat exchangers in the presence of fouling. Simulations of closed-loop control were performed in MATLAB/Simulink environment and the results demonstrated the efficacy of the proposed strategies and the potential to achieve energy savings in CDU operation.