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Analysis of switching strategies for the optimization of periodic chemical reactions with controlled flow-rate

Peter Benner, Andreas Seidel-Morgenstern, Alexander Zuyev

Abstract: An isoperimetric optimal control problem with non-convex cost is considered for a class of nonlinear control systems with periodic boundary conditions. This problem arises in chemical engineering as the maximization of the product of non-isothermal reactions by consuming a fixed amount of input reactants. It follows from the Pontryagin maximum principle that the optimal controls are piecewise constant in the considered case. We focus on a parametrization of optimal controls in terms of switching times in order to estimate the cost under different switching strategies. We exploit the Chen-Fliess functional expansion of solutions to the considered nonlinear system with bang-bang controls to satisfy the boundary conditions and evaluate the cost analytically for small periods. In contrast to the previous results in this area, the system under consideration is not control-affine, and the integrand of the cost depends on the state. This approach is applied to non-isothermal chemical reactions with simultaneous modulation of the input concentration and the volumetric flow-rate.

[1)] Peter Benner, Professor: Max Planck Institute for Dynamics of Complex Technical Systems, Sandtorstr. 1, 39106 Magdeburg, Germany (DE), benner@mpi-magdeburg.mpg.de.

[2)] Andreas Seidel-Morgenstern, Professor: Max Planck Institute for Dynamics of Complex Technical Systems, Sandtorstr. 1, 39106 Magdeburg, Germany (DE), seidel@mpi-magdeburg.mpg.de.

[3)] Alexander Zuyev, Professor: Max Planck Institute for Dynamics of Complex Technical Systems, Sandtorstr. 1, 39106 Magdeburg, Germany (DE), zuyev@mpi-magdeburg.mpg.de.