Success and Surprises in the Optimizing Control of SMB Processes

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SMB - simulated moving bed chromatographic processes have become a show-case for the online application of advanced optimization methods and algorithms in process control. SMB processes are complex, nonlinear, distributed-parameter systems where the optimal operation is at the limit of the specified product purity. Instead of a traditional, layered control scheme where set-points for certain process variables are computed by steady-state optimization and implemented by low-lever (mostly linear) controllers, we have proposed and successfully implemented a direct optimizing control scheme where the operation cost is directly minimized over a prediction horizon while enforcing constraints on the product purities and recoveries.

In model-based optimization, model accuracy is of course crucial, and the integration of the effect of model errors in the formulation of the optimization problems is still an open issue. There is an often-used practical solution, the modification of the set-points and/or of the constraints by a (usually constant) extrapolation of the plant-model mismatch observed in the past. In the case of SMB processes, we have investigated the sensitivity of the optimization-based control scheme with this error correction mechanism by numerical experiments and found that in certain cases, there are two distinctly different operating regimes with quite similar cost that largely differ in their sensitivity to plant-model mismatch. By introducing additional constraints, the process can be forced to the more robust solution which is in fact the conventional SMB operation which has a slightly higher cost then the other variant. This underlines that optimization cannot and should not be applied considering the process as a black box, but process understanding is indispensable to judge the merits of a solution and to arrive at adequate formulations of the optimization problems.