

## **Abstract**

This thesis is focused on the development and application of innovative methods and algorithms for the multi-level, online optimization and control of batch processes under uncertainty. Specifically, it proposes novel solutions for the deterministic and stochastic dynamic optimization/optimal control of single batch operations and introduces new strategies for the integrated scheduling, dynamic optimization and optimal control of multi-unit/multi-step batch process. Moreover, it develops innovative approaches for the rapid estimation of the probability distribution of the uncertain parameters of dynamic process models from experimental measurements as well as new methodologies for selection of the optimal set of uncertain parameters in stochastic optimization problems. These computational frameworks are designed to be flexible and adaptable, thus are suitable for applications in many different sectors, e.g. the pharmaceutical industry, the production of fine chemicals, food processing and drug delivery. Moreover, their architecture allows us to easily combine them to yield efficient and reliable optimization/control systems that can automatically cope with common non-ideal aspects of batch processing, such as equipment fouling, variable quality of raw materials, and operator performance variability, with very limited need for manual intervention. The latter aspect makes this work one of the very few attempts to simplify and promote the application of model-based online optimization/control to real-life industrial problems. The aforementioned methodologies are demonstrated on several industrially motivated problems, including batch and fed-batch reaction systems as well as a multi-stage batch process for the production of a fine chemical.