Assessment of the current application of plant wide control practices in a biochemical production plant

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Abstract

Recipe-driven production with or even without basic feedback control is encountered frequently in biochemical processes to date. Processes as well control systems have advanced over time in correspondence with the growing knowledge-base on manufacturing side. Heuristically obtained resolutions are likely to yield good results, in particular if developed over a long period of time. Nevertheless, they are restricted to gradual advances, whereas systematic model-based analysis is able to provide a much broader perspective. It is expected that mechanistic modelling of bioprocesses allows the extension of several plant wide control methods, practices and technologies to industrial bioprocesses.

To begin with, the current scope of plant wide control applications in the biochemical industry is to be assessed. Consecutively, a structured mapping of case study processes should allow identifying a set of suitable analytical methods as well as control- and monitoring strategies. Where automatic control fails, visualisation and other decision making tools for operators may be examined. Ultimately, an extensive model-based study at hand of a benchmark-like process is to be used in the derivation of a framework for application of plant wide control to biochemical processes.

The ongoing case study deals with the solid-liquid batch extraction of pectin from citrus peel. The extractions are carried out in a battery of tanks which are drained one-at-a-time. Aside from this, the production line consists of a continuous part for downstream processing. A variety of unit operations (several purification steps, evaporation, precipitation, and after-treatment) are seen; all of them representative of industrial applications. The downstream line needs to be fed without interruptions, and the length of the tank-draining process is determined by the strongly disturbed flow rate through this downstream part. Extraction time, however, needs to be within bounds to ensure that quality attributes are met. This results in a sophisticated scheduling task that is currently carried out by the operators. If the process is subjected to strong disturbances, poor consistency may be experienced in the product. A structured cause-and-effect mapping with respect to recurrently encountered problems, disturbances and methods of dealing with them has been carried out. Contextual interviews of stakeholders involved with production, site engineering as well as the

R&D department bring together distributed process knowledge. This mapping suggests that the predominant disturbances are 1) the raw material, 2) cleaning of filters - discrete events whose frequency depends largely on the raw material, 3) downtimes - large changes in viscosity are experienced from raw material to raw material as well as from product to product, which is challenging for the equipment, 4) operators tend to underestimate the effect of their actions, which leads to a chattering-like process behaviour. In terms of advanced monitoring and control algorithms, an observer implementation that allows tracing the batches throughout the continuous process already exists and allows batch-wise quality feedback to some extent. However, the feedback dead time is immense, the actions to be taken not straightforward and the results are likely to be blurred when hold-ups are large (residence time distribution) or when product / raw material / extraction conditions have been changed recently. Future work will contain identifying possible feedback structures and attempts at robust scheduling.