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Published in:
Proceedings of the 17th Nordic Process Control Workshop

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Proceedings of the 17th Nordic Process Control Workshop
Technical University of Denmark, Kgs Lyngby, Denmark
January 25-27, 2012

Modeling Operating Modes during Plant Life Cycle

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Abstract

Modelling process plants during normal operation requires a set a basic assumptions to define the desired functionalities which lead to fullfillment of the operational goal(-s) for the plant. However during during start-up and shut down as well as during batch operation an ensemble of interrelated modes are required to cover the whole operational window of a processs plant including intermediary operating modes. Development of such an model ensemble for a plant would constitute a systematic way of defining the possible plant operating modes and thus provide a platform for also defining a set of candidate control structures. The present contribution focuses on development of a model ensemble for a plant with an illustartive example for a bioreactor.

Starting from a functional model a process plant may be conceptually designed and qualitative operating models may be developed to cover the different regions within the plant operating window, including transitions between operating regions. Subsequently qualitative functional models may be developed when the means for achieving the desired functionality are sufficiently specified during the design process. Quantitative mathematical models of plant physics can be used for detailed design and optimization. However the qualitative functional models already provide a systematic framework based on the notion of means-end abstraction hierarchies. Thereby functional modeling provides a scientific basis for managing complexity. A functional modelling framework has been implemented to facilitate model development and application in a computer environment. Defining means-end causal relations makes it possible to perform qualitative causal reasoning within a functional modelling framework. Thus such a framework renders it possible to develop potentially feasible control structures. This ability is based on goal reasoning and development of goal trees from causal relations. These capabilities of functional models extend the application potential of functional modelling significantly beyond that of conventional mathematical modeling representing quantitative physical phenomena.

The example case is a continuously operating bioreactor for manufacturing single cell protein from methane where also the bioreactor start-up is illustrated with switching between operating modes and their associated control structures as seen in a multiloop control configuration.