Simulation-based strategic decision support in uncertain supply chain systems

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Material flow analysis for site and supply chain analysis

Making decisions in integrated production and supply chain systems is a complex task. This task is getting even more complicated if several uncertain influences, like failures, maintenance, and environmental boundaries, affect the plant operations and logistics on different time scales. For this reason, material flow simulation is applied as a strategic tool to support the decision making process. Within material flow analysis, the single operational units and material streams are modeled on a rough level, barely taking detailed thermodynamics into account. This low-detail modeling level enables to simulate long term plant operation and material logistics (1-5 years) within reasonable computing time. To demonstrate the potential of material flow simulation, an industrial case study will be presented, highlighting several aspects how decision making processes can be supported.

Modeling a multi-site production network

Core of this case study is the modeling, simulation, and analysis of a multi-site production of a large scale base chemical including the storage and transportation logistics for feed, product, and byproduct materials. Especially the transportation logistics by ship influenced by varying water levels of cruised rivers and the related ship docking utilization has been a critical factor during the decision making process. The modeling of the plant characteristics, the creation of operational rules, and the implementation of uncertain influences, like failures and river level, will be demonstrated. An additional critical point has been the scheduled yearly (short) maintenance shut downs and the (long) maintenance shut downs every five years. Therefore, the simulated period has been adapted to this time scale, to cover this 5-yearly maintenance and enable proper analysis of its effects for the different simulation scenarios. To handle the different uncertain influences, the 5 year period has been simulated 20 times with varying random numbers, which results in a total simulated period of 100 virtual years.

Analysis and rating for an improved decision making process

To rate the executed simulations runs, a set of benchmark parameters has been defined and calculated during the simulation. First the supply service level for internal use and external sales for the different scenario settings has been taken into account. Further rating of the results has been done based on operational aspects, e.g., plant utilization, docking frequency, waiting times, and storage levels. Based on this results, the decision process has been clearly guided by an authoritative forecast for the defined scenario settings.
Summary

Application of digital tools is one major benefit to overcome the lack of handling and evaluation of complex dynamic systems. Especially, if those systems are subject to uncertainties and unpredictable influences, a manual approach is neither productive nor reasonably applicable. Therefore, dedicated and established software tools should be used to manage the complexity and accelerate the engineering process.