A Stochastic Inventory Approach for Optimal Planning of Flexible Process Networks under Uncertainty

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Due to global competition and dynamic market environment, a major challenge in enterprise-wide optimization [1-3] has become to simultaneously optimize the production planning and inventory control decisions for chemical complexes under demand and supply uncertainty [4, 5]. Because chemical complexes are usually composed of many interconnected processes and various chemicals, it is an important but non-trivial task to integrate the production and inventory planning decisions with the uncertain supply and demand variations, and coordinate the activities of purchase, production, inventory and sale to minimize the total cost. The challenges arise not only from the modeling part about how to quantify the internal demand uncertainty and its propagation, but also from the computational perspective about how to effectively solve the resulting optimization problem that leads to a large-scale nonconvex mixed-integer nonlinear program (MINLP).

In this work, we address the mid-term planning under supply and demand uncertainty of flexible chemical process networks with dedicated and flexible processes. We propose a MINLP model that captures the stochastic nature of the supply and demand variations based on guaranteed service approach [6, 7], and integrates stochastic inventory control decisions with production planning and cyclic scheduling decisions. The model takes into account multiple tradeoffs and simultaneously determines the optimal purchases of feedstocks, production levels of processes, cyclic schedules of flexible processes, sales of final products and inventory levels of all chemicals in the process network. To solve the MINLP problems with modest computational times, we propose a tailored global optimization algorithm based on the transformation techniques [8] and successive piece-wise linear approximation [5]. The application of the model and the performance of the proposed algorithm are illustrated through two industrial-scale case studies.

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