Process Design under Uncertainty. A Review Note and References

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Review Note

Decision-making in the presence of uncertainty is a key issue in process systems design, since at this early stage decisions have to be made with limited knowledge, whether concerning the assumed process model (kinetic constants, transfer coefficients, etc.) or the external environment (product demand, raw material availability, etc.). The traditional approach to deal with these uncertainties is to design the process based on nominal values of the uncertain parameters and then apply empirical overdesign factors to the solution thus obtained. These corrections are somewhat arbitrary, depending on the decision-maker experience and intuition, and may lead to unfeasible or too conservative design solutions.

In the last three decades, however, several approaches have been proposed to address in an explicit and systematic way the topic of uncertainty in process design, based upon optimization formulations and decision-making under uncertainty theory (a list of selected references is given below). In these methodologies, uncertain parameters are described by probability distribution functions and the design problem is then formulated using probabilistic decision criterions, such as the maximization of the expected value of a given process performance metric. The design solution thus obtained represents the best decision in face of the actual knowledge available about the process and corresponds to a rigorous overdesign relative to a deterministic solution where the process parameters are considered to be perfectly known.

Based on this probabilistic design framework, several formulations have been developed, incorporating operational issues such as flexibility (the ability of the process to operate with feasible conditions under variable inputs), robustness (the ability of the process to respond to variable inputs with relatively invariable outputs) or controllability (the ability of the process to respond efficiently to disturbances in input variables), as well as issues related to decision theory, such as the value of information (the value of reducing uncertainty). In terms of applications, the optimization under uncertainty tools initially developed for process synthesis and design problems have also been applied to other PSE problems, such as process planning, design and operation of batch processes and product design.

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