Dynamic Optimization of Fed-batch Fermentation with Constraint on Waste Water Discharge

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Abstract

Fed-batch cultures appear frequently in fermentation process in which the cell growth or product formation is sensitive to the concentration of the limiting substrate. Compared to batch cultures and continuous cultures, the operation in fed-batch mode provides an excellent means of regulating the substrate feed rate to optimize the productivity while at the same time obviating the production of unnecessary by-products. Since high concentration of substrate at the beginning of the fermentation inhibits production, fed-batch is an ideal operation mode to obtain a high production.

As a dynamic process, fed-batch operation can be optimized by accordingly adjusting substrate feed rate, and several papers on the optimization of fed-batch cultures have been reported\textsuperscript{[1-3]}. Among these works, the objective function is usually defined as product yield, productivity, or the robustness of the operation. However, besides the product itself, a large amount of waste is also generated simultaneously, which also requires significant treatment facilities and energy consumption. Thus, not only the product-related issues should be focused, but also the environmental issue should also be properly considered in the optimization of fed-batch processes.

In this work, a fed-batch process of penicillin fermentation is investigated as a case study. Its dynamic model is available in the literature\textsuperscript{[4,5]}. The objective of dynamic optimization is to maximize the productivity, while waste concentration in discharge water is included as a constraint. The optimal solution is obtained by \textit{dynopt} as a trajectory of feed flowrate along operating time.