Chemical and Biological Reactor Optimization

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Optimization of chemical reactions through the manipulation of the inlet and outlet flow rates leads to reactor configurations that include a batch reactor (BR), a continuous flow reactor (CSTR), a plug flow reactor (PFR) and a semi-batch reactor (SBR, a PFR with distributed feed). The optimum policy calls for a concatenation of maximum, minimum and singular (intermediate) feed rates only. The necessary condition for admiting singular feed rate is that the rate expression must be non-monotonic. Biochemical and biological reactions involve inductions, repressions, inhibitions and feedback regulation so that the specific rates of cell growth, product formation and reactant consumption are non-monotonic. When the yield coefficients are constant, the optimal policy maximizes the specific growth rate by maintaining the substrate concentration constant. For variable yield the singular feed rate maximizes the yield by maintaining the substrate concentration constant when the final time is free, and when the final time is fixed, the singular feed rate maximize a weighted sum of the specific growth rate and the product yield by varying the substrate concentration. When the yield coefficient is variable, the fed-batch operation mimics an unsteady state CSTR followed by a BR.