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Optimization and Stability of Chemical Reactor Models

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We analyze two classes of mathematical models describing chemical reactions of the type "$A \to$ product," conducted in tubular reactors. The first class involves nonlinear hyperbolic partial differential equations modeling a plug flow reactor (PFR) in the presence of an inert component. For this system, an isoperimetric optimal control problem is formulated to maximize the mean product yield over a period under input constraints. The optimality of a bang-bang control strategy is rigorously proved within the class of bounded measurable inputs. Additionally, numerical case studies demonstrate the efficiency of the proposed strategies.

The second class involves a nonlinear parabolic partial differential equation that models a dispersed flow tubular reactor with a single boundary control input. The existence and uniqueness of solutions to the associated nonlinear Cauchy problem are established using the theory of strongly continuous semigroups. Furthermore, by employing Lyapunov's direct method, we design a feedback control strategy that ensures the exponential stability of the steady state and evaluates the decay rate of the solutions. Together, these results provide a comprehensive framework for the analysis and control of chemical reactor models.

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