Robust Simulation and Design Using Parametric Interval Methods

M. D. Stuber[1)] and **P. I. Barton**[2)]

[1)]Dept. of Chemical Engineering, Massachusetts Institute of Technology
Cambridge MA 02139, USA, stuber@mit.edu

[2)]Dept. of Chemical Engineering, Massachusetts Institute of Technology
Cambridge MA 02139, USA, pib@mit.edu

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Abstract

Taking into account disturbance uncertainty is required to guarantee robust operation of chemical processes. Likewise, a model-based approach must be taken, inherently introducing model uncertainty, to allow engineers to make robustness guarantees for physical systems at the design stage. One such application of interest is in remote deep sea oil recovery technologies, where the hazards and costs associated with repairs to subsea processing units are extraordinarily high.

Swaney and Grossman (1985) and Floudas *et al.* (2001) considered such robustness problems with steady-state process models expressed as equality constraints and performance specifications as inequality constraints in a bilevel optimization formulation. Due to problem complexity, the bilevel formulation is difficult to solve.

A new approach is proposed in which the equality constraints are numerically solved for the process variables as implicit functions of the uncertainty parameters and controls and then formulated as a semi-infinite program (SIP) constrained only by the performance specifications as inequality constraints. Bhattacharjee *et al.* (2004) developed an interval approach to SIPs with explicit constraints. Stuber and Barton (2009) have applied interval Newton-type methods to parametric nonlinear problems to calculate valid bounds on the range of the implicit function solutions. These two ideas are coupled, resulting in an effective way to solve the implicitly constrained SIP formulation and give robust performance guarantees under uncertainty.

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