

243i Optimization under Uncertainty Applied to Optical Fiber and Pultrusion Processes

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Process design under uncertainty has received considerable attention in recent years, and has led to the development of several modeling and solution approaches. These approaches are broadly categorized under stochastic formulations (model parameters with probability distributions), multiperiod formulations (where uncertain parameters are discretized into a number of deterministic realizations) and parametric programming formulations. The vast majority of work done in this area has focused on systems in which the cost function is analytic and continuous. On the other hand, uncertainty considerations in systems where the cost function is non-analytic (differential-algebraic, DAE) in nature remain largely unexplored. Two application areas which fall under this domain are the fabrication of polymer-matrix composites and optical fibers. These thermal manufacturing processes are governed by highly non-linear system of partial differential-algebraic equations. This paper presents an application of the one-stage optimization problem (OSOP), a deterministic multiperiod method, to two case studies. The first case study investigated the impact of process and model parameter uncertainty on the design of optimal cure temperature cycles for the fabrication of polymer-matrix composites using the pultrusion process. In the pultrusion problem, the objective was to minimize cure time subject to constraints on the maximum allowable temperature, maximum temperature difference across the composite cross section and the degree of cure. The results show that, in general, the cure time increases with increase in the uncertainty level. The second case study focused on the impact of uncertainty on the optical fiber drawing process. In the real manufacturing process, high draw speeds often lead to inferior quality fiber with poor mechanical properties. On the other hand, low draw speeds lead to superior quality fiber with better mechanical properties. Here, quality is achieved at the expense of production output. For the fiber drawing problem therefore, the objective was to maximize the fiber draw speed subject to constraints on fiber mechanical properties (e.g. defects, residual stress and drawing tension) and fiber transmission properties (e.g. refractive index profile) while taking into account the effect of uncertainty in process and model parameters. It was found that, increase in the level of uncertainty leads to decrease in the fiber draw speed and hence a decrease in production throughput.