521e Optimization of Drying Process

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The drying process in film coating industry plays an important role in controlling the quality of products, so factors affecting the drying process have been intensively studied experimentally. Finding the optimum conditions experimentally is difficult and costly, as most necessary parameters are hard to measure in a high speed dryer. Based on these concerns, the importance of numerical simulation and optimization of such kind of complicated processes has been commonly recognized.

Drying of coated films is a complex process combining polymer thermodynamics and various heat and mass transfer phenomena giving rise to computationally demanding simulations. Therefore, in optimizing a multi-zone drying operation, the objective function evaluation is expensive, but the optimization variables are relatively few. An asynchronous parallel pattern search (APPSPACK) optimization algorithm developed by Sandia National Laboratories was chosen as ideally suited to deal with such an application based optimization.

A few critical parameters of the drying models such as diffusion coefficients for complex industrial systems are usually hard to obtain from the literature. In this study, we first estimate the parameters by fitting a few experimental data from the actual production line. The relative error between the measured and simulated properties is used as the objective function in this part. In the parameter fitting procedure a “wrapper” program is designed to act as an interface to our legacy drying model codes.

Once the relevant parameters are fitted, process optimization can proceed. More specifically in this study, our purpose is to find the optimal drying air temperatures so that the web speed is maximized while constraints such as maximum vapor pressure and residual solvent concentration are satisfied. As the current APPSPACK version does not handle nonlinear constraints, we tested the traditional exact penalty method which, however, didn't work well dealing with these nonlinear constraints. A modified penalty-barrier method was developed with satisfactory results.

Our parameter fitting and process optimization procedures have been successfully applied to RFID (Radio Frequency Identification) antenna ink and adhesive drying processes.