Zhou, H.Q., "Design for High Performance Process Control"

Advisor: L.S. Shieh

In process engineering, unstable systems are fundamentally and quantifiably more difficult to control than stable ones. This is largely due to the facts that controllers for unstable systems are operationally critical and that closed-loop systems with unstable components are only locally stable. Therefore, unstable process control has been an active research area with an extensive literature developed in recent years. Thus, a comparative study is motivated to provide an overview of the control schemes and their effects in terms of different performance specifications. Furthermore, nonlinear PID control strategies and linear time-variant control components are used to enhance control performance of the existing methods. On the other hand, disturbance attenuation is always of the primary concern for any control system design. As a special but often encountered case, periodic disturbances need to be taken care of in many scenarios. In this dissertation, two control designs for periodic disturbance attenuation are proposed.

One is the improved virtual feedforward control based on frequency spectrum analysis of the plant output, which facilitates the application on non-minimum phase processes with simple implementation. The other is modified from the well-known Smith predictor structure to reject periodic disturbance in both stable and unstable processes, which, in a feedback way, can be a counter measure for any periodic disturbance with detectable frequency. In practice, most industrial processes are inherently multivariable. Therefore, it has been desirable to develop effective control strategies for complex multivariable systems. A state-space digital controller design is proposed for multivariable stochastic systems, which combines a centralized PI controller with observer based state-feedback control. Thus the discrete linear quadratic regulator (LQR) approach with pole placement can be used to achieve satisfactory setpoint tracking with guaranteed closed-loop stability. In addition, the innovation form of Kalman gain is employed for state estimation without prior knowledge of noise properties. Moreover, the proposed scheme is extended to control nonlinear systems, by constructing state-dependant optimal linear plant models and updating the controller setting at each sampling period. The schemes and results presented in the dissertation make theoretical contributions and have practical value, and they can be utilized to improve the performance of industrial control systems.