041-ENGR

Control-oriented Modeling to Investigating Nonlinear Behavior of Cooling Coil System

Effective control of the cooling coil system is critical for thermal comfort and energy efficiency. The nonlinearity of the cooling coil presents a complex control problem that necessitates an investigation into its nonlinear behavior and its effects on the control of AHU systems. This research tackles the challenges posed by conventional PI controllers under varying operational conditions, such as fluctuations in cooling load and chilled-water loop pressure differentials. These nonlinearities can lead to overcooling or inefficient cooling, adversely affecting system performance. The aim is to understand and quantify the dynamic behavior of the control system across different operational factors to enhance stability and efficiency. A control-oriented mathematical model based on energy balance and heat transfer principles has been developed to incorporate key operational factors, including supply air flow rate, mixing air temperature, and chilled water flow rate. The study performs a parametric analysis to investigate how these variables affect the cooling coil gain and time constant. Comparing experimental data with theoretical calculations using root mean squared errors indicates that lower flow rates result in higher gains and longer time constants. The cooling coil gain and time constant contribute to more aggressive responses and instability with a fixed PI controller. Conversely, higher flow rates generate a lower time constant, which aids in stabilizing the system. These findings offer valuable insights for improving control performance, guiding effective controller design, and minimizing inefficiencies in AHU systems.