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ARX-PID/NARX-PID Modelling and Control of UV/H_2O_2 Tubular Photoreactor for PVA Degradation in Water

Yi Ping Lin, Ramdhane Dhib, Mehrab Mehrvar
Department of Chemical Engineering, Ryerson University
350 Victoria Street, Toronto, ON M5B 2K3, Canada
yplin@ryerson.ca; rdhib@ryerson.ca; mmehrvar@ryerson.ca

Extended Abstract

Various industries rely on water-soluble polymers as additives, therefore, it is imperative to treat them so that they do not enter our environment as persistent pollutants. Though used as a leading method for degradation of organic pollutants, biological treatment can only treat wastewater that is readily degradable by living organisms. If that is not possible, researchers mainly focused on the oxidation of polyvinyl alcohol (PVA) in an Advanced Oxidation Process (AOP) such as UV/H_2O_2 process as an easy process owing to its relatively developed kinetics, non-selective degradation, low cost, and ease in operation at large-scale [1-3]. In particular, the UV/H_2O_2 process requires modelling to establish a control system that prevents adverse effects of PVA and residual hydrogen peroxide (H_2O_2) to the aquatic system and subsequent biological processes by maintaining H_2O_2 residuals in the treated effluent within a safe level. During this study, the performance of black-box methods was examined in determining the dynamics of polyvinyl alcohol degradation in various UV/H_2O_2 systems, where process inputs and responses involved hydrogen peroxide concentration and acidity, respectively. The complete data analysis and model fitting is undertaken with MATLAB R2019b software. Models including the linear AutoRegressive with eXogenous Input (ARX), the nonlinear ARX (NARX), and the Hammerstein-Wiener model are compared for their success in providing an accurate representation of statistical dynamics. Comparatively, the sigmoid-network-based NARX was better at representing the process dynamics when compared to others. The study also explores the design of PID controllers via ARX and sigmoid-network-based NARX models and analyzes controller performance for set-point tracking and disturbance rejection. The ARX-P, ARX-PI, NARX-P, and NARX-PI controllers were not adequate for a good control design as they exhibit higher offset from set-point, higher overshoot, and longer settling time. The ARX-PID and NARX-PID provide adequate closed-loop responses, while NARX-PID seems better suited for the studied process. However, the ARX-PID has a higher IAE and produces a more robust output response against disturbances as it is adequate for processing disturbances but less useful in tracking process set-points. As a result, to compensate for the complexity in generating models and tuning the parameters with the NARX model, an approximation based on the ARX model is appropriate when its implementation will be followed by another set-up for H_2O_2 elimination. Although feasibility of linear control scheme was presented, it is suggested that similar scenarios should be considered in future designs, validations, and performance evaluations of the entire controlled system, especially for improving controller robustness by implementing multivariate adaptive controls and linear or non-linear predictive controls [4-9].

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