



MIMO control application for pulp and paper mill wastewater treatment by electrocoagulation

Sule Camcioglu*, Baran Ozyurt, Hale Hapoglu

Ankara University, Faculty of Engineering, Department of Chemical Engineering, Tandogan Ankara, Turkey, Tel. +90 3122033465, email: camcioglu@eng.ankara.edu.tr (S. Camcioglu), bozyurt@ankara.edu.tr (B. Ozyurt), hapoglu@eng.ankara.edu.tr (H. Hapoglu)

Received 15 March 2017; Accepted 21 June 2017

ABSTRACT

In this work batch treatment of pulp and paper mill wastewater using electrocoagulation (EC) has been investigated. Electrical conductivity, temperature and pH were selected as controlled variables; supporting electrolyte, cooling water, coordinated acid and base solution flow rates were selected as manipulated variables respectively. Dynamic analyses were carried out to statistically model the variations of controlled variables with time. Second order auto regressive moving average with external input (ARMAX) was used as model and obtained dynamic data were used to fit model parameters with recursive least squares (RLS) method. Pole placement approach was utilized to design robust proportional integral derivative (PID) controllers. PID parameters were found as 5, 0.05 and 0.01 for conductivity, 48, 0.5 and 0.01 for temperature, 1000, 0.05, 0.01 and 1, 0.06, 0.4 for coordinated pH acid and base controllers respectively. Controllers were tested in simulation environments depending on ARMAX models. Experimental multi input-multi output (MIMO) control of variables was achieved using real time PID control algorithms coded in Simulink®. MIMO conductivity, temperature and pH control increased color, turbidity and chemical oxygen demand (COD) removal efficiency as 8.19%, 13.29% and 10.81% respectively, when compared with uncontrolled treatment. Energy consumption of the EC process was reduced by 31.65% and 21.72% compared to the energy consumption of the uncontrolled process using MIMO conductivity and temperature control and MIMO control of three parameters, respectively. It is observed that MIMO control increased pollutant removal and decreased energy consumption simultaneously, which makes the process more economical.

Keywords: Multi input–multi output control; Coordinated control; Electrocoagulation; Pulp and paper mill wastewater

*Corresponding author.

Presented at the 3rd International Conference on Recycling and Reuse, 28–30 September 2016, Istanbul, Turkey