UNIVERSITI TEKNOLOGI MARA

ALUMINUM SULPHATE DOSAGE CONTROL FOR ARTIFICIAL CLAY WATER FILTRATION USING MODEL PREDICTIVE CONTROLLER (MPC)

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PhD

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AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Flood is commonly considered to be an overflow of a large amount of highly turbid water. In some cases, the flood is filtered to be used as a portable water source. In the conventional method, the flood has been treated using Aluminum Sulphate (alum) as a coagulant. The main problems associated with the conventional method are long treatment duration and difficulty to determine the optimum coagulant dosage for the desired turbidity level. Moreover, high sediment levels in the flood can reduce the lifespan of the filter as it requires regular backwashing. In light of this matter, the study is focused on a multidisciplinary approach relating to environmental engineering and electrical control engineering to produce an efficient turbidity removal system. The main objective of this study is to regulate Aluminum Sulphate dosing for optimal water filtration under various water turbidity conditions. The scope of the research involved the development of a process control system based on the combination of alum and water filters technique to remove turbidity from the water. An artificial flood using clay water was treated using an innovative Smart Tube Aqua Filter (STAF) system equipped with a special filter tube staging for coagulation and flocculation process. The STAF process is controlled using a single-input-single-output (SISO) system that has a single input from the turbidity sensor and an analog control valve as an output for optimum alum dosing control. Thus, the efficiency of the turbidity removal process was improved through the implementation of a proper dosage control technique. The system performance was evaluated based on transient response such as settling time, rise time and percentage of overshoot. The water turbidity exhibits nonlinear behavior, thus three suitable controllers namely Proportional Control (PI ZN, PI CC, PID ZN and PID CC), Self-Tuning Fuzzy PID (SFTPID) and Model Predictive Control (MPC) were implemented in order to compare the transient response. While for simulation modeling, First-Order-Plus-Dead-Time (FOPDT) model was applied to represent the STAF plant characteristic behavior and the system dynamics. From the result, MPC has exhibited the best transient response in all categories of the test (step, set point change, and load disturbance) during the simulation test. The result was consistent with previous studies that demonstrated MPC greater capability in handling the nonlinearity process compared to the conventional and other control techniques. The proposed system was implemented in an experimental validation application for evaluation purposes, and the finding validated MPC high performance in terms of transient response. As a result, in simulation for step test, shows that MPC managed to produce improved of rise time, settling time and percentage of overshoot compared to PID ZN, with the difference of 31.97 min faster for rise time, 30.14 min faster for settling time and reduction of 18.88 % for percentage overshoot. Identically to experimental validation step test found that again MPC managed to produce better results compared to PID ZN, wherewith difference of 31.97 min faster for rise time, 30.14 min faster for settling time and reduction of 18.88 % for percentage overshoot. Although there was a slight difference in the amount of each test performed, however, it did prove that MPC has advantages over PID ZN in both simulation and experimental validation. Therefore the implementation of MPC is highly recommended for turbidity removal especially in flood treatment.

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