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Improving total nitrogen removal using a neural network ammonia-based aeration control in activated sludge process

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Abstract

Aeration control is a way to have a wastewater treatment plant (WWTP) that uses less energy and produces higher effluent quality to meet state and federal regulations. The goal of this research is to develop a neural network (NN) ammonia-based aeration control (ABAC) that focuses on reducing total nitrogen and ammonia concentration violations by regulating dissolved oxygen (DO) concentration based on the ammonia concentration in the final tank, rather than maintaining the DO concentration at a set elevated value, as most studies do. Simulation platform used in this study is Benchmark Simulation Model No. 1, and the NN ABAC is compared to the Proportional-Integral (PI) ABAC and PI controller. In comparison to the PI controller, the simulation results showed that the proposed controller has a significant improvement in reducing the AECI up to 23.86%, improving the EQCI up to 1.94%, and reducing the overall OCI up to 4.61%. The results of the study show that the NN ABAC can be utilized to improve the performance of a WWTP's activated sludge system.

Keywords

ABAC, Effluent, Energy consumption, Neural network, Wastewater treatment.

Introduction

Wastewater treatment plant (WWTP) is a topic of pivotal importance in providing a sanitary water which is a vital resource for everyone. Protecting water sources and safeguarding the ecosystem is a long-standing challenge for the WWTP industry. WWTP are facing more stringent effluent standards which were formed for a safer ecosystem (Åmand and Carlsson, 2013; Han and Qiao, 2014; Olsson et al., 2014). The WWTP industry must come up with a solution that abide the stringent effluent requirements and is also economical.

Studies have shown that the energy consumption in the biological system such as activated sludge process, biological trickling filters, and membrane bioreactors can be curbed through good control of the aeration system. The issue of energy consumption has been investigated by various researchers and the findings suggest that the aeration section which is needed in the WWTP to detract nitrogen and natural or inorganic carbon in the biological process, contributes to 50–90% of the overall energy requirement of the WWTP (Åmand et al., 2013; Cristea et al., 2011; Ghoneim et al., 2016; Vrečko and Hvala, 2013).

In the last decade, there have been various studies investigating the effectiveness of various controller design utilizing dissolved oxygen (DO) control in lowering the aeration cost. This control configuration is the highlight during that time due to the availability of DO sensor probe that can continuously measure the DO concentration in the tank. The fundamental of using the DO sensor probe is to control the DO supply according to the oxygen demand of the microorganism in the tank. However,