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Optimized PIDI^{2}D^2 controller based on genetic algorithm for three-tank liquid level control System

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Abstract

This paper considers the optimized PIDI^{2}D^2 controller based on genetic algorithm for three tank liquid level control systems. The process control of the liquid level inside the tank is an important issue for today's industrial processes due to the requirement of mixing the liquid components. Thus, the designing and implementation of the controllers for such a system are major problems which need to be considered. At the moment, most controllers using in the process control are basic PID controllers. However, sometimes the poor performance for the system with PID controller will be acquired; i.e., the slow settling time and high overshoot. Therefore, this paper proposes an efficient method of tuning controller PIDI^{2}D^2 parameters by using genetic algorithm (GA). According to the proposed technique in this paper, the simulation results that the improvement of the settling time and overshoot for the system is obtained by comparing with the tuning controller PID parameters based on GA and PSO techniques.

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Keywords: Genetic algorithm ; Liquid level control ; PIDI^{2}D^2 controller, Three tank system

1. Introduction

Liquid level control is one of the most important technologies in the industrial's process which is able to determine the quality of its products, and it is one of safety system in the process. However, the liquid level system has some problem with the maximum overshoot, steady-state error and the oscillating transient response. These problems can be reduced or solved by applying the closed loop control system between outlet and inlet systems by

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PID controller or other methodology.

PID controller is a kind of widely famous tools applied in processing control in the world's industrial which is so extensive, simple and comfortable to use. Hence, there are many factors effect to the internal parameters of PID controller, i.e., P, I and D in each plant. The advantage of using a PID controller is that it can provide the robust performance for a wide range of operating conditions by the values of K_p, K_i and K_d which are different and variable. It was very interesting from a lot of research studies related to the various optimization methods to find the optimal parameters to control the plant e.g. tuning of PID controller for liquid level tank system using intelligent techniques [1], PID tuning by genetic algorithm for double-tank liquid level control [2], and three tank system using hybrid GA-PSO algorithm [3]. However, in the studying of those researches, it is found out that there are still some techniques need to be improved for controlling the parameters to minimize the objective target.

The objective of this paper is to implement a $PIDI^2D^2$ controller based on genetic algorithm for obtaining the optimal parameters on the PID controller for three-tank system that is the interacting system type. A desire of the minimum overshoot, rise time, settling time and peak are obtained by minimizing the objective function which can be determined by GA function on MATLAB program. The result is then compared with the results of PID controller based on GA tuning method, PSO tuning method and hybrid GA-PSO to how that the proposed method of this paper performs better than other techniques.

2. Liquid level control

Liquid level control in this research is a type of three-tank interacting system. All tanks are laid at the same level in the horizontal line in order to stably control the flowrate of each tank. To be successful in controlling flowrate supply to the 1st tank and the outlet control level is at the 3rd tank, the target setting must be initiated to meet and the reduction of some errors is required.

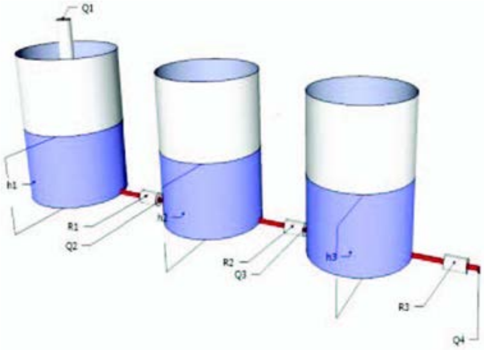

Fig. 1. Mathematical Modeling of Interacting system [3]

The mathematical modeling to represent the three-tank system can be shown as follows.

$$Q_1 - Q_2 = A_1 \times \frac{d(H_1)}{dT}, Q_2 - Q_3 = A_2 \times \frac{d(H_2)}{dT}, Q_3 - Q_4 = A_3 \times \frac{d(H_3)}{dT} \quad (1)$$

$$Q_2 = \frac{H_1 - H_2}{R_1}, \; Q_3 = \frac{H_2 - H_3}{R_2}, \; Q_4 = \frac{H_3}{R_3} \quad (2)$$

Where H_1, H_2, H_3 are the liquid level in 1st tank, 2nd tank and 3rd tank respectively. Q_1 is inlet flowrate of 1st tank. Q_2, Q_3, Q_4 are outlet flowrate of the 1st tank, 2nd tank and 3rd tank respectively. A_1, A_2, A_3 are the cross section area of the 1st tank, 2nd tank and 3rd tank respectively. At the outlet of each tank, there is a control valve with resistance R_1, R_2 and R_3 of the 1st tank, 2nd tank and 3rd tank respectively.

After substituting Laplace transform transfer in equation (1) and (2), transfer function $H_3(s) / Q_1(s)$ could be written in equation (3). Based on [3], the parameter configurations are $A_1 = A_2 = 1m^2$, $A3 = 0.5m^2$, $R_1 = R_2 = 2$ $(m/(m^3/s))$, and $R_3 = 4$ $(m/(m^3/s))$.

$$G_{(s)} = \frac{H_3(s)}{Q_1(s)} = \frac{2}{4s^3 + 14s^2 + 11s + 1} \quad (3)$$