Liquid Level Controlling Using the Intelligent Techniques

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***Abstract*— The control of liquid levels is one of the most important topics in many industrial applications. In this work, a liquid level control system model was built in a water system consisting of 2-tanks. The control system was designed using intelligent techniques, which were represented by adopting Fuzzy Logic to adjust the important factors in the PID controller. Also, the design factors for the system were chosen, such as the resistance of the valves to flow and the capacity of the tanks, using a genetic algorithm with multiple-objectives optimization. The objectives were to derive mathematical equations for the damping factor, settling time, and steady-state error. The results of optimization have resulted in obtaining a set of design factors for the system that enables an acceptable response based on the application used. Additionally, the design of the main controller is in two types based on the membership function, the number of rules, and the other factors. The results showed that the controller used can reach an acceptable rise time and a significantly lower maximum overshoot compared to the comparable controller.**

Keywords*— *Liquid level control, Fuzzy logic, Steady state error, Optimization, Maximum overshoot, Multi-objective genetic algorithm, Settling time, Rise time.

I. INTRODUCTION

The control of liquid levels has a great interest in industrial applications such as filtration processes, chemical industries, nuclear plants, petroleum industries, purification water processes, dairy industries, and many other similar processes [1-5]. Furthermore, better control of liquid levels in these industrial applications will increase production efficiency and reduce operating costs [8].

The different techniques used to control the liquid level system were pronounced in the following survey.

Rahmat and Rozali [1] used different mathematical techniques, such as transient response analysis, the least square method, and pseudo-random binary sequence (PRBS) analysis to build a model to control the liquid level of the coupled-tank system. Also, they designed a controller comprised of Fuzzy Logic and PID controllers for under study system. The utilization of the two controllers in industrial applications was compared and analyzed. Muhasain and Muhasain [2] designed a new model to control the flow rate delivered to two tanks system so that the liquid level will be maintained constant. In their model, they did not use any sensor or float by knowing the pipe parameters and cross-section area of the tanks. They utilized the Matlab environment to perform the model design and related simulations. Kumar and Dhiman [3] estimated the best values of the PID controller using Genetic Algorithms (GAs) and Particle Swarm Optimizations (PSOs) to control the liquid level of the three tanks system using the Matlab environment. They demonstrated that the PSO method was better than GA and ZN (Ziegler and Nichols). Mahmood and Taha [4], Thivya and Nagaraju [5] developed the liquid level controller of the coupled-tanks system using a Fuzzy Logic Controller (FLC) model by employing the Matlab environment.

They concluded that FLC was better than the PID controller in controlling the liquid level system. Fellani and Gabaj [6] used different controllers such as P, PI, PD, and PID to control the liquid level of two tanks system utilizing the Matlab environment. They used the trial-and-error technique to tune the parameters of the PID. They concluded the PID was the most efficient controller among the others by giving a rapid response. Pratama et al. [7] developed a PID controller with Gain scheduling and Back Calculation Integrator Anti-windup to control the performance of the water level system. They reported that the proposed controller can improve the response of the water level system more than traditional PID. Mien [8] conducted a simulation model based on three controllers: PID-ZNI, Fuzzy-PID, and PID-CHR to control the level of liquid of the coupled-tank. The simulation has been performed in a Matlab environment. The author deduced that the controller of Fuzzy-PID was the best one compared to other controllers in improving control and performance of the liquid level system. Jibril et al. [9] proposed a smart control system of the nonlinear coupled system to control the liquid level comprised of three tanks. Two controllers were used to conduct the control system, the first was nonlinear autoregressive moving average (NARMA L-2) and the second was neural network predicting. They noticed that the mechanism of set-point tracking became better using the NARMA controller than the ANN controller, consequently, the performance of the system got better. Urrea and Páez [10] designed four control techniques namely: PID, gain scheduling (GS), Fuzzy logic (FL), and internal model control to control the liquid level of a reversed cone-shaped tank. To determine the performance of the tank system, they achieved a comparative survey for all aforementioned strategies. They deduced that fuzzy logic controllers improved the tank system performance in contrast to other controlling techniques.

In the present study, the liquid level of the cascaded tank system comprised of two tanks was controlled by utilizing a modified Fuzzy Logic-PID controller. The Fuzzy logic model was used to tune the parameters of the PID controller. Also,

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