Research on Optimizing PID Controller Parameters using for a Heating System Applied to the Relay Feedback Method with PLC S7-200

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Abstract

Although there is a large number of control methods applied successfully to control systems in industrial field, the advantages of the PID controller can be considered as significant. The PID controller is being used widerly due to the simplicity of the control algorithm and the ease of implement. But until now, the most difficult problem is to determine a set of optimal parameters of the proposed controller. While each method has its own benefits and drawbacks, applying Modified Relay Feedback meaning to parameter optimization of PID controller in PLC for a heating system is proposed.

Keywords

PLC, PID controller in PLC, heating system, the relay feedback method, optimizing PID controller parameters.

I. INTRODUCTION

With a simple structure and easy implement, the PID controller has been used over 95% in control loops [2]. This controller proves effective performances when controlling process variables such as tank levels, liquid flows, pressure and temperature. Nowadays, automation and control device manufacturers have developed and intergrated the PID controller to make applications more convenient. In particularly, PLC Siemens S7-200 [6] is intergrated with tools optimizing PID controller parameters based on the modified relay feedback method.

II. THE EXPERIMENTAL SYSTEM OF THE TEMPERATURE CONTROL

The heating system in the experiment is shown in figure 1.

Fig 1: The heating object

in which the regulated temperature range is from 0oC-250oC; the temperature sensor is a thermocouple; a 24-DC fan acts as a type of distubance affecting directly the system; a power amplifier receiving output signals of EM235 - module to change AC voltage supplied to the heating object. The PID controller is installed in PLC S7-200 revealed in figure 2.

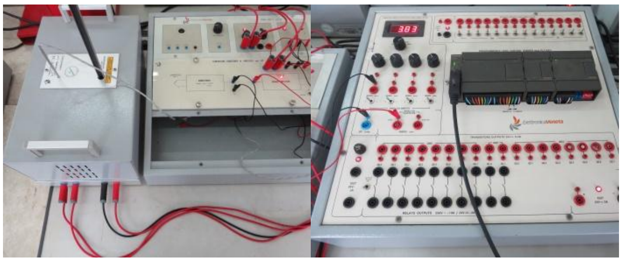


Fig 2: Connecting theheating object to PLC S7-200

III. OPTIMIZING THE PID CONTROLLER PARAMETERS

The paper concentrates on adjusting PID parameters automatically in PLC. The function of the PID controller as equation (1).

$$u(n) = k_p e(n) + \frac{k_p T_s}{T_I} \sum_{1}^{n} e(k) + \frac{k_p T_D}{T_s}(y(n) - y(n-1)) \quad (1)$$

In order to solve this problem, there are different tackles which are taken. One of the methods of tuning the PID controller which is used widerly is the Ziegler-Nichols tuning method developed by John G. Ziegler and Nathaniel B. Nichols. It yields an aggressive gain and overshoot wish to instead minimize or eliminate overshoot. However, this method cannot orientate due to be unpredictable. The shortcoming of the Ziegler-Nichols method can be made good by the Modified Relay feedback method of Astrom and Hagglund proposed in 1984 [8]. After that, this method was intergrated as an automatic tuning and optimizing tool in PLC S7-200.

The "relay feedback" is to generate small oscillations but remain continuous in a stable process. Based on the oscillation period and changed amplitude of process variables, the oscillation period and gains are determined. After that, from these metarials, the PID controller parameters are calculated. The model of optimizing the PID controller parameters accompanied with a relay circuit in the PID controller is indicated in figure 3.

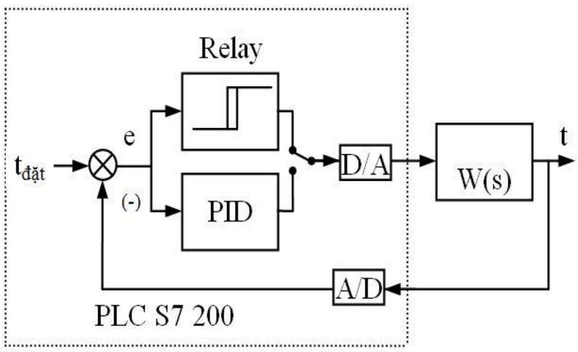


Fig 3: The structure diagram optimizing parameters

Automatically optimizing parameter process is perform as follow: when the microprocessor is activated and the PID controller is not activated, control signals bring to the relay circuit. After identifying the control parameters, the PID controller is activated again with calculated parameters. The reference signal is shown as Fig. 4 and its response is deen as Fig. 5.

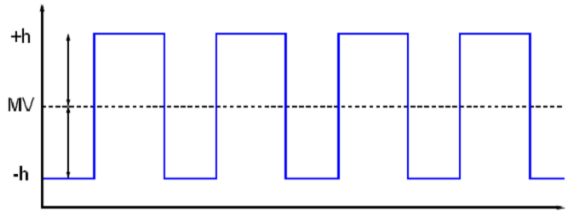


Fig 4: The reference input signal

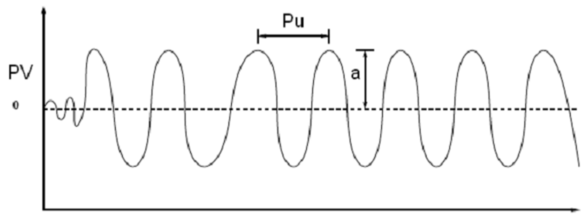


Fig 5: The system response

In the case the time-delay Relay is used, the gain coefficient can be figured by equation (2)

$$K_u = \frac{4h}{\pi \sqrt{a^2 - \varepsilon^2}} \quad (2)$$

Where *h* denotes the amplitude of the stimulation in the relay circuit; ε is latency and *a* defines the amplitude of the output oscillation. The period of oscillation (P_u) is chosen directly from the oscillation as figure 5.

When K_u and P_u are calculated, the parameters of the PID controller are figured as table 1

Table 1

	K_p	T_i	T_d
P	$0.5K_u$		
PI	$0.4K_u$	$0.8P_u$	
PID	$0.6K_u$	$0.5P_u$	$0.125P_u$

In theory, if the model structure reachs accuracy, calculating coefficients and frequency will be seen as approximately. However, a better model will lead to a more exact optimizing result in short time period. In order to simplify, the study proposes a model recognition algorithm in MATLAB/Simulink to identify the mathematical model. The next step is to establish the set of PID controller parameters.

The object response is seen as figure 6.

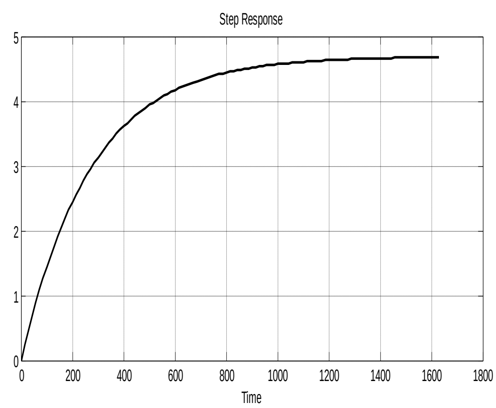


Fig 6: The object characteristic

The object transfer function is written as:

$$W = \frac{4.689}{1 + 272.51s} \quad (3)$$

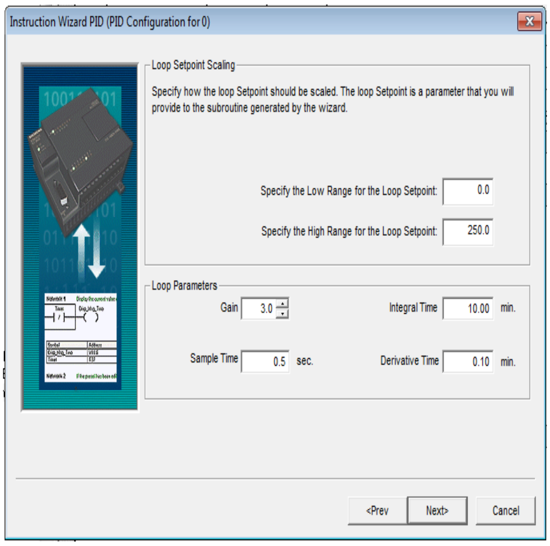
The set of PID controller parameters is obtained from the classic synthesis method with $K_p = 3$; $T_i = 10$; $T_d = 0.1$.

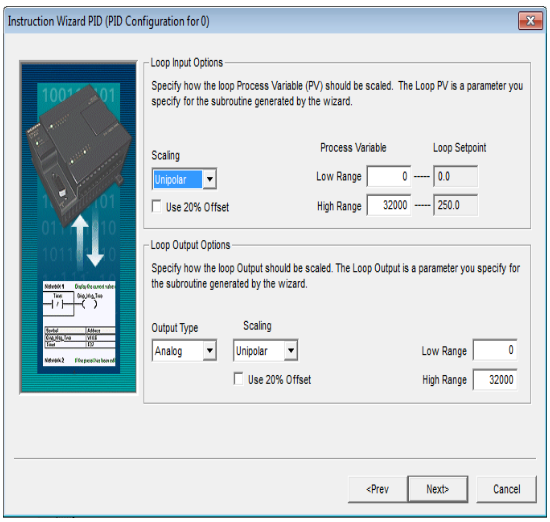
Optimization is implemented with the initial parameters of the PID controller as above.

IV. EXPERIMENTAL RESULTS

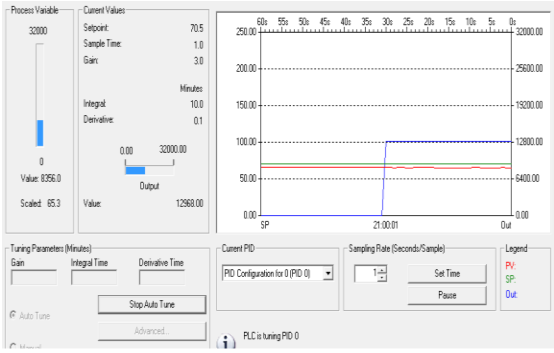
This Experimental process includes some steps:

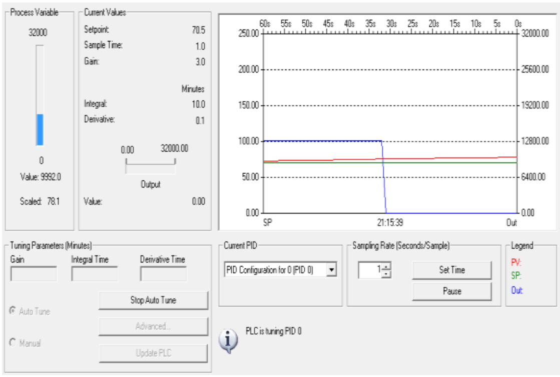
Step 1: Installing the PID controller with the parameters [3] derived from the canonical synthesis.





Step 2: Connecting the computer to the PLC and performing online the algorithm for parameter optimization.





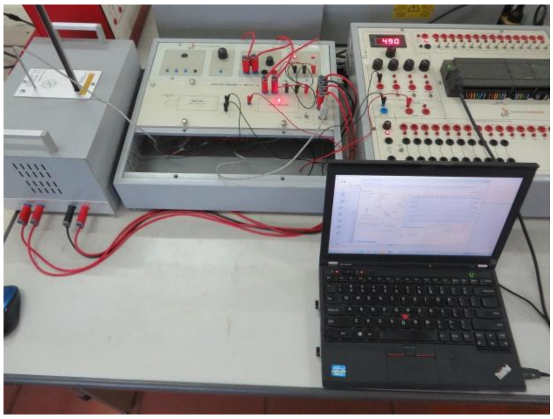
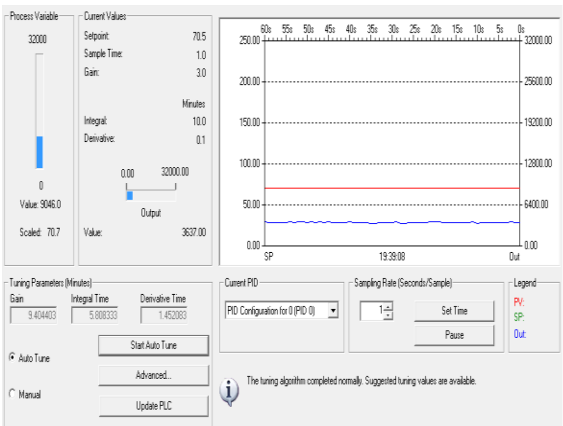


Fig 7: The heating control system when optimizing PID parameters

Step 3: Updating the optimization parameters.



After finishing the optimization process, we get the PID controller optimal parameters when using the Relay feedback algorithm having $K_p = 9.404403$; $T_i = 5.808333$; $T_d = 1.452083$.

Updating the PID controller parameters and running the experiment, we have the response of the system as figure 8.

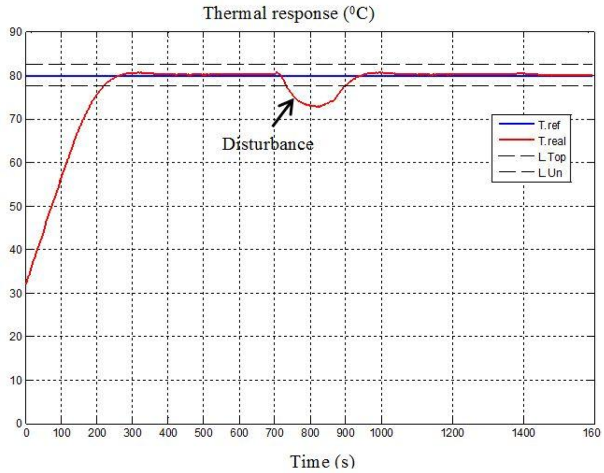


Fig 8: The optimal parameters-based response with existence of disturbance

In conclusion, optimizing the parameters of the PID controller is carried out online, the controlled output tracks the reference signal with small error.

V. CONCLUSIONS

PLCs are now used in most control systems in order to perform different control processes. Optimizing controller parameters is very important for improving the quality of control. In the paper, the algorithm in optimizing the PID controller parameters is synthetized online, which plays an important role in improving the control quality while reducing the time.

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