International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2186-2190 www.ijaem.net ISSN: 2395-5252

The Design of Fuzzy Control Adjusts the PID Parameter to Improve the Control of the Heater Object

Tran Thi Thanh Thao
[1]Thai Nguyen University ofTechnology, Thai Nguyen, Viet Nam

Submitted: 15-05-2022 Revised: 25-05-2022 Accepted: 28-05-2022

ABSTRACT: The heater is an industrial object with nonlinear and delay characteristics. If we use a linear controller to control the heating device, it can be response with systems requiring the low control quality. But for systems requiring the high control quality,the linear controller does not response the control requirements. To improve control quality, the article proposes the solution "Research and application of the fuzzy controller to adjust the PID parameters for the heating object".

KEYWORDS: Heating system, The fuzzy controller, the PID parameter adjustment fuzzy controller.

I. INTRODUCTION

In life as well as in production, the requirements for the use of heat are very large. This heat source is received by electrical devices that convert from electricity. This is a clean energy source, does not cause smoke and dust, so it does not affect the living environment, convenient and easy to use.

Heating methods: induction heating, arc wire heating, resistance wire heating. In this paper, the author focuses on analyzing the heating device by resistance wire.

Resistance heating method is based on Joule - Lence's law: when a current flows through a wire, a heat is released in the conductor, this heat is calculated according to the expression (2.1)

$$Q = I^2 Rt \qquad (1.1)$$

With:

Q – Heat (J)
I – Amperage (A)
R – Resistance (Ω)
t – Time (s)

Some types of sensors measure temperature in practice such as: mercury thermometer, thermistor, thermocouple.

II. THE BUILDING A MATHEMATICAL MODEL OF THE RESISTANCE FURNACE BY EXPERIMENTAL METHOD

To design a controller for the object needs to build a descriptive mathematical model for the object. The author uses zaded 's object recognition method.

In order to estimate the model of the object, we provide an AC voltage source to the resistance coil. Then, we measure the temperature response of the system.Voltage and thermal signals are achieved by Arduino UNO and then sent to MATLAB/Simulink. We perform data collection of voltage and temperature over time with a sampling period of 200ms. After that, we find the mathematical model of heating object (called tranfer funtion describing approximately real object) by using Identification Toolbox in MATLAB.

This process includes several steps and finally, we have a set of data as shown in Figure 2.1 and Figure 2.2.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2186-2190 www.ijaem.net ISSN: 2395-5252

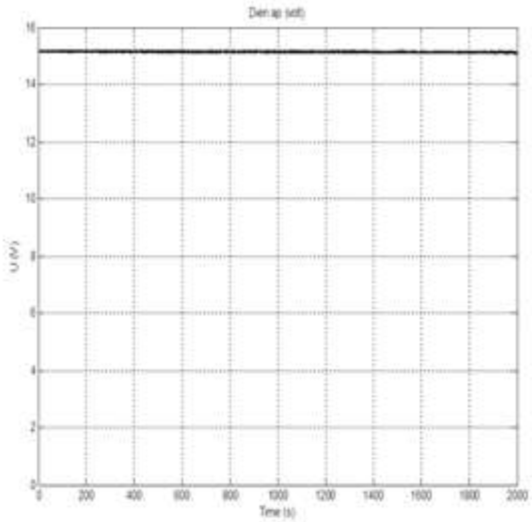

Figure 2.1: Voltage data (Volt)

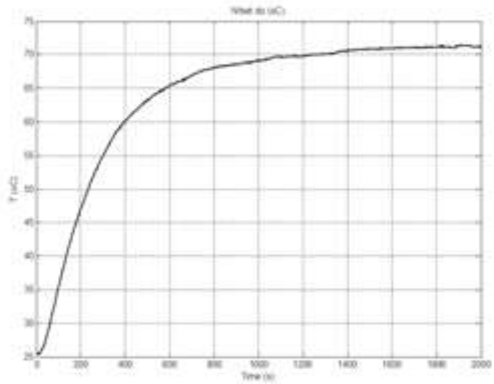

Figure 2.2: Temperature data (°C)

The mathematical model of resistance wire is written as in equation

$$W(s) = \frac{T(s)}{U(s)} = \frac{K}{1+\tau s} \quad (2.2)$$

Where:

$K = 4,689; \tau = 272,51$

We get the transfer function of the system after replacing the number:

$$W(s) = \frac{T(s)}{U(s)} = \frac{4,689}{1+272,51s} \quad (2.3)$$

Figure 2.3: The object model after

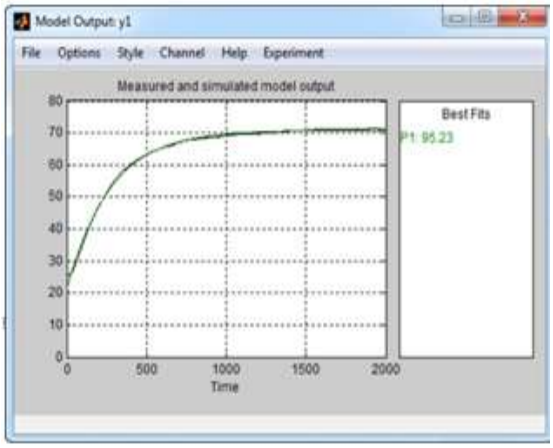

Figure 2.4: The best fit between model and data

We continue to conduct to estimate models, and receive a result with the fit level between the identificated model and data reaches 95.23%.

Additionally, the temperature of the resistance wire is varied by altering the voltage of an AC-AC converter from 36V to 10V. Its transfer funtion is shown in:

$$W_b(s) = \frac{U(s)}{u_{dk}(s)} = \frac{K_b}{1+\tau_b s} = \frac{3,6}{1+0,005s} \quad (2.4)$$

The controlled object includes the converter and the resistance coil connected in series. we have the transfer funtion of heating object:

$$G(s) = W(s).W_b(s)$$

$$G(s) = \frac{16,8804}{(1+272,51s).(1+0,005s)} \quad (2.5)$$

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2186-2190 www.ijaem.net ISSN: 2395-5252

III. CONTROLLER DESIGN FOR THE HEATING OBJECTS BY OPTIMAL MODUL METHOD

This paper applies a PID controller to the proposed heating system. This research aims at controlling and keeping the degree of heat stable:

$$G_{dk}(s) = K_p(1 + \frac{1}{T_i s} + T_D s) \qquad (3.1)$$

Determining parameters of the controller (K_P, T_I, T_D) will have direct effect on the quality of system.

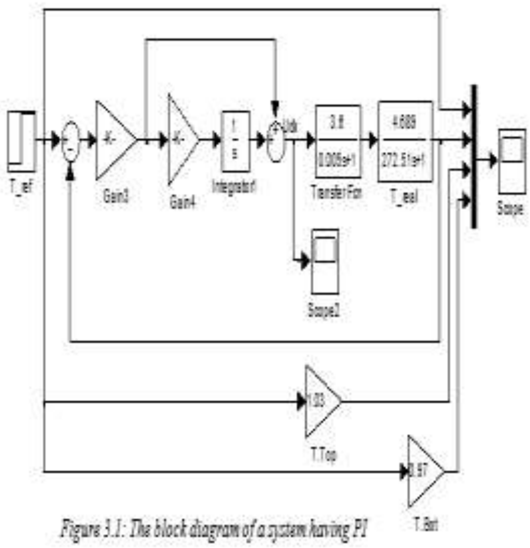

Figure 3.1: The block diagram of a system having PI

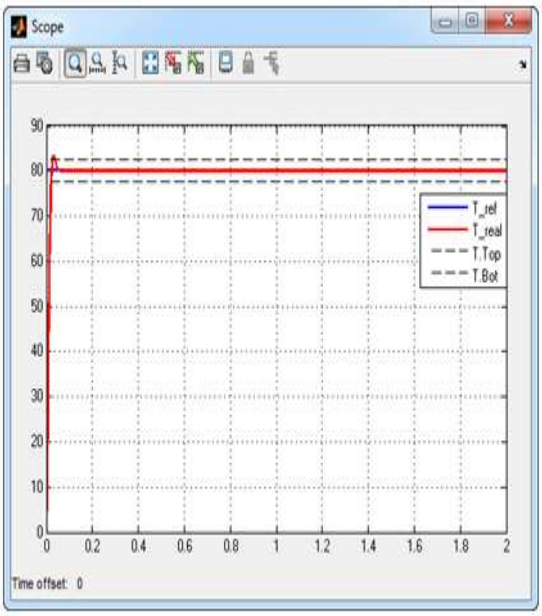

Figure 3.2: The transient characteristic of control system according to optimal module method

This process is implemented by an optimal modul $|W_k(j\omega)| = 1$.

The transfer function of the controller is written as follows:

$$G_{dk}(s) = \frac{1 + 272,51s}{16,8804.2.0,005s} = 1614,3575(1 + \frac{1}{272,51s}) \quad (3.2)$$

The PI controller is determined according to the method of Optimal Modulas shown in Figure 3.1. It can be seen that the result of control is quite good with 4.0% of overshoot and 0.004s of settling time but control voltage has too high at about 120000V. The value of the control voltage is so large that it does not fit the reality. To solve this problem, we add the 0 ÷ 24V control signal limitation in the control structure. On the other hand, the heating object is a delay device. So, in order to fit in the control structure, it is necessary to add a delay of 3 seconds. The control structure is shown in Figure 3. 3.

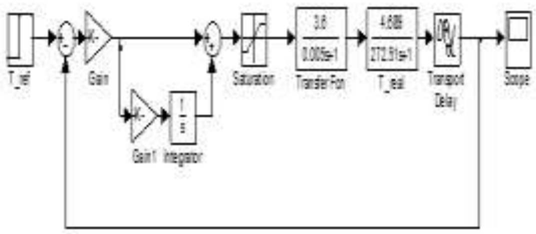

Figure 3.3: The block diagram of a system having PI

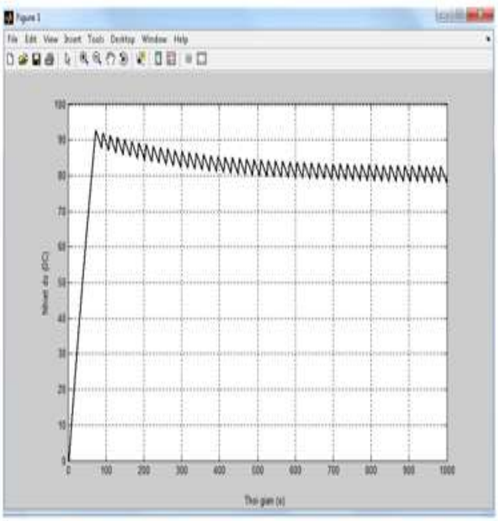

Figure 3.4: The transient characteristic of control system according to optimal module method.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2186-2190 www.ijaem.net ISSN: 2395-5252

From the transient graph of the system, we can see that if in the control structure there is a control signal limitation and a delay, the quality of the system does not response the requirements.

IV. THE DESIGN OF THE FUZZY CONTROLLER ADJUSTS A PID

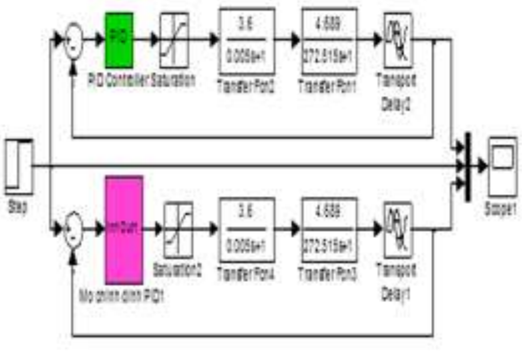

Figure 4.1: System simulation structure with PID controller andthe fuzzy controller with PID parameter adjustment

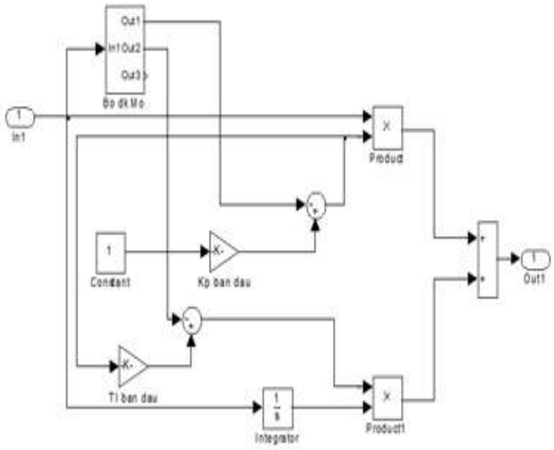

Figure 4.2: Structure of parameter adjustment K_p and K_I

PARAMETERS TO IMPROVE THE CONTROL OF THE HEATER OBJECT

System simulation structure with PID controller and fuzzy controller with parameters Kp and Ki as shown in Figure 4.1:

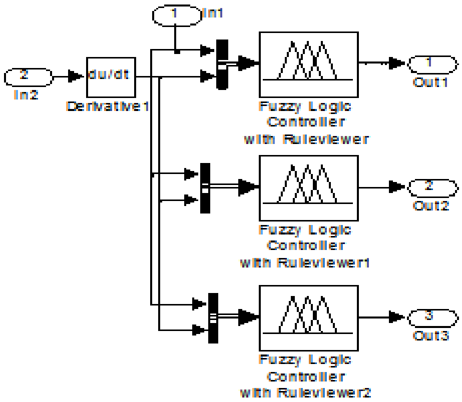

Figure 4.3: The fuzzy controller in figure 4.2 structure.

The controllers all have a 2-in-1 structure. The paper presents a fuzzy controller with k_D parameters as follows:

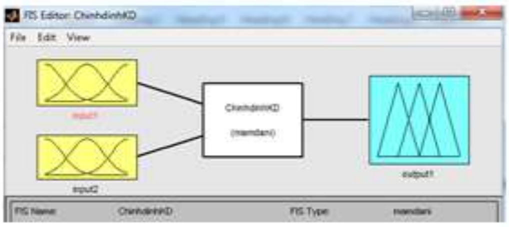

Figure 4.4: Structure of The k_D adjust fuzzy controller

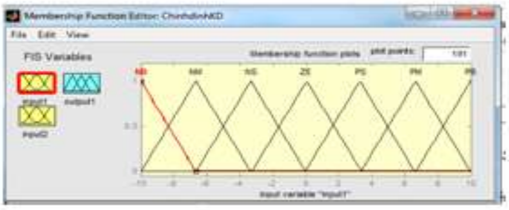

Figure 4.5: Input affilicated function form

Simulation results as shown in Figure 4.7

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2186-2190 www.ijaem.net ISSN: 2395-5252

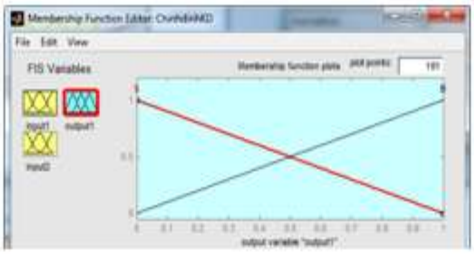

Figure 4.6: Output affilicated function form

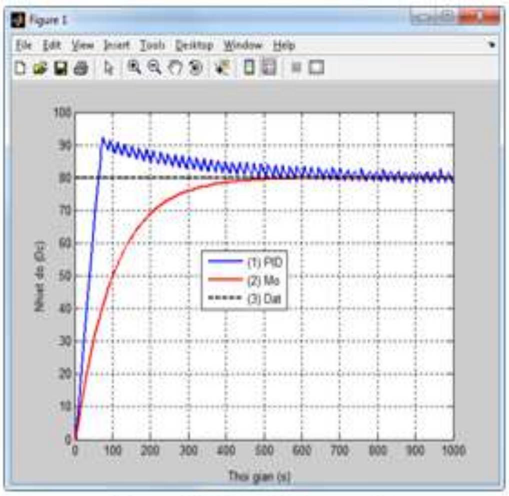

Figure 4.7: Simulation results

Through simulation result, it is found that the fuzzy controller with PID parameter adjustment has improved the control quality of the heating object, the system is not over-adjusted, the transient time is about 430 seconds.

V. CONCLUSION

Through simulation, the controller according to the optimal Modul method without limiting the control signal for very good quality, the transient time is very short even though the object has large inertia. However, this control signal is very large and not suitable for reality, so in the simulation structure it is necessary to have an additional stage of limiting the control signal to suit reality.

The structure has a limited stage and a delay, the control quality does not response the requirements. To improve the quality, the paper uses a fuzzy controller that adjusts the parameters Kp and KI of the PID controller. At this time, the control quality has been improved compared to the original PID controller.

ACKNOWLEDGEMENT

This research was supported by a grant for the university research from the TNUT (Thai Nguyen University of Technology), No. 666, 3/2 Street, Thai Nguyen, Viet Nam. We thank our colleagues from the TNUT who provided insightand expertise that greatly assisted the research.

REFERENCES

[1]. Nguyen Doan Phuoc, “Lý thuyết điều khiển tuyến tính”, Science and technology publisher, 2010.
[2]. Nguyen Doan Phuoc and Phan Xuan Minh, “Nhận dạng hệ thống điều khiển”,Science and technology publisher, 2005.
[3]. Nguyễn Phùng Quang, MATLAB và SIMULINK dành cho kỹ sư điều khiển tự động, Nhà xuất bản khoa học và kỹ thuật, Hà Nội, 2006.
[4]. Nguyen Phung Quang, “Matlab & Simulink”, Science and technology publisher, 2006.
[5]. Phan Xuan Minh and Nguyen Doan Phuoc “Lý thuyết điều khiển mờ”, Science and technology publisher, 2002.