Journal of Engineering Mechanics and Machinery (2021) Vol. 6: 75-84
Clausius Scientific Press, Canada
DOI: 10.23977/jemm.2021.060109
ISSN 2371-9133

Design of Power System of Algae Cleaning Mechanism Based On Fuzzy Controller

Lulu Li[1,*], Yucong Wang[2]

[1] *Mechanical Institute, North China University of Water Resources and Electric Power University, Beihuan Street, Zhengzhou, China*
[2] *Materials Institute, North China University of Water Resources and Electric Power University, Beihuan Street, Zhengzhou, China*
**corresponding author*

Keywords: fuzzy controller, algae cleaning mechanism, MATLAB.

Abstract: Aiming at the problem of algae in the South-to-North Water Transfer Project, an algae-clearing mechanism based on fuzzy controller is designed. Use MATLAB software to simulate, establish the simulation model of the fuzzy control system in Simulink module according to the actual situation, select the two-dimensional Mamdani typed fuzzy controller, design the fuzzy control GUI according to the logic algorithm of the fuzzy control theory, and set a reasonable simulation timed to analyse the algae-clearing mechanism The law of the dynamic system. According to the simulation results, the optimal lifting interval timed and high-pressure water spraying time of the algae blocking net are obtained to control the start and stop of the motor and the water pump, so that the controller can be set to achieve the purpose of automatic control. The simulation results show that the method meets the requirements of the actual work of the algae removal machinery, so the fuzzy control system is suitable for the algae removal machinery and realizes the automatic control of the algae removal machinery.

1. Introduction To Algae-clearing Mechanism

The algae cleaning mechanism mainly includes a drive unit, welding frame, a track, steel wire drum, guide wheels, algae-blocking net, a water tank, and washing device [1]. Its working principle is as follows. First, the various parts are welded and installed on the dam building surface. Secondly, the work of the drive unit drives the chain to drive. Driven by the power, the chain moves along the guide wheels with the algae blocking net. And through the forward and reverse rotation of the motor, the algae blocking net enters and exits the water surface. When the motor rotates forward, the algae blocking net enters below the water surface to block algae. When the algae blocking net reaches the maximum working state, the motor reverses to lift the algae blocking net out of the water surface. Finally, the high-pressure flushing device works to flush the algae on the algae blocking net into the collection box. However, when the algae blocking net reaches the maximum working state, when it is taken out to remove the algae, and the cleaning time of the high-pressure nozzle is not automated, it still requires personnel supervision. Therefore, it is necessary to design a fuzzy controller for the power system of the algae-clearing mechanism, analyse the simulation results, and find the optimal algae blocking net interval time and high-pressure water spraying time to achieve a reasonable sett of the controller.

2. Fuzzy Control

2.1. The Emergence of Fuzzy Cybernetics

With the increase of the complexity, nonlinearity, hysteresis and coupling of the control object [2], people's ability to obtain accurate knowledge is relatively reduced, and the possibility of using traditional precise control is also reduced. At this time, fuzzy control is produced. Fuzzy control is based on fuzzy set theory and fuzzy logic reasoning. The knowledge and control experience expressed by experts in natural language are converted into mathematical functions of fuzzy theory, and then processed by computers [3]. Integrating the concept of fuzzy set into the controller can directly express our thinking and processing methods of simple and clear mathematics, and then combine the methods that conform to our way of thinking and the real situation into complex systems. Among the control, a series of problems have been solved for the emergence of classic controllers.

2.2. Classic Fuzzy Controller

The basic principle of the fuzzy controller's work is to change the input digital signal into a fuzzy quantity of fuzzification (D/F) and send it to the fuzzy inference module (·R) containing fuzzy rules. After approximate inference, a conclusion is drawn-fuzzy [4]. The collection is then transformed by the clarification module (F/D) into a clarification quantity u, and then output to the next stage to adjust the controlled object to make it output satisfactory results. The primary task of designing a fuzzy controller is to summarize, summarize and analyse the operating experience or test data, determine the input and output variables, and then determine the structure of the fuzzy controller [5].

The input and output of the fuzzy controller are all interconnected inputs, and the input and output are all expressed and output in vector format. The dimensions of the input and output components are one-dimensional, two-dimensional, three-dimensional, etc. But the commonly used dimensions are three-dimensional and three-dimensional controller modules below. Usually the control variables have deviations, deviation change rates, and deviation change rates. They are often combined according to the characteristics of the system, and those with high requirements for system control characteristics are used. Three-dimensional representation, less demanding one-dimensional representation.

2.2.1. Mamdani Type Fuzzy Controller

When Assilian explored the automatic control of a small boiler-steam engine system, because the relationship between air pressure and heating, speed and valve opening is highly non-linear, and the boiler and steam engine are coupled with each other and are affected by other factors, Unable to establish their clear mathematical models. Mamdani used the fuzzy language control rules proposed by Zadeh and finally successfully realized the automatic control of this system through fuzzy logic inference. In the process of researching and controlling this system, it is found that this kind of controller has the advantages of less information, no overshoot, fast response, less error, etc., and this kind of control method has a very wide range of universality.

2.2.2. T-S Type Fuzzy Controller

When studying the fuzzy control system, Japanese scholars Takagi and Sugeno proposed a new fuzzy inference models, namely the T-S fuzzy inference model [6]. This model is particularly suitable for a segmented system that is locally linear and can be controlled in segments [4]. When it represents a certain system, a large amount of test data should be inputting first, and the structure and parameters of these data should be identified, and then the correct model should be gradually established.

3. Design of Fuzzy Controller for Algae Cleaning Mechanism

3.1. Principles of Fuzzy Control of Power System

According to actual investigations, the main factors that affects the interval time of algae blocking net lifting (i.e., algae blocking time) and the algae removal time of high-pressure nozzles (i.e., water spraying time) is the water flow velocity and the algae concentration. Among them, the water flow speed is measured by a water flow sensor, and the algae concentration is measured by an algae concentration detection analyser.

3.2. Fuzzy Control GUI Design

3.2.1. Controller Structure and Choice of Fuzzy Logic Algorithm

This paper adopts the design of a two-dimensional Mamdani controller, which is a dual-input dual-output controller. The input variables are water flow velocity (V) and algae concentration (C), and the output variables are algae retention time (T1) and water spray time (T2), the algorithm of each unit in the fuzzy logic algorithm is shown in the figure 1.

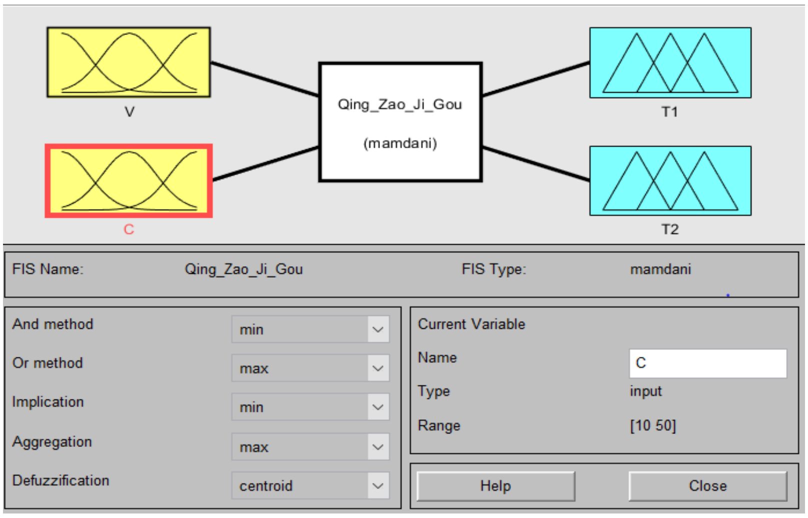

Figure 1: Selection of controller structure and fuzzy logic algorithm.

3.2.2. Define Fuzzy Subsets of Input Variables

After consulting the data, it can be seen that the water flow velocity of the water delivery channel of the South-to-North Water Transfer Project is maintained at 0-2m/s, so the domain of the water flow velocity is set to [0 2], which is divided into three levels, low velocity, medium velocity and high velocity. Algae concentration ranged between 10%-50%, so the field of view to set the algae concentration is [10 50], which is divided into three levels, low concentration, medium concentration and high concentration. In summary, the universe of input variables, fuzzy subset names, membership function types and parameters are shown in Table 1.

Table 1: Input variable parameters.

Input	Domain of discourse	Subset name	Function type	Function parameters
Water flow speed (V)	[0 2]	LV	Trapmf	[0 0 0.2 1]
		MV	Trimf	[0.4 1 1.6]
		HV	Trapmf	[1 1.8 2 2]
Algae concentration (C)	[10 50]	LC	Trapmf	[10 10 15 30]
		MC	Trapmf	[15 30 45]
		HC	Trapmf	[30 45 50 50]

Enter the domain, subset name, function parameters, etc. in the fuzzy editor to get the line graph of the membership function, as shown in the figures2 and 3.

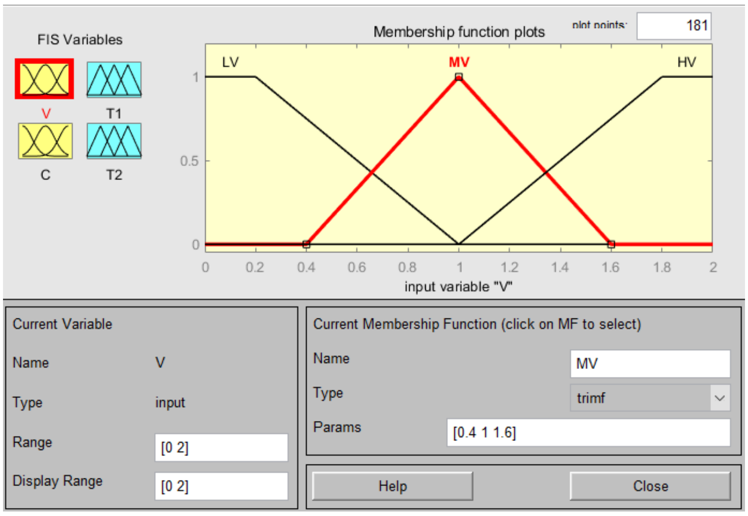

Figure 2: Selection of flow velocity function.

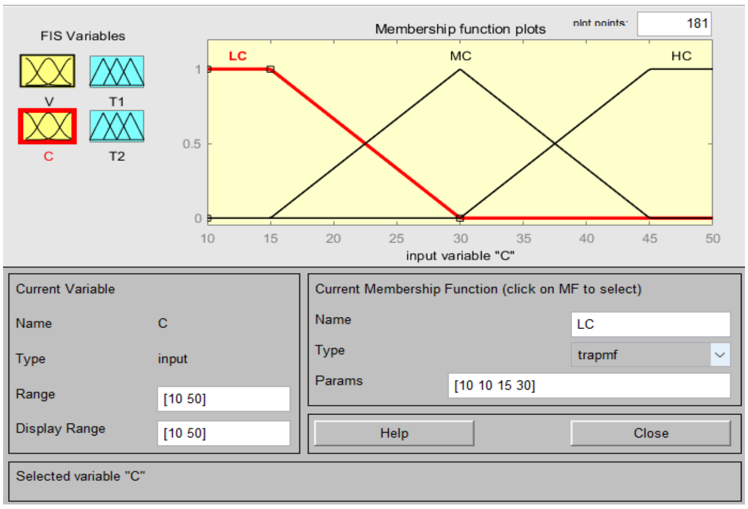

Figure 3: Selection of algae concentration function.

3.2.3. Define Fuzzy Subsets of Output Variables

The definition of fuzzy subset of output variables: the universe of output variables algae blocking time (T1) and water spraying time (T2), the name of the subset and the type of membership function is shown in the following table2.

Table 2: Output variable parameters.

Output	Domain of discourse	Subset name	Function type	Function parameters
Algae blocking time(T1)	[0 6]	VS	trimf	[0 1 2]
		S		[1 2 3]
		M		[2 3 4]
		L		[3 4 5]
		VL		[4 5 6]
Water spray time(T2)	[0 60]	VS	trimf	[0 0 10]
		S		[0 10 25]
		M		[10 25 40]
		L		[25 40 60]
		VL		[40 60 60]

After analysis, the algae blocking time is set to 6 hours, and the algae blocking net is raised every 6 hours; the water spraying time is set to 1 minute, and the spraying time is controlled and adjusted according to the number of algae on the algae blocking net. After editing the parameters of the output variable in the MF editor, as shown in Figures 4 and 5.

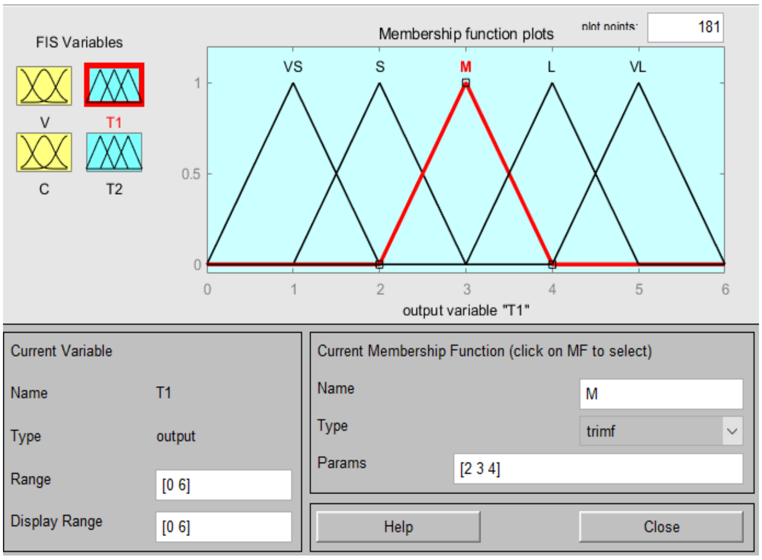

Figure 4: Selection of algal blocking time function.

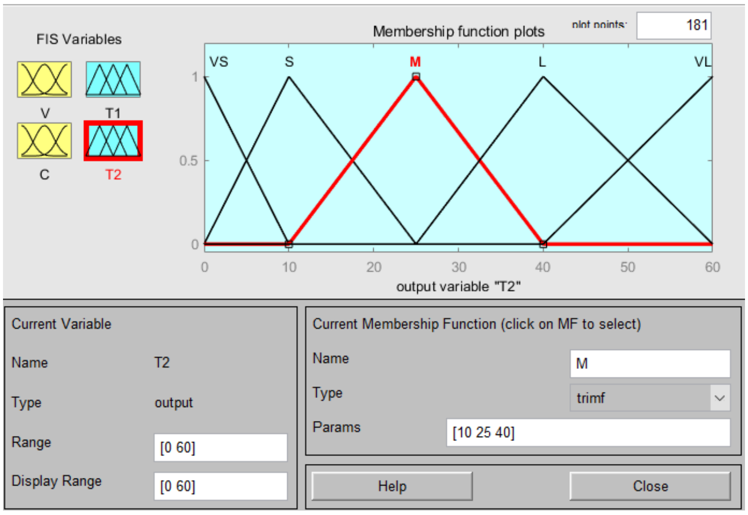

Figure 5: Selection of water spray time function.

3.2.4. Edit Fuzzy Control Rules

According to actual experience, the following control rules are summarized, which are the basis of the fuzzy controller to achieve control.

Table 3: Experience control table for algal blocking time.

Water flow speed / Algae concentration	LV	MV	HV
LC	VL	L	M
MC	L	M	S
HC	M	S	VS

Table 4: experience control table for water spray time.

Water flow speed / Algae concentration	LV	MV	HV
LC	VS	S	M
MC	S	M	L
HC	S	M	VL

After merging the rules described in the above table 3and 4, there are a total of nine rules. Call up the Rule editor, enter the nine rules into the rule editor, and display them in language type, as shown in Figure 6.

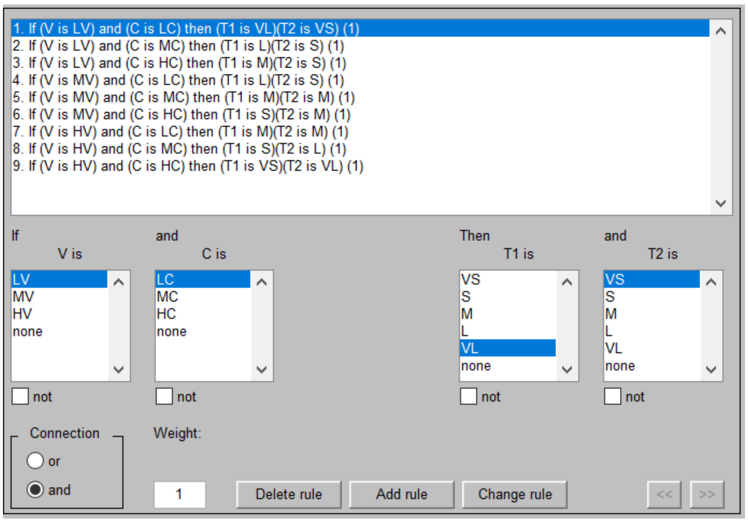

Figure 6: rule editor.

3.2.5. Observe

After editing the rule table, you can observe it through the observation window. The relationship between input and output is shown in Figure 7. Observe the overall correlation between output and input, open the Surface Viewer interface, the relationship between output T1 and input is shown in Figure 8, and the relationship between output T2 and input is shown in Figure 9 Show.

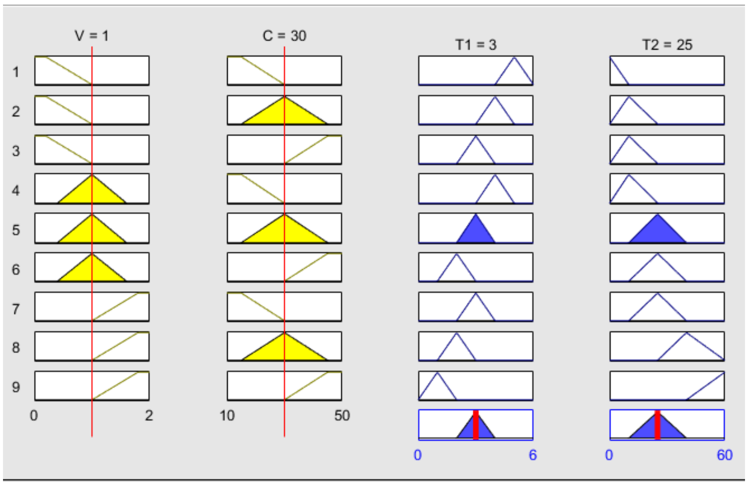

Figure 7: Rule observation window for algal removal machinery.

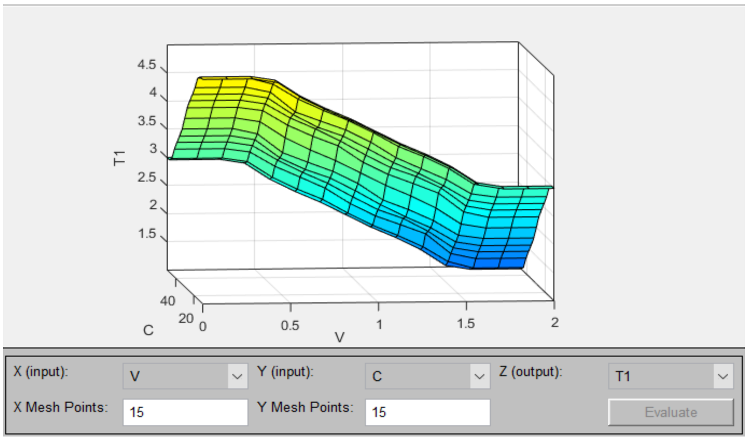

Figure 8: The relationship between T1 and input.

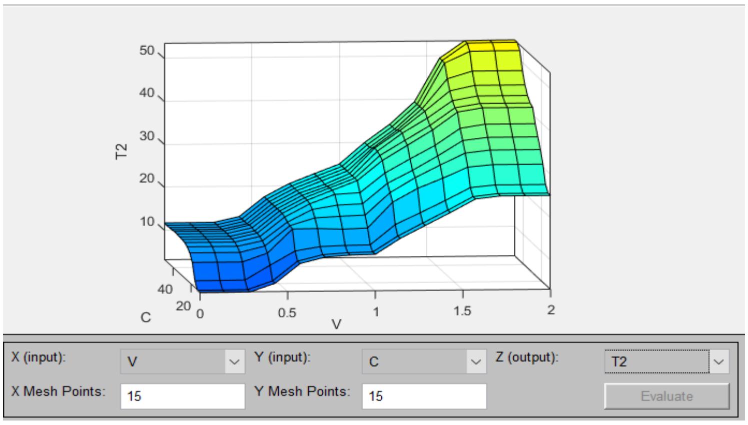

Figure 9: The relationship between T2 and input.

3.3. Simulink Simulation Model

After the fuzzy controller is edited, the connection work between the fuzzy control module and the Simulink module is carried out. The quality of the fuzzy controller editing can only be displayed after connecting with the simulation module, so first input the fuzzy control module into the simulation space. Then assign each representative module to the corresponding value range. The built simulation module is shown in Figure 10.

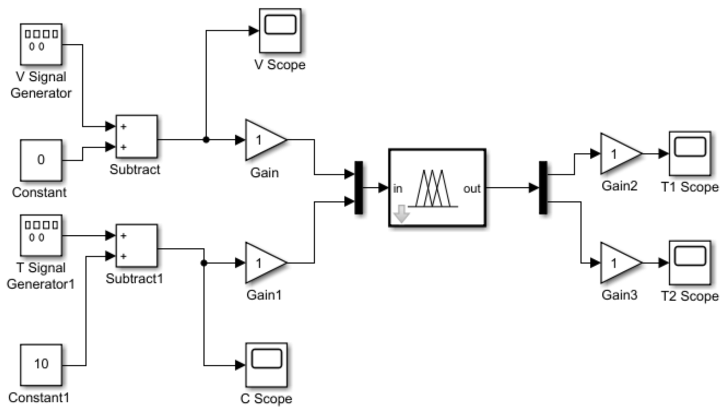

Figure 10: Simulation model diagram of fuzzy control system of algae cleaning mechanism.

3.4. Simulation Result Analysis

After the simulation module is set up, connect the FIS of the GUI design with the Simulink model diagram. The input variables water flowed velocity V and algae content C are set according to the change law of water flow velocity and algae content in the river every month during the year. In order to comply with the law, sine waves of different amplitudes are used here to represent. After running, get the time curve diagram of algae blocking time and water spraying time. The abscissa is the time, which represents different months here; the ordinate in Fig. 11 represents the algae blocking time of the algae blocking net, and the ordinate in Fig. 12 represents the water spraying time of the high-pressure water gun.

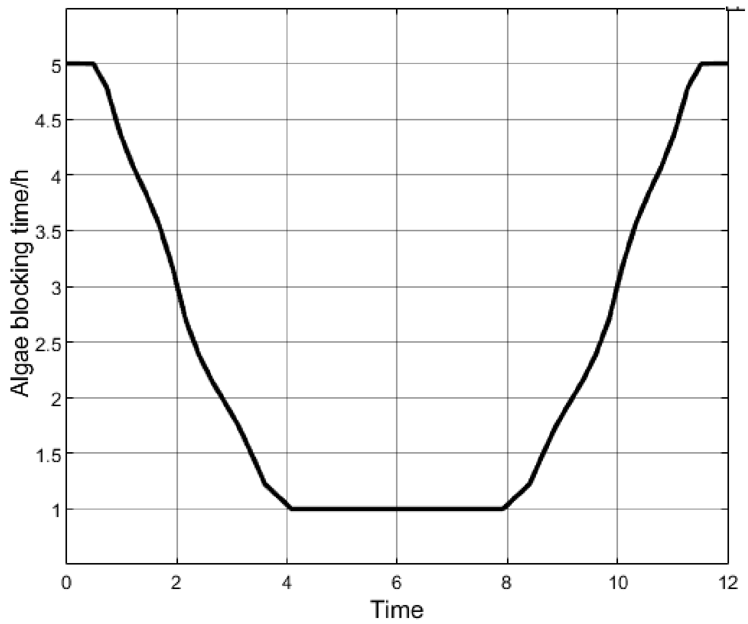

Figure 11: The oscilloscope of T1.

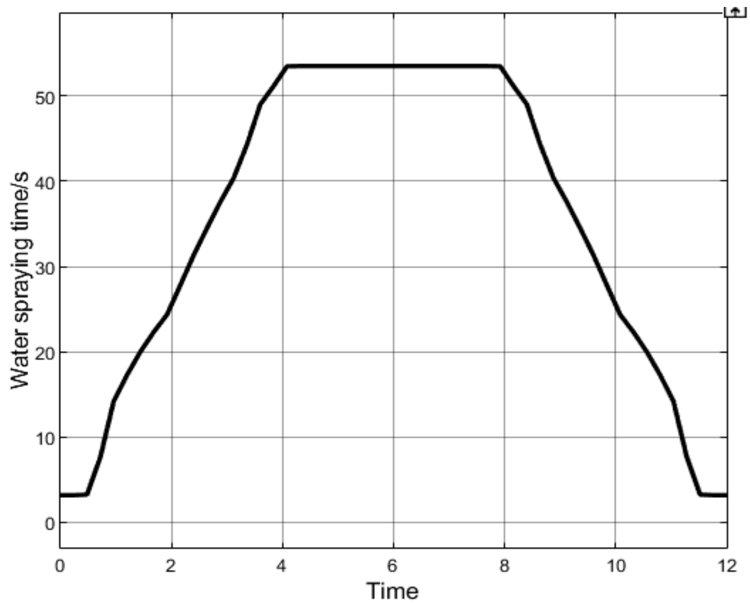

Figure 12: The oscilloscope of T2.

It can be seen from the curve change rule on the graph that as the water flow speed and the algae content change, the algae blocking time and the water spraying time will change accordingly. From the simulation analysis results, when the water flow speed and algae concentration increase, the algae blocking time decreases and the water spraying time increases. From January to December, the algae blocking time first changed from long to short, and then from short to long, showing a cyclical change; and the corresponding water spraying time changed from short to long, and then from long to short, which also showed a cyclical change.

4. Summary

a) Aiming at the problem of algae in the South-to-North Water Transfer Project, this paper applies the fuzzy controller based on the Mamdani model to the control of the algae-clearing mechanism's power system. The continuous controlled object is simulated. The simulation results show that the design of the power system of the algae cleaning mechanism based on the fuzzy controller can adjust the algae blocking time and flushing time in real time according to the water flow speed and the algae concentration, which is more in line with the actual application of the algae cleaning machine. Working conditions. Compared with traditional manual adjustment and control, it can improve the efficiency of algae cleaning, reduce labor costs, and realize the automation of algae cleaning machinery.

b) Fuzzy control can simplify the complexity of system designs, and is especially suitable for systems with nonlinear, time-varying, and incomplete models. It can maximize system performance and significantly improve system control accuracy.

References

[1] M.H, Ma. (2018) Study on the mechanical structure design and hydrodynamic characteristics of algae removal in the South-to-North Water Transfer Channel". 06

[2] Z.Z, Zhang. (2010) Design and Realization of Train Autonomous Driving Simulation System Based on DSPACE.

[3] X.Y, Lv. (2012) Research on Active Speed Control of Vehicles.

[4] H.L, Li. (2009) Research on Autoleveling System Model and Control Mechanism of Draw Frame.

[5] X.M. Shi., Z.Q, Hao. (2008) Fuzzy control and its MATLAB simulation. Tsinghua University Press; Beijing Jiaotong University Press, 2.

[6] J, Zhang. (2017) Research on Autonomous Follow Control System of Crawler Agricultural Mobile Robot. 01.01