Design of Fungi Fermentation Cultivation System Based on Single-Chip Microcomputer

Lingling Zhong 1*, Jianan Cao 1 and Changkai Li 1

1 School of Electronic and Communication Engineering, Anhui Xinhua University, Hefei, 230088, China
* zhonglingling@axhu.edu.cn, zhll3610@163.com

Abstract. With the development of science and technology, the application field of fungi fermentation production is becoming wide than ever before. In view of the strict requirements of high-quality fungi fermentation on the cultivation environment, a fungi fermentation cultivation based on STC89C52 single-chip microcomputer is designed. The system uses STC89C52 single-chip microcomputer as the control unit. The sensor detects the temperature, humidity and alcohol content of the cultivation environment. Then the data is analyzed and adjusted by the single-chip microcomputer in real time. Thus, the temperature, humidity and alcohol content in the cultivation environment can be in the optimal range and the parameters control of cultivation environment is realized. The system can monitor and adjust the parameters of cultivation environment in real time and improve the efficiency and productivity of fungi cultivation through the preliminary test. It can be predicted that the comprehensive research of electronic science and technology and technique of microorganisms cultivation will inevitably become the important matter and research aspect in the future.

1. Introduction
With the rapid development of science and technology, more and more attention has been paid to the application of microbial technology and it has been widely used in medical, industrial, agricultural, catering fields and so on. Temperature, humidity and alcohol content have a vital impact on the survival quantity and quality of fungi, so the fermentation and cultivation system of fungi needs to be improved and developed continuously, so as to produce colonies with various characteristics and apply them in various fields [1-2]. The microbial fermentation and cultivation system based on single-chip microcomputer combines electronic science and technology with microbial cultivation technology, which can monitor and control overall environment of fungi fermentation cultivation, optimize the implementation, effectively control and regulate the fermentation process, improve the production capacity of various fungi and meet the needs of various fermentation industries. The system has the characteristics of simple structure, high precision of acquisition and control.

2. Analysis of temperature and humidity detection and control
The temperature and humidity detection and control of fermentation cultivation system is shown in Figure 1, which is cascade control algorithm based on DMC algorithm (dynamic matrix predictive control) and classic PID algorithm (Proportion Integration Differentiation) [3-4]. The measured data of temperature and humidity sensors are simples by PID, and the collected values are digitally filtered after A/D conversion to remove clutter noise interference, then the feedback quantity is processed by differential processing to reduce the measurement error. DMC algorithm is modeled on unit step
response, implement the optimal control of the control system through the model prediction, online rolling optimization and feedback correction. The output of temperature and humidity control is \( y(k+i | k) \) (i = 1, 2, ..., M), compared with the preset standard temperature value \( r(k+i | k) \), the error value \( e(k+i | k) \) is obtained. After PID differential output, the output of the controller at the kth sampling time is the output to control and adjust the temperature and humidity values. The whole system adopts a closed-loop structure, through continuous feedback and correction, the stability and accuracy of the system are improved. The system temperature regulation includes cold cycle module and thermal cycle module. When temperature is too high, it will cool down, and when it is too low, the system temperature will heat up so that it will always keep in the preset temperature range. There are dehumidification module and humidification module in humidity regulation. It will dehumidifier when it is higher than the preset humidity and vice versa, so that the system is always kept in the preset humidity range.

3. Control of alcohol content detection

The reason why a certain number of alcohol content is detected in the cultivation system is that the fermentation process produces alcohol due to the decomposition of sugar, and some products indirectly promote the change of alcohol content. In the process of fungi fermentation, due to the utilization of glucose in the cultivation medium, a certain amount of carbon source was accumulated and alcohol was produced. The factors such as nutrient consumption, energy decomposition and new products in fermentation further caused the fluctuation of alcohol content in the cultivation medium[5]. The suitable alcohol concentration make the fungi adapt well and make the fermentation yield high. The system adopts composite glass electrode detection device, which has high conversion coefficient electrode, oxidation resistance and high temperature resistance. When the alcohol content in the cultivation system exceeds the preset value, the alcohol content regulation system will be triggered. The system will add 55% acetic acid solution to react with alcohol, so as to reduce the inhibition of alcohol on bacterial cell activity.

4. Overall design of the system

The system is mainly composed of microcontroller, data acquisition, parameter control, man-machine manual intervention module, liquid crystal display, alarm circuit and power management module. The overall design is shown in Figure 2. Working process: temperature and humidity sensor DHT11 and alcohol sensor MQ-3 collect corresponding temperature, humidity and alcohol content values of fungi fermentation environment, which are converted into digital signals by A/D analog-to-digital converter ASC0809, and processed by microcontroller STC89C52. After processing, the values are compared with the preset values, if the values do not reach the expected values, then the controller corresponding to the data with low precision is added, and the value is increased. If the value has exceeded the expected values, it will be back adjusted, so that the fermentation environment can finally reach the preset value of parameters. Among them, the D/A digital-to-analog converter DAC0832 converts the digital signals output from the microcontroller to the analog signal output; the LCD module LCD1602 displays the data in real time, which is convenient for debugging and observing the data; the alarm
circuit is that when the system parameter changes beyond the preset value and reaches the alarm value, the buzzer vibrates and sounds.

In the process of fungi fermentation, man-machine manual intervention module can deal with emergencies and avoid the damage of fermentation equipment to people and fermentation equipment itself, and ensure the overall control of fermentation system. The module uses relay control mode, through the construction of hardware circuit, the system carries out corresponding manual intervention: manually open and close the temperature regulation switch to adjust the system temperature; manually turn on and off humidity regulation switch to adjust the system humidity; accelerate the alcohol volatilization, and make the fermentation environment more suitable for fungi fermentation.

5. System testing
Before the single-chip microcomputer works, it is necessary to download the program code to STC89C52 single-chip microcomputer, select the port of the single-chip microcomputer, input the hex file of the program through stc-isp-15xx-v6.86v, turn on the switch after checking, and adjust the preset value of fermentation environment by processing the key, as shown in Table 1. The system test is divided into three parts:

- Simulated temperature test: put the system in a low temperature environment. When the detection temperature is lower than the preset temperature lower limit (the current temperature is 19°C), the buzzer will give an alarm, the green light will be on, and the thermal cycle module will start to work. When the temperature rises to the preset range, the buzzer stops and the thermal cycle module stops working, as shown in Figure 3. On the contrary, the working principle of cold cycle module is the same.

- Simulated humidity test: spray water from a water spray pot to increase the system humidity. When the detected humidity is higher than the preset upper limit (the current humidity is 94%), the buzzer will give an alarm and the green light will be on, and the dehumidification module will start to work. When the humidity drops to the preset range, the buzzer stops and the dehumidification module stops working, as shown in Figure 4. On the contrary, the principle of humidification module is the same.

- Simulated alcohol content test: due to the volatility of alcohol, the unignited lighter is used to simulate the evaporation of alcohol. When the detected alcohol content is higher than the preset upper limit (the current alcohol content is 8%), the buzzer will alarm and the green light will be on, and the alcohol content adjustment module will start to work. When the alcohol content drops to the preset
range, the buzzer stops and the alcohol content adjustment module stops working, as shown in Figure 5.

| Parameters       | Control range | Control target |
|------------------|---------------|----------------|
| Temperature      | 25-35℃        | ±5 ℃           |
| Humidity         | 35%-50%       | ±3%            |
| Alcohol content  | 1%-5%         | ±2%            |

6. Conclusion
In this paper, an intelligent and automatic fungi fermentation cultivation system is designed to monitor the situation of fungi fermentation in real time, compare and analyze the data in the fermentation process, and then adjust the parameters of temperature, humidity and alcohol content that affect the fermentation of fungi, so as to make the fermentation environment of fungi reach the optimal state. The system has the characteristics of high precision, economical and applicable.

Acknowledgments
The work is supported by Talent of Discipline and Specialty in Colleges and Universities of Anhui Province (No.gxbjZD54), Electronic Information Engineering brand cultivation project of Anhui Xinhua University (No.2018ppzyx01), Key Teaching and Research Project of Anhui Xinhua University (No. 2018jy006).

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