Medical culture device for microorganism based on the control of microcontrollers

[*1]Zhang Haowei

Abstract

In order to reduce the influence of external environment on microbial culture and improve the survival rate of culture, the microcontrollers control part was added to the existing microbial culture device, and a medical culture device for microorganism based on the control of microcontrollers with data teletransmissionwas established. When the microbial medical culture device detects abnormal light intensity signal, oxygen concentration signal, temperature signal, humidity signal and nutrient solution concentration signal, the microcontroller will send instructions to the subordinate executive mechanism to control these indicators to maintain normal value. The measured data are uploaded to the master server through the data transmission unit, which can better meet the functional requirements of data teletransmission in modern microbial culture. The microcontroller control belongs to the precise control, through the internal programming to set the preset value, its control precision can reach more than 90%. The microbiological medical culture device based on the control of microcontrollers not only greatly improves the cultivation efficiency of microbe, but also realizes the function of data teletransmission and reduces the recording error.

Keywords: Microbial cultivation, Microcontrollers,Data teletransmission,Culture device

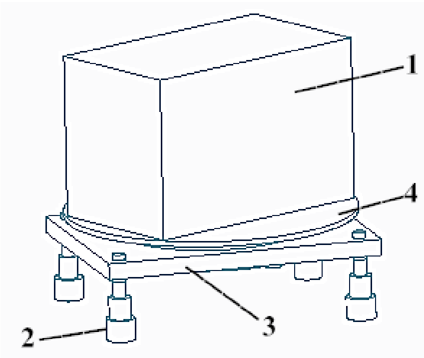
I. Introduction

Microorganisms, including bacteria, viruses, fungi and some small protozoa, are a large group of organisms with small individuals closely related to human life [1]. Microbial research plays a very positive role in our daily life. In the process of medical experiment and biological research, the microbial culture device is often used for observation of microbial culture experiment. There are many methods. The traditional culture method is to culture microorganisms in a culture vessel under natural environment [2,3]. Due to different preferences of microorganisms and different requirements on indicators of various natural environments, the natural environment will inevitably fail to meet their growth requirements and eventually lead to failure of experiments or low efficiency. And the petri dishes are all covered on the dishes, with poor tightness, which is not easy to form a sterile environment, and the indicators are not easy to control. The medium will fail in about 3-5 days [4].When cultivating anaerobic bacteria, anaerobic tanks are relatively expensive, large space is wasted in the dryer. Oxygen absorption reagent is wasted. Inverted plate anaerobic is not strict, and easy to pollution [5]. Although some existing incubators can meet some of the corresponding indicators, they all have certain limitations. And the data of environmental indicators can only be collected on site [6,7], which increases the workload of personnel to a certain extent. For example, the cultivation methods of shaking bed and fermentation tank can only control a certain indicator [8].Therefore, the efficient, safe, practical, convenient and accurate microbial medical culture device is particularly important.

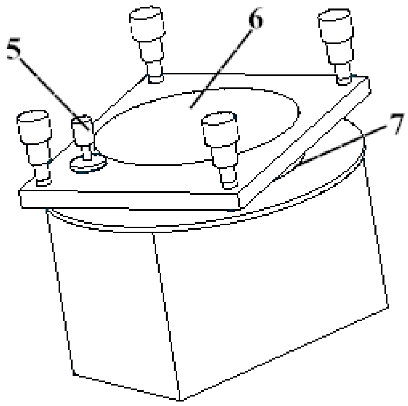
*Corresponding Author: Zhang Haowei
(*E-mail:446118236@qq.com*).
[1]*Fukang Hospital, Hongqiao, Tianjin, China,300134*

II. The external structure of the culture device

The external structure of the culture device is the detection module of the whole device. As shown in figure 1, 1 is the incubator, 2 is the support rod, 3 is the base, 4 is the tray, 5 is the motor, 6 is the gear, and 7 is the shaft. The external structure is composed of these parts, in which the shaft is connected to the base and tray by bearing, which is designed to reduce the friction resistance during rotation. The incubator is placed on the tray, and the motor drives the rotation shaft through the gear, so that the tray and the incubator rotate together. All four sides of the incubator are equipped with the same transparent material, which can accept certain light irradiation. The speed and direction of rotation are set in advance through the internal programming of the single-chip microcomputer that controls the module. The aim of this method is to ensure that the side light can be evenly illuminated into the incubator, so as to control the illumination of microorganisms in the incubator. Of course, if the culture is Yin - loving microorganisms, use black shading paper to cover the transparent material at the same time. The motor does not have to rotate movement. The device can be static culture.



(a)



(b)

Figure 1 The external structure of the culture device

As shown in table 1, it is a set of data obtained through experiments, and the influence of light intensity on specific growth rate, maximum cell concentration, yield per unit area and yield per unit volume of a certain microorganism [9,10].

Table 1 shows that light intensity has a great influence on the growth of microorganisms. It can be observed from the table that, within the light intensity range of 1500lx ~ 9000lx, the specific growth rate increases with the increase of light intensity. It reaches the highest value at 4500lx, which is 0.102u, but decreases at 9000lx. This is consistent with the research results of previous scholars [11-12].The highest cell density increased with the enhancement of light intensity, reaching the maximum at 9000lx (64300000ml-1), followed by the second highest at 4500lx (62250000ml-1); However, the effect of light intensity on yield per unit area and volume was consistent with that of the maximum cell density. The highest values were 2.175g.m-2.d-1 and 42.212mg.L-1.d-1, respectively, when the light intensity was 9000lx. (If the range of light intensity is more precise and smaller, the peak specific growth rate fluctuates around 4500lx, and the maximum cell density, yield per unit area and yield per unit volume also fluctuate around the maximum light intensity, making the results more accurate and reliable).

Table 1 the influence of light intensity on specific growth rate

light intensity(lx)	1500	2500	4500	9000
specific growth rate(u)	0.082	0.084	0.102	0.903
maximum cell concentration(10^7mL)	3.680	3.920	6.225	6.430
yield per unit area($g.m^{-2}.d^{-1}$)	0.949	1.150	1.636	2.175
yield per unit volume($mg.L^{-1}.d^{-1}$)	18.895	22.886	32.569	42.212

It can be seen that light intensity has a great influence on microorganisms. In this paper, the microbe medical cultivation device based on single-chip microcomputer can achieve the cultivation under the optimal illumination intensity by transmitting the illumination intensity data signal needed by the microorganisms to be cultivated in advance to the single-chip microcomputer, so as to control the rotation of the motor based on this standard. However, the determination of optimal illumination intensity should comprehensively consider various factors, because the optimal illumination intensity of each aspect is different, mainly considering the purpose of cultivation, and finally determine the optimal illumination intensity.

III. The control portion of the culture device

The control part of the culture device is the most critical part of the device. Figure 2 shows the frame diagram of the control part of the culture device, which mainly includes detection module, control mechanism, actuator and control panel. The control mechanism includes A/D conversion circuit and single chip microcomputer. Because MCU can only deal with digital signals, it is necessary to convert all kinds of detected analog signals through A/D conversion circuit. Among them, the signals of detection module, actuator and control panel are connected with the corresponding input/output pins of the single-chip microcomputer.

3.1 The detection module

The detection module of the culture device, as shown in figure 3, includes oxygen concentration meter, temperature sensor, hygrometer, and nutrient solution detector. The PA0-PA3 pin of the single chip microcomputer, which is the input control guide of single chip, is connected to the A/D switching circuit in the control mechanism. The various analog signals are entered into the single chip microcomputer by the conversion circuit. The single chip can set a standard value to each index by using internal programming to compare it, so that the single chip can send the instructions.

3.2 The executing agency

The actuator of the culture device, as shown in figure 4, includes motor, air valve, anaerobic valve, high concentration nutrient valve, diluent valve, humidifier and temperature control switch. The motor is used to drive the incubator to rotate and control the light intensity. Air valves are used to increase oxygen concentration; Oxygen free valves are used to reduce oxygen concentration; High concentration nutrient valve is used to increase the concentration of culture liquid. Diluent valve is used to reduce the concentration of medium. Humidifier is used to control the humidity in the incubator. Temperature control switch is used to control the temperature in the incubator. They are connected with seven output pins of PA0-PB6 of single chip microcomputer respectively. As output control pins, they receive the instructions transmitted by these pins and carry out the execution of corresponding actions to jointly control the optimal cultivation environment in the incubator.

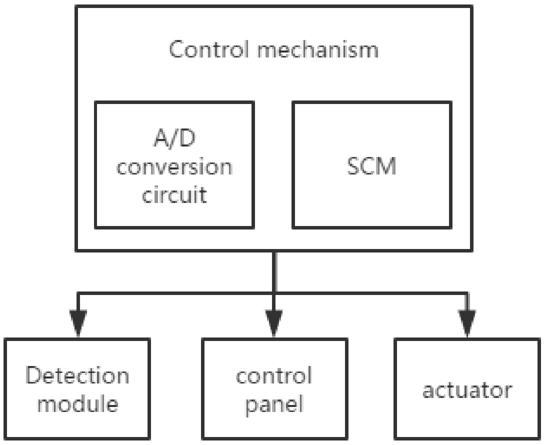


Figure 2 The control part

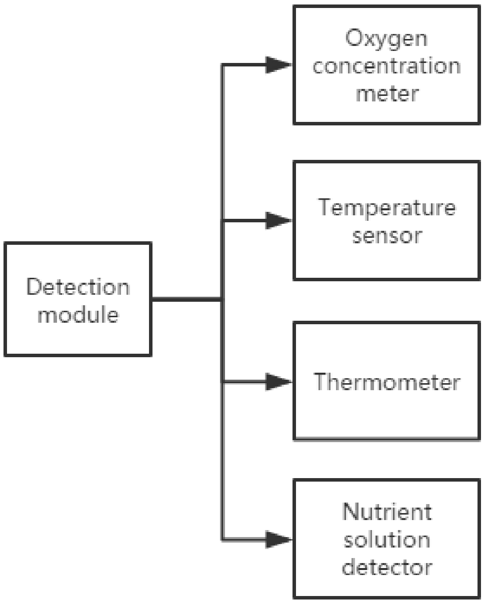


Figure 3 The detection module

3.3 The control panel

The control panel of the culture device includes display screen, indicator light and data transmission unit. The signal detected by the detection institution is converted into digital signal through A/D conversion circuit and then sent to the single-chip microcomputer. After the processing is completed, the real-time indicator can be displayed on the display screen through PB7 pin. At the same time, the remote transmission function of data is finally realized through the data transmission unit. Under normal circumstances, the green indicator light, when there is an abnormal situation, the red indicator light to remind the troubleshooting.

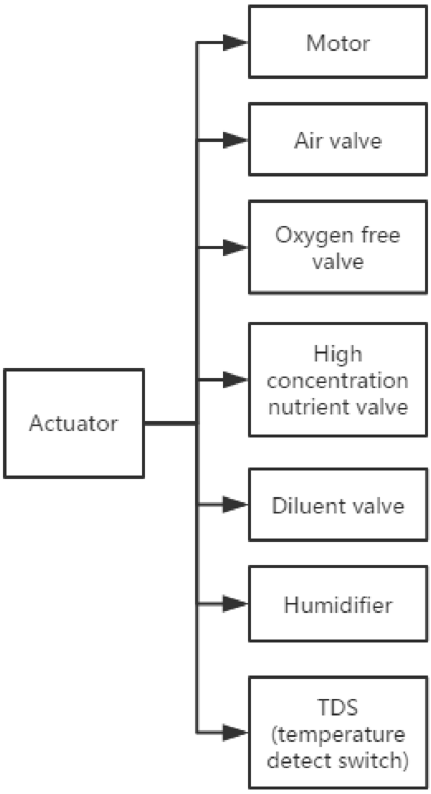


Figure 4 The actuator

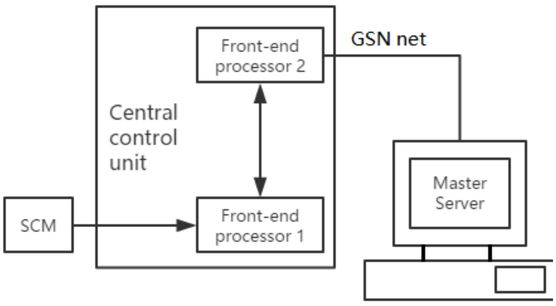


Figure5Thestructure of the dataremote communication

As shown in figure 5, As shown in figure 5, a structure of the dataremote communication was shown. The central control unit includes the front-end processor and the rs-485 bus, The single chip machine will pass the detection of various indicators to the front end processor 1, The front-end processor 1 is processed and then passed to the front-end processor by the rs-485 bus. The front-end microprocessor 2 is different from the front-end microprocessor 1, which not only requires data processing and some data transfer for the rs-485 bus, but also USES its own remote wireless transmission module to carry the data remote transmission through the GSM network, so it is used to implement this function by using the open base m22 chip to ensure the implementation of relevant communication. The front-end processor 1 is implemented using stc12c5410ad. The main server is connected to the specified network and set up its own IP address. The front-end processor 2 contains the GPRS module, which passes the signal from the microprocessor 1 to the main server through the GSM network, which implements the wireless remote transmission of the data.

The sensitivity of the receiving detection is that the voltage difference between the difference input end VA and VB must be greater than or equal to $\pm 200mV$. When the voltage between VA and VB is -200mv, the output is 0. When the absolute value of the electrical difference between the VA and VB is less than 200, the output is uncertain. In order to solve this problem, the design of a person is more than the VB end potential, so the rs-485 bus's RXD level will remain 1 while not sent, and the main control chip will not be in a code.

IV.work procedure

(1)Workflow for light control

If the microorganisms to be cultivated are shade-loving, the transparent material part of the culture device is covered with black awning paper to construct a matte environment. If the microorganism that is developed is the Yang type, first, the rotation speed of the motor is set in the single chip microcomputer of the control mechanism, and the light source of the side is open at the same time. The rotation of the motor drives the rotation of the tray, so that the plant can rotate around the source of light. This makes it possible to ensure that microbes can receive uniform light without causing its local light to be too strong or too weak, even causing the uneven temperature of each part of the temperature to eventually affect the normal growth of microorganisms.

(2)Workflow for the control of index

In the process of microbial culture, various cultural indicators will change constantly. The flow chart of oxygen concentration control is shown in figure 6.After the program starts to run, firstly reset and pre-define all parameters involved in the program, initialize each module, and finally enter the loop control. Oxygen concentration is an important measure of microbial growth. All kinds of microbial growth require different concentrations of oxygen. Because most of the microbes that are cultured are anaerobic bacteria, the characteristics of anaerobic bacteria are that when the oxygen concentration is a relatively low concentration, the growth condition is the best, and the growth is inhibited when it is above a certain concentration. If it is aerobic bacteria, when oxygen levels are lower than one concentration, growth is suppressed and even died.[15,16] The oxygen concentration detector converts the detected oxygen content signal in the cultivation device into digital signal through A/D conversion circuit and then transmits it to the microcontroller. The microcontroller compares the oxygen concentration data signal with the pre-set oxygen content data. When oxygen content is too high, the oxygen content is added to reduce the oxygen content, when the oxygen content is too low, it is added to the air valve sending instruction for aerobic air, which is to increase the oxygen content, and it is important to note that all the gas valves have a filter to disinfect the gas that enters the culture device to ensure that the gas in the culture device is sterile.

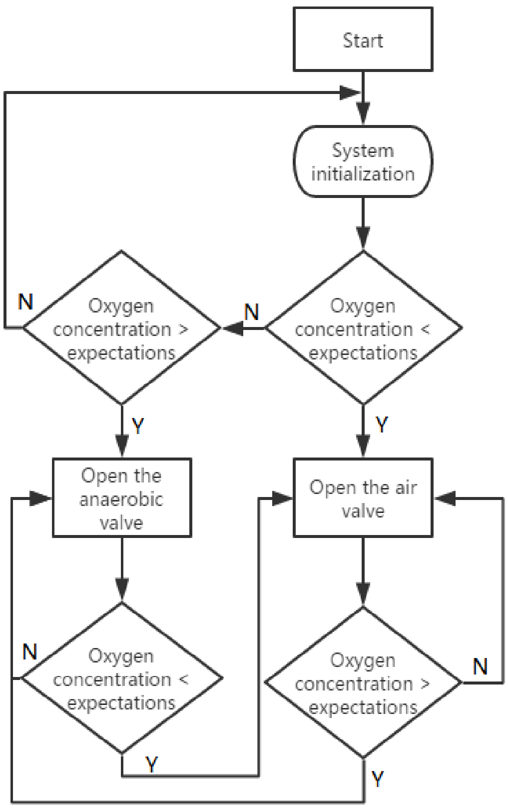


Figure 6 Oxygen concentration control flow chart

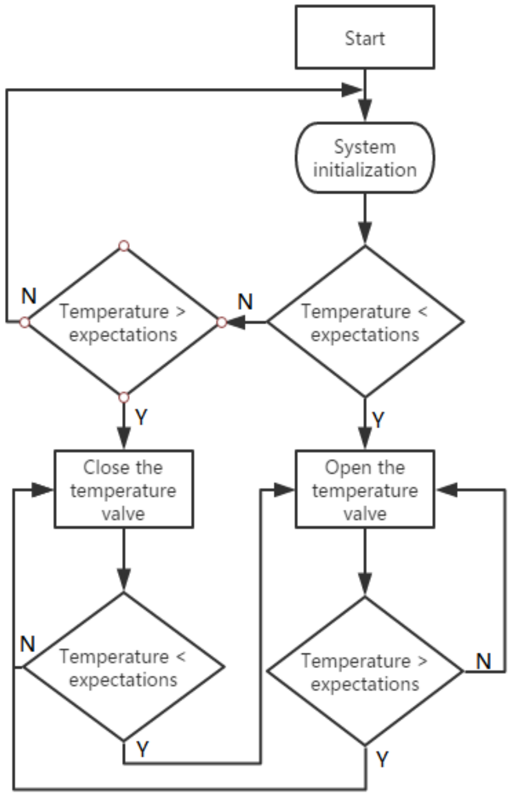


Figure 7 Temperaturecontrol flow chart

The temperature control flow chart is shown in figure 6. After the program starts to run, the parameters that are involved in the program are first defined. The various modules are initialized and the loop control is finally entered. Temperature is an important measure in the growth process of microorganisms. The optimum temperature of various microbial growth is not the same. When the optimum temperature of the microorganism is not available (too high or too low), it will seriously affect the growth and growth cycles of microorganisms, and will stop growth and even death when severe[17]. The temperature sensor converts the detected temperture signal into digital signal through A/D conversion circuit and then transmits it to the microcontroller. The microcontroller compares the temperture data signal with the pre-settemperture data. When the real-time temperature is too high or too low, it is controlled by sending instructions to the temperature control switch to keep it open or closed. Here, the heating device adopts the structure of the spiral shape, which is intended to increase the heat dissipation effect, and the change of temperature is more rapid and obvious, which is beneficial to the growth of microorganisms.

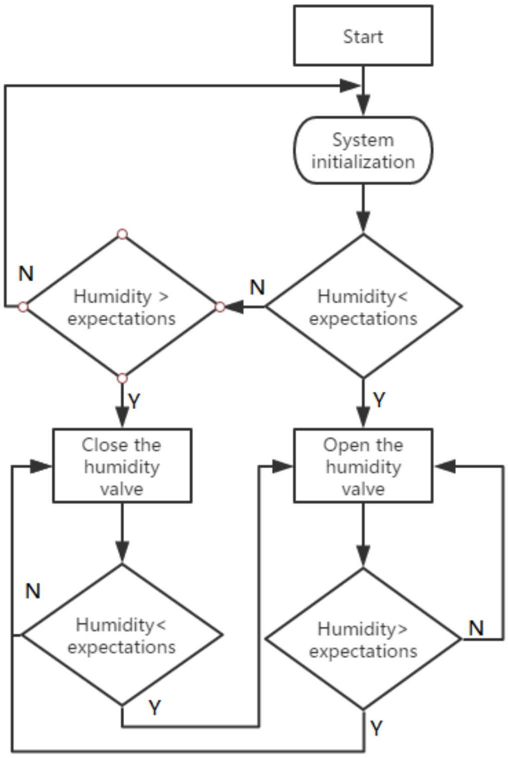


Figure 8 Humiditycontrol flow chart

The humidity control flow chart is shown in figure 8 above. After the program starts to run, the parameters that are involved in the program are first defined and the various modules are initialized and the loop control is finally entered. Humidity is an important measure of microbial growth. The humidity of various microbial growth is different. When the optimal humidity of the microorganism is not reached (too high or too low), it will seriously affect the growth and growth cycle of microorganisms, and will stop growth and even death. The humidity signal detected by the moisture meter is converted into a number signal by A/D transformation circuit and is delivered to a single chip. The single chip microcomputer compares the optimal humidity data signal with the most optimal humidity data signal that is developed in the training device in advance. When the humidity is low or high, and the humidifier sends the instruction to keep it open or closed, and to train the humidity in the box, and finally in the optimum humidity.

The flow chart of nutrient concentration is shown in figure 9. After the program starts to run, the parameters that are involved in the program are first defined and the various modules are initialized and the loop control is finally entered. Nutrient concentration is an important measure in the growth process of microorganisms. The concentration of nutrient fluid required for various microbial growth is different. When the most appropriate nutrient concentration is not available for microbial growth (too high or too low), it will seriously affect the growth and growth cycles of microorganisms, and will stop growth and even death when severe. The nutrient fluid concentration signal was transferred to the single chip, and the data signal was compared with the optimal nutrient fluid concentration data signal of the microorganism that was developed in the training device in advance, when the nutrient fluid concentration was low, the single chip microcomputer sent the high concentration nutrient fluid to the high concentration nutrient fluid valve, and when the concentration of the nutrient fluid in the culture device was so high, the injection of the liquid was sent to the liquid valve. Through this adjustment, the cultivation of the optimum nutrient concentration of microorganisms is finally realized.

Moreover, the signal is converted into a number of words and is processed by a single chip microcomputer. The processing signal is transferred to the central control unit. After the process of the front-end processor 1，RS-485 bus and the front-end processor 2, Finally, the data of GSM network realizes the interconnection of the master server, and the wireless communication remote interconnection is realized.

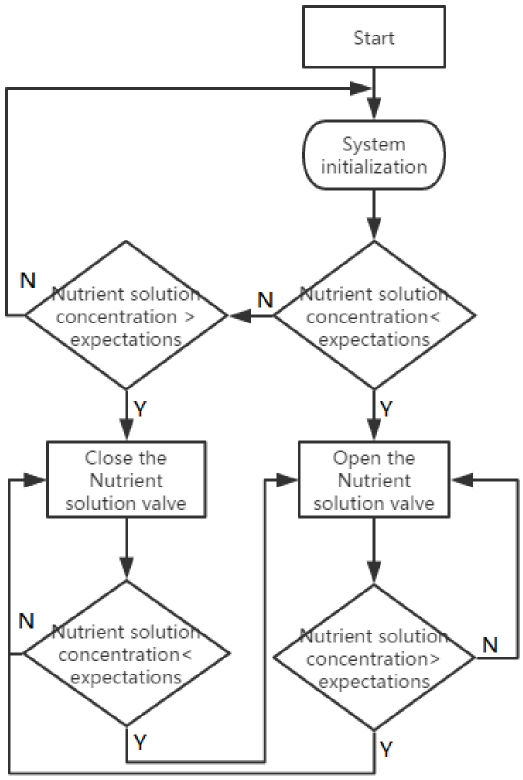


Figure 9 Nutrient concentrationcontrol flow chart

V. Conclusion

The microcontroller control part was added to the existing microbe culture device and the medical culture device for microorganism based on the control of microcontrollers with data teletransmission was established. Through the collection of oxygen concentration, temperature, humidity, nutrient concentration and other indicator signals, after the processing of microcontrollers, it can simultaneously realize the control of multiple indicators, to set the microbial culture environment, make its various indicators reach the optimal, achieve the control of light at the same time.

All controls are realized by comparing the detected control signal with the signal data set in advance in the microcontrollers, so as to give instructions. The control precision of its microcontrollers can reach more than 90%, and the completely optimal culture environment greatly shortens the training period. Through the research of rs-485 bus and GSM network, the device can realize the wireless remote communication of data and avoid the tedious work of collecting field index data. It is efficient, safe, stable, reliable, convenient and fast, and will have a wide application prospect.

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