# DESIGN OF TEMPERATURE AND HUMIDITY CONTROLLER OF AGRICULTURAL INTELLIGENT TOBACCO HOUSE BASED ON STM32
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# 基于 STM32 的农业智能烤烟房温湿度控制仪的设计

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## ABSTRACT

*The quality of tobacco baking is one of the important factors affecting the economic benefits of tobacco enterprises. Because of the low efficiency of traditional manual baking methods and the poor quality of tobacco, the economic benefits of tobacco enterprises and tobacco farmers are also greatly affected. In view of this, this research takes the temperature and humidity control as the research object, and proposes an agricultural intelligent tobacco house temperature and humidity controller based on STM32. Firstly, the general design scheme, hardware circuit design scheme and software design scheme of the control system are described, in which the human-machine interface circuit design of the hardware circuit design is emphatically analysed, and finally, the design of this research is applied The agricultural intelligent temperature and humidity controller measures the temperature and humidity of the flue-cured tobacco house, and verifies the control effect. The results show that the temperature control accuracy based on STM32 is significantly higher than that of traditional control method, which is conducive to the improvement of tobacco baking quality. It is hoped that this study can provide a significant reference for the research of temperature and humidity control in tobacco industry in China.*

## 摘要

*烤烟的质量是影响烟草企业经济效益的重要因素之一。由于传统的手工烘烤方法效率低下以及烟草质量差，烟草企业和烟农的经济利益也受到很大影响。有鉴于此，本研究以温湿度控制为研究对象，提出了一种基于 STM32 的农用智能烟房温湿度控制器。首先介绍了控制系统的总体设计方案，硬件电路设计方案和软件设计方案，着重分析了硬件电路设计的人机界面电路设计，最后应用了本研究的设计。农业智能温湿度控制器测量烤烟房的温度和湿度，并验证控制效果。结果表明，基于 STM32 的温度控制精度明显高于传统控制方法，有利于提高烤烟质量。希望这项研究能为我国烟草工业的温湿度控制研究提供一定的参考和参考。*

## INTRODUCTION

China is a big country of tobacco planting, and tobacco industry plays an important role in our national economy. According to statistics, the tobacco industry accounts for 10% of China's annual tax revenue, and the tobacco industry has become an important source of China's financial revenue *(Enrico, Corti, Michele. 2017)*. With the improvement of the quality of life of Chinese residents, the public demand for tobacco products is also higher and higher, which requires that tobacco enterprises can bake high-quality tobacco products. However, due to the backward baking equipment and the low professional level of the staff in the remote mountainous areas, China's tobacco planting areas generally fail to bake out high-quality tobacco products *(Yasser Abdelaziz, 2017)*. Therefore, it is necessary to improve the technology of tobacco baking to further improve the income of tobacco enterprises and farmers. Due to the low efficiency of the traditional artificial baking method and the poor quality of tobacco leaves, the economic benefits of tobacco enterprises and tobacco farmers have been greatly affected, which is not in line with the development trend of intelligence. Although some tobacco baking equipment has appeared in China, the temperature and humidity control of tobacco houses is often accompanied by coupling, non-linear and time-varying factors, resulting in the temperature and humidity control poor accuracy *(Khan et al., 2015)*. In this study, STM32 microcontroller is introduced into the temperature and humidity automatic control technology, which takes the system control accuracy as the core, and optimizes the integration degree of the control system.

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Aiming at the control of temperature and humidity in the flue-cured tobacco house, STM32 microcontroller is introduced in this study. This technology belongs to an integrated circuit chip, and uses VLSI technology to integrate the original parts with data processing ability, and integrates these functional elements on the silicon chip to form a microprocessor. STM32 microcontroller is widely used in various fields because of its small size, simple structure and relatively cheap price.

The innovation of this study is to use the real-time measurement method of tobacco surface temperature, which cannot test the current situation of tobacco leaf surface temperature in the flue-cured tobacco house, and use the real-time detection method of leaf temperature to measure the surface temperature of tobacco leaf. In the process of baking experiment, the temperature difference between the environment of the flue-cured tobacco house and the surface temperature of tobacco leaf is measured, which provides reliable detection data for this research work.

This study is divided into four parts. The second part is about the research status of the application of temperature and humidity intelligent control technology in various fields at home and abroad; the third part mainly introduces the research method, the first section introduces the overall design scheme of the temperature and humidity controller based on STM32 intelligent flue-cured tobacco house, the second section introduces the hardware circuit design method of the control system, the third section introduces the software of the control system design method. In the fourth part, the control system is tested and analysed. The results show that the temperature control accuracy based on STM32 is significantly higher than that of traditional control method, which is conducive to the improvement of tobacco baking quality.

In recent years, people attach great importance to the intelligent control technology of temperature and humidity, which has a profound impact on the future direction of social development.

Researchers at home and abroad also conduct in-depth research on this technology.

*Wei Zheng et al.* proposed a Multivariable Decoupling Fuzzy logic control method, which designed two kinds of fuzzy controllers based on fuzzy logic theory. Fan, heater and humidifier are used to control the temperature and humidity. The temperature and humidity drop caused by ventilation is compensated by heater and humidifier respectively, which realizes multivariable decoupling. The results show that the power consumption of this method is 19% lower than that of manual regulation *(Wei-Zheng et al., 2019)*.

*Elkhayat et al*. studied the prediction method of temperature and humidity by capacitive humidity sensor, and analysed the change of temperature and humidity by using circuit temperature control method. The results show that the prediction accuracy is very high, and it is suitable for self-diagnosis of humidity sensor *(Elkhayat et al., 2016)*.

*Yan and others* developed the capacity controller of the three-evaporator air conditioning system to realize the analogue controllability of the capacity controller. According to the operation characteristics of the three-evaporator air conditioning (TEAC) system, the capacity controller was further improved and an improved controller was developed. The results show that the improved controller can realize the indoor temperature and humidity synchronous control of TEAC system *(Yan H et al., 2017)*.

*Mirzaee Ghaleh et al*. monitored indoor climate management of typical poultry farms in Iran, and compared fuzzy logic with switch controller. Three fuzzy controllers were developed and tested by LabVIEW software. The results show that the fuzzy controller has a good response to temperature and humidity *(Mirzaee-Ghaleh et al., 2015)*.

Infant incubators such as *Singla et al.* provide a controlled environment for premature infants in need of special care. The results show that the temperature and humidity controller of infant incubator based on microcontroller is very important for the normal growth of newborns (premature) *(Singla S. and Singh V., 2015)*.

*Mien T.L.* analysed the indoor air, established the nonlinear interactive mathematical model of indoor air, proposed the design method of traditional PI controller, decoupling controller and parameter self-tuning PI controller based on the combination of fuzzy logic principle and decoupling controller in the process of indoor air heating and humidification, and simulated and tested the proposed temperature and humidity process controller on MATLAB *(Mien T.L., 2016).*

*Li Shujiang et al*. proposed a control algorithm based on genetic algorithm (GA) to optimize PID controller parameters. The predictive decoupling method was used to decouple the temperature and humidity. The objective function was used as the evaluation value of the controller. Through the selection, crossover and variation of genetic algorithm, the optimal solution of PID control parameters was obtained. The simulation experiment was carried out with MATLAB.

The results show that GA-PID control algorithm can effectively decouple the temperature and humidity, and the control system has better control performance *(Li Shujiang, et al., 2017)*.

*Shigang Cui* and others have developed a temperature and humidity monitoring system based on embedded technology. This system uses STM32 microprocessor as the core controller to realize the accurate collection, display and control of environmental factors (including temperature and humidity) in the plant growth box through the monitoring system. According to the principle of optimal weight distribution, each layer of sensor data is adaptively weighted and fused to get accurate temperature and humidity values. The results show that the system can accurately monitor and display the temperature and humidity in the plant growth box *(Shigang Cui et al., 2017)*.

*Nurainaa Elias et al*. designed a fuzzy logic controller to simulate the control system based on user's expected temperature, user's expected humidity and deviation from expected parameters. The results will be described by the speed of the output actuator varying with the input temperature and humidity *(Nurainaa Elias et al, 2018)*.

*Juliana D.S.G.B. et al*. used two kinds of temperature control technology to evaluate the spatial distribution of farm thermal environment variables, evaluated the climate variables such as dry bulb temperature (TBS), relative air humidity (RH), temperature and humidity index (THI) and enthalpy, and drew the spatial distribution diagram of these variables by Kriging method. The results show that the resistance heating system with PID controller improves the thermal comfort conditions of pig farm in the coldest time, and maintains the spatial distribution uniformity of indoor air temperature *(Juliana de Souza Grand Barossa et al., 2017)*.

*Ou K* et al. proposed a multi input multi output (MIMO) fuzzy controller, and proved its real-time control ability to the strong nonlinear power fuel cell system, constructed a five input two output fuzzy logic controller, which is used to adjust the temperature and relative humidity of the open cathode fuel cell in real time. The results show that the fuzzy controller effectively improves the output power of PEM fuel cell *(Ou K, Yuan W.W. and Choi M., 2017)*.

*Yan et al.* introduced the development of a capacity controller of three-evaporator air conditioning (TEAC) system, which is used to improve indoor air humidity control. The results show that the controller can improve the indoor humidity control and energy efficiency *(Yan H. et al., 2016)*.

Through the analysis and research of temperature and humidity intelligent control technology, it can be seen that STM32 microcontroller is the main carrier of temperature and humidity control technology, but the research work in this field in China is still in the initial stage, and the research of temperature and humidity control technology based on STM32 needs to be expanded. Therefore, this study mainly aims at the control of temperature and humidity in the flue-cured tobacco house. STM32 microcontroller is introduced into the temperature and humidity automatic control technology.

## MATERIALS AND METHODS

### The overall design of the temperature and humidity controller in the tobacco house

The main control object of this research system is the circulating fan, air door and combustion supporting fan, and the controlled object is the temperature and humidity measured in the flue-cured tobacco room. The system consists of five parts, including power supply, RS485 communication interface, man-machine interface, control output, STM32F103 microcontroller. The core component of the control system is STM32F103 chip, and the LCD screen is installed on the field controller, so that the indoor temperature and humidity changes can be known by the field staff at any time, and the system can be debugged in real time according to the changes. The temperature and humidity sensor is used to import the temperature and humidity collected in the flue-cured tobacco room into the STM32 controller, and the data is imported into the upper computer monitoring system by the field bus, and the temperature and humidity data is displayed on the LCD screen in real time. The control system adjusts the driving module through the internal stored expert curve and the preset temperature and humidity curve, so as to control the revolving speed of the circulating fan, the start and stop of the combustion supporting fan and the opening of the air door, and realize the adjustment of the indoor temperature and humidity. In case of phase loss, circuit failure, open circuit of sensor, abnormal temperature and humidity, the control system will give voice alarm through the upper computer and voice chip at the same time.

The controller is irregularly attached to the bus through the system interface, and the network bus is connected to the data adapter through the system interface, and then the data adapter is connected to the upper machine monitoring by the USB interface, and finally the data is received and sent. As shown in Figure 1.

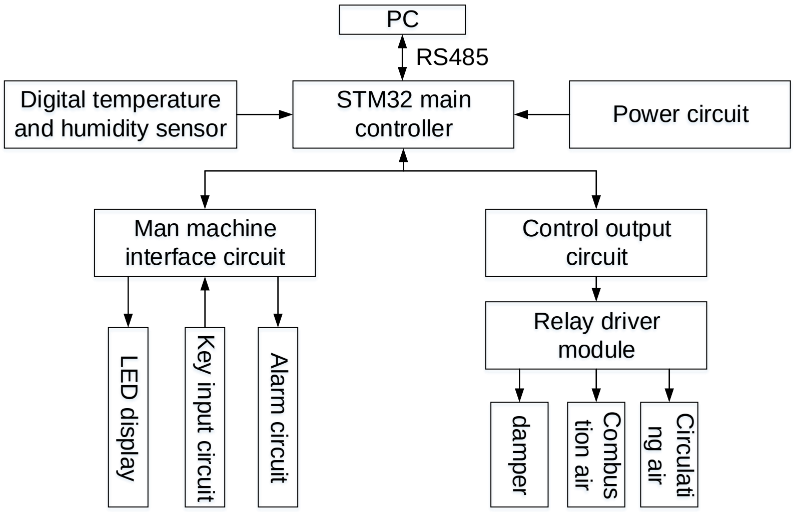


**Fig. 1 - General structure of controller design**

## Hardware design of temperature and humidity controller in tobacco room

The system in this study not only needs to collect the temperature and humidity data of the flue-cured tobacco house, but also provides the detection signals needed for system alarm. The detection signals include the detection signals of system voltage, working state of the circulating fan, phase loss overload and so on. Among them, the phase loss overload signal is the most special, which is supported by the double current transformer. Because STM32F103 is embedded with a digital simulator and there are 16 ADC channels, the analogue signals collected are processed by means of filtering and voltage dividing, and the processed data are input into the system. The circuit design of this study is relatively simple and will not be described too much. Because the key work of the system is to collect the temperature and humidity in the flue-cured tobacco room, the sensor selected by the system should have the characteristics of accurate measurement and convenient use. In addition, the system needs to measure the temperature of four test points in the flue-cured tobacco room, two temperature and humidity measurement points in the upper and lower shed. The digital temperature sensor of the control system is a series of HSTL sensors, which adopts a single interface mode and applies the mode of one wire bus. There are only three pins DQ, GDN and VDD in the sensor, which have fast conversion rate and stable performance. Moreover, the output of the measured data is also the interface directly applying the mode. Therefore, the control system only needs simple noise reduction for data, which can be directly connected to the input and output interfaces of STM32, improving the anti-interference ability of the system, and reducing the frequency of circuit components and input and output ports. The temperature range of HSTL series sensor is [- 55, + 125] $^oC$. If it is between [- 10, + 85] $^oC$, the accuracy error of measurement is about 0.5$^oC$, and the voltage is [3.0, 5.5] V. The control system directly allocated four groups of input and output ports, PB3, PB11, PB12 and PB10, and connected these ports to the sensor at the same time. Generally, in the detection circuit, if the resistor R21 has a certain current limiting protection function, the single bus is pulled high through the pull-up resistor R22 to reach the receiving mode, and it is kept between [15,60] us. The capacitor C28 controls the electric frequency of the host at the level of not less than 480us to form a reset pulse.

In order to enable the staff to adjust and control the controller conveniently on site, the man-machine interface circuit system in this study mainly includes key input, LCD display drive, voice alarm and other circuits, as shown in Figure 2. The display screen of the control system is pen Segment LCD, which has a backlight control mode of low brightness and high brightness. Low brightness indicates the normal operation of the control system, and high brightness indicates the operation of the control system. When the control system works normally, the LCD display shows the calendar clock, control curve data, working time, measured temperature in the flue-cured tobacco room, target temperature and humidity, etc. Set 8 keys of the control system, and drive ls165m by pb0, PC4 and PC5 ports of STM32, so as to achieve the function

realization purpose of the control system in the stop or operation state, such as alarm end, data record query, baking curve modification and other functions. On the basis of the pull-up resistance, the system also adds the anti-shake capacitance, which greatly increases the reliability of the system data in the input. In this study, wtv170-16p chip is selected as the chip of voice alarm.
The data converter of the chip is 16bitsdac, voice duration is 170s, frequency is 6KHz, and the chip belongs to one-time programmable burning chip. In this study, the serial port control mode is applied, and the voltage is 3.4V.

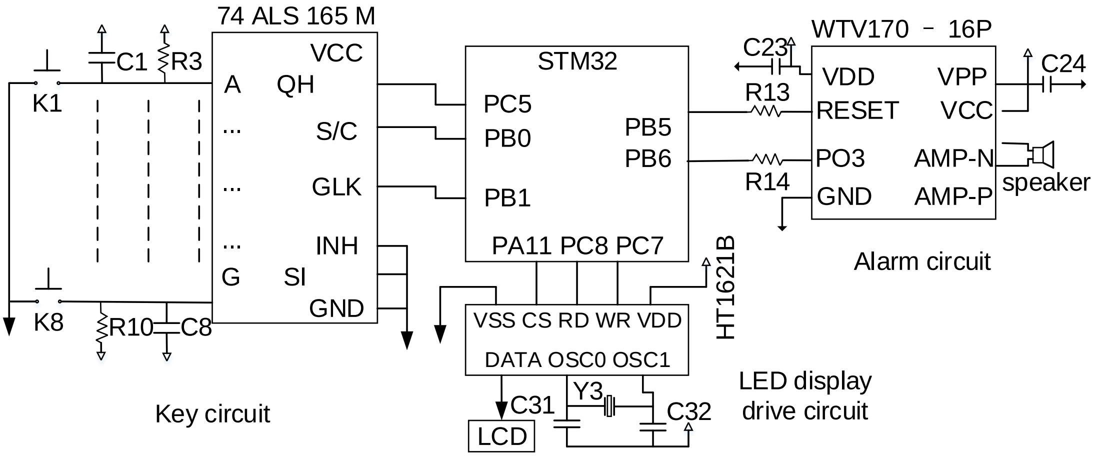


**Fig. 2 - Design of human-machine interface circuit of the system**

In the control system, RS485 bus communication interface is selected, sp485ee chip is applied, and Modbus RTU communication protocol is added, which can read the memory record in PC port. In the memory, the relevant historical data are recorded, such as the power failure, data setting, baking time and temperature and humidity in the baking room, so as to provide reference for the staff. In the system, the controller has designed the circulation fan with manual and automatic control. When the controller is under automatic control, the system can realize the communication between the external inverter and the controller through the frequency conversion communication interface, and realize the automatic control of the rotation speed of the circulation fan. When the controller is under manual control, the rotation speed of the circulation fan can be controlled according to the speed regulating switch. The communication interface circuit of this study is shown in Figure 3.

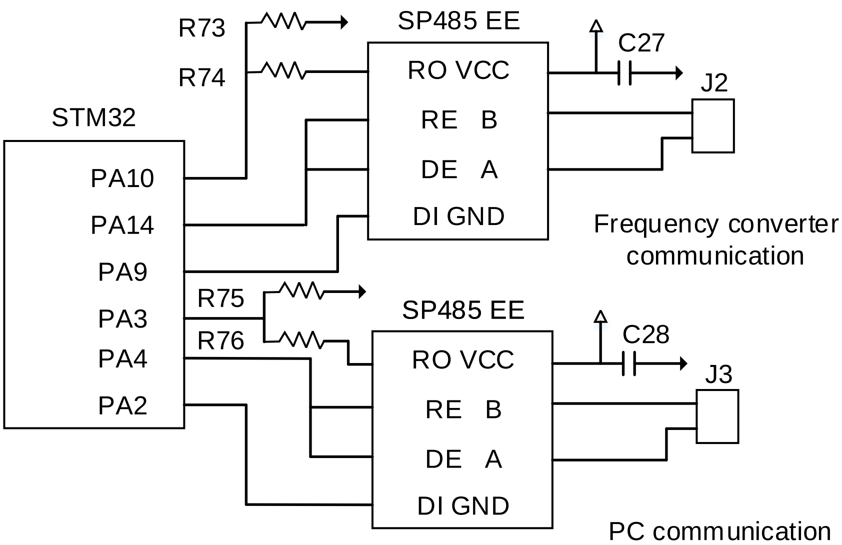


**Fig. 3 - Design of system communication interface circuit**

**Software design of temperature and humidity controller in tobacco house**

The realization of the specific control task of the control system needs to be realized by the system software. The software design of this study is divided into the upper computer and the lower computer. The composition of the lower computer software corresponds to the design of the system hardware. The control system includes communication, algorithm, voice alarm, display driver, key processing, temperature and humidity acquisition and other subroutines. The normal operation of the system depends on whether the software design is reasonable. The flow chart of the main control system is shown in Figure 4, including control output, fuzzy adaptive algorithm, temperature and humidity collection, key subprogram, interrupt program, initialization configuration, etc.

After the control system is powered on and reset, initialize the system, scan the on-site controller, determine whether the data has been input into the key, and display it on the on-site LCD screen; at this time, the upper computer starts to collect the data, successively receives the data on the keyboard and the sensor, stores the received data in the RAM controller, and makes it in the RAM controller through data conversion The bus can realize the transmission of data frame. If the command of the upper machine is transmitted to the system, the data frame will be sent through the controller until the end of data receiving and sending, and there is no data conflict in the process of receiving and sending, then the algorithm subroutine will run.

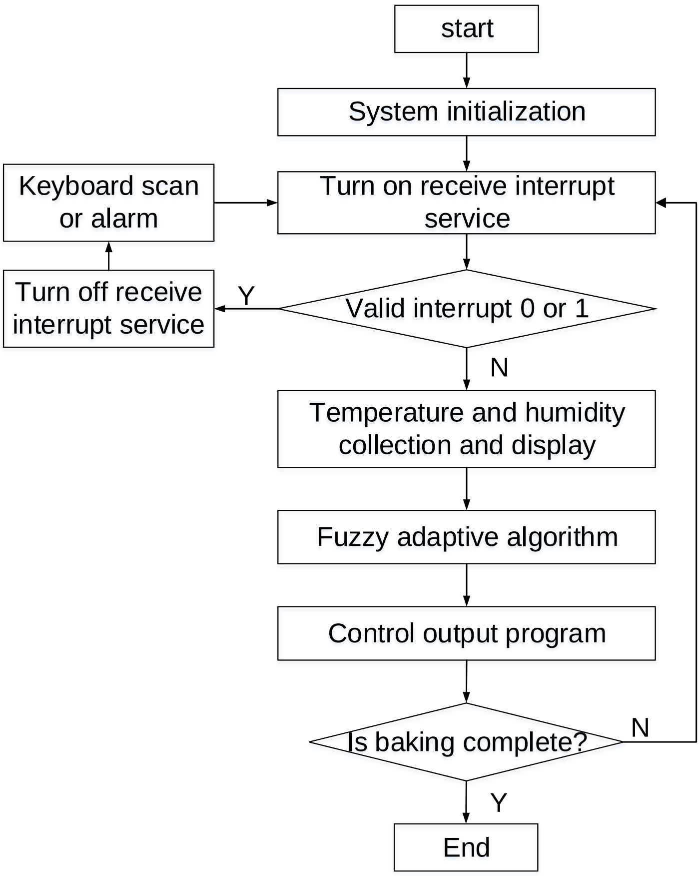


**Fig. 4 - System main control flow chart**

Two external interrupts 0 and 1 are designed in the system. The external interrupt 0 is used to process the alarm request. When the temperature and humidity are too high or too low, or lack of equal faults, the system will give a voice alarm and stop the system work as required. External interrupt 1 is used for key request. If it is a query key or a set key request, the system will enter the temperature and humidity setting subroutine or query record subroutine to make corresponding settings, and press the OK key to jump back to the main program after the end of setting data or query history. The flow chart is shown in Figure 5.

## RESULTS

### Experimental design of temperature and humidity measurement in flue-cured tobacco room

The agricultural intelligent temperature and humidity controller designed in this study was used to measure the temperature and humidity of flue-cured tobacco house, and the control effect was verified. According to the different targets, the experimental scheme is designed. The first is to compare the test results of this design with the traditional test methods. Before the test, fix the tobacco leaf and sensor on the fixture, use the instrument to monitor the temperature and indoor humidity of the tobacco leaf during the baking process, record the data every 4 hours, and use the dry and wet bulb thermometer to measure the temperature of the tobacco leaf surface until the end of the baking. Compare the room temperature monitored by the dry and wet bulb thermometer and the instrument, and analyse the results of comparison;

second, verify the control effect of the control design proposed in this study, compare the whole measurement process of the experiment, and experiment twice in the same flue-cured tobacco room. In the first experiment, we did not use the control design scheme proposed in this study, but only used the traditional manual adjustment method to control the temperature and humidity of the baking room.
In the second experiment, according to the same technological process, we used the control design scheme proposed in this study to control the equipment of the baking room. The measurement object in the experiment is shown in Figure 5.

**Fig. 5 - Physical picture of measurement experiment**

**Experimental results and analysis**

As shown in Table 1, the room temperature and tobacco surface temperature after the first experiment are obtained. It can be seen from table 1 that when the surface temperature of leaves on several bulb thermometers is heated to [34, 36] ºC, and when the room temperature is heated to [34,38] ºC, the difference between them is small. When the room temperature of some bulb thermometers is above 38ºC, and the surface temperature of the blade is [38, 48]ºC, the dry bulb temperature is in direct proportion to the surface temperature of the blade, and the difference between them is significant, and the temperature difference is fixed between [2.5, 3.5]ºC. When the room temperature on several bulb thermometers is heated to [48, 68] ºC, the temperature difference between the dry bulb thermometer and the blade temperature is relatively stable, and the temperature difference is fixed between [2, 4] ºC. When the leaf temperature is fixed between [34, 36] ºC, the humidity in the room is within [98.6, 90.2] %. If the leaf temperature increases gradually in [36, 48] ºC, the room temperature in the baking room will also decrease gradually. When the humidity in the baking room is 42ºC, the leaf temperature is 46.3ºC. If the temperature of the leaves is [48, 66] ºC, the humidity in the oven is within [42.0, 9.9] %.

**Table 1**

**Comparison of room temperature and leaf temperature data from the first experiment**

| Time (h) | Traditional measurement (ºC) | Instrument measurement (ºC) | Difference (ºC) | Time(h) | Traditional measurement (ºC) | Instrument measurement (ºC) | Difference (ºC) |
|---|---|---|---|---|---|---|---|
| 0 | 21.8 | 20.1 | 1.7 | 64 | 46.3 | 40.3 | 6.0 |
| 4 | 33.9 | 33.9 | 0 | 68 | 45.6 | 41.8 | 3.8 |
| 8 | 36.1 | 34.0 | 2.1 | 72 | 45.6 | 41.3 | 4.3 |
| 12 | 36.2 | 34.6 | 1.6 | 76 | 49.0 | 44.2 | 4.8 |
| 16 | 37.1 | 34.9 | 2.2 | 80 | 49.1 | 46.1 | 3.0 |
| 20 | 38.0 | 36.8 | 1.2 | 84 | 49.6 | 46.1 | 3.5 |
| 24 | 37.9 | 36.6 | 1.3 | 88 | 49.2 | 46.2 | 3.0 |
| 28 | 37.5 | 35.8 | 1.7 | 92 | 53.2 | 51.0 | 2.2 |
| 32 | 37.4 | 35.1 | 2.3 | 96 | 53.1 | 51.2 | 1.9 |
| 36 | 39.7 | 35.0 | 4.7 | 100 | 54.1 | 52.3 | 1.8 |
| 40 | 39.6 | 35.1 | 4.5 | 104 | 57.0 | 54.7 | 2.3 |
| 44 | 41.9 | 36.2 | 5.7 | 108 | 59.5 | 57.5 | 2.0 |
| 48 | 42.6 | 36.9 | 5.7 | 112 | 60.0 | 57.8 | 2.2 |
| 52 | 42.7 | 37.0 | 5.7 | 116 | 66.6 | 62.8 | 3.8 |
| 56 | 42.4 | 37.2 | 5.2 | 120 | 68.3 | 65.4 | 2.9 |
| 60 | 45.7 | 37.3 | 8.4 | 124 | 68.1 | 66.2 | 1.9 |

As shown in Table 2, the room temperature and tobacco surface temperature after the second experiment are obtained. It can be seen from table 2 that the second time is higher than the first time. In the process of flue-cured tobacco, when the surface temperature of the leaves on several bulb thermometers is heated to [34,37] ºC, and when the room temperature is heated to [34,45] ºC, the difference between them is small. When the room temperature of some bulb thermometers is above 45ºC, and the surface temperature of the blade is at [45, 60] ºC, the dry bulb temperature is in direct proportion to the surface temperature of the blade, and the difference between them is significant, and the temperature difference is fixed between [2.5, 3.5] ºC. When the room temperature on several bulb thermometers is heated to [60, 68] ºC, the temperature difference between the dry bulb thermometer and the blade temperature is relatively stable, and the temperature difference is fixed between [2, 4] ºC. When the leaf temperature is fixed between [34, 37.3] ºC, the humidity in the room is within [99.9, 75.0] %. If the leaf temperature increases gradually within [37.3, 57.8] ºC, the room temperature in the baking room will also decrease gradually. When the humidity in the baking room is 22.8ºC, the leaf temperature will be 57.8ºC. If the leaf temperature is [57.8, 66.2] ºC, the humidity in the baking room is within [22.9, 12.8] %.

**Table 2**

**Comparing the data of room temperature and leaf temperature in the second experiment**

| Time (h) | Traditional measurement (ºC) | Instrument measurement (ºC) | Difference (ºC) | Time (h) | Traditional measurement (ºC) | Instrument measurement (ºC) | Difference (ºC) |
|---|---|---|---|---|---|---|---|
| 0 | 30.4 | 27.9 | 2.5 | 88 | 46.1 | 41.6 | 4.5 |
| 4 | 34.6 | 31.7 | 2.9 | 92 | 46.4 | 42.4 | 4.0 |
| 8 | 36.3 | 35.6 | 0.7 | 96 | 46.4 | 43.2 | 3.2 |
| 12 | 36.4 | 36.0 | 0.4 | 100 | 46.2 | 43.4 | 2.8 |
| 16 | 36.4 | 35.5 | 0.9 | 104 | 46.1 | 43.7 | 2.4 |
| 20 | 36.2 | 34.5 | 1.7 | 108 | 48.1 | 45.1 | 3.0 |
| 24 | 37.4 | 36.1 | 1.3 | 112 | 49.7 | 46.3 | 3.4 |
| 28 | 37.1 | 36.3 | 0.8 | 116 | 48.6 | 46.3 | 2.3 |
| 32 | 37.4 | 36.2 | 1.2 | 120 | 49.2 | 46.4 | 2.8 |
| 36 | 38.2 | 35.6 | 2.6 | 124 | 48.7 | 46.5 | 2.2 |
| 40 | 37.6 | 32.4 | 5.2 | 128 | 51.9 | 48.0 | 3.9 |
| 44 | 38.7 | 34.5 | 4.2 | 132 | 52.1 | 49.6 | 2.5 |
| 48 | 38.1 | 36.0 | 2.1 | 136 | 55.3 | 51.7 | 3.6 |
| 52 | 37.2 | 34.7 | 2.5 | 140 | 56.2 | 53.9 | 2.3 |
| 56 | 41.0 | 36.6 | 4.4 | 144 | 60.1 | 56.4 | 3.7 |
| 60 | 40.4 | 37.1 | 3.3 | 148 | 60.1 | 57.1 | 3.0 |
| 64 | 41.1 | 37.0 | 4.1 | 152 | 59.6 | 57.0 | 2.6 |
| 68 | 42.7 | 38.7 | 4.0 | 156 | 65.1 | 61.7 | 3.4 |
| 72 | 43.0 | 38.9 | 4.1 | 160 | 67.9 | 65.3 | 2.6 |
| 76 | 43.2 | 39.1 | 4.1 | 164 | 68.3 | 66.2 | 2.1 |
| 80 | 42.9 | 39.0 | 3.9 | 168 | 67.9 | 65.8 | 2.1 |
| 84 | 44.4 | 40.0 | 4.4 | | | | |

In order to verify the control system proposed in this study, two baking experiments with different control modes were carried out, and the results were compared. According to the results of three-stage baking process and measurement, the comparison curve before and after adding the controller is obtained, as shown in Figure 6. Figure (a) shows the comparison curve between the baking process temperature and the results measured by the traditional measurement method. The temperature difference is relatively obvious, and overshoot is formed at some temperature points, such as 68ºC, 60ºC, 50ºC, 48ºC, 46ºC, 37ºC, 34ºC, with poor control effect. Figure (a) shows the comparison curve between the results of the temperature control experiment based on STM32 and the measured temperature. The results show that the curve is consistent. Even if there are some places with obvious temperature difference, such as 60ºC, 48ºC and 37ºC, it can be seen that the overshoot phenomenon is significantly reduced from the comparison curve, reflecting that the temperature control accuracy based on STM32 is significantly higher than that of the traditional control methods It is conducive to the improvement of tobacco baking quality.

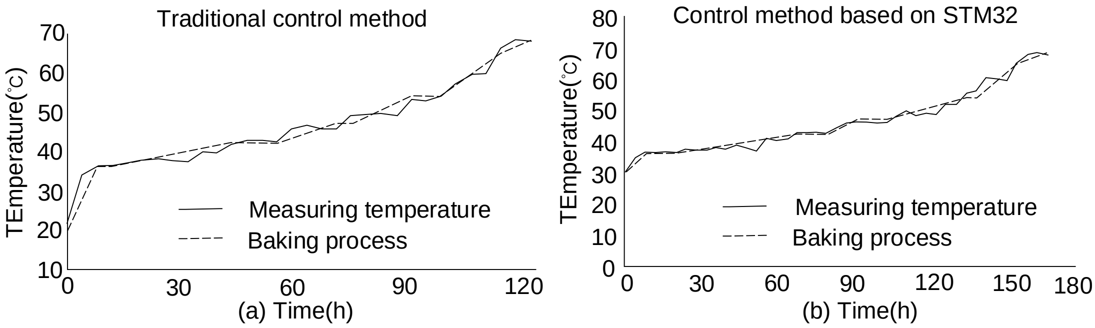


**Fig. 6 - Comparison between STM32 based control method and traditional control method**

## CONCLUSIONS

Aiming at the problem of temperature and humidity control in the flue-cured tobacco house, STM32 microcontroller is introduced into the temperature and humidity automatic control technology, and the temperature and humidity controller of the agricultural intelligent flue-cured tobacco house based on STM32 is designed. Finally, the designed system scheme is tested. The test results show that the temperature difference between the baking process temperature and the results measured by the traditional measurement method is obvious, and the overshoot is formed at some temperature points, such as 68ºC, 60ºC, 50ºC, 48ºC, 46ºC, 37ºC, 34ºC, which has poor control effect; the comparison curve between the temperature control experiment and the measured temperature based on STM32 is consistent Even if there are some places with obvious temperature difference, such as 60ºC, 48ºC and 37ºC, we can see that the overshoot phenomenon is significantly reduced from the comparison curve, reflecting that the temperature control precision based on STM32 is significantly higher than the traditional control method, which is conducive to the improvement of tobacco baking quality. There are also some shortcomings in this study, because in the field measurement in the flue-cured tobacco room, the temperature points vary greatly. In order to reduce the measurement error, in the future research, the number of detection points will be increased to reduce the experimental error.

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