CONSTANT TEMPERATURE CONTROL SYSTEM OF BUILDING ENERGY SYSTEM

by

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Due to the poor effect of traditional systems on constant temperature control, the paper proposes to design an embedded continuous temperature control system in a dynamic, intelligent building. In the smart building, the thesis takes the building as the research object and uses the embedded technology to design the overall structure diagram of the system. The thesis aims at the output control module of the thermostat. It uses the Peltier effect to develop the thermocouple closed-loop and drives the semiconductor refrigeration device select. In the software part, the paper establishes a cross-compilation environment, transplants embedded kernels, and sets fuzzy rules for constant temperature control. The validity of the system design is verified through experiments. It can be seen from the experimental results that the system has a better thermostat control effect.

Key words: *intelligent building, embedded, constant temperature control, system design*

Introduction

The USA has produced intelligent buildings since the last century. The rise of smart buildings has mainly gone through two-stages: the first stage is the initial stage of construction; this stage is composed of two independent subsystems; there is no communication or co-operation relationship between these systems and the second stage is communication to connect various separate subsystems to complete a task, such as remote operation, making plans*, etc.* For the joint execution of functions in the second stage, the information and environment need to be processed on time. For the intelligent buildings developed in my country, the main feature is to realize real-time data collection based on system software and hardware and process and share data, thereby improving system collaboration capabilities. In information processing, we generally need to use fuzzy control and embedded technology to achieve natural building intelligence. Embedded technology is currently one of the most widely used technologies in the IT industry. It is mainly applied to the realization of functions [1]. It is much easier to operate using the kernel method than traditional systems. We found that conventional approaches to control the temperature are inferior, so the paper proposes an embedded constant temperature control system design. The embedded constant temperature control system in intelligent buildings is an embedded operating system based on a hardware platform used for continuous temperature

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control of the user interface. The temperature of the constant temperature box can be obtained through a real-time interface display. We can prove that the system design is effective by setting up a comparison experiment.

Embedded thermostat control system design

In the intelligent building, we use the building as the research platform and use the computer communication technology and control technology to design the constant temperature control of the embedded system. This is the symbol of a new generation of civilization and the fruit of information technology. The rapid economic development makes people's living standards continue to improve, and it is fully reflected in people's requirements for the beauty and comfort of the living environment. The design of the embedded constant temperature control system for intelligent buildings is also a symbol of each enterprise's competitive strength and important status [2]. The method of the thermostat control system can be divided into two parts, hardware with ARM as the core and software with the embedded system as the primary working environment. The overall block diagram of the system is shown in fig. 1.

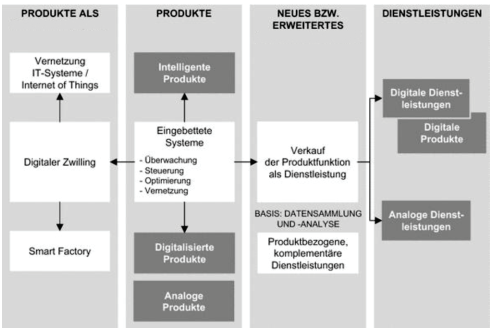

Figure 1. Block diagram of the overall system structure

System hardware design

Thermostat output control module

The thermostat output control module is a heating and refrigeration cycle module, which uses semiconductor refrigeration chips to realize the heating and cooling functions of the system. Semiconductor refrigeration sheets use semiconductors as raw materials and use the Peltier effect to make electronic components. The semiconductor refrigeration chip will have a small load voltage. Once the two ends of the semiconductor generate heat, the temperature of one end of the cooler will begin to drop, and its temperature will slowly decrease with the loss of heat. The weather at the other end of the cooler is the opposite. It will rise with the loss of heat [3]. If the current changes the direction, the direction of the heat movement will follow the current campaign, and then the heat will be input from one end of the Peltier to the other. Therefore, while cooling and heating, we should complete heat transfer on the semiconductor refrigeration chip. In terms of temperature control, accurate temperature sensor transmission data is required. The principle of thermoelectric cooler realizes the transmission effect. The working code of the semiconductor refrigeration film is actually an operational mode of heat transfer. The paper designs a closed thermocouple loop to make the heat transfer effect better, as shown in fig. 2.

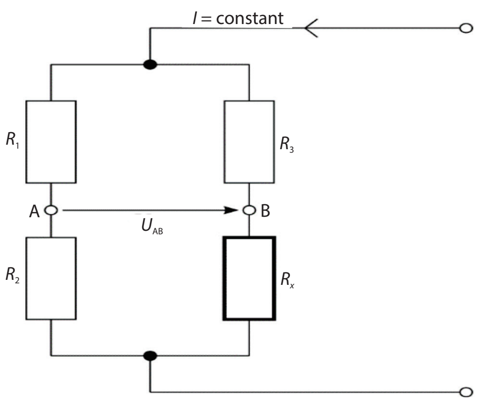

Figure 2. Schematic diagram of thermocouple closed circuit

It can be seen from fig. 2 that the thermocouple closed-loop designed by the Peltier effect in the thesis adopts a reverse connection method. The two nodes A1 and A2 are input to the same voltage value, and a positive current value is generated in the loop. The heat generated at the material Y will be absorbed by the circuit and produce a relatively weak cooling effect. On the contrary, the heat generated at material X will flow into the course, and the temperature at X will rise at this time. Since the Peltier effect is reversible when the direction of the current changes, heat transfer will also change accordingly. The mathematical formula of the Peltier effect can be expressed:

$$Q_{xy} = S_{xy} I \tag{1}$$

It can be seen from fig. 2 that S_{xy} represents the difference in the Peltier effect coefficients of the two materials X and Y; I is the current flowing out of the circuit when the circuit is working, Q_1 and Q_2 are the speeds of cooling and heating, respectively, when the course is working, as long as it passes through the place where the current flows, the conductor will generate heat, thereby reducing the cooling intensity in the refrigerator.

Selection of semiconductor refrigeration device driver

The selection of the semiconductor refrigeration device driver mainly depends on the size and direction of the current of the cooling sheet, where the current size depends on the heating or cooling effect, and the current approach depends on the heating or cooling state. To keep the semiconductor refrigeration sheet at a constant temperature for a long time, we need to improve the design of the drive circuit diagram. In selecting the driving improvement, we designed the drive circuit at M as the core drive circuit of the semiconductor refrigerator. The block diagram of the semiconductor refrigeration sheet is shown in fig. 3.

The micro-processor can obtain the actual temperature detected by the sensor, and we can bring the corresponding heating or cooling effect through the control algorithm of the software part. We control the working development of the refrigeration sheet through the output control on time and then achieve the purpose of keeping the temperature constant.

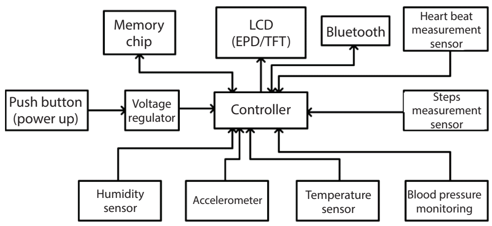

Figure 3. Block diagram of the semiconductor refrigeration sheet

System software function design

Cross-compilation environment establishment

Multiple operating systems can be run in the same compilation architecture. Although the architectures are different, the operating steps are the same. If an application program wants to run on another platform, we need to recompile the program code for that platform. In this case, a flawed compilation should be used. We can use cross-compilation to compile different codes on one platform for another outlet in the embedded software development process. In the compilation process, many intermediate files will be generated and occupy ample memory space, so we directly compile them on the PC. To quickly integrate the compiled program on the platform, we need to collect the schedule for the platform compiler and finally generate a target platform with code.

For this reason, installing cross-compilationols on the host is the first task. By default, we decompress the cross-compilation device to the //usr/local/arm directory and store

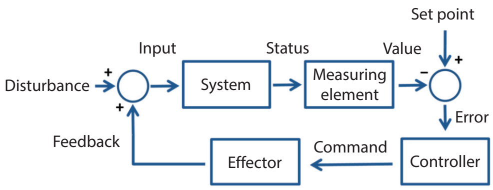

Figure 4. Partial design process of the system software

executable files in the manual, which shows that the compiler has the best compilation effect on the architecture and embedded operating system [4]. The design process of the system software is shown in fig. 4.

Porting the embedded kernel

An embedded kernel is the central software of the system. We can use the Linux2.6.31 version get more platform support. Using scheduling mode can realize the improvement of module subsystem and file system, and then support hardware driver. The paper suppresses the kernel source code to the processor and compiles the kernel in each directory. With the support of the CPU architecture hardware driver, gather the relevant code.

Fuzzy rules of constant temperature control

A fuzzy control method is needed to control the thermostatic effect in the thermostat. This control method needs to be transmitted through human language to form instructions to complete the control. Fuzzy inference and anti-fuzzification are the core steps of the imprecise calculation, and the paper uses the same fuzzy controller. The controller is multi-hole input and single-hole output. It first fuzzified the input vector and then obtained the current control matching strategy based on the control method to perform fuzzy inference. Secondly, the fuzzy control variables obtained by de-fuzzification are accurate data, and finally, the purpose of constant temperature control can be achieved. Due to the delay in the running process under continuous temperature control, the controlled object has hysteresis properties.

For this reason, the thesis regards it as a staged link. The temperature rises faster in the low temperature stage, so it needs to be increased and in the high temperature background, the temperature rises slowly, so it needs to be adjusted down [5]. The management should be improved in the high temperature stage to increase the operating speed, taking complete account of the temperature range set by the system. Set up seven fuzzy states, namely: AB, AM, AS, AO, O, PM, PB, the Q domain is divided into 12 areas from –6 to 6, using full power control mode, five fuzzy states, respectively These are AB, AS, O, PS, PB; 9 undefined states, namely: DB, DM, DS, DO, AOP, CS, CB, set the fuzzy control rules as shown in tab. 1.

Table 1. Fuzzy rules of constant temperature control

EC	Q						
	AB	AM	AS	AO	O	PM	PB
AB	DB	DB	DM	DS	DS	CM	CB
AS	DB	DM	DS	DS	DO	CM	CB
O	DB	DM	DS	DO	AOP	CM	CB
PS	DB	DM	DS	AOP	AOP	CB	CB
PB	DB	DS	DO	DO	CS	CB	CB

Although the control rules are designed in an ideal state, there is a particular deviation from the actual temperature, but it is enough for most systems. Unless there is a significant change in the internal temperature of the system, it is not applicable. Suppose you need to cool down to keep the temperature constant. In that case, you need to use the *overblowing* method, which can prevent uneven heat exchange due to excessive temperature and help control the weather.

Design of furnace temperature and constant temperature control system based on PID control algorithm

The PID algorithm and simulation of furnace temperature control system

The article automatically turns on or off the thermal energy supplied to the furnace according to the given deviation of the furnace temperature or continuously changes the size of the thermal energy system. To stabilize the furnace temperature within a given temperature range to meet the needs of the process. The furnace temperature control room of the electric heating furnace is a feedback control and adjustment process, and the deviation is obtained from the actual furnace temperature and the required furnace temperature. We receive the control signal by processing the variation to adjust the thermal power of the resistance furnace to realize the control of the furnace temperature [6]. The proportional, integral, and derivative control of the deviation (PID control) is a widely used control form for complete process control. Figure 5 is a typical PID control system structure diagram.

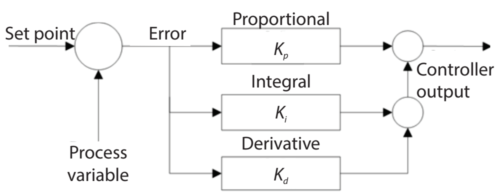

Figure 5. The PID system structure diagram

Under the action of the PID regulator, the article performs proportional, integral, and derivative combined control on the error signal, respectively. The paper takes the output of the regulator as the input control quantity of the controlled object. The analog expression of the PID control algorithm:

$$U(t) = K_p \left[e(t) + \frac{1}{T_I} \int e(t)\mathrm{d}t + \frac{T_D \mathrm{d}e(t)}{\mathrm{d}t} \right] \tag{2}$$

where $P(t)$ represents the regulator's output, $e(t)$ – the deviation signal of the regulator, K_p – the proportional coefficient, T_I – the integral time, and T_D – the derivative time. Discretizing the previous formula is a digital difference equation:

$$U(k) = K_p \left\{ E(k) + \frac{T}{T_I} \sum_{j=0}^{k} E(j) + T_D \frac{E(k-1)}{T} \right\} \tag{3}$$

where T represents the sampling period, $E(k)$ – the deviation value during the k^{th} sampling, $E(k\text{-}1)$ – the deviation value during the $k-1^{\text{th}}$ selection, k – the sampling sequence number, and $P(k)$ – the It output of the regulator at k samples.

Incremental PID algorithm program design

Incremental PID means that the output of the digital controller is only the increment $\Delta u(k)$ of the control quantity. When we use the incremental algorithm, the control variable $\Delta u(k)$ output by the computer corresponds to the increment of the actuator position this time, rather than the actual position of the actuator. Therefore, the actuator must have the cumulative function of the increment of the control quantity. To complete the control operation of the controlled object [7]. The accumulative position of the actuator can be realized by hardware or software. The incremental PID flow chart is shown in fig. 6.

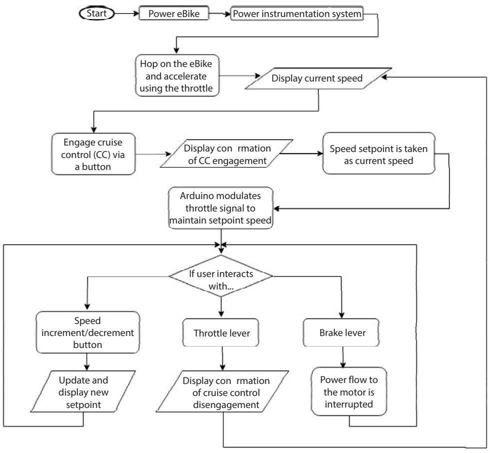

Figure 6. Incremental PID flow chart

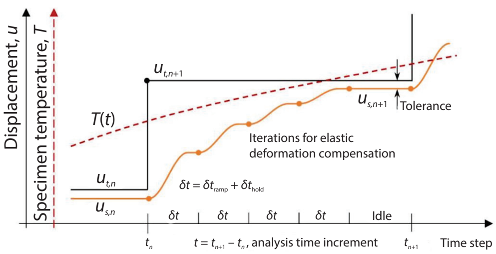

Figure 7. Simulation diagram of resistance furnace temperature control system

Simulation of resistance furnace temperature control system

Since this design is a furnace temperature control system, the closed-loop regulation system can be approximated by a step-lag link, represented by the classic transfer function of the resistance furnace:

$$G(S)=\frac{Ke^{-\tau}}{1+T} \tag{4}$$

where K is the total magnification of the regulating system, τ – the pure lag time of the system, and T – the inertial time constant. According to the subject design, it can be known that $K = 1$, $T = 240\text{s}$, and $\tau = 10$ s:

$$G(S)=\frac{e^{-10}}{1+240} \tag{5}$$

Enter the SIMULINK environment, select the required component in the component library, and connect the members with the mouse to get a complete block diagram, as shown in fig. 7.

Experiment

Experimental environment settings

Since the core of the operating system and the design interface are wholly separated, a graphics window frame should be set before each operation. Our graphics window standard in the embedded environment is implemented by WINDOWS 2010. Because the system develops the embedded system, the embedded system also has compatible attributes. According to the hardware design, the thesis connects all the software functions, and downloads the software in the embedded system, and connects the temperature sensor to the fuzzy controller through a serial interface, and then builds an experimental environment to complete the experimental verification.

Experimental results and analysis

The paper sets the system operation effect under different temperature conditions and compares the traditional system with the improved system. The results are shown in fig. 8.

- When the temperature is 60 °C, the control results of the two systems are shown in fig. 8(a).
- When the temperature is assumed to be 30 °C, the control results of the two systems are shown in fig. 8(b).

It can be seen from fig. 8 that the temperature difference between the two control systems at the initial stage is slight. With the increase of the number of peaks, the fluctuation of the traditional system temperature is still significant, while the improved system gradually stabi-

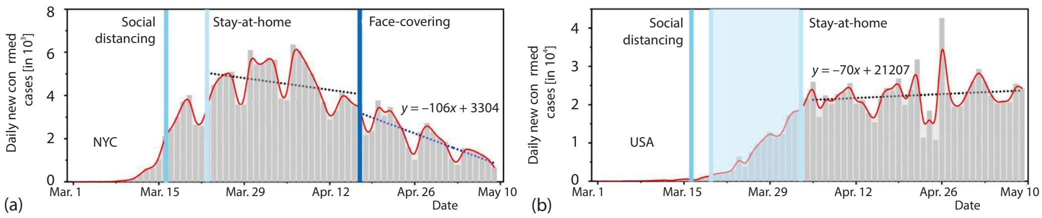

Figure 8. Comparison of control results of two systems at 60 °C and 30 °C

lizes. When the peak value is the sixth, the temperature control of the conventional system and the enhanced system are progressively stabilized. Finally, the system in this paper is stabilized at around 60 °C, while the traditional system is stabilized at around 70 °C.

The temperature values of the two control systems are the same in the initial stage. As the number of peaks increases, the range of temperature fluctuations in the traditional system gradually decreases. However, the method in this paper has stabilized at 30 °C at the third peak, even at subsequent peaks. There are slight fluctuations in the medium but little change.

According to the aforementioned experimental content, the empirical conclusion can be drawn: the design of an embedded constant temperature control system in an intelligent building is effective. When we compare the traditional approach with the improved method, the temperature difference in the initial stage is slight. As the number of peaks increases, the temperature of the conventional system fluctuates wildly. In contrast, the improved system gradually stabilizes, and finally, the enhanced system stabilizes at a constant temperature near the value. It can be seen that the enhanced system control effect is good.

Conclusion

The core technology of software research and development is embedded technology, which combines the hardware structure of the embedded system to innovate the constant temperature control system. We use a temperature sensor to display the temperature change value in real-time. By analyzing the drive circuit diagram, we can select the circuit suitable for the system drive and then realize the heating and cooling of the cooling plate. After we complete the embedded system design, users can interact with information through a WEB browser. The paper shows that the system has a good control effect through experimental design and has broad application prospects.

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