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Analysis of Temperature Field and Design of Temperature and Humidity Control in Green Energy Saving Maintenance Room of Cement Products

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Abstract: This paper proposes a green energy-saving maintenance room. The maintenance room can solve most of the problems faced by most cement product curing rooms during use. For example, poor insulation performance and low level of automation. According to the specific requirements of the maintenance of room temperature and humidity, a cement room temperature and humidity control system was designed to detect and control the temperature, humidity and other parameters of the cement product curing room. The temperature field during the operation of the green energy-saving room through ANSYS was analyzed. The results showed that the optimum temperature of solar hot air blowing in the curing room was 70°C.

1. Introduction

The concrete standard curing room is a special house for curing concrete specimens under specific temperature and humidity conditions. National standards for the maintenance of concrete specimens are: temperature $(20 \pm 2)^\circ\text{C}$, relative humidity of 95%. Tests have shown that temperature and humidity are two major factors that determine the development of concrete strength. The smaller the deviation of temperature and humidity are, the better the comparability of concrete strength data will be [1]. The higher the maintenance temperature and humidity of the curing room are, the faster the initial hydration speed of the concrete will be, and the faster the early strength development of the concrete will be; on the contrary, the lower the maintenance temperature and humidity, the slower the hydration rate of the cement, the early strength development of the concrete is also slower; Therefore, the maintenance of concrete temperature and humidity is one of the important factors affecting the development of concrete strength [2].

China's curing rooms generally suffer from low automation, unstable performance and energy waste. In terms of temperature control, air conditioning is used for temperature control. In order to meet the humidity requirement above 95% RH, humidification equipment must be added, but the indoor air humidity is high. This problem will increase the air conditioning dehumidification load, also increases the equipment maintenance costs [3]. In terms of humidity control, artificial spraying requires opening and closing of water valves several times a day, or regular watering, etc. which leads to greater labor intensity and reduces the quality of cement products [4].

As a clean energy source, solar energy has an inexhaustible function [5]. This article uses the characteristics of solar energy to design a green energy-saving curing room with a solar hot water spray curing system. The curing room is controlled by a temperature and humidity sensor, and the automatic control and adjustment of the room temperature humidity is achieved through a single-chip



microcomputer control. This paper uses ANSYS software to analyzed the temperature field of the green energy room, analyzed the distribution law of the curing room temperature field, and get the best temperature in the curing process.

2. Green energy-saving curing room design

In order to maximize energy conservation and emission reduction during the conservation process, the conservation room uses solar energy as a green energy source. First, solar energy raises tap water temperature to 70°C. Then the hot water is atomized in the curing room through a special material nozzle. The temperature in the hot water is instantaneously transmitted to the curing room. Even if the temperature of the curing room increases, the air is increased. In the humidity, to achieve the purpose of conservation. This article is mainly about the design of solar hot water spray curing system. Solar hot water spray system is mainly composed of solar hot water supply system and hot water spray curing system. Solar energy curing room appearance as shown in Figure 1.

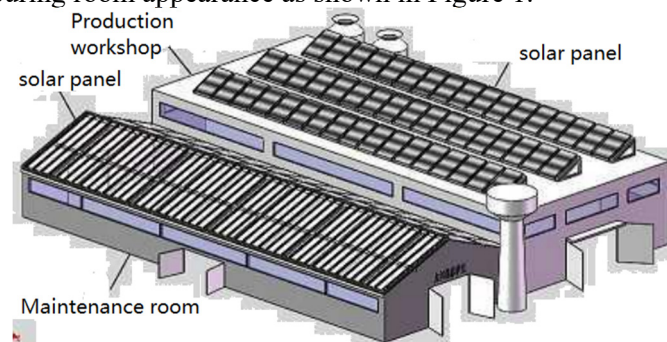


Figure 1 Solar curing room appearance

2.1 Solar Hot Water Supply System

The system uses solar energy as a source of energy, using electricity as an energy source when necessary. The solar hot water supply system consists of an ordinary hot water tank and a connecting tube solar collector.

2.2 Hot water spray system.

The hot water spray system consists of a pressure pump, pipes, valves and nozzles. The function of the booster pump is to pressurize the hot water through the nozzle. The spray system can provide the curing chamber with the required temperature and humidity.

2.3 The feedback adjustment system of the curing room is designed

The feedback conditioning system of the curing room is designed to control the indoor temperature within the range of 60~80°C. We have installed multiple temperature and humidity sensors in the curing room to detect changes in temperature and humidity in the maintenance room in real time and feed back to the microcontroller in time. When the temperature signal received by the temperature sensor is low, the spray head automatically sprays hot water, and the hot water is atomized in the room to cause the indoor temperature to rise. When the temperature signal received by the temperature sensor is high, the window in the room will open, so that the temperature in the curing room will decrease, and the effect of automatically controlling the temperature can be achieved.

3. Temperature and humidity control system design

3.1 System Principles and Functions

According to the specific requirements of the green and energy saving maintenance room temperature and humidity, the work flow of the control system is mainly the temperature and humidity sensors installed in the curing room in the curing room to collect the temperature and humidity of the curing

room in real time and transmit the collected data to the control center in time. System, the one-chip computer carries on the comparison to the corresponding data and the set temperature and humidity value, and makes the judgment, when the temperature is low, the one-chip computer sends out the signal to start the hot water spray to raise the temperature, when the temperature is too high, the one-chip computer sends out the signal to start the cooling device to ventilate to cool down. The system control flow chart is shown as in Figure 2.

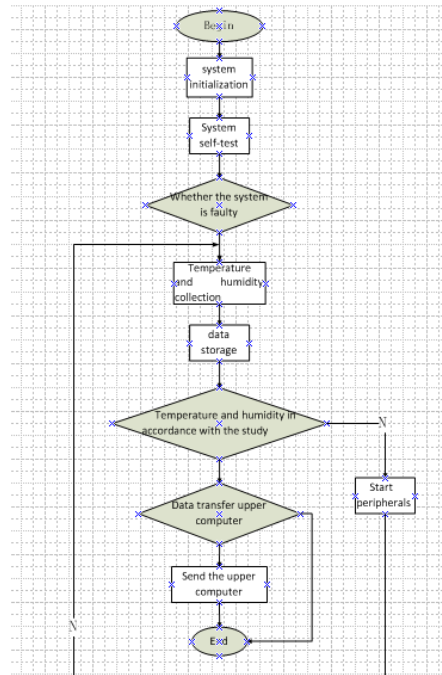


Figure 2 System Control Flow chart

3.2 Hardware Circuit Design

The system of this article is mainly to complete the collection, storage, display and transmission of temperature and humidity data. The hardware structure mainly includes: SCM module, data acquisition, data storage, serial communication and external devices. The hardware block diagram is shown in Figure 3.

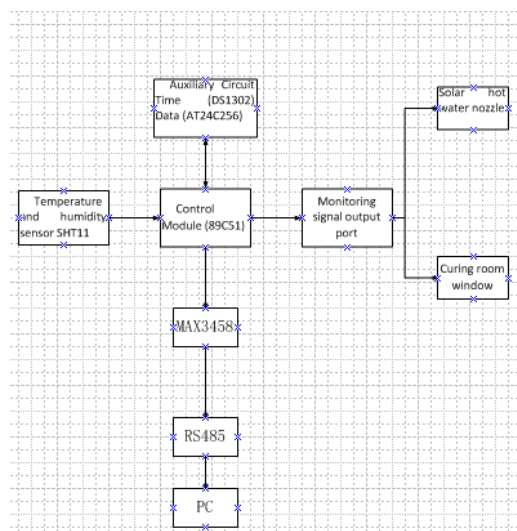


Figure 3 Hardware block diagram

This system uses the STC89C53 microcontroller as the core part of the controller. It checks the temperature and humidity of the storage in real-time communication with the PC, and controls the nozzle and maintenance of the too hot water pipe in the controlled object according to the collected temperature and humidity and the temperature value set by the user. The window of the room opens and closes. Temperature and humidity sensor selection SHT11, the sensor is widely used in cement products curing room. SCM and temperature and humidity sensor interface shown in Figure 4. The communication between the single-chip microcomputer and each module adopts RS485 serial port communication, uses MAX488 to realize the level conversion, increases the transmission distance.

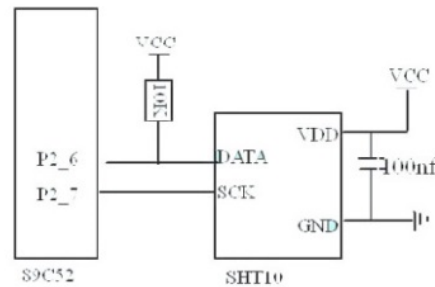


Figure 4 SCM and temperature and humidity sensor interface diagram

4. Curing room temperature field analysis

4.1 Parameter settings

The air density ρ is generally 1.225 kg/m^3 , and the specific volume of air is the reciprocal of the density. The density of water is 10^3 kg/m^3 , and the specific heat of water is $4.186 \text{ KJ/kg}^\circ\text{C}$. The density of cement is 3000 kg/m^3 , and the specific heat capacity of cement is $0.84 \times 10^3 / (\text{kg}^\circ\text{C})$.

4.2 Simulation Mathematical Model

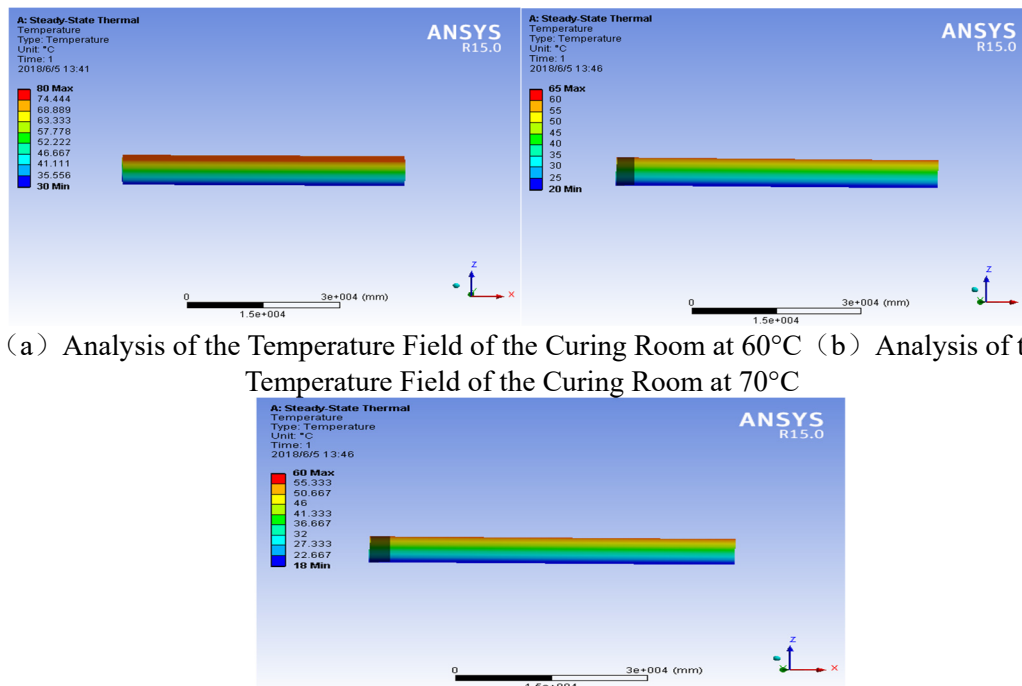
In this paper, the mathematical model of heat transfer is determined. In fluid flow in nature, it is necessary to follow the law of physical conservation. The three basic laws are the law of conservation of mass, the law of conservation of momentum, and the law of conservation of energy, if the flow contains different components. The flow must also comply with the law of conservation of components and establish a differential heat conduction equation.

$$\rho c \frac{\partial t}{\partial \tau} = \frac{\partial t}{\partial x} \left(\lambda \frac{\partial t}{\partial x} \right) + \frac{\partial t}{\partial y} \left(\lambda \frac{\partial t}{\partial y} \right) + \frac{\partial t}{\partial z} \left(\lambda \frac{\partial t}{\partial z} \right) + \phi \quad (1)$$

The items on the left side of the equal sign are non-steady-state items, the middle three items on the right are heat conduction items, and the one on the right is a heat source.

4.3 Temperature Field Analysis Results

In this paper, the temperature field of the curing room is analyzed based on the solar hot water spray at different temperatures. The temperature field distribution of the curing room at 60°C , 70°C and 80°C respectively is shown in Figure 5.



(a) Analysis of the Temperature Field of the Curing Room at 60°C (b) Analysis of the Temperature Field of the Curing Room at 70°C

(c) Analysis of the Temperature Field of the Curing Room at 80°C

Figure 5. Temperature Field Analysis of the Curing Room

5. Conclusion

This article describes a new type of green energy-saving solar energy curing room, and simply explained the temperature and humidity control system of the new curing room, and analyzed the temperature field when the curing room was working. Under the premise of meeting the conservation requirements of standard concrete curing rooms, taking into account the energy conservation and other factors, the optimum solar hot water spray temperature of the green energy-saving curing room is 70°C.

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