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Retraction

Retracted: Microcomputer Control System of Bridge Dehumidification Based on Energy Consumption Optimization and Wireless Communication

Wireless Communications and Mobile Computing

This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Zhou, F. Xiong, P. Li, and Q. Yu, "Microcomputer Control System of Bridge Dehumidification Based on Energy Consumption Optimization and Wireless Communication," *Wireless Communications and Mobile Computing*, vol. 2021, Article ID 2689878, 5 pages, 2021.

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Research Article

Microcomputer Control System of Bridge Dehumidification Based on Energy Consumption Optimization and Wireless Communication

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At present, with the development of wireless communication and microcomputer control system, the design and construction level of long-span bridges in China are also improving. How to improve the durability of bridge structure has become a major scientific and technological problem in bridge design and construction. This paper studies a microcomputer control system of bridge dehumidification based on energy consumption optimization and wireless communication. It compares three kinds of dehumidification and anticorrosion methods of bridge engineering, namely, freezing dehumidification system, rotary dehumidification system, and hybrid dehumidification system. In the hardware design of microcomputer control system of dehumidification system, ATmega128 bit main control chip and aluminum designer are used to draw the power circuit. Then, the MCU program of the air dehumidifier is written, and the power of the air dehumidifier is controlled by the PWM signal generated by the timer 0 of the MCU. The air dehumidifier is divided into three tap positions corresponding to three duty cycles, and the power of the air dehumidifier is changed according to the input tap position.

1. Introduction

In the long history of development, all kinds of bridges have emerged, such as arch bridge, beam bridge, and suspension bridge [1]. In the early days, people used bamboo strips, vines, and other natural materials to build simple suspension bridges. This kind of small pedestrian suspension bridge is considered to be the prototype of modern suspension bridge. The main cable of the suspension bridge mainly bears the tension from the action of load and at the same time produces the transverse and longitudinal forces at the anchorage so that the tensile performance of the steel material can be best exerted, which is also the reason why the suspension bridge can have a large span. The general environment of suspension bridges is very harsh. It not only has to withstand wind load, vehicle load, and dynamic load but also be affected by corrosive media such as temperature and humidity. The main cable of suspension bridge is the main load-bearing system. The suspension system is based on current technology. The main cable system is a one-time system that can only be repaired but cannot be replaced. The main cable corrosion seriously affects the safety of the bridge. Examples of accidents occurring due to the corrosion of the cable system in the use of bridges abound [2, 3]. Corrosion of the bridge main cable is a common engineering phenomenon and a worldwide problem. Because the main cable is wrapped, it is difficult to detect this phenomenon, which brings serious hidden danger to the bridge safety and high maintenance costs [4].

The purpose of main cable protection is to prevent water from entering the main cable and keep the main cable in a relatively closed, dry environment. However, due to the existence of a series of problems mentioned above, it is difficult to achieve this goal. This paper explains and discusses the case from the main cable and cable-stayed bridge as well as points out the way of water intake and the reasons for the

two structures. On this basis, Jensen et al. discuss the disadvantages of different wire rope concepts and then make the different mitigation measures [5].

This paper mainly studies the microcomputer control system of the dehumidification system, selects the appropriate type of single-chip microcomputer as the control core, designs the corresponding control circuit, and produces a device that can detect the relative humidity of the air according to a set of expected humidity and humidity values. The controller is able to communicate with the single-chip microcomputer connected to the Internet.

2. Bridge Main Cable Dehumidification System

2.1. Overview of Dehumidification Systems

2.1.1. Refrigeration and Dehumidification System.
The principle of the refrigeration and dehumidification system is to filter the outside air through a set of filtering device. Firstly, the impurities contained in the gas itself are removed. The filtered gas enters the refrigerator to cool the air and remove moisture. Then, it is heated to a similar temperature and low humidity by a heater. At last, dry gas is delivered to the bridge cable [6].

2.1.2. Wheel Dehumidification System.
The working principle of the rotary dehumidifier: the outside air is filtered through the filter, and the fresh air passes through the desiccant wheel to remove part of the moisture and gas and then passes through the filter again to remove the desiccant residue in the air, and the filter is filtered again to cool air. Then, cool to a similar temperature and low humidity environment to bridge the cables. On the other side of the dehumidification wheel, the air passes through the filter and then is heated by the heater. The heated gas will dry the residual moisture of the dehumidification wheel during the dehumidification process to ensure that the dehumidification wheel is in a relatively dry state when it enters the working area [7]. In this way, the drying and dehumidification process and the regeneration process are performed at the same time, and the continuous drying process of moisture is realized.

2.1.3. Mixed Dehumidification System.
The working principle of the hybrid dehumidification system is that the outside air is first filtered through a filter. The filtered air enters a refrigerator to cool the air to remove the moisture. The cooled low-temperature and high-humidity air passes through the dehumidification wheel to remove part of the moisture. The outgoing air is filtered through a filter and then frozen to remove the desiccant residue in the air. The filtered air is heated to a low humidity and similar temperature to the environment through a heater and then sent to the bridge cable [8]. On the other side of the dehumidification wheel, the air is heated by a heater, and the heated gas blows off the residual moisture in the dehumidification wheel to ensure that the dehumidification wheel is relatively dry when it enters the working area.

2.2. Hardware Design of the Dehumidification System.
The whole dehumidification system uses ATmega128 as the control core. A series of low-voltage pulses are generated by controlling the output of the signal, which is used as the source circuit of the dehumidifier. In addition, the microcontroller will output another PWM signal to control the dehumidification power. The temperature and humidity sensor will measure the temperature and humidity of the bridge cable and collect the data and transmit it to the MCU control unit through the network. The display unit, which is mainly based on touch screen, is connected with MCU to display the temperature and humidity of bridge cable and various parameters representing the operation status of dehumidification system. Wi-Fi module is the bridge between MCU control unit and Internet, which plays an important role in the remote control process of the dehumidification system.

ATmega128 MCU is an AVR MCU produced by ATMEL company. ATmega128 MCU has rich I/O pin resources, including two 8-bit timers/counters, two 16-bit extended timers/counters, one real-time clock counter, two 8-bit PWM channels, six 2–16-bit PWM channels, and programmable continuous serial port UART 2, which fully meet the needs of each function of the dehumidification system [9, 10].

The 17 V DC output from the bridge rectifier is connected with a set of three terminal voltage-stabilizing integrated circuit lm7812 and an NPN triode. lm7812 stabilizes the unstable 17 V voltage to 12 V and uses three grounding capacitors for filtering.

3. Energy Consumption Analysis of the Dehumidification System

The dehumidification process of the main cable of a suspension bridge is to pass cold and dry air through the main cable. The cold and dry air takes away the hot and humid air in the main cable and then exits from the exhaust point [10, 11]. During the dehumidification process, the air in the main cable is not circulating, that is, the main cable dehumidification system is an open design; dry air enters through the air inlet and flows along the main cable, gradually leaking into the atmosphere along the way. Condensation along the main cable is avoided by relying on dry air from inside the main cable. Therefore, the return air does not need to be considered in the calculation of enthalpy and humidity relationship of the system. According to the construction drawing in the design stage, it can be known that the design parameters of the dehumidification of the main cable of the bridge are dry bulb temperature $T_n = 20°$C, relative humidity $\phi_n = 10\%$, ambient dry bulb temperature $T_w = 20°$C, and relative humidity $\phi_n = 70\%$. If the air supply temperature difference is 5°C and the moisture content of the air remains unchanged, then the temperature of the air supply point is $T_n = 15°$C, $\phi_n = 54.86\%$, and the enthalpy value of the corresponding air supply point is 29.8 kj/kg. By referring to the construction drawings at the design stage, one 1100CMH process air volume dehumidifier is selected for the main cable dehumidification of one suspension bridge in the Pearl River Delta of China, with a

power of 11.1 kW. The air supply to the main cable dehumidification system is $G = 2500\,\text{m}^3/\text{h}$. The following is a detailed calculation and design for the three systems.

4. Energy Consumption Results of Different Dehumidification Systems and Computer Control Program Design

4.1. Energy Consumption Results of the Dehumidification System

4.1.1. Refrigeration Dehumidification System.
Figure 1 shows the dehumidification process of freezing dehumidification. The external air state point W is processed by the freezer to reach the state point O and then heated by the heater to reach the state point N, which is then fed into the main cable of the suspension bridge. Through the enthalpy humidity chart, the enthalpy humidity of each state point of the dehumidification system can be calculated as follows: dry bulb temperature of O point $t_o = 6.01°\text{C}$, humidity content $d_o = 5.8\,\text{g/kg}$, enthalpy value $i_o = 20.63\,\text{kj/kg}$, this point is the dew point temperature of N point, relative humidity $\varphi_o = 100\%$, and this point is the same as the humidity content of N point. The dry bulb temperature at W point $t_w = 30°\text{C}$, moisture content $d_w = 18.79\,\text{g/kg}$, and enthalpy $i_w = 78.34\,\text{kj/kg}$.

The calculation formula of energy consumption of refrigerating dehumidification system is shown in

$$Q = \frac{1.2 \cdot G \cdot \Delta i}{3600}, \tag{1}$$

where Q is the cooling load at each state point; G is air supply volume, unit m^3/h; and 1.2 is the density of the treated gas in kg/m^3.

The cooling load of the refrigerating dehumidification system can be calculated as shown in

$$Q_{\text{cold}} = \frac{1.2 \cdot 2500 \cdot (78.343 - 20.63)}{3600} = 48.09\,\text{kW}. \tag{2}$$

The heat load of the refrigerating dehumidification system is shown in

$$Q_{\text{hot}} = \frac{1.2 \cdot 2500 \cdot (29.807 - 20.63)}{3600} = 7.65\,\text{kW}. \tag{3}$$

It can be obtained that the total energy consumption of the refrigerating dehumidification system is shown in

$$Q_{\text{total}} = Q_{\text{cold}} + Q_{\text{hot}} = 56.74\,\text{kW}. \tag{4}$$

Feasibility analysis of freezing dehumidification system: in order to meet the dehumidification requirements, the dew point temperature of the air supply outlet can be obtained by calculation as $6°\text{C}$, and the moisture content of the air outlet is $5.8\,\text{g/kg}$. When the air moisture content of the freezer dehumidifier is lower than $6.5\,\text{g/kg}$, the surface of the evaporator of the freezer is prone to frosting, which
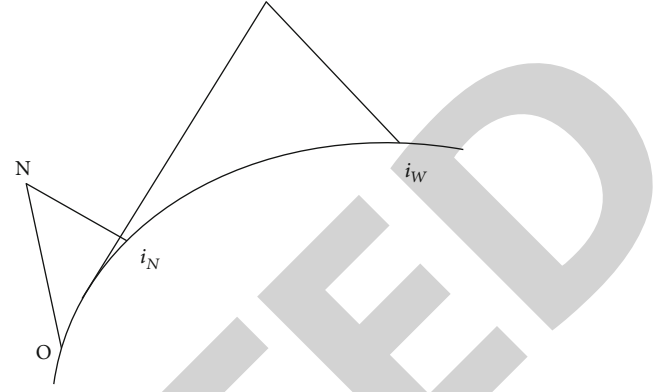

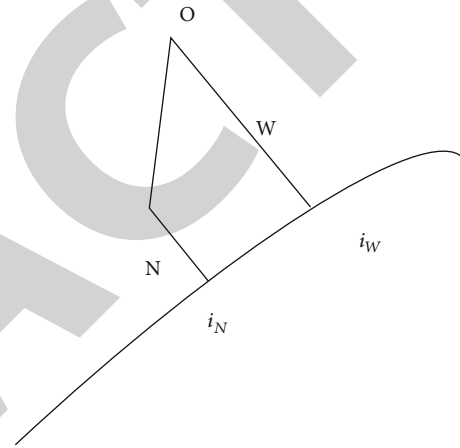Figure 1: Refrigeration dehumidification system.

Figure 2: Wheel dehumidification system.

affects the dehumidification efficiency of the dehumidifier. Therefore, for the feasibility of the dehumidification system, freezing dehumidification is difficult to meet the demand.

Therefore, for the dehumidification system, the effect of freezing dehumidification is not very ideal or cannot fully meet the design requirements. In this case, it is unreasonable to select freezing dehumidification alone.

4.1.2. Wheel Dehumidification System.
As shown in Figure 2, the external air state point is dehumidified by the runner W to reach the state point O, and then by surface cooling, the hot and dry gas reaches the point N and finally is sent into the main cable of the suspension bridge. Through the enthalpy humidity chart, the enthalpy humidity of each state point of the dehumidification system can be calculated as follows: dry bulb temperature of O point $t_o = 62.55°\text{C}$, moisture content $t_o = 5.8\,\text{g/kg}$, enthalpy $i_o = 78.343\,\text{g/kg}$, and relative humidity $\varphi_o = 4.17\%$.

Similarly, according to Equation (1), the cooling load of the refrigerating dehumidification system can be calculated as shown in

$$Q_{\text{cold}} = \frac{1.2 \cdot 2500 \cdot (78.343 - 29.807)}{3600} = 40.45\,\text{kW}. \tag{5}$$
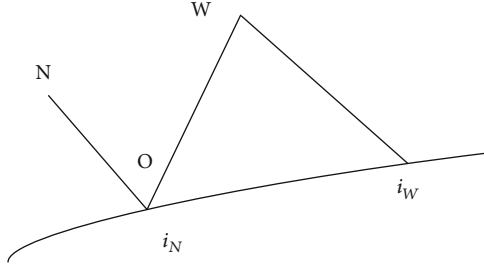
Figure 3: Hybrid dehumidification system.

For the same moisture content method (runner dehumidifier), directly take the runner dehumidifier rated power 11.1 kW, as shown in

$$Q_{\text{cold}} = 40.45 + 11.1 = 51.55 \, \text{kW}. \tag{6}$$

Runner dehumidification system feasibility analysis: according to the requirements of dehumidification, if the runner is used alone to dehumidify, the temperature of the runner treatment will reach more than 60°C, which will undoubtedly damage the drying wheel of the runner dehumidification system and will greatly reduce the life of the runner dehumidifier.

4.1.3. Mixed Dehumidification System. As shown in Figure 3, the external air state point W is cooled and dehumidified by the freezer to reach state point O, and then, the dry and cold air reached point N through the runner and finally sent into the main cable of the suspension bridge. Through the enthalpy humidity chart, the enthalpy humidity of each state point of the dehumidification system can be calculated as follows: dry bulb temperature of O point $t_o = 10.207$°C, moisture content $d_o = 7.738$ g/kg, enthalpy $i_o = 29.807$ kj/kg, and relative humidity $\varphi_o = 100\%$.

Feasibility analysis of the wheel dehumidification system: for the mixed dehumidification system, the cooler will preprocess the hot and humid air, and the dry air will be dehumidified by the wheel, which can both take into account the dehumidification advantage of the freezing dehumidification on the hot and humid air and the dehumidification advantage of the wheel on the low-temperature air. According to the calculation results of the moisture content of the outlet air, the evaporator of the refrigerator will not frost, and according to the calculation results of the temperature, the dehumidifier will not overheat, so it is the best choice in terms of the feasibility of the scheme.

4.2. MCU Subroutine Design. The two fans of dehumidifier are parallel with the semiconductor refrigeration plate. Changing the duty cycle of PWM signal can change the fan speed and cooling power of the cooling plate at the same time, thus changing the dehumidification rate. According to PWM signal duty score, the dehumidifier is three working gears, and the corresponding working voltage is 100%, 60%, and 30% of the maximum working voltage, respectively. The gear can be determined according to the difference between the expected air humidity and the actual

Table 1: The parameters of the three working gears of the dehumidifier.

Work gear	Umax percentage	PWM duty cycle	OCr0
1	45%	55%	164
2	75%	25%	82
3	100%	0	0

measured value and the size of dehumidification space. The gear is set by the touch screen.

The timer T0 of ATmega128 microcontroller is used to generate the PWM control signal of the air dehumidifier. The timer T0 is 8-bit. TCNT0 counts from 0 to 255, and then, 1 is added to return 0, as shown in

$$k = \frac{{}^k \alpha \beta}{m \times 255} = 1961 \text{Hz}, \tag{7}$$

where $n = 8$ (8 frequency divider), the size of the output comparison register OCr0 determines the duty cycle and changes the duty cycle by changing the value of OCr0. The corresponding relations of working gear, maximum working voltage percentage, PWM duty cycle, and OCr0 are shown in Table 1.

5. Conclusions

This paper first introduces the working principles of refrigeration dehumidification system, rotary dehumidification system, and hybrid dehumidification system, then analyzes the feasibility, and points out the advantages and disadvantages of these three dehumidification systems. The analysis shows that the hybrid dehumidification system can effectively dehumidify both the cold air and the hot and humid air and is the best choice in the feasibility. In addition, this paper focuses on the design of single-chip microcomputer program of dehumidification system. MCU program mainly includes pulse generation subroutine, which generates two PWM signals by timer. Dehumidifier subroutine uses PWM signal produced by timer T0 to drive the semiconductor chip. Because the difference between the actual humidity measured by dht1 temperature and humidity sensor and the expected humidity is different, the air dehumidifier is divided into three tap levels, corresponding to the three values of OCr0. Using ADC subroutine of single-chip microcomputer to measure the Outv in current sampling circuit, the analog quantity is converted into digital quantity, and the current of MPS multipulse electro osmotic dehumidification circuit is obtained. Through this set of intelligent microcomputer control system, the dehumidification efficiency of the bridge can be greatly enhanced, the cost can be saved, and the temperature can be accurately controlled according to different climate environments, which has important promotion and practical significance. However, this system also has some shortcomings, such as high dependence on the network environment, requiring professional technical personnel to operate, and not being practical in some extreme environments. However, with the popularization of 5G networks, I believe this system will be widely promoted and used.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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