Research on new water-cooled textile air conditioning system

Boyu Liu¹, Jingkai Ma² and Wu Chen¹*

¹National Engineering Laboratory for Advanced Yarn and Fabric Formation and Clean Production, Wuhan Textile University, 430200, China
²National Engineering Laboratory for Advanced Yarn and Fabric Formation and Clean Production, Wuhan Textile University, 430200, China
*Corresponding author’s e-mail: 86082321@qq.com

Abstract. Aiming at the existing textile air conditioning system in China, the temperature and relative humidity do not meet the process requirements, the air exchange is uneven, and the energy consumption is high. This paper refers to the working principle of traditional textile air conditioner, combined with the requirements of temperature and humidity in textile workshop, and designs a new water-cooled textile air conditioning system from three aspects: air conditioning design, various components and Flow simulation. The results show that the temperature and relative humidity errors are 4.3% and 2.0%, respectively. The spring temperature can be maintained at 22.1 °C, the relative humidity is 77.3%, the electric energy is saved by 30%, and the water is saved by 27%.

1. Introduction

In textile process, the air temperature and relative humidity have a close relationship with the moisture absorption of the fiber. The basic idea of cleaner production also requires that the textile process environment must ensure the health of the workers; the change of air temperature and humidity in textile workshop will lead to the change of fiber properties, especially the moisture regain of fiber is greatly affected by the relative humidity of air in the workshop. The strict control of temperature and humidity directly affects the quality of textiles. Summer temperature below 32°C is feasible [1]. In the spinning workshop with the maximum calorific value, the summer temperature is guaranteed to be below 34°C, and the blowing feeling of the operating part is appropriately increased. The workshop change season can not only meet the requirements of the process production but also can meet the workers’ feeling requirements. It is better to control it at 22°C-25°C in spring and autumn, and 18°C-25°C[2] in winter according to the technological characteristics of the product. The relative humidity of the air outlet reaches 75%-85% which can meet the process requirements[3]. At present, the air conditioning system used by many textile enterprises can not meet the requirements of the process or the stability is poorer, and the energy consumption is high. To this end, many textile companies are also looking for a textile air conditioning system with high stability and reliability.

In response to this phenomenon, we have improved and optimized the traditional textile air conditioning system, designed a new water-cooled textile air conditioning system, improved the heat exchange efficiency, and solved the problem for the enterprise.

2. Air conditioning system design

In the design of air conditioning system of textile factory, in order to improve the heat exchange efficiency of the shower room and reduce the energy consumption of the air conditioning system, the
design of air conditioning system, the design of air distribution system, and the energy saving operation of air conditioning system are three important aspects.

2.1. New water-cooled textile air conditioning system process flow
The designed air conditioning system process is as shown in Figure 1.

![Figure 1 New water-cooled textile air conditioning system process flow](image)

Figure 1 New water-cooled textile air conditioning system process flow
1-Adjusting damper 2-Fan frequency converter regulator 3-Fan 4-Air conditioner shower room 5-Water pump 6-Water pump frequency converter regulator 7-Air outlet 8-Return air filter.

An air conditioning system should be multifunctional, including adjusting the indoor temperature and relative humidity, keeping a certain air flow rule, cleaning and refreshing the air in a certain extent.

2.2. Accessory design of auxiliary equipment
In order to prevent the nozzle from clogging and to ensure that the working environment in the textile workshop passes through the water circulation system and enters the pool through the water circulation system, a filter is arranged in the pool to filter the impurities in the circulating water. The PX-1 type nozzle is selected for use, and the atomization effect and flow value are the best. Compared with the Luwa type, the total heat exchange efficiency is increased by 51.7%, and the contact coefficient is increased by 21.9%[4].

3. Design of each composition unit of Air-conditioning system

3.1. Shower room design
The structure of the shower room is as shown in Figure 2
The spray system consists of a spray tube group, a nozzle, a corrugated baffle and a sewerage pipe. The spray system is arranged in the downwind direction by the nozzles on the 4-row tube discharge sprinkler. After the airflow passes through the axial flow fan, it is directly blown into the spray chamber due to the negative pressure effect, and the air droplets are directly collided with the water droplets. The air is exchanged with the small water droplets, and then dehumidified by the corrugated water deflector and then enters the air supply chamber. The air supply port on the air supply duct is allocated to the process area. After the inflowing air heat and mass exchange is completed, it falls into the spray pool, and the sewage pipe at the bottom of the spray pool discharges the falling objects in the air. The water pump connected to the external pool is pumped from the pool to provide spray. The bottom of the water pump is connected with the spray pool in the air-conditioned room to achieve the purpose of water circulation to save water. The pool is equipped with a float valve. The low-time float valve triggers the inlet pipe to replenish water. When the water level is too high, the overflow pipe in the pool will drain excess water without causing overflow phenomenon.

3.2. Air distribution system design
The new water-cooled air-conditioning system adopts the air distribution method of sending up and returning, and two air outlets are arranged side by side on some main air duct. Due to the downward movement of the cold air, the hot air moves upwards, and the cold air sent by the air supply port in the production process area after sinking through the process production area is heated upward by the heat source, and finally sucked into the return air duct by the return air inlet. At this time, a convection phenomenon is formed in the working area, and the bottom-up circulating humid air satisfies the stability of temperature and relative humidity in the process area.

The air duct adopts 1300mm×1100mm, 1300mm×900mm, 1000mm×780mm, three sizes, and adopts variable diameter to increase the air supply volume at the end of the branch pipe and the end of the main pipe, which solves the problems of uneven supply air, insufficient air supply and waste of energy consumption.

3.3. The improvement of fan
The fan adopts a blade angle adjustable axial flow fan, and its structure is as shown in Figure 3. Increase fan flow by increasing fan blade angle. The method of gradually increasing the angle of the fan blade is adopted, and the wind flow rate is tested, and the energy consumption of the motor is detected at the same time. Under the same energy consumption, the improved fan wind flow rate is increased by 20%, energy saving is achieved, and the noise decibel is not increased.
3.4. Design of tuyere filter and return air door
Outdoor fresh air filter is used H11 grade or above the filter. Characteristics: large dust containing capacity, high filtration accuracy, can be processed according to customer needs into various sizes and shapes, suitable for different dimensions.

If the outdoor air is relatively clean and does not need to be filtered, open the return air door and directly enter the return air chamber to mix, reducing system resistance and system energy consumption.

4. Working principle
The new water-cooled textile air-conditioning system allows air to be sucked back into the return air chamber through the return air duct for a return air, and then the wind is blown into the shower room by the fan, and the hot and wet water is exchanged with the atomized water droplet sprayed from the spray head in the spray chamber. The water mist accelerates the vaporization of the water, absorbs heat during vaporization, and takes away the heat in the air, thereby achieving the purpose of cooling, and the humidity of the treated air is relatively large, and the water vapor separation by the water retaining plate reduces the water content of the air. The treated air is sent to the textile workshop through the air supply duct in the air supply chamber to meet the process requirements. Figure 4 is a structural diagram of the new water-cooled air conditioning unit.

5. Comparison of experimental data and simulated data
Due to the larger area of the factory to be tested, this experimental test will draw the square lattices of the equal size of the factory, and select the representative points at the equal distance in focus to collect, test and analyze the data. The experiment selected 28 test points for the plant to collect data and process the data.

The new water-cooled air-conditioning system has been tested to meet the temperature and humidity requirements of the textile process. In the spring, the indoor temperature is adjusted to
21.8°C-22.9°C, the indoor maximum temperature difference is 1.1°C, and the relative humidity is 72.4%-80.2%. The maximum relative humidity difference is 7.8%, fluctuations are within the allowable range.

In order to verify the reliability of the new water-cooled air-conditioning system, Flow simulation is used to simulate any set of data, and the error is analyzed by comparing the experimental data.

5.1. Experimental data
The equipment developed according to this design has been installed and commissioned in “Qinghai Xiatang Yakwool Industry Co., Ltd.” and “Tibet Holy Trust Industry and Trade Co., Ltd.”. Both the experimental water pump and the fan are controlled by frequency conversion. When collecting data, the water pump and fan are frequency-modulated at 30Hz. The measured water temperature of the pool is 9°C, the local elevation is 2261.2m, the air pressure is 77.35KPa, the outdoor average temperature is 30°C, the outdoor average humidity is 35%; the indoor average temperature is measured at 22.1°C, the highest temperature 22.7°C, the minimum temperature is 21.9°C, the maximum temperature difference is 0.8°C, compared with the outdoor average temperature indoors by 7.9°C; measured indoor average humidity of 78.3% maximum relative humidity of 79.1%, the minimum relative humidity of 73.8%. The maximum humidity difference is 6.2%. The indoor relative humidity increased by 42.3% compared to the outdoor average humidity.

5.2. Simulation data
According to the above conditions, the simulation parameters are set, and the real conditions of the external environment are simulated and analyzed. The simulated temperature and relative humidity are shown in Figure 5 and Figure 6 below.
The simulation results show that the mean air inlet temperature is 20.1℃ and the average relative humidity is 76.7%.

5.3. Comparative result analysis
The simulated average temperature is 1℃ lower than the indoor average temperature, the error is 4.7%, the difference between the average relative humidity and the indoor average relative humidity is 0.6%, and the error is 2%.

The temperature error is the biggest. This is caused by the heat source in the plant and the work heat of the machine. In the three-dimensional modeling, the structure of the nozzle is complicated. The steps of assembling on the spray pipe are cumbersome and the calculation amount is too large when the simulated numerical value is calculated, which wastes a lot of time. In short, the range of fluctuations is within the allowable range of the process, and the stability is relatively higher.

6. Conclusion
Under the same conditions, compared with the traditional textile air conditioner and the new water-cooled air conditioner, the energy saving is reduced by 30%, the water energy can be saved by 27%, and the air supply volume is increased by 20%. From this comparison, it can be seen that the new water-cooled air conditioner has lower energy consumption than the existing textile air conditioner and achieves the purpose of energy saving. It is proved in both theory and practice.

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