Design of cooling water circulation system for vacuum moisture regain machine

Xiufang Li*

（Golden leaf production and manufacturing center of China Tobacco Henan Industrial Co.Ltd., Zhengzhou 450016, China)

LXF0071658@163.com

Abstract. In order to understand the design of cooling water circulation system, a design study of cooling water circulation system of vacuum moisture regain machine is put forward. The phenomenon of "water shortage" often occurs in the cooling water circulating tank of vacuum dehumidifier, which makes the cooling water entering the condenser insufficient, which causes the efficiency of vacuum dehumidifier to decrease and affects the product quality. In this paper, an automatic water supply device is designed by using automation technology and condensate recovery technology. At the same time, the condensate from the production line is recovered as the water supply source. When the cooling circulating water tank is "short of water", the water supply device automatically supplies water. The results show that after the automatic water replenishment device is installed in the cooling water circulation system of vacuum humidifier, the normal operation of the equipment can be guaranteed, the permeability rate is greatly improved, the stability of the system is improved, and the precise control of cooling water replenishment is realized.

Keywords: Dampening machine; Cooling water; Circulatory system

1 Introduction

Vacuum moisture regain equipment is mainly used in tobacco shred production line, which is a main process of tobacco pretreatment. The working flow of the cooling water circulation system of the existing vacuum moisture regain equipment is shown in Figure 1. The hot water discharged from the vacuum moisture regain equipment enters the cooling water tower for cooling, and the cooled water flows into the cooling circulating water tank, and then is pumped into the vacuum moisture regain equipment by the circulating water pump. In the production process, the cooling efficiency of the existing cooling water circulation system is not high, which leads to the continuous operation of vacuum moisture regain equipment in summer, often because the cooling water temperature is too high, which leads to the extension of evacuation time, and the steam consumption increases greatly. In serious cases, even because the cooling water temperature is too high, long-term evacuation leads to material breakage in the subsequent process, which affects the production efficiency of the equipment. The tem-

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perature of circulating water is measured and displayed by the on-line temperature detector on the circulating water return pipe, and controlled by the variable frequency fan of cooling water and the temperature regulating valve of the bypass pipe (set as required); The speed of cooling water fan should be close to the requirements of circulating water and the change of climate conditions. If the temperature measured on the circulating water return pipe is too high, the fan will accelerate, otherwise it will decelerate. If the circulating water return temperature continues to drop and all fans have stopped, part of the circulating water return will directly enter the water collection tank through the bypass pipe, so that the temperature of circulating water will not be too low. The bypass flux of this circulating water is controlled by the temperature regulating valve [1-2].

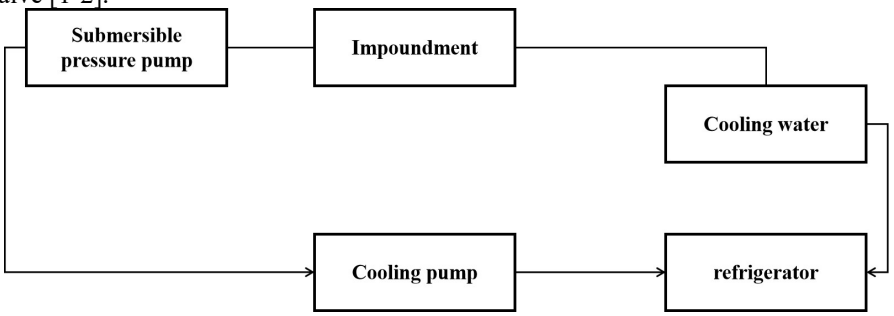

Fig. 1. Cooling water circulation system

2 Cooling water circulation method

Based on the investigation of the vacuum dehumidifier using this principle in the industry, it is preliminarily known that when the temperature drops in winter, the cooling fan of the cooling tower freezes and slows down the flow rate of circulating water, and there is also the problem of "water shortage" in the circulating water tank. Some manufacturers have upgraded the equipment, changing the open cooling of outdoor cooling tower into closed condensation of indoor freon, so as to avoid hidden dangers such as the influence of external environment on water temperature and water quality. However, through further understanding of the relevant technical manufacturers, the technical transformation project is large, the transformation cost and operation cost are high, and the maintenance is complicated, and the condensate recovery problem is not considered. Based on the experience of the above industries, this project puts forward the following three solutions with innovative thinking: (1) Through statistical analysis of cooling water consumption, find the optimal water replenishment cycle, revise the Operation Rules of Vacuum Moisturizer, and make water replenishment regularly by operators; (2) According to the weather changes, the running time of the cooling tower fan is controlled by the cooling water inlet temperature to avoid freezing caused by too low cooling water temperature; (3) According to the water level of the circulating water tank, the condensed water of the production line is recovered, and the cooling water circulation system is automatically replenished. Considering the

economy, implementation, reliability, maintainability and effectiveness, we decided to choose the third way [3].

2.1 System design

(1) A drain bypass line is connected in parallel to the drain pipe at the end of the condensate water, and the drain bypass line has normal drain function; (2) A condensate water recovery tank is designed, and temperature and liquid level detection elements are added, which has the functions of recovery, water storage and cooling; (3) Add a liquid level gauge to the circulating water tank of the vacuum moisture regain machine to monitor the liquid level from time to time; (4) the electromagnetic valve is controlled to open and close by the liquid level signal; (5) After cooling, the condensed water is discharged into the circulating water tank of the vacuum moisture regain machine for use by the cooling water circulating system, so as to meet the demand for water replenishment; (6) Add the input box of "Make-up Water" button on the man-machine interface of the industrial computer, and set the automatic and manual states for the make-up water operation. Manual water replenishment is mainly used for regular cleaning of cooling tower pipelines and water replenishment in the tower during holidays; Automatic control is mainly used to replenish cooling water lost in production [4-5].

2.2 Design of recycling part

A drain bypass is connected in parallel to the drain pipeline at the end of the pretreatment section of the processing line. The function of the bypass is to recover the condensed water to the recovery water tank of the water replenishing device, and the drain bypass is designed in strict accordance with the drain specification of condensed water. The condensed water collected by the hydrophobic bypass leads to the recovery water tank. Because of the high temperature of the condensed water, there is a hidden danger of corrosion when it is placed in the outdoor environment. Stainless steel with good hardness, wear resistance and corrosion is used as the material of the recovery water tank. The condensed water produced in one hour is about 0.4m3 Two 500L-L tanks are selected as the recovery water tanks, one for recovery and the other for cooling. An overflow hole is opened on the recovery and cooling water tank, and a safety valve is added. After cooling, the water pump is pumped into the cooling water tank for further cooling. The water pump adopts an electric gear pump with good corrosion resistance and high working efficiency. Liquid level detection is installed on the circulating water tank, cooling water tank and recovery water tank as a condition for starting and stopping the pump. The low liquid level detection of recovery water tank also plays a role in preventing the pump from working without water. According to the requirement that the make-up water flow is greater than 4m3/h, the pipe diameter of DN35 is selected, and the pipeline length is arranged according to the on-site installation position [6].

2.3 Design of water supply part

To install pipelines under the cooling water tank, it is necessary to install a set of pipelines under the cooling water tank and introduce automatic opening and closing functions to achieve automatic control of the system. For the convenience of subsequent maintenance and repair, we have installed a shut-off valve in front of the solenoid valve, so that when the solenoid valve needs to be repaired, the water flow can be conveniently cut off without affecting the entire system operation. There are also two water tanks in the cooling system, one is the circulating water tank and the other is the cooling water tank. We have installed temperature detection devices in these two water tanks to monitor the water temperature in real-time. In order to ensure the normal operation of the system, especially during the cooling process, we have set a requirement that the water temperature should not exceed 32 ℃, which is to ensure the cooling effect and prevent the system from overheating. When the cooling system is running, the solenoid valve will automatically open or close according to the preset control logic to control the flow of cooling water. Under certain conditions (such as when the water temperature in the cooling water tank exceeds 32 ℃), the system will automatically perform a water replenishment operation to maintain the water temperature in the cooling water tank within a controllable range. Overall, this cooling system ensures that the temperature of the cooling water remains below 32 ℃ through automatic control and temperature detection, effectively meeting cooling needs and maintaining stability and efficiency during operation. At the same time, the installation of the shut-off valve also provides convenience for future maintenance and repair[7].

3 Improve the control mode of cooling water replenishment

1.Install PLC-controlled pneumatic butterfly valve on the water supply main pipeline of cooling tower, and add the button of "water supply for cooling tower" and the input box of "water supply time for cooling tower" on the man-machine interface of industrial computer. Automatic and manual modes are set for water replenishment operation, and the man-machine interface can display automatic water replenishment time and countdown, manual water replenishment time and countdown. Manual water replenishment is mainly used for regular cleaning of cooling tower pipelines and water replenishment in the tower during holidays; Automatic control is mainly used to replenish production loss cooling water before starting every day.

2. Four water storage tanks of cooling tower are connected to the cooling system of vacuum moisture regain machine for direct cooling, and the cooling tower has independent cooling section, water storage tank and pipeline system. Because the evaporation of water in the four cooling towers is not equal, and the water storage capacity in the water storage tank of the cooling tower is also different, some cooling towers will be "short of water" when working and some water storage tanks will be "overflowing" when replenishing water. Therefore, pipelines are added at the bottom of four cooling tower water storage tanks to connect the four water storage tanks, so as to balance the

water storage capacity of the four water storage tanks and reduce the probability of "water overflow" and "water shortage".

3. Control the start and stop of cooling water tower through water temperature detection.

The cooling water is cooled by the outdoor cooling tower fan. When the outside temperature is too low in winter, the fan operation will cause the cooling water to freeze, resulting in water shortage in the cooling tower [8-9].

4 Control optimization of cooling water circulating pump

The cooling tower of the cooling water system of the vacuum humidifier corresponds to the circulating water pump one by one, and four circulating pumps are arranged in total. In actual production, two circulating pumps can meet the cooling water demand of two vacuum humidifiers. In the improvement, the control mode of cooling water circulating pump is optimized, and two circulating pumps of each moisture regain machine are used for one purpose and one for standby, which can not only solve the problems of serious corrosion, high failure rate and no standby pump due to the long-term demineralized water and outdoor environment, but also save energy. As shown in Table 1.

Table 1. Comparison before and after

	Before transformation	After transformation
Minimum vacuum degree	0.68kpa	0.5KKpa
Maximum inlet temperature of cooling water	33.8°	31°
Outlet moisture	12.25%	14%

Through the above transformation, the problem that the cooling water circulation system of the vacuum humidifier is partially frozen due to the low temperature in winter has been solved, the phenomena of "water overflow" and "water shortage" caused by improper control of the water replenishment system have been avoided, the downtime of equipment failure has been reduced, the power consumption, the consumption of softened water for cooling and maintenance costs have been saved, and the problem that the online quality stability of the processing line has been affected by the unstable water pressure in other processes caused by water replenishment during production has also been solved. See Table 2 for the comparison of the effects before and after the transformation.

Table 2. Comparison of cooling water system of vacuum moisture regain machine before and after renovation

project	Water consumption /kg	Power consumption/KE·H	Downtime /h
In 2021	101000	28060	8.6
In 2022	88000	20860	1..6
contrast	13000	7200	7

Compared with the same period of last year, the reformed January 2022 saved 13t softened water, 7200kW·h electricity and reduced the downtime of vacuum humidifier by 7 hours. It lightens the labor intensity of workers and has positive significance for the stability of online quality of the silk-making line [10].

5 Conclusion

The cooling water circulation system of vacuum moisture regain machine realized the function of automatically replenishing cooling water, and solved the hidden trouble of equipment failure. In order to verify the improvement effect, the permeability of vacuum moisture regain machine is tested, and the permeability rate is improved. Recycling the condensed water produced by the production line ensures that the water quality of cooling water meets the use requirements, reduces the consumption of water energy, completely solves the problem of "water shortage" in the circulating water tank, improves the stability of the system, and realizes the accurate control of cooling water replenishment.

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