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Retraction

Retracted: Application of a Frequency Converter in Electric Automatic Control of Central Heating

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets 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 own 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.

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[1] J. Yin and G. Zhang, "Application of a Frequency Converter in Electric Automatic Control of Central Heating," *Journal of Control Science and Engineering*, vol. 2022, Article ID 1516362, 7 pages, 2022.

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Research Article

Application of a Frequency Converter in Electric Automatic Control of Central Heating

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In order to improve the efficiency of a central heating system's control system, this paper puts forward the application scheme of a frequency converter in central heating electrical automation control. In the central heating electrical automation control system, the frequency converter plays an important role. It can regulate and control the relevant equipment, realize the electrical automation of the heating system under the action of the frequency converter AC motor, and effectively adjust the performance and speed, so as to achieve the purpose of energy saving. The experimental results show that the temperature control strategy using a frequency converter automatic compensation method reduces the energy waste caused by manual regulation to a certain extent. When the speed of a water pump motor decreases to 4/5 of the original, the power consumption will decrease to about 52% of the original and save about 48% of the power; When the speed drops by 3/5, the power consumption is about 22% of the original, saving about 78% of the power. *Conclusion*. This technology can fully realize the demand of electrical automatic control of the heating system, greatly improve the stability and safety of the heating system, have good energy-saving effect, and greatly save energy consumption. The frequency converter has a remarkable effect in ensuring heating quality and improving heating efficiency in the heating industry.

1. Introduction

At this stage, the central heating mode has become a part of China's urbanization construction. Due to the increasing demand for central heating, it has also promoted the rapid development of the central heating industry to a certain extent. In the process of development, the electrical automatic control of the heat supply network has been welcomed and supported by the public [1]. As for the current heating system in China, the emphasis on heating automatic control is mainly divided into two directions, one is the automatic control system of a heat supply network and the other is the automatic control system of heat source. Automatic control of the heat supply network highlights its advantages in the implementation of urbanization construction, which can improve the quality of central heating in the whole city. It can not only find the fault in time during operation but also effectively reduce energy consumption, so as to realize the coordinated relationship between heat supply network operation and environmental protection. China's urban central heating automatic control system started relatively late and now belongs to the primary stage of development. The automatic control system of the heat supply network cannot fully realize informatization and automatic management, and there are still some defects in the control and management of the heat supply network [2]. Further research and optimization are needed to achieve informatization and automatic management. According to the current situation of the application of an automatic control system in China, although it involves many fields and has obvious effects in the central heating system, there is still a lot of room for improvement in automatic control because the technology is not mature enough. Figure 1 shows the application of a frequency converter in central heating electrical automation control.

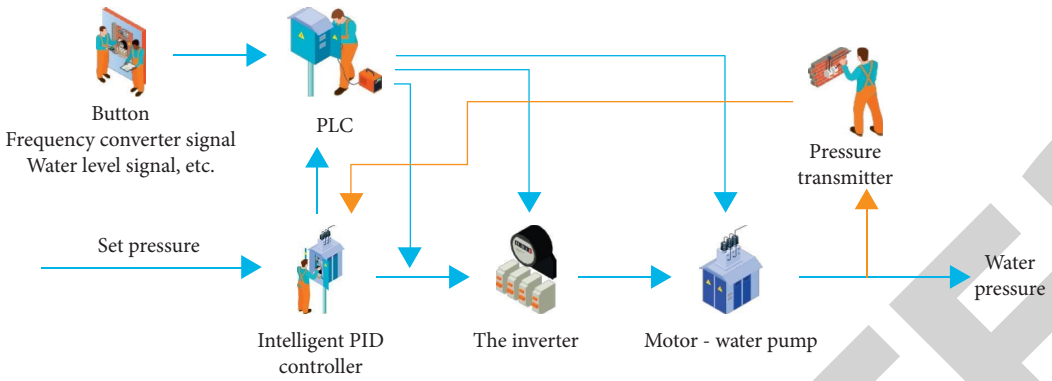

Figure 1: Application of a frequency converter in electric automatic control of central heating.

Lobanov et al. monitored the influencing factors of heating system in individual regions of northern Europe in detail and finally determined the main factors affecting heating, such as geographical location, outdoor temperature, wind speed, and sunlight. The test and research found that various factors have different effects on the heating load. The size of the heating load is mainly affected by the outdoor temperature, up to about 60%, the impact of wind speed on the heat load accounts for 1%~4%, and the domestic hot water load uses 30% of the heating capacity. In the process of heat transmission, the unavoidable loss of pipe network accounts for 10% of the total heat load [3]. Bertelsen et al. analyzed the influence of many factors such as ambient temperature, solar radiation, and air velocity on the pre-estimation of heat supply in central heating [4]. Gao and others studied the prediction of building energy consumption in tropical areas by using the support vector machine method. Taking a commercial building in Singapore as the research object, they selected outdoor temperature, illumination intensity, and air relative humidity as the input parameters of the energy consumption model. The predicted building energy consumption was very close to the actual energy consumption and the relative error of energy consumption fluctuates was within the acceptable range of 5%. The experiment shows that the support vector machine method is highly feasible in the research of building energy consumption [5]. Kumar et al. collected and analyzed the supply and return water temperature and other values in the local heating system and predicted the supply and return water temperature in the heating system by using the impulse response method. The error between the final prediction result and the actual measurement result is no more than 0.5°C [6]. Chen et al. made great progress in the research on the accuracy of heating load prediction [7]. Lemos et al. stated in detail that the progressiveness and superiority of the application of an artificial neural network structure in the field of heating and ventilation by collecting the current heating status and applying the neural network technology to the system operation management, heat statistics management, and system fault identification in the heating system achieved good results [8]. Sapin combined the neural network technology with the heat load forecasting in the heating system, studied the feasibility of the BP network in the heating load forecasting model, which was verified in practical engineering, and achieved good practical engineering application results [9, 10].

In the process of urbanization, the central heating system also shows great advantages, mainly in terms of energy conservation, environmental protection, and cleanliness. The central heating system optimizes the traditional heating mode of a regional boiler room, which is also the main trend of future development. At this stage, the scale of central heating in China's cities is expanding, but there are also some problems, such as heat balance. Therefore, advanced technology should be integrated into it. The use of automatic control technology realizes the self-regulation of central heating and can effectively solve the problems in the heating process. In the central heating electrical automation control system, the frequency converter plays an important role. It can regulate and control the relevant equipment, realize the electrical automation of the heating system under the action of the frequency converter AC motor, and effectively adjust the performance and speed, so as to achieve the purpose of energy saving. The integration of frequency conversion technology into the central heating electrical automation control system can improve the function of the whole system and ensure the efficiency and quality of central heating.

2. Research Methods

2.1. Central Heating System. Take a heating company as an example; the heating company adopts the heating method of cogeneration. As a heat source, the thermal power plant provides high-temperature, high-pressure hot water carrying heat energy. The hot water is transported to more than 200 thermal power stations distributed in all corners of the city through a huge heating pipeline (primary network). The heat energy carried by the high-pressure hot water is exchanged to the user pipe network (secondary network) with lower pressure and temperature level, and the user pipe network then transports the heat energy to thousands of households [11]. During the conveying process, a large amount of water pump loads are required to realize the circulation of the medium and achieve the purpose of conveying thermal energy. However, due to factors such as the huge laying area of the heating pipe network, the length of the pipe network, and the old basic equipment of the heat users, it is easy to cause problems such as uneven heat

distribution in the pipe network system and unstable system operation, and with the continuous and rapid expansion of the system, the abovementioned problems will become increasingly prominent.

2.2. Performance of a Frequency Converter and Its Role in Automation Technology

(1) Frequency converter is a controller that mainly uses frequency conversion speed regulation technology to control the running speed of equipment [12]. When using it to control the AC motor, it can realize the stepless speed regulation of the motor. Generally, the running speed of the motor represents its running power. According to this principle, the frequency converter can control the energy consumption of the motor. Compared with the motor running at power frequency, it has a good energy-saving effect. At the same time, the stepless speed change performance of the frequency converter can greatly reduce the impulse current generated by the motor in the process of starting or speed change, avoid adverse effects on the equipment itself and the controlled system, prolong the service life of the equipment, and improve the stability and safety of the system.

(2) The automatic control system is composed of measurement units, signal transmission units, data processing units, execution units, etc. [13]. As a control equipment between the data processing unit and execution unit, the frequency converter makes the function of the automatic control system fully realized. First of all, the data processing unit receives the external signal and outputs the signal to the frequency converter after analysis and processing. The frequency converter converts the received command into the power signal of its own control circuit and transmits the required voltage and frequency to the motor to smoothly control the speed of the motor, making the automatic regulation system more accurate and effective. For example, the data processing unit has a PLC controller. The PLC controller collects the temperature, pressure, and other parameters collected in real time in the process flow, compares and calculates them with the set values, or transmits the instructions to the frequency converter according to the instructions sent by the upper computer. The frequency converter starts, stops, or speeds up and slows down the motor according to the instructions and finally obtains the parameters required by the system.

2.3. Function of a Frequency Converter in an Automatic Control System of the Heating System. The central heating system usually adopts pump load to adjust the hydraulic condition of the whole network. Figure 2 shows the operation diagram of the heat supply network [14]. As shown in Figure 2, the circulating pump is used to ensure the circulating flow of the user pipe network of the thermal power station to realize heat exchange; the makeup pump is used to makeup water for the primary pipe network system and the secondary pipe network system of each thermal power station to ensure the operating pressure of the pipe network. The return water booster pump of the primary network is used to adjust the hydraulic imbalance caused by the long pipe network and other factors in the primary network system, so that each thermal power station can obtain balanced heat.

2.3.1. Regulation of a Frequency Converter in the Circulating System of Thermal Power Station. The secondary network of thermal power station usually adopts "quantity regulation" to control the heat output, that is, to adjust the flow of circulating water in the heat network to control the heat output. Figure 3 shows the automatic heating regulation of a user pipe network. As shown in Figure 3, the system takes the return water temperature of the secondary network as the controlled object for regulation [15]. In the process of adjustment, the measuring unit in the automatic control system transmits the temperature data measured on site to the field controller, and the field controller compares and calculates the received temperature data with the parameter requirements of the upper computer (obtained according to the outdoor temperature). Then, we send a command to the frequency converter [16]. According to the received control signal, the frequency converter adjusts the speed of the water pump by adjusting the frequency of the power supply voltage to control the flow rate of the pipe network system and then adjusting the return water temperature of the pipe network.

2.3.2. Adjustment of a Frequency Converter in the Automatic Water Replenishment System of a Pipe Network. The water pressure of the heating network system determines the stable operation of the whole system. In actual operation, the old phenomenon of user pipe network system is more common, which is easy to cause the instability of pipe network pressure. In the past, the electric contact and other methods were used to control the water makeup pump for water makeup, which has a poor control accuracy and large power frequency starting current, which is easy to cause equipment damage and system operation failure. The above problems can be overcome by using frequency converter control in the automatic water replenishment system. The field controller sets the minimum and maximum pressure values suitable for the operation of the pipe network in advance. Through comparison and calculation with the pipe network pressure values obtained by the measuring unit, the water makeup pump is started when the pipe network pressure reaches the minimum value, and the water makeup pump is stopped when the pipe network pressure reaches the maximum value, so as to maintain the stability of the system water pressure. In this process, due to the smooth start and stepless speed change characteristics of the frequency converter, the failure risk of the makeup pump and the pressure impact on the pipe network system are reduced. Figure 4 shows the automatic control of the water supply system of a heat supply network [17].

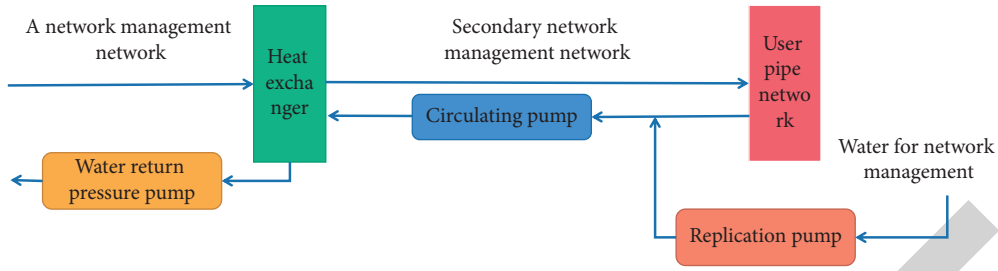

Figure 2: Operation diagram of the heat supply network.

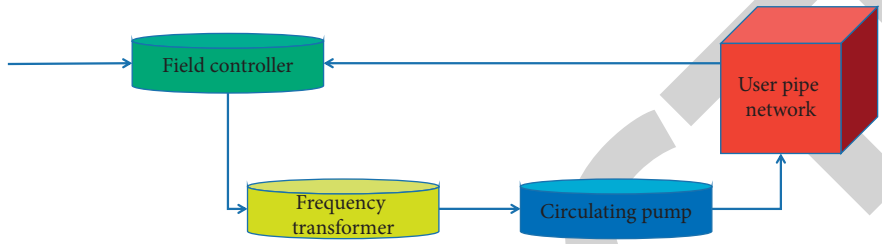

Figure 3: Automatic regulation of user pipe network heating.

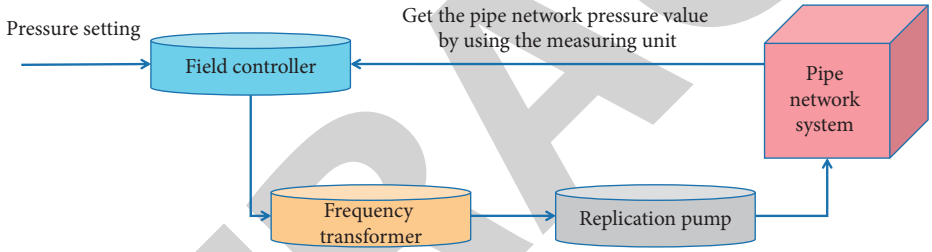

Figure 4: Automatic control of the water supply system of a heat supply network.

After the control system is started, the makeup pump is in manual mode by default. If it is switched to automatic mode through the manual automatic transfer switch of the control cabinet, the makeup pump is in automatic state. During the operation of the heat exchange station, the return water pressure must be maintained at a constant value, while the makeup water pump is in power frequency operation under the manual state, so the constant value control of the return water pressure cannot be realized. Therefore, the manual state is rarely used. It can only be started when the control equipment fails or the heat exchange station needs a lot of water replenishment. In the automatic mode, the controller needs to read the set value of the return water pressure and the liquid level of the water tank at the same time. The water supplemented by the makeup pump to the secondary network of the heat exchange station comes from the water tank. The liquid level of the water tank determines whether the makeup pump can operate. When the liquid level of the water tank is too low, the water pump will be damaged for a long time. Therefore, it is necessary to design the pump stop function at a low liquid level in the program. When the liquid level of the water tank is higher than the set value, the makeup pump operates normally. The PLC controller detects the return water pressure value in real time and compares it with the set value and continuously adjusts the speed of the makeup pump through PID to realize the constant value control of the return water pressure. In case of a system failure or potential safety hazard, the whole system can be stopped through the emergency stop button of the electrical cabinet [18, 19].

2.3.3. Regulation of a Frequency Converter on the Return Water Booster Pump of a Primary Network. Due to the different distances between each thermal station and the total heat source, the pressure distribution at each point of the huge thermal pipe network is very easy to be uneven, resulting in the decline of heating quality and the waste of energy. In this regard, the primary network return water booster pump and corresponding frequency converter are installed in the primary pipe network system of each thermal power station, and each frequency converter is connected with the industrial control computer in the central control room through the field controller. The industrial control computer is equipped with configuration software and the whole network balance software. Through the parameters such as pressure, temperature, and flow collected by the on-site measurement units, using a certain algorithm, the on-site controller sends respective corresponding signals to the frequency converter of the return water booster pump of the

primary network of each thermal station and outputs different voltage frequencies to adjust the speed of the booster pump, so as to promote the balance of the output heat of the primary network to each thermal station and reduce the horizontal imbalance of the thermal network.

2.4. Variable Frequency Speed Regulation Control System. Before the advent of variable frequency speed regulation technology, industrial motors mostly used the mode of power frequency operation. Power frequency operation means that the motor takes the output frequency of industrial network as the input and the motor runs at a constant speed. This control mode reduces the adjustability of the controlled motor and cannot meet the needs of different industrial production. Variable frequency speed regulation technology not only realizes motor speed regulation but also reduces system energy consumption. It has been widely used in industrial control. The equipment requiring variable frequency speed regulation in the heat exchange station are a circulating pump and makeup pump. According to the external feedback signal, they dynamically adjust the speed through the frequency converter to realize the stable operation of the heat exchange station [20]. In addition, according to the actual operation of the heat exchange station, the power consumption of a circulating pump and makeup pump accounts for more than 80% of the total power consumption of the operation system of the whole heat exchange station. Therefore, the use of frequency conversion technology is more conducive to the energy saving of the heat exchange station.

The formula of motor slip is the following formula:

$$s = \frac{n_0 - n}{n_0} = 1 - \frac{n}{n_0}. \quad (1)$$

According to the above formula, the motor speed is as follows:

$$n = \frac{60f}{p}(1 - s), \quad (2)$$

where n—actual speed of motor, r/min; n_0—Synchronous speed of motor, r/min; f—Working power frequency of motor, Hz; s—Motor slip rate; and p—Motor pole pairs.

According to equation (2), the motor speed can be adjusted by changing the power supply frequency.

The purpose of variable frequency speed regulation of the water pump is to realize flow control. Therefore, it is necessary to analyze the basic characteristics of the water pump. As shown in Figure 5, the speed regulation $H \sim Q$ curve of the water pump. In Figure 5, curve 1 is the relationship between the flow and head of the water pump when the motor speed is n_1; curve 4 is the relationship between pump flow and head when the motor speed is n_2, where $n_1 > n_2$; curves 2 and 3 show the pipeline water resistance characteristics of solenoid valves with different opening degrees.

3. Result Analysis

In the cogeneration heating system, all kinds of water pump loads are the main way of energy consumption. Compared

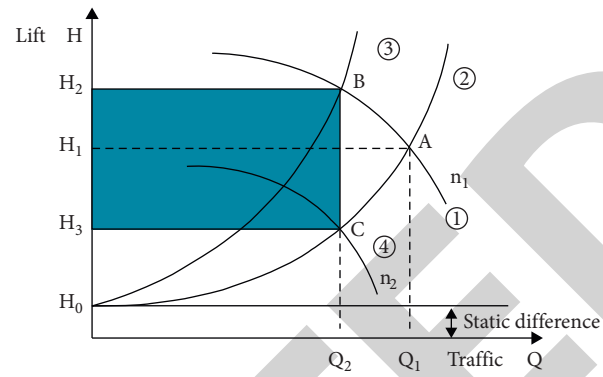

Figure 5: $H \sim Q$ curve of speed regulating operation of the water pump.

with the method of controlling the flow of pipe network by controlling the opening of valve, frequency converter control has great advantages in energy saving. In the traditional method of regulating flow, the motor operates at power frequency, its output power is large, and more electric energy is consumed in the process of intercepting the valve plate, resulting in a waste of electric energy. Frequency converter regulation can reduce the power consumption by reducing the voltage frequency of the power supply and reducing the motor speed in a low cold period. From the knowledge of hydrodynamics and electromechanics, the power consumption of a water pump motor is approximately in direct proportion to the rotating speed, that is, $P \propto n^3$.

The automatic transformation of the heat exchange station in a community is carried out, and the remote centralized management and control of the heat exchange station is realized [21]. At present, the overall commissioning of the control system of the heat exchange station has been completed and the system has been put into normal use. The overall operation of the system is stable and the monitoring and management function is perfect. It can be seen from Figure 6 that the water supply temperature of the secondary network is adjusted by itself with the change of outdoor temperature, which meets the control requirements of on-demand heating of the heat exchange station. Before the automatic transformation of the heat exchange station, the personnel on duty will generally manually adjust the heating temperature twice at 9 a.m. and 18 p.m. according to experience. It can be seen from the Figure 6 that the temperature control strategy of frequency converter automatic compensation method reduces the energy waste caused by manual adjustment to a certain extent, so as to achieve the effect of energy conservation and emission reduction.

When the rotation speed of a water pump motor drops to 4/5 of the original, the power consumption will drop to about 52% of the original, saving about 48% of the power. When the speed drops by 3/5, the power consumption is about 22% of the original, saving about 78% of the power. It can be seen that the energy-saving effect of the frequency converter is very significant. In the actual use process, because it does not need power frequency operation for a long time, it can save most of the electricity and has very considerable economic benefits.

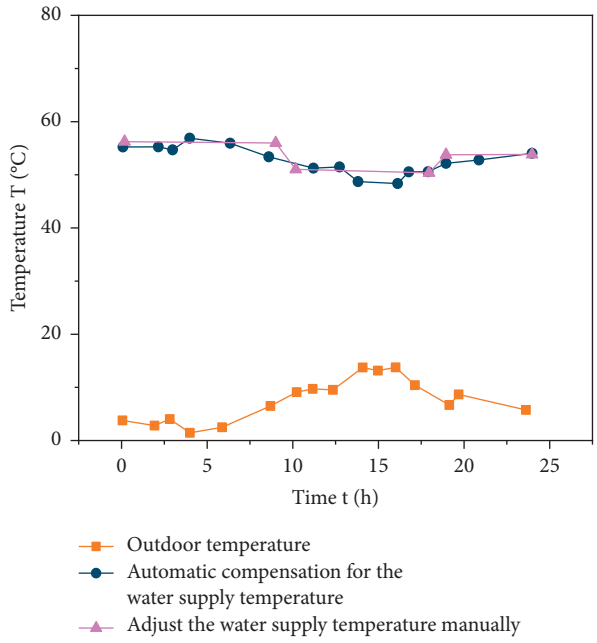

Figure 6: 24-hour operation data of heat exchange station.

4. Conclusion

It can be seen that the frequency converter, as an important part of the electrical automatic control of the heating system, makes the automatic control function more perfect and achieves the best control effect. Moreover, this not only effectively ensures the system regulation but also ensures the more stable and safe operation of the system and has excellent energy-saving effects. It should be noted that high-order harmonic current will be generated during the operation of the frequency converter, which will cause power quality problems and interfere with the operation of other electronic equipment. In this case, filter reactors are generally installed on the input side of the frequency converter to effectively reduce harmonic interference. Therefore, in the future application process, on the one hand, we should constantly improve the frequency converter technology to achieve the effect of optimizing the process of the heating system. On the other hand, we continue to strengthen the measures of frequency converter to reduce interference and optimize the operation environment of the equipment.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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