ARTIFICIAL INTELLIGENCE CONTROL SYSTEM OF HEAT RECOVERY IN THERMAL POWER PLANT

by

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In order to improve the comprehensive utilization rate of energy in power plants, the author puts forward the research of artificial intelligence control system for heat and power plant waste heat recovery. In the heating system of waste heat recovery, intelligent time-sharing and zoning control is set according to user needs, which enables the heating system to adjust the temperature of heating water outlet in real time according to the dynamic change of outdoor climate, in the heating system of waste heat recovery, intelligent time-sharing and zoning control is set according to user needs, which enables the heating system to adjust the temperature of heating water outlet in real time according to the dynamic change of outdoor climate. The results show that the energy saving rate of time-sharing heating increases with the increase of outdoor temperature, when the outdoor temperature is 8 °C, the energy saving rate is 0.35, in addition, the energy saving rate of the heating system is not only related to the outdoor temperature, but also to the length of the intermittent period, it is obvious that the longer the intermittent period is, the higher the energy saving rate is. In conclusion, the application of time division temperature control technology in the heating system greatly improves the energy saving effect of buildings, saves energy, and has extremely high economic, environmental and social benefits, which is worth advocating and promoting.

Key words*: cogeneration system, residual heat of circulating water, intelligent control, waste heat utilization*

Introduction

With the rapid development of the economy, China's installed power generation capacity and power generation capacity have advanced to the forefront of the world. At the end of 2017, China's total electric power generation capacity reached 1.777 billion kWh, and the total annual power generation was 6.4179 trillion kWh. In 2017, more than 70% of electric energy was provided by thermal power generation, and the consumption of standard coal accounted for 31.3% of the total energy consumption in China. After years of efforts, in 2017, the standard coal consumption for power supply of power plants with 6000 dry W and above has decreased to 309 g per kWh, with an average annual decrease of 3.4 g per kWh. With the increase of large capacity units, it is difficult to reduce the coal consumption of power supply by simply shutting down small units. By improving the efficiency of new units and tapping the energy saving potential of services in the sector, it plays an important role in achieving energy savings and reducing emissions in China [1, 2].

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The use of waste heat from boiler flue gas is an important way of saving energy and reducing emissions for thermal power equipment. The flue gas heat loss of the power station boilers is the most important part of the water heater heat loss. The flue gas temperature of the power station boilers is usually 120-140 °C. Research shows that if the flue gas temperature is reduced by about 50 °C, the efficiency of the boiler can be improved by 1-3, and the unit's power consumption can be Voluntarily reduced by 1-3 g per kWh. Although many domestic power plants have made waste-to-energy conversions, most of them only reduce the exhaust gas to 100 °C. The waste heat of the flue gas of the power station boilers has a mature known heat and latent heat. The latent heat carried by moisture in flue gas accounts for approximately 30 of the total heat. In order to avoid low temperature rust, most boilers only return the heat of the flue gas and provide the latent heat of the flue gas. At the same time, moisture in the flue gas disappears. Limited by the low flue gas temperature reduction, the space for better design and integration of the use of waste heat is limited [3].

Therefore, it is important to learn how to use the waste heat of the power plant boiler flue gas, to make the best recovery of the mature and latent heat of flue gas, and at the same time recover part of the moisture in flue gas to achieve energy saving and emission reduction of thermal power units in service.

Literature review

Pan *et al*. [4] developed an advanced cogeneration system based on biomass direct connection, and analyzed its feasibility. In the new system, instead of using the traditional heat (gas), the gas comes from the generator, the cold water comes from the condenser of the electric power and the water is not low pressure from the electronic preheating system is jointly used to generate heat in the area. Therefore, significant energy savings can be achieved and the overall efficiency of the cogeneration system can be improved. Taking a 35 MW biomass cogeneration unit as an example, the thermal performance and economics of the new system were studied. While the biomass feed rate and the heat output do not change, because of the proposed upgrade, the electric power should increase by 1.36 MW. As a result, the overall system efficiency and electrical efficiency increased by 1.23% and 1.50% points, respectively. The internal mechanism of performance is learned from the characteristics of strength and resistance. Economic research shows that the effective pay-back period of the change is only 1.20 years, and the current price is 579600 dollars. In conclusion, the proposed strategy proved to be useful and useful. Chan *et al*. [5] proposed CoSAM. Based on 499 content points collected by hotel managers, the effectiveness of CoSAM was studied using the balanced scorecard. The results show that the attitude of hotel managers towards the use of the CHP system positively determines their willingness to use the system, and the attitude of the CHP is directly affected by the agreement. profitability, risk and income understanding. In addition, with perceived value as a mediator, basic conditions and environmental awareness have a positive effect on the behavior of using cogeneration systems, when seen that indirect costs have negative effects on behavior. Based on the results of this study, policy recommendations are put forward to encourage the hotel industry to adopt cogeneration techniques, in order to save energy and reduce the electricity bill in the hotel. This research is the first to have a deep understanding of the factors that affect the acceptance of cogeneration systems. Bulmez *et al*. [6] have studied the mathematical model of the main heat pump that recovers the waste heat of the circulating water by consuming 300 MW controlled heating example, and evaluate and analyze the efficiency of heat pump heat by calculating its design and out of design. Liu *et al.* [7] conduct modelling and simulation analysis and research on the effect of double suction chiller in the heat, electricity and cooling triple supply system, proving that it is possible for the chiller to work as a pump heating in the winter, and concluded that the main factors affecting the increase of the heat pump are the solution, pressure and temperature. According to the characteristics of these factors affecting the temperature rise of the heat pump, we can take the parameter adjustment in the actual operation process of the unit. Ntonda *et al*. [8] conducted a discussion and research in the evaluation of the feasibility of using heat pumps to recover the waste heat of the low power plants electricity at power plants for district heating, and also successfully investigate and study the impact of heat pump waste heat recovery models on fire production electricity at power plants.

In order to make the house really energy efficient, the heat in the winter must be replaced with air while keeping the temperature inside the house stable. In this paper, intelligent time sharing and zoning control are used to control the water flow and water temperature of the heat recovery, to achieve the required heating and reduce the waste of energy. while maintaining the comfort of the indoor temperature.

Research methods

Features and problems of university buildings

Due to the limitation of energy-saving concept and technical conditions, the following problems generally exist in the heating system of university buildings:

- Boiler workers usually burn fire according to the weather, the heating regulation mode is relatively rough, with low energy utilization rate and high energy consumption.
- In order to be on the safe side, the boiler, circulating water pump and other equipment selected for the system have a large surplus, which increases the investment and at the same time makes the working state of the system often deviate from the design state, resulting in a waste of cost.
- In order to achieve the ideal heating effect, office buildings, teaching buildings and other buildings are generally installed with more radiators, and the designed heat load is also too large, even the phenomenon of opening windows for heat dissipation occurs, causing serious energy waste.
- Some university buildings use the *unified* heating method, teaching buildings, dormitories, office buildings, *etc*., are heated according to the same time period and temperature, the heating cost is high, and the economic and social benefits are poor.
- There are many people in the room, and the windows are opened frequently, which is easily affected by the change of outdoor air.
- Older heating systems do not have branch regulating valves.
- There are some defects in building thermal insulation and air tightness [9].

Table 1. Time division of time sharing heating for university buildings

Building	Heating time
Academic Building	7:30-21:30
Office building	7:30-17:30
Laboratory Building	7:30-17:30
Library	7:30-17:30
Student apartment	5:00-7:00, 12:00-14:00
Faculty apartment	16:00-18:00, 21:00-24:00
	Continuous heating
Canteen	7:00-8:30, 11:30-13:30, 16.30-18.30

In view of the diversity of building uses, especially the university buildings, their teaching buildings, office buildings, student apartments, libraries, faculty residential buildings and other uses are different, so their heating demand and time period are different.

For example, the teaching building only needs to be heated normally from 7:00 to 21:30, and the room only needs antifreeze temperature at other times. The biggest feature of colleges and universities is that they have a long winter vacation, during the winter vacation, except for the faculty residential buildings, other buildings only need to maintain the antifreeze temperature, tab. 1. The division of heating time periods of different buildings in colleges and universities is listed in detail.

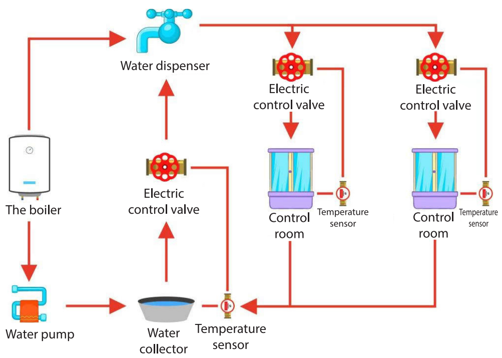

Figure 1. Schematic diagram of time-sharing heating control

Principle of intelligent time-sharing control technology

On the premise of ensuring the stability and comfort of indoor temperature, in order to save energy for university buildings, flow control valves can be installed on the hot water network pipe network on the basis of installing climate compensation devices, implement time-sharing and zoning control on the building, with the cooperation of climate compensation device, adjust the water supply flow in real time according to the change of outdoor temperature to ensure the comfort of the user's room [10]. The principle of time-sharing heating control is shown in fig. 1. The implementation process is:

– When the building is in use, the heating system is in full load operation ensure the comfort and stability of the indoor temperature, the indoor temperature in Weifang is 18 °C during heating.
– During the building intermittent period, the flow of hot water for heating is changed by adjusting the opening of the control valve, so as to adjust the indoor temperature to keep it at the antifreeze temperature, the indoor antifreeze temperature is 6 °C during the heating period in Weifang.

Result analysis

It can be obtained through theoretical calculation of many buildings or statistical induction and sorting of many measured data, which can be seen from relevant design manuals or data accumulated by local design units over the years.

This paper intends to use the building's heat capacity as a measure of energy consumption equivalent to heat. The building heat volume refers to the heat produced per cubic meter of the building volume when the difference between inside and outside is 1 °C, the size of q_v is related to many factors such as the heat transfer coefficient of the building envelope, ventilation conditions, the periphery, the shape and type of the building, and the area ratio of walls and windows, appropriate data can be selected through theoretical calculation, statistical analysis of measured data, design manual, and data accumulated by local design units over the years, since high power electrical appliances are prohibited in university buildings, the fluctuation of building volume heat index with outdoor temperature change can be ignored in the engineering application field:

– Energy consumption analysis of traditional heating system

When analyzing the energy consumption of traditional buildings without time-sharing heating, the volume heat index method can be used, the calculation formula of building heat load:

$$Q = q_v V\left(t_n - t_w\right) \tag{1}$$

where Q [kW] is the building heat load, q_v [Wm^{-3}°C^{-1}] – building volume heat index, V – [m^3] building volume, t_n [°C] – the indoor calculated temperature, and t_w [°C] – the outdoor calculated temperature.

In order to simplify the calculation, let $K = q_v V$, then the heat load, Q, is only related to the indoor temperature, t_n, and the outdoor temperature, t_w, then the eq. (1) is changed into:

$$Q_1 = K\left(t_n - t_w\right) \tag{2}$$

where Q_1 [kW] is the heat load of traditional buildings and K – the proportional coefficient.

– Energy consumption analysis of time-sharing heating system

The time-sharing heating system has obvious time segmentation, and the control temperature curve of rooms in different time periods is shown in fig. 2 [11].

According to eq. (2) and fig. 2, the energy consumption equation of time-sharing heating system can be obtained:

$$Q_2 = K\left(t_{n1} - t_w\right)\frac{17}{24} + K\left(t_{n2} - t_w\right)\frac{7}{24} \tag{3}$$

where Q_2 [kW] is the building heat load of time-sharing heating system, t_{n1} – the set temperature in the service life of the room, generally t_{n1} =18 °C, t_{n2} – the temperature set in the intermittent cycle of the room, generally t_{n2} = 6 °C, and t_w [°C] – the outdoor calculated temperature.

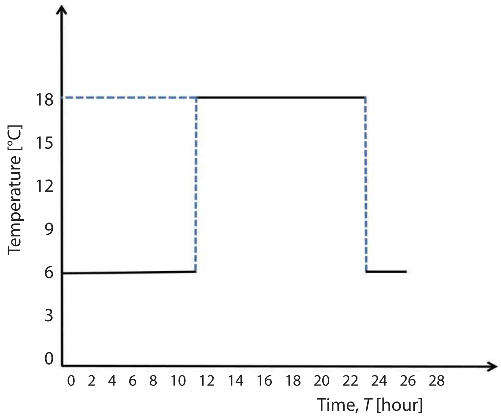

Figure 2. Setting value of indoor temperature in different time

– Energy saving rate analysis

In this project, the energy saving rate refers to the ratio of the energy consumption reduced by the system after time-sharing heating and the energy consumption of the original heating system without transformation:

$$\eta = \frac{Q_1 - Q_2}{Q_1} \tag{4}$$

Substitute eqs. (2) and (3) into eq. (4) to get:

$$\eta = \frac{7}{36 - 2t_w} \tag{5}$$

The derivation of the previous equation leads to:

$$\frac{\mathrm{d}\eta}{\mathrm{d}t_w} = \frac{14}{\left(36 - 2t_w\right)^2} \tag{6}$$

The following is an example of energy saving rate analysis based on the characteristics of outdoor temperature changes in winter in a region, taking a day as the calculation cycle, –8 °C, –5 °C, 0 °C, 5 °C, and 8 °C are selected as outdoor temperatures:

$$t_{\mathrm{w}} = -8\ ^\circ\mathrm{C},\ \eta = \frac{7}{36 - 2t_w} = 0.135 \tag{7}$$

$$t_w = -5\ ^\circ\mathrm{C},\ \eta = \frac{7}{36 - 2t_w} = 0.152 \tag{8}$$

$$t_w = 0\ ^\circ\mathrm{C},\ \eta = \frac{7}{36 - 2t_w} = 0.194 \tag{9}$$

$$t_w = 5\ ^\circ\mathrm{C},\ \eta = \frac{7}{36 - 2t_w} = 0.269 \tag{10}$$

$$t_w = 8\ ^\circ\mathrm{C},\ \eta = \frac{7}{36 - 2t_w} = 0.35 \tag{11}$$

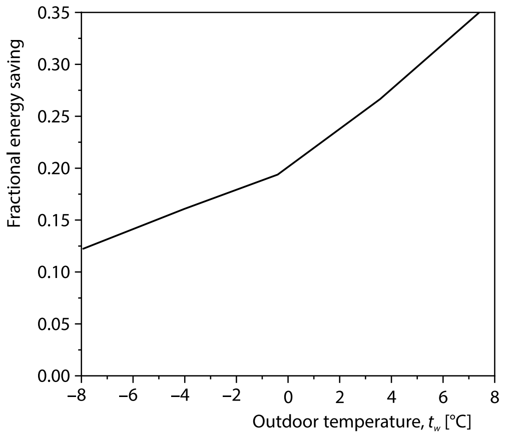

Figure 3. Energy saving rate curve

According to the energy saving rate calculated previously, the curve of energy saving rate *vs.* outdoor temperature is shown in fig. 3.

It can be seen from eq. (6) and the energy saving value Curve 3 that the energy saving value will gradually increase with the increase of the outdoor temperature, and exhibit an informal change law.

It can be seen from the energy saving value curve that the energy saving time of the joint heating increases with the increase of the outdoor temperature. When the outdoor temperature is 8 °C, the energy saving is 0.35. In addition, the energy saving of heating is not only related to the outdoor temperature, but also to the length of the intermittent period, obviously, the longer the intermittent period is, the higher the energy saving rate is, however, if the service cycle and intermittent cycle are frequently changed, the stability of indoor temperature cannot be guaranteed, in order to meet the heat demand of residents and achieve their satisfaction, normal heating should be carried out two hours in advance [5, 12-14].

Conclusion

The author mainly introduces the application of intelligent time division temperature control technology in heating system. In buildings with large differences in heating periods, the time division temperature control technology shall be used, while ensuring the stability of indoor temperature, further save energy and make the heating system operate with maximum energy conservation. The application of time-sharing temperature control technology in the heating system has greatly improved the energy-saving effect of buildings and saved energy, it has extremely high economic, environmental and social benefits and is worth promoting.

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