Energy-saving optimization control method of commercial building double cold source air conditioning units

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Abstract: In order to improve the energy-saving level of commercial buildings' air-conditioning units with double cold sources and reduce the energy cost, an energy-saving optimal control method of commercial buildings' air-conditioning units with double cold sources based on self-organizing neural network is proposed. Constrained parameter model of energy-saving control of commercial buildings' double-cold-source air-conditioning units is constructed. Taking the balanced real-time dynamic adjustment characteristic quantity of inverter of commercial buildings' double-cold-source air-conditioning units as the control object, combined with the fuzzy constraint method of variable frequency speed adjustment parameters and stroke adjustment power of commercial buildings' double-cold-source air-conditioning units, the steady-state adjustment of energy-saving output of commercial buildings' double-cold-source air-conditioning units is realized, and the self-organizing neural network control model of periodic potential energy load of building HVAC system is established. Combined with the small disturbance suppression method of motor rated power, the optimal control design of energy-saving of commercial buildings. The simulation results show that the output stability of the energy-saving control of commercial building air-conditioning units with double cold sources is good, the steady-state working ability is strong, and the energy-saving effect of commercial building air-conditioning units with double cold sources is good.

Key words: Commercial buildings; Double-source air conditioner; Periodic potential energy load; Energy saving control; Steady state regulation

1. Introduction

With the progress of society, the living standard of residents has also been improved. Under this background, people expect a more comfortable living environment, which means that people have higher and higher requirements for indoor environment. Therefore, as an important part of improving indoor environment, air conditioning plays an increasingly important role [1-3]. In addition, the working environment of modern office workers is relatively simple. If a better indoor environment can be obtained, it will have positive significance for improving work efficiency. Therefore, the comfort degree of indoor environment has gradually become an important standard to judge whether the air-conditioned environment meets people's needs [4]. In the process of air conditioning regulation, it is necessary to establish an energy-saving optimal control model for commercial buildings with double cold sources, so as to improve the energy-saving performance of commercial buildings, thereby reducing energy expenditure and promoting the development of green building industry [5].

Energy-saving technology design of commercial building double-cold-source air-conditioning units is based on the design of energy-saving control algorithm of air-conditioning system, combined with the fusion processing and optimization identification of energy-saving control parameters of commercial building double-cold-source air-conditioning units, the energy-saving control object model of commercial building double-cold-source air-conditioning units is constructed, and the energy-saving control of commercial building double-cold-source air-conditioning units is realized through distributed node detection and control law design. In recent years, the hidden problems of health and high energy consumption behind the traditional steady-state thermal environment construction mode have attracted the attention of researchers in related fields [6]. The research shows that different room setting temperatures will lead to different energy consumption of air conditioning system. If the indoor temperature setting value is lowered by 1℃ in summer or increased by 1℃ in winter, the energy consumption of HVAC system will increase by about 8% ". Based on this situation, the concept of "indoor dynamic thermal environment" has attracted more and more attention. Dynamic thermal environment control provides a favorable way for the dynamic optimization of indoor thermal environment. Giving full play to its small regular fluctuation in the thermal environment can not only effectively control the dynamic thermal environment, but also meet the needs of human thermal comfort. In the aspect of operation and maintenance of air-conditioning automatic control system, dynamic thermal environment control has become a research hotspot in the field of centralized air-conditioning system control in intelligent buildings, and has achieved good results in terms of thermal comfort requirements and energy saving. Since the end of last century [7], Professor Zhao Rongyi of Tsinghua University put forward the control strategy of dynamic air conditioning, the research group has conducted research from different angles, such as human response test of dynamic thermal environment and energy consumption of air conditioning, and pointed out its healthy, comfortable and energy-saving prospects [8]. By a lot of theoretical and practical research, Tsinghua University and other scholars found that reasonable dynamic temperature control can create a healthier indoor thermal environment. Therefore, how to set the hourly temperature value to adjust the air supply temperature of the air conditioner, so that the indoor thermal environment changes correspondingly with the real-time change of the outdoor natural environment, and achieve the purpose of human thermal comfort is an urgent problem to be solved at present [9]. However, creating a comfortable and healthy indoor thermal environment is at the cost of a certain energy consumption of the air conditioning system. In recent years, the building energy consumption in developed countries has increased rapidly, accounting for about 40% of the total social energy consumption, of which the energy consumption of HVAC accounts for more than 50% of the total building energy consumption. In contrast, artificial neural network has strong nonlinear approximation ability, which is more suitable for the prediction of energy consumption of air conditioning system. Among them, the Back Prop agation Neural Network (BPNN) has been widely used for its powerful nonlinear mapping and fault tolerance, but it also has some shortcomings such as slow convergence and local minimization. Some researchers use PSO algorithm to optimize the parameters of BPNN [10], which improves the prediction accuracy and convergence speed of BPNN. Using data mining technology to analyze the energy consumption of air conditioning system under dynamic temperature control strategy, and based on this, it is of great research significance to establish an energy consumption prediction model [11].

Shen Yandong [12] et al. proposed the development of energy saving control device for campus air conditioning. PLC was adopted as the controller and force control configuration software was installed on the computer for managing staff to realize the rational use and scientific management of air conditioning in colleges and universities, so as to avoid energy waste caused by unreasonable use of air conditioning in colleges and universities to the maximum extent. The device is small in size, cost-effective, easy to install and maintain, and set up humanized management and operation mode, very convenient to use, can be suitable for a variety of places to use. However, the output power of this method is high and the cost performance is not high. Yu Dan [13] et al. is proposed based on the Internet of things of fission air conditioning energy saving control method, the application of Internet technology, and by controlling the compressor efficiency, reduce the summer caused by users set temperature too low energy waste, realize the air-conditioning energy saving control of the Internet of things, achieve the goal of energy saving, but this method have limitations, the energy cost is larger. The actual application effect is not good. Fan Xinzhou [14] et al. proposed an energy-saving optimization strategy for the water system of central air conditioning. Under the premise of meeting the end cooling load and aiming at minimizing the total energy consumption of the system, they proposed an optimization strategy for the start-up and shutdown of chiller and pump and a global optimization method for control parameters. Taking chilled water supply temperature and cooling water flow as independent optimization control parameters, the energy consumption model of centralized air conditioning water system is established to achieve the purpose of reducing air conditioning energy consumption. However, the voltage gain of this method is small and the voltage fluctuation is large.

In view of the above problems, this paper proposes an energy-saving optimal control method of commercial building double cold source air conditioning units based on self-organizing neural network. Firstly, the constraint parameter model of energy-saving control of commercial buildings' double cold source air-conditioning units is established, and the self-organizing neural network control model of periodic potential energy load of HVAC system in assembled buildings is established. Then, the energy-saving optimal control design of commercial buildings' double cold source air-conditioning units is realized by combining the small disturbance suppression method of motor rated power. Finally, the simulation test analysis shows the superior performance of this method in improving the energy-saving control ability of commercial building double cold source air conditioning units.

2. Energy-saving control object model and constraint parameter analysis

Before constructing the energy-saving optimization control method of the dual-cooling air conditioning unit in commercial buildings, it is necessary to build the energy-saving control object model and analyze the energy-saving control constraint parameters of the dual-cooling air conditioning unit in commercial buildings, so as to improve the energy-saving optimization control purpose of the dual-cooling air conditioning unit and reduce the energy cost. In this process, the energy saving control structure of commercial building dual cooling source air conditioning is designed, and the model parameter identification method, current three-loop cascade control method, variable frequency speed regulation parameters and stroke regulation power fuzzy constraint method are used to realize the model construction and constraint parameter analysis.

2.1 Energy-saving control object model

In order to realize the energy-saving control of commercial buildings' double-cold-source air-conditioning units, a constraint parameter model of energy-saving control of commercial buildings' double-cold-source air-conditioning units is established. The output steady-state distribution characteristic quantity of inverter of commercial buildings' double-cold-source air-conditioning units is taken as the constraint independent variable, and the control object model is established [15]. The sample parameter analysis model of energy-saving of commercial buildings' double-cold-source air-conditioning units is established by the method of model parameter identification. By analyzing the state parameter set of energy-saving control of commercial buildings' double cold source air-conditioning units, and combining with the method of sample model updating, the control object model construction and characteristic parameter optimization identification are realized, and the realization structure block diagram of energy-saving control of commercial buildings' double cold source air-conditioning units is obtained as shown in Figure 1.

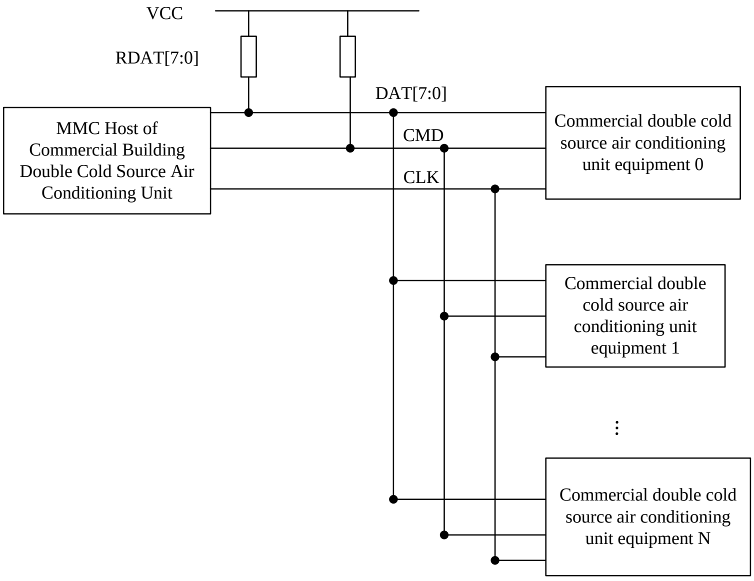

Figure 1 Structure block diagram of energy-saving control of double cold source air-conditioning in assembly building

Analyze the terminal power consumption of the double cold source air-conditioning system in the assembled building, and through reactive power control and load balancing scheduling method, get the load intensity of the building HVAC energy-saving system as follows:

$$S_N(t,v) = \frac{x(v,t)}{c(v)}, S_N(t,v) \le 1 \tag{1}$$

Wherein, $S_N(t,v)$ represents the balance lag angle, $S_N(t,v)$ represents the maximum torque of the balancing device, and $c(v)$ represents the multi-stage voltage regulating device. By using the power factor parameters of the commercial building double cold source air conditioning unit itself, in the building, through the optimal deployment of the air outlet node of the air conditioner, the energy expenditure of the commercial building double cold source air conditioner in the regional e_s can be obtained as follows:

$$W(e_S) = \sum_{v \in e_s} S_N(t^-, v), \forall v \in e_s \tag{2}$$

Where $W(e_s)$ represents the reactive power control parameter of voltage fluctuation, the constant power factor of the air outlet node of the air conditioner is P and Q respectively, and the relative energy consumption is:

$$T_{l1} = \sqrt{F_{p1}{}^2 + F_{q1}{}^2} \tag{3}$$

Wherein, F_{p1} is the inner surface heat transfer flux, F_{q1} is the outer surface heat transfer flux, and the energy-saving state function of commercial building double cold source air-conditioning unit is constructed by the method of multi-mode state characteristic parameter fusion of room inner surface heat balance and room outer surface heat balance as follows:

$$B_{N\times 1} = S_{N\times L} \bullet T_{L\times 1} \tag{4}$$

Wherein, $S_{N\times L}$ is the long-wave radiation exchange flux of indoor walls and $T_{L\times 1}$ is the short-wave radiation flux of indoor lighting. Under limited conditions, the motor rated power regulation model of the motor group is obtained through the analytical transformation of the whole network energy balance:

$$P_{\text{AOMDV}} = (1-P_d)^2 \left\{1-\left[1-(1-P_e)^n (1-P_d)^{n-1}\right]^m\right\} \tag{5}$$

Wherein, P_d is the long-wave radiant heat flux, and P_e is the outdoor air convection heat flux. According to the above model, an energy-saving control object model is constructed by using the methods of terminal voltage fluctuation detection and power consumption analysis [16].

2.2 Analysis of constraint parameters of energy-saving control of commercial double cold source air-conditioning units

Taking the balance real-time dynamic regulation characteristic quantity of inverter of commercial building double-cooling air-conditioning unit as the control object, and combining with the fuzzy constraint method of variable frequency speed regulation parameters and stroke regulation power of commercial building double-cooling air-conditioning unit [17], the PID fuzzy control function of energy-saving output steady-state regulation of commercial building double-cooling air-conditioning unit is constructed as follows:

$$\frac{Y(s)}{R(s)} = \frac{G_C(s)G_0(s)e^{-\tau s}}{1+G_C(s)G_0(s)} \tag{6}$$

In which: $Y(s)$ — the output control parameters of double cold source air-conditioning units in commercial buildings; $R(s)$ -input control parameters of double cold source air conditioning units in commercial buildings; $e^{-\tau s}$ — Fuzzy time-delay characteristic parameters of double cold source air conditioning units in commercial buildings.

By adopting the method of active-reactive power joint control, the sum of the number of nodes in the energy-saving configuration of the double cold source air conditioner in the assembly building is obtained, and the rated power of the motor unit is analyzed, and the weight state distribution model of the output nodes is obtained as follows:

$$\begin{cases} C\dfrac{dV}{dt} = g_{Na}m^3h(E_{Na}-V) + g_K n^4(E_K - V) + g_L(E_L - V) + I_{ext} \\ m = m_\infty = \alpha_m(V)/(\alpha_m(V)+\beta_m(V)) \\ \dfrac{dn}{dt} = \alpha_n(V)(1-n) - \beta_n(V)n \\ h = \max(1-1.25n, 0) \end{cases} \tag{7}$$

In the above formula, g_{Na} is the viscosity coefficient of the air-conditioning fan, α_m is the optimal speed of power, g_L is the air density, and α_m is the power fluctuation transfer coefficient, which is the rated wind speed. When the constant-speed unit is in a steady state, the joint state equation of energy-saving control of the double cold source air conditioner in the assembly building is obtained as follows:

$$\frac{Y(s)}{R(s)} = \frac{G_C(s)G_0(s)e^{-\tau s}}{1+G_C(s)G_0(s)-G_m(s)e^{-t_m s}} \tag{8}$$

Where: $G_m(s)e^{-t_m s}$ is compensation factor of constant power section. Combined with inertial parameter fusion analysis, the constraint parameter analysis model of energy-saving control of air-conditioning system is constructed, and the sensitivity of energy-saving control of double cold source air-conditioning in assembly building is improved [18].

3. Energy-saving technology optimization of air conditioning system

After completing the energy saving control object model and constraint parameter analysis, the stability of the energy saving output of the dual-cooling air conditioning in commercial buildings is adjusted, and the energy saving control output of the air conditioning system is designed to optimize the energy saving technology of the air conditioning system. Should have a process according to variable speed commercial building double cold source power fluctuation characteristics of the air conditioning unit, for commercial building aerodynamic parameters of the double cold source air conditioning unit, the application of fuzzy PID controller, combined with the self-organizing neural network control, obtaining fuzzy constraint conditions, at the same time by using self-organizing neural network learning method for energy saving control of adaptive learning, The equivalent control law is obtained by the method of load balance regulation and smooth tracking of active power fluctuation, so as to realize the optimization of energy saving technology of air-conditioning system.

3.1 Adjust the stability of energy-saving output of double cold source air conditioner in assembly building.

Combined with the fuzzy constraint method of variable frequency speed regulation parameters and stroke regulation power of commercial building double cold source air conditioning units, the steady-state regulation of energy-saving output of commercial building double cold source air conditioning units is realized [19]. According to the power fluctuation characteristics of variable-speed commercial building double cold source air conditioning units, the aerodynamic parameters of commercial building double cold source air conditioning units are recorded as follows:

$$\boldsymbol{\sigma}(\varphi_a,\dot{\varphi}_a)=\left[\sigma_1(\varphi_a,\dot{\varphi}_a) \quad \sigma_2(\varphi_a,\dot{\varphi}_a) \quad \sigma_3(\varphi_a,\dot{\varphi}_a)\right] \tag{9}$$

Using fuzzy PID regulator, the torque reference value of energy-saving control of commercial building air-conditioning unit with double cold sources is set as $\boldsymbol{x}=\left[\varphi_a \quad \dot{\varphi}_a\right]$, and the upper bound estimation value of control parameter distribution is obtained when commercial building air-conditioning unit with double cold sources is in full wind speed range, and the calculation formula is as follows:

$$\begin{aligned}\hat{\bar{\rho}}(x,\omega)=\omega_1'\sigma_1(\varphi_a,\dot{\varphi}_a)+\omega_2'\sigma_2(\varphi_a,\dot{\varphi}_a)\\+\omega_3'\sigma_3(\varphi_a,\dot{\varphi}_a)\end{aligned} \tag{10}$$

Among them, σ_1,σ_2, σ_3 respectively represents the indoor air heat balance parameters. At any moment, in the first neuron in the area before the constant power section, self-organizing neural network control is adopted to obtain the input of the unit at the rated wind speed. According to the steady-state parameter adjustment, the optimal tip speed ratio of the unit tracking is obtained as follows:

$$f_0(\mathrm{X})=w_pP_1(\mathrm{X})+w_vV_t(\mathrm{X})+w_cC(\mathrm{X}) \tag{11}$$

Where, w_p, w_v, w_c are the weight coefficient and $P_1=P_{cu}+P_h+P_e+P_b+P_w$ is the rotor current at the stator side, and the torque characteristic quantity of the energy-saving control of the double cold source air conditioner in the assembly building is expressed as:

$$T_{em} = \frac{\pi k_f k_c k_1 k_\beta B_r l_m l_s l_w (2r_r + 2l_g + l_w) J_{cu}}{\ln(\frac{r_r + l_g + l_w}{r_r - l_m})} - (\frac{P_e + P_h}{\omega_r}) \tag{12}$$

Wherein, P_e is the heat caused by air convection and water evaporation, P_h is the heat flux of cold air infiltration, and ω_r is the heat flux of heating system. According to the transfer function, the Bode diagram is drawn. Using self-organizing neural network control, the fuzzy constraint conditions of energy-saving control of double cold source air-conditioning in assembly building are obtained as follows:

$$\frac{\partial e_{dq}}{\partial z_{kj}} = \frac{-\partial Y_{dq}}{\partial z_{kj}} = -\frac{\partial g(o_{dq})}{\partial z_{kj}} \tag{13}$$

Where: Y_{dq} is power fluctuation output parameter of air conditioner; o_{dq} is speed loop parameters. Namely:

$$\begin{aligned} \frac{\partial e_{dq}}{\partial z_{kj}} &= -g'(o_{dq}) \frac{\partial \left(\sum_{j=1}^{t} z_{dj} a_{jq} \right)}{\partial z_{kj}} \\ &= \begin{cases} -g'(o_{dq}) a_{jq}, & d = k \\ 0, & d \neq k \end{cases} \end{aligned} \tag{14}$$

Wherein, in the self-organizing neural network, the weight from the input layer to the hidden layer is $\omega_{ij} (i = 1, 2; j = 1, 2, 3)$, and the power fluctuation component is $\sigma_j (\varphi_a, \dot{\varphi}_a)$. According to the above analysis, the steady-state regulation model of energy-savi ng output of double cold source air-conditioning units in commercial buildings is constructed [20].

3.2. Energy-saving control output of air conditioning system

Combined with the fuzzy constraint method of variable frequency speed regulation parameters and stroke regulation power of commercial building double cold source air-conditioning units, the steady-state regulation of energy-saving output of commercial building double cold source air-conditioning units is realized, and the fuzzy learning vector of energy-saving control of assembly building double cold source air-conditioning units is obtained under limited initial conditions:

$$x(t) = (x_0(t), x_1(t), \cdots, x_{k-1}(t))^T \tag{15}$$

Self-organizing neural network learning method is used for adaptive learning of energy-saving control. The neural network model is shown in Figure 2.

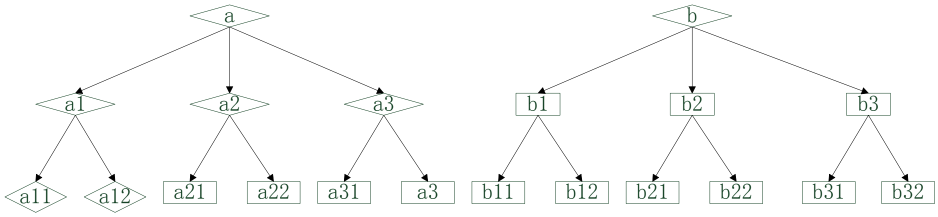

Figure 2 Neural network model

In the input layer of the self-organizing neural network, the voltage wave generated by the power fluctuation component is introduced, and combined with the knowledge model base, the neural network adaptive learning control output of the energy-saving control of the double cold source air conditioner in the assembly building is obtained as follows:

$$\begin{cases} \sigma_1(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1+e^{-(\omega_{11}\varphi_a + \omega_{21}\dot{\varphi}_a)}} \\ \sigma_2(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1+e^{-\int(\omega_{21}\varphi_a + \omega_{22}\dot{\varphi}_a)dt}} \\ \sigma_3(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1+e^{-d(\omega_{11}\varphi_a + \omega_{21}\dot{\varphi}_a)}} \end{cases} \tag{16}$$

Where $\int(\bullet)dt$ is the integrator of energy-saving control of double-cold-source air-conditioning in building, and $d(\bullet)$ is a differential symbol? When $l = l_s$, $r = r_r + l_g$, $NI = A_w J_{cu} k_f$. The active and reactive levels are analyzed, and the analytical process of optimal parameters for energy-saving control of double-cold-source air-conditioning in building is obtained by the method of joint adjustment of horizontal deviation and dynamic deviation:

$$T_{em} = \frac{\pi k_f k_c k_1 k_\beta B_r l_m l_s l_w (2r_r + 2l_g + l_w) J_{cu}}{\ln(\dfrac{r_r + l_g + l_w}{r_r - l_m})} \tag{17}$$

$$k_1 = 1 - \frac{1}{0.9[r_r / (\beta p(l_g + l_w))]^2 + 1} \tag{18}$$

$$k_\beta = \frac{\alpha(\beta, k_c)}{k_c} \tag{19}$$

By analyzing the influence of active power fluctuation component on voltage fluctuation [21], it is found that the active power consumption of energy-saving control of double cold source air-conditioning in assembly building under frequency domain regulation of speed fluctuation is:

$$P_{loss} = I_P^2(R_p + R_{cp} + 2R_{IGBT}) + I_s^2(R_s + R_{cs} + 2R_{don}) \tag{20}$$

According to the fluctuation of terminal voltage, the output efficiency of double cold source air conditioner in commercial building is as follows:

$$\eta = \frac{I_s^2 R_{eq}}{P_{loss} + I_s^2 R_{eq}} \tag{21}$$

By adopting the load balance adjustment method and error feedback adjustment, the electromagnetic coupling control equation of double cold source air-conditioning units in commercial buildings is obtained as follows:

$$\begin{bmatrix} \dot{\boldsymbol{\delta}} \\ \ddot{\boldsymbol{\delta}} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -DK_m K_e b_6 / R \end{bmatrix} \begin{bmatrix} \delta \\ \dot{\boldsymbol{\delta}} \end{bmatrix} + \begin{bmatrix} 0 \\ K_m b_6 \end{bmatrix} \boldsymbol{U}_\delta \tag{22}$$

Assume that $p_i(t): R_+ \to R, p_i(t) \in C^n[0,\infty), \dot{p}_i, \cdots, p_i^{(n)} \in L^\infty$. Using the method of smooth tracking of active power fluctuation, the equivalent control law is obtained as follows:

$$u_{eqx} = \lambda(-\hat{f}_x - \lambda_x \dot{e}_x - \alpha e_x + \ddot{x})/(\lambda g_x + g_\theta) \tag{23}$$

$$u_{eq\theta} = (-\hat{f}_\theta - \lambda_\theta \dot{e} - \beta e_\theta + \ddot{\theta}_d)/(\lambda g_x + g_\theta) \tag{24}$$

There is a constant $T > 0$, $p_i(t)$ represents the steady-state characteristic solution, and combined with the small disturbance suppression method of motor rated power, the energy-saving optimal control design of double cold source air-conditioning units in commercial buildings is realized [22].

4. Simulation and result analysis

4.1 The experiment to prepare

In order to verify the effectiveness of this method in realizing the energy-saving control of commercial buildings' double cold source air-conditioning units, the Matlab simulation method is adopted to carry out the simulation experiment. The wind turbine of commercial buildings' double cold source air-conditioning units is set as a 1.5MW fixed speed unit, with the speed loop parameter of 0.36, the constant speed of variable speed commercial buildings' double cold source air-conditioning units of 256rad/s, the power factor angle of 14rad, the fluctuation frequency of assembled buildings' double cold source air-conditioning units of 0.02Hz, and the distribution of energy-saving parameters of commercial buildings' cold source air-conditioning units are shown

Table 1 Energy saving parameters of cold source air conditioning in commercial buildings

Air conditioning node	Unit energy consumption /KW	Cold air infiltration heat flow /KW	Air heat capacity /dB
Node 1	38.493	2540.323	12.990
Node 2	40.232	5436.728	12.924
Node 3	38.569	6702.915	13.785
Node 4	37.557	4057.379	13.912
Node 5	39.917	11880.003	14.586
Node 6	38.743	519.048	13.125
Node 7	40.006	2789.991	13.736
Node 8	39.272	1387.401	14.049
Node 9	40.130	1888.573	12.600
Node 10	39.151	4222.242	12.668

4.2. Experimental performance indicators

To analyze double cold source of commercial building air conditioning unit energy-saving performance and efficiency of optimization control method, control method in the experiment, experiment with the air conditioning system under the conditions of the power factor Angle change voltage gain, constant speed control parameters, the system output power, commercial buildings, air conditioning cold source of air conditioning unit energy costs to run the Numbers and cold source system overall COP. The calculation formula of each performance indicator is as follows:

The formula of system output power is:

$$P0 = U * I - I^2 * R \tag{25}$$

Where, U represents the system voltage.

The energy cost formula of dual-cooling air conditioning units in commercial buildings is as follows:

$$W0 = P2 * t \tag{26}$$

In the formula, $P2$ represents the power of the dual-cooling air conditioner, and t represents the time consuming.

The overall COP calculation formula of cold source system is as follows:

$$C_0 = \frac{a_1}{a_2} \tag{27}$$

Where, a_1 represents the average heating capacity, a_2 represents the average power consumption.

Other performance indicators are automatically monitored by the system's own software.

In the experiment, the larger the voltage gain index of the air-conditioning system is under the change of power factor Angle, the more stable the designed energy-saving control method is. Constant speed control parameter index is the degree of consistency between the experimental value and the actual value. The more consistent the experimental value is, the better the control method is. The smaller the system output power consumption, the energy cost of dual-cooling air conditioning units in commercial buildings, and the number of operating air conditioning units, the better the energy saving effect of the verification method is. The higher the overall COP index value of the cold source system is, the higher the conversion effect between energy and heat energy of the control method is, that is, the more obvious the energy-saving effect is.

4.3. Analysis of experimental performance

4.3.1 Voltage gain analysis of air conditioning system under power factor Angle change

According to the above parameter Settings, the voltage gain of the air-conditioning system under the change of power factor Angle was tested, and the stability of the design method was analyzed. The specific experimental results are shown in Figure 3.

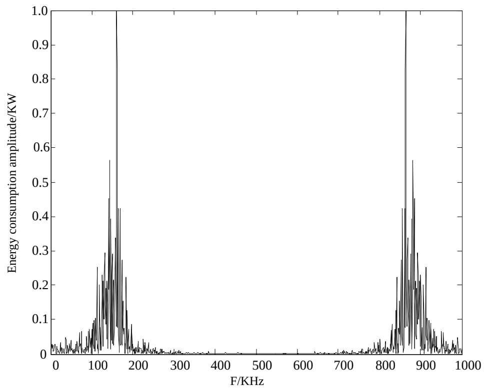

Figure 3 Voltage gain of cold source air conditioners in commercial buildings under different power consumption factors

The voltage gain of the air-conditioning system under the change of power factor Angle is analyzed in Figure 3. The method presented in this paper is used for energy-saving control of dual-cooling air-conditioning in commercial buildings, and the voltage gain of the air-conditioning system is large and the voltage fluctuation is small. Therefore, the design method has good stability.

4.3.2 Analysis of control parameters in constant speed section

In order to further analyze the stability of the design method, the control parameters of the constant speed section were tested. The specific experimental results are shown in Figure 4.

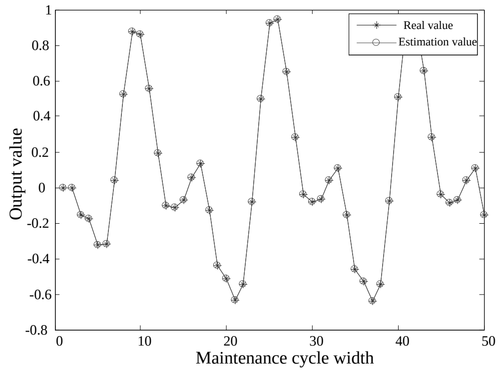

Figure 4 Test results of control parameters in constant speed section

Analysis diagram 4, the method of double cold source of commercial building energy-saving control stability is better, the control of air conditioning unit in figure 4, as the change of width of maintenance cycle, the output value change, the change of the design method of the value and the actual value is consistent, does not appear deviation, error is small, therefore, the further verify the stability of air conditioning energy saving control method more, effectively improve the stability.

4.3.3 System output power analysis

After the stability analysis of the energy-saving control method is completed, the system output power of the design method needs to be analyzed. Therefore, the power output is tested. The specific experimental results are shown in Figure 5.

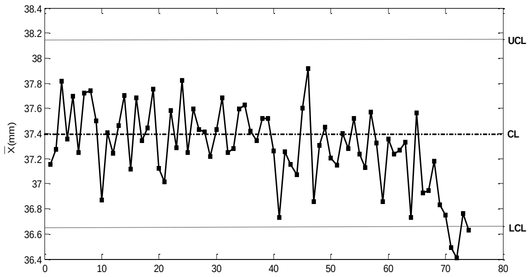

Figure 5 System Output Power Consumption

Analysis of the system output power in FIG. 5 shows that before 50s, the system output power is between 36.8MW and 38.0. After the test 50s, the output power of the design system begins to decrease, and the lowest value of the system output power reaches 36.4MW. The overall output power of the design method presents a downward trend. In addition, the output power consumption of energy-saving control of dual-cooling air conditioning units in commercial buildings using the method in this paper is small, so the method can effectively reduce the system output power consumption.

4.3.4 Analysis on energy switching of commercial building dual cooling source air conditioning unit

After analyzing the output power of the system, different methods were used to compare the energy cost of energy-saving control of dual-cooling air conditioning units in commercial buildings. The specific experimental results are shown in Table 2.

Table 2 Energy expenditure of double cold source air conditioning units in commercial buildings (unit KW/h)

Test times	Methods of this paper	BP	Integral control
10	4.572	31.246	12.557
20	4.069	66.872	12.802
30	4.860	82.446	12.872
40	4.544	49.906	12.928

By analyzing the data in Table 2, it can be seen that after the application of the control method in this paper, the energy cost of the dual-cooling air conditioning unit is only 4.860KW/h and the lowest value is 4.069KW/h. The energy cost of the dual-cooling air conditioning unit using BP method is only 82.446KW/h and the lowest value is 31.246KW/h. The energy cost of the dual-cooling air conditioning unit using the integral control method is only 12.928kW /h, and the lowest value is 12.557kW /h. The energy cost of the dual-cooling air conditioning unit using the comparison method is all more than 10KW/h. The comparison between the three control methods shows that: Compared with the comparison method, the energy cost of the minimum dual-cooling air conditioning unit in this paper is 26.386KW/h and 7.697KW/h, respectively. Therefore, the energy cost of the energy-saving control of the dual-cooling air conditioning unit in commercial buildings in this paper is the least, indicating that the energy-saving effect is good.

4.3.5 Analysis of the number of air conditioners in operation

Under the set conditions, that is, the temperature is constant 26℃, the number of air conditioners running within 10 hours is tested, and the total number of air conditioners is 60. If the number of air conditioners running is less, the better the performance of the design method is, and the energy saving is achieved while the economic cost is indirectly reduced. The specific results of the experiment are shown in Table 3.

Table 3 Comparison of air conditioning operating units

Test time /h	Number of air conditioning units in operation: Before applying the method in this paper	Number of air conditioning units in operation: After applying the method in this paper
1	57	45
2	56	45
3	57	44
4	55	46
5	56	44
6	57	44
7	56	44
8	56	45
9	56	46
10	55	45

According to the data in table 3, the application of the method in front of the air conditioning running the Numbers are in more than 55 machines, 57, reached the highest basic running at full capacity, but after application of the method, the operation of the air conditioner sets significantly lower, the highest air conditioning running the Numbers are only for 46 units, the lowest running air conditioning sets the 44 units, air conditioning running the Numbers were below 50, Compared with the application of the method in this paper, more than 9 air conditioners are reduced. Therefore, the method in this paper can effectively reduce the number of air conditioners in operation and achieve the purpose of energy saving while maintaining a constant temperature.

4.3.6 Overall COP analysis of cold source system

Further analyze the energy saving effect of the designed energy saving control method, and use COP to verify the performance of the energy saving control method. COP is the energy efficiency ratio, in general, the greater the energy efficiency ratio, the more energy saved. The specific experimental results are shown in Table 4.

Table 4 Overall COP comparison results of cold source system

Load rate	COP	
	Before applying the method in this paper	After applying the method in this paper
0.1	2.1	2.0
0.2	3.4	4.1
0.3	4.8	5.8
0.4	5.0	6.5
0.5	4.6	6.9
0.6	4.8	7.1
0.7	4.9	6.8
0.8	5.1	6.5
0.9	4.5	6.9
1.0	4.7	6.7

According to the data in Table 4, the overall COP of the cold source system before and after the application of the method in this paper increases with the increase of the load rate in the early stage. When the load rate is about 0.5, the overall COP value of the cold source system before and after the application of the method in this paper basically reaches a stable state. The highest overall COP value of the cold source system before the application of the method in this paper is 5.1. After application of the method of cold source of the system's overall top COP value is 7.1, 0.5, the lowest rate after 6.5, after the application of the method than the cold source system used the method before the overall COP value could be improved by more than 1.4, so the situation shows that application of commercial building double cold source energy saving optimization control method can effectively improve the air conditioning unit can affect comparing, Reduce energy consumption.

5. Conclusions

In this paper, a self-organizing neural network-based energy-saving optimal control method for commercial building double-cooling air-conditioning units is proposed, and a load balancing dispatching model for commercial building double-cooling air-conditioning units is constructed. The node optimal deployment method of commercial building double-cooling air-conditioning units is adopted to improve the energy-saving effect of commercial building double-cooling air-conditioning units. This paper proposes a self-organizing neural network-based energy-saving control method for commercial building double-cooling air-conditioning units. Through the method of air-conditioning commutation control, this paper analyzes the state parameter set of energy-saving control of commercial buildings' double cold source air-conditioning units, and realizes the steady-state regulation and energy-saving control of energy-saving output of commercial buildings' double cold source air-conditioning units by combining the variable frequency speed regulation parameters and the fuzzy constraint method of stroke regulation power. The research shows that the method in this paper has high stability and reliability for energy-saving control of commercial building air-conditioning units with double cold sources.

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