Simulation of Frequency Conversion and Energy Saving Of Circulating Water System

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Abstract. The frequency conversion energy saving of circulating water has a broad prospect of engineering application, but in view of the less research on its simulation application and development, the general steps of the pump frequency conversion and energy saving in the circulating water system are put forward, the virtual simulation scene of the circulating water system is developed, the large screen display device is used, and the practice proves that the virtual simulation technology is in the work. The field has a wider application space.

1. Introduction
Circulating water mainly has two kinds of industry and household. Industrial circulating water is mainly used in cooling water system, so it is also called circulating cooling water [1]. The scope of its application is shown in Figure 1. Industrial application: in the process of industrial production, a large amount of waste heat is produced. It needs to be transferred to the natural environment with heat transfer medium in order to ensure the normal operation of the production process. Natural water has excellent heat transfer performance, low cost and abundant resources. It is used as heat transfer medium for industrial waste heat and cooling for production equipment. The power consumption of circulating water system is about \(4 \times 10^{12}\) kW·h per year. Circulating water pumping station is the main equipment for energy consumption of circulating water system. Its power consumption is about \(2 \times 10^{12}\) kW·H. The energy consumption of the circulating water pump system is great, but its energy efficiency is very low. Compared with the advanced foreign level, the efficiency of the system is 2% to 5%, and the system operation efficiency is low by 20%. At present, the energy saving technology can achieve the annual energy of \(2.2 \times 10^9\) kW·H, and the volume of the standard coal is about 730 thousand tons [2]. The operating efficiency of the circulating cooling water system is low and the reason for energy waste is as follows: 1. the actual operating conditions are less regulated, the adjustment is not timely, or it is not adjusted according to the actual working conditions. The selection of pumps is large and the choice of water pumps takes account of extreme weather conditions [3-4]. In general, the water pump and motor remainder in the circulating cooling water system are too large. In addition, the designed capacity of motor is much higher than the actual value, which leads to the great waste of electricity energy, which causes the serious waste of energy consumption.
2. Typical working conditions

2.1. System overview
The water pumping station of a factory's circulating water system is made up of two pumps (one standby). The annual power consumption of the system is $2 \times 10^5 \text{Kw} \cdot \text{H}$. The main equipment of the system are pumps, motors, cooling towers, pipes, storage tanks, filters, heat exchangers, valves (ball valves, butterfly valves, etc.). The working principle of the system: cooling tower fan cooling, cooling water flow through the filter into the storage tank, using the pump to transport the cooling water to the heat exchanger, after heat exchange, the circulating water is returned to the cooling tower to cool down again (As shown in Figure 2).

2.2. Main parameters of the system
Rated flow of water flow: $Q = 220 \text{m}^3/\text{h}$, rated head: $H = 25 \text{m}$, rated speed: 1450rmp; motor model: Y200L-4, rated power: 30KW, rated voltage: 380V, rated current: 56.8A, rated efficiency: 92.2%, rated speed: 1470rpm; 37 degrees of intake, water temperature: 32 degrees centigrade, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, environment, and environment Wet bulb temperature: 28.5 degrees Celsius, cooling capacity: $250 \text{m}^3/\text{h}$.
2.3. The operating conditions before the transformation
The inlet temperature of the cooling tower is 34-36 degrees centigrade; the cooling tower water temperature is 28-30 degrees centigrade; the process of cooling equipment requires the inlet water temperature: not more than 32 degrees centigrade; the process of cooling equipment requires the outlet water temperature: not more than 37 degrees centigrade; the outlet standard of the cooling tower is 6m. Adjust the user valve according to the need.

2.4. Operation data of frequency working condition
The following table 1 is made on the operation data of the working frequency. The H in the table shows the running time point of the system. The Qc is the water flow through the pump, the Pout is the outlet pressure of the pump, the P is the input power of the motor, the T is the inlet temperature of the cooling tower, and the delta T is the water temperature difference.

| Table 1. Operation data of power frequency |
|--------------------------------------------|
| H/h | 1 | 2 | 3 | 4 |
| Qc/m³/h | 150 | 186 | 210 | 250 |
| Pout/kPa | 325 | 311 | 285 | 260 |
| P/kw | 17.5 | 21.9 | 22.5 | 24 |
| T/°C | 30 | 32 | 33.5 | 34 |
| ΔT/°C | 4.3 | 4.2 | 4.4 | 4.3 |

2.5. Energy saving operation data in frequency conversion
After switching to frequency control, the system operates as table 2. The F in the table indicates the frequency of the converter, and the remaining parameters are the same as that in Table 1, and the power saving rate is calculated accordingly.

| Table 2. Operating data for frequency conversion |
|-----------------------------------------------|
| H/h | 1 | 2 | 3 | 4 |
| Qc/m³/h | 130 | 161 | 188 | 215 |
| Pout/kPa | 225 | 271 | 297 | 305 |
| P/kw | 10.4 | 13.9 | 15.3 | 17.1 |
| T/°C | 36.5 | 36.3 | 36.3 | 36.4 |
| ΔT/°C | 5.0 | 4.9 | 4.9 | 5.0 |
| f/Hz | 32.5 | 40.1 | 47.5 | 49.0 |

According to the input power of the motor in Table 1 and table 2, the instantaneous power rate of the system is obtained. The P0 in the table is the input power of the motor under the working frequency condition. The P1 is the input power of the motor under the frequency conversion condition, and the unit KW is the instantaneous rate of electricity.
Table 3. Calculation of electricity saving rate

| H/h | 1   | 2   | 3   | 4   |
|-----|-----|-----|-----|-----|
| P₀  | 17.5| 21.9| 22.5| 24  |
| P₁  | 10.4| 13.9| 15.3| 17.1|
| µ   | 40.6%| 36.5%| 32%| 28.8%|

3. System development based on Virtual Simulation Technology

3.1. Establishment of a three dimensional model of case
In SolidWorks software, a three-dimensional model of each component of the system is established, such as Figure 3. The system includes pump, motor, cooling tower, pipe, tank, filter, heat exchanger, and virtual model of the valve equipment.

3.2. Interface design of simulation system
For example, figure 3, the system is developed by Unity3D software. The UGUI in Unity3D has the characteristics of flexible use, beautiful interface and support for customization [5-6].

Figure 3. System virtual scenes

3.3. Simulation design of dynamic curve
As shown in Figure 4, the upper left corner of the interface shows constant temperature difference control to ensure that the cooling water temperature in the pipeline is 5 degrees. The upper right corner shows the quantity of electricity and carbon dioxide, the reduction of carbon dioxide and the saving of electricity. The lower left corner interface shows that the characteristic curve of the pump moves down with the flow. The lower right angle interface shows the real time change of the frequency conversion power, the greater the water flow, the higher the frequency.
3.4. Design of circulating water particle system
Circulating water particle system script control code:

```csharp
this.objRootOfObjects.BroadcastMessage("OnStateChange", iState, SendMessageOptions.DontRequireReceiver);
```

3.5. Development of system roaming technology
Roaming function code:

```csharp
privateNavMeshAgentplayer;
PublicTransformtarget; VoidStart()
{
Player = gameObject.
GetComponent<NavMeshAgent>();
}
VoidUpdate()
{
Player.SetDestination(target.position);
}
```

Roaming path design is shown in Figure 5:

4. System application based on touch screen device
As shown in Figure 6, the 65 inch large screen display system is used to demonstrate the effect of the system [7].
5. Summaries and Prospect
The energy saving of the circulating water system is a comprehensive measure and evaluation of the energy saving effect from the point of view of the system. It not only requires high efficiency of the pump and motor, but also requires a small energy consumption of the system and control elements including the pipeline, valve, frequency converter and so on. At the same time, the pump and the system device can be well matched to make the pump work. In the optimal workspace. Virtual simulation technology and circulating water energy saving system can well demonstrate the results of energy saving, and have good popularization and application.

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