# Research and application of online monitoring system for circulating water cooling system in hot stamping plant of automotive parts and components

Huan Wang
*Geso Technology Co., Ltd, Wuhan 430075, China*
*E-mail: poly.wang@gesuo.com*

The cooling system of hot stamping plant for automotive parts is a crucial part of automobile manufacturing. This study aims to propose an intelligent monitoring solution to solve the defects of the traditional cooling system and realize energy saving and productivity improvement. Through digital information technology, a three-layer network architecture monitoring model is established to achieve condition monitoring, intelligent monitoring, energy consumption monitoring and production optimization. Design reasonable system function planning, including data acquisition, processing, storage, real-time monitoring, alarm and warning, remote control, data analysis and system maintenance and upgrading. The application monitoring system interface real-time monitoring of equipment operating status and historical data retrospective function, support for mobile monitoring and remote debugging, improve the efficiency and safety of equipment operation, reduce maintenance costs, and provide users with convenient and efficient monitoring solutions.

*Keywords*: High-strength steel; Hot stamping and forming; Circulating water cooling system; Online monitoring; Industrial internet.

## 1. Introduction

Cooling water system is an important heat removal system, which is widely used in building air conditioning, industrial production and data center cooling operations. With the development of global economy, the size of cooling water systems has gradually increased. The lack of reasonable energy-saving optimization methods for cooling water systems leads to huge energy consumption [1]. Cooling water systems are usually designed with the most unfavorable conditions in mind, and they are usually operated under more than not off-design conditions. As a result, actual cooling water systems have significant energy saving potential. When designing a cooling water system, reasonable parameters between the user-side equipment model and the water supply equipment are the basis for an optimized model of the cooling water system.

The research and application of intelligent monitoring and control of the cooling system in hot stamping plants for automotive parts is an important part of the automotive manufacturing industry in the field of intelligent manufacturing. With the rapid development of the automobile industry, the production efficiency and quality of automobile parts as well as the green requirements of the production process are getting higher and higher. The hot stamping process is a key link in the manufacturing of automotive parts [2], and the cooling system plays a crucial role in ensuring part quality and production efficiency. There are many defects such as outdated design, serious energy


Y. Zhang and M. Ma (eds.), *Proceedings of the 7th International Conference on Advanced High Strength Steel and Press Hardening (ICHSU 2024)*, Atlantis Highlights in Materials Science and Technology 3,
https://doi.org/10.2991/978-94-6463-581-2_65

waste and high energy consumption in the centralized cooling system of traditional hot stamping plants.

## 2. Problems and Solutions

### 2.1. *Defects of the original application system*

The traditional centralized cooling system of hot stamping plant has backward design, serious energy waste and high energy consumption. The thermoforming refrigeration system relies on local PLC control, which requires a lot of manual intervention, a low degree of intelligence, and insufficient refined management. This situation leads to a large amount of wasted energy resources, while energy consumption levels remain high. Labor management costs also increase, because the thermoforming freezer system requires manual inspection, the workload is huge, inefficient, and located in harsh environments, resulting in many details of the inspection is difficult. Equipment maintenance is also facing difficulties, because the state of the equipment can not be effectively controlled, failures can not be timely warning, mechanical and electrical risk is very high. The safety of the system can not be guaranteed, due to the lack of data analysis and historical data storage support, repair and maintenance of the lack of data support, once the failure of the system will be a total shutdown, it is difficult to determine the source of the failure, which poses a serious security risk.

### 2.2. *Solution mainly based on digital Informa ionization*

The data of the monitoring system of the hot press forming plant will be realized online monitoring through the unified information platform and collection communication statute, in order to form a system with comprehensive functions such as information pooling, resource sharing and optimization management [3]. By improving the collection, storage, management and utilization of energy information, a perfect energy information collection system is established to realize real-time mastery of the system operation and take timely scheduling measures, so that the system can run in the best state possible [4]. At the same time, it strengthens the fault and abnormality processing of the energy system and improves the response ability to enterprise energy accidents. Intelligent control of energy equipment is introduced, including monitoring data, control functions, real-time alarm management, historical data analysis, network status monitoring, and maintenance monitoring to ensure stable operation of energy equipment and system safety.

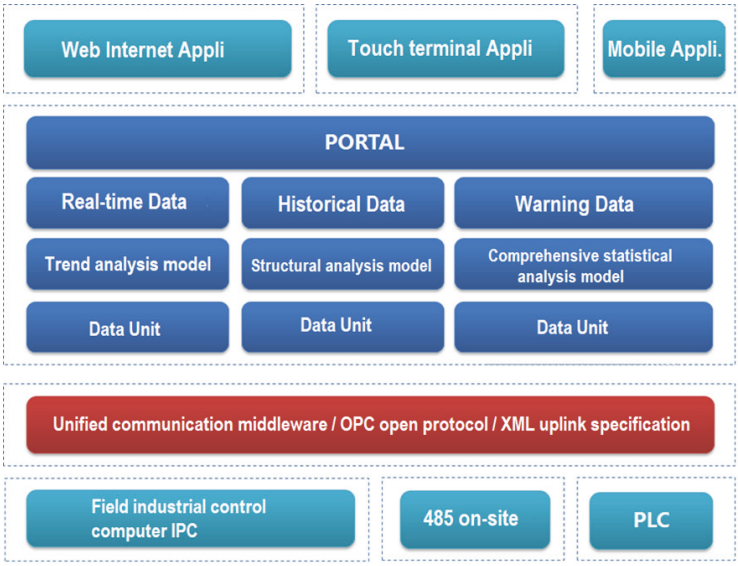
The system is a three-layer network architecture, i.e., system management layer, network control layer, and field equipment layer, as shown in Figure 1.

- System management layer:
  The address information of each PLC system in the thermoforming refrigeration system is read to the gateway through Ethernet, which is used in the upper software of the energy control system for analysis and screen display to realize unified monitoring and management.
- Network control layer:

Network control layer is the core of the whole energy control system, and plays the role of "starting and ending" in the whole system. It collects data from all control systems and measuring instruments on site and uploads them to the server of the energy control system.

- Field equipment layer:

The equipment with data collection and execution functions in the field include: system PLC, controller, water meter, power meter, press, refrigeration mainframe, frequency converter and so on.




Fit. 1 Three-layer architecture monitoring model of the system

**(1) Condition monitoring of cooling system equipment**

Through real-time monitoring of the working parameters of the cooling equipment, such as water flow, water temperature, pressure, etc., to determine the operating status of the equipment, timely detection of abnormalities and early warning, so as to avoid production interruptions caused by equipment failure, see Fig. 2, and the main monitoring of the equipment is shown in Table 1.

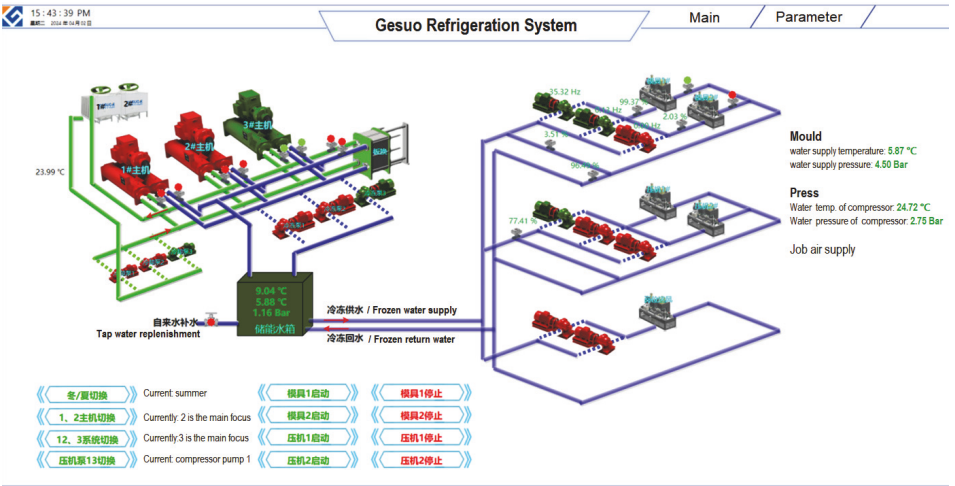



Fig. 2 Cooling system of the refrigeration system monitoring

Table 1 Equipment operation status

| System device | Number of devices | Operating units |
|---|---|---|
| Cooling tower | 2 | 2 |
| Host | 3 | 1 |
| Freezing pump | 3 | 1 |
| Cooling pump | 3 | 1 |
| Process mold pump | 3 | 2 |
| Process press pump | 3 | 1 |

## (2) Intelligent monitoring of cooling effect

Through real-time monitoring of the cooling process of the stamped parts, the cooling effect is evaluated and the cooling parameters are adjusted to ensure the quality and productivity of the parts. For example, through the sensor real-time measurement of the temperature of the parts, combined with artificial intelligence algorithms, optimize the flow rate and temperature of the cooling water to achieve intelligent control of the cooling process, see Table 2.

Table 2 Cooling effect-real-time data

| Item | Parameter Name | Monitor Value |
|---|---|---|
| 1 | Water tank pressure | 1.19 Bar |
| 2 | Cold end temperature | 5.20 ℃ |
| 3 | Hot end temperature | 5.58 ℃ |
| 4 | Mold water supply temperature | 5.20 ℃ |
| 5 | Mold water supply pressure | 4.52 Bar |
| 6 | Mold bypass valve opening | 3.52 % |
| 7 | Pressure supply water temperature | 25.1 ℃ |
| 8 | Water supply pressure of the compressor | 2.78 Bar |
| 9 | Pressure supply valve opening | 100 % |

**(3) Energy consumption monitoring**

By analyzing the data of cooling system energy consumption, the energy efficiency of the cooling system is evaluated and measures for energy saving and consumption reduction are proposed [4]. For example, by analyzing the energy consumption of cooling water pumps, fans and other equipment, the operation mode is optimized to reduce energy consumption.

**(4) Intelligent optimization of production process**

Combining the production plan, equipment status, cooling effect and other aspects of data, the use of big data analysis and artificial intelligence algorithms to optimize the production process and improve production efficiency. For example, according to the operating status of equipment and cooling effect, the production sequence and production rhythm are dynamically adjusted to realize the intelligence of the production process.

## 3. The circulating water of the factory but the design of monitoring system

Screw pump frequency control device includes screw pumps, sensors, data collectors, regulators, frequency converters, PLC and industrial Internet input and output modules, and other components. Its working principle is shown in Figure 3, the selected monitoring data is output to the system monitoring system through the industrial Ethernet output.

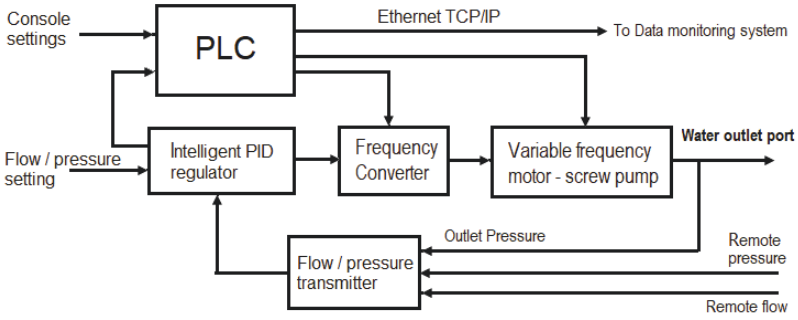



Fig.3 Principle of Variable Frequency Automatic Control for Screw Pump

Among the data being monitored are key parameters of the screw pump inverter automatic control principle screw pump inverter technology, such as soft stop time, torque value, rotational speed and so on. Through the use of frequency conversion control device energy consumption. Its measures to reduce energy consumption are as follows:

(1) Change the power supply frequency and adjust the motor speed to meet the actual working needs.
(2) Change the motor input voltage to make the working voltage range reasonable.
(3) Adopt soft-start function to improve the service life of the equipment.
(4) Improve power factor and reduce reactive power loss.

### 3.1. *Data monitoring of operating status*

In the circulating water cooling monitoring system of a hot stamping plant, data monitoring of the operating status is crucial. The following are the key data to be monitored as follows:

(1) Circulating water flow: Monitor the amount of circulating water to ensure that the system is operating within the appropriate flow range.
(2) Circulating water temperature: Monitor the temperature of the circulating water to ensure that the system operates within the appropriate temperature range.
(3) Cooling tower operation status: monitor the operation status of the cooling tower to ensure normal operation of the cooling tower.
(4) Circulating water pump operation status: monitor the operation status of the circulating water pump to ensure normal operation of the circulating water pump.
(5) System pressure: monitor the pressure in the system to ensure that the system operates within the appropriate pressure range.
(6) Water quality condition: monitor the water quality of circulating water to prevent the production of scale, algae and other pollutants.
(7) Equipment operation status: monitor the operation status of equipment using circulating water to ensure normal operation of the equipment.

### 3.2. *System function planning*

In order to realize efficient and stable circulating water cooling monitoring, the system function planning is as follows:

(1) Data collection: collect the operation data of circulating water cooling system through various sensors and controllers.
(2) Data processing: Process the collected data, such as data filtering and alarm judgment.
(3) Data storage: store the processed data into the database for historical data analysis and troubleshooting.
(4) Real-time monitoring: real-time display of the operating status of the circulating water cooling system, including the operating parameters of each device.
(5) Alarm and Early Warning: When the system runs abnormally, an alarm signal is issued to prompt the operator to deal with it in time.
(6) Remote control: realize remote control of circulating water cooling system through remote monitoring system.
(7) Data analysis and optimization: analyze the historical data, optimize the operating parameters of the circulating water cooling system, and improve the energy efficiency of the system.
(8) System maintenance and upgrading: regular maintenance and upgrading of the circulating water cooling monitoring system to ensure stable operation of the system.

Through the above function planning, it can realize the comprehensive monitoring of the circulating water cooling system of the hot stamping plant, ensure the efficient and stable operation of the system, reduce energy consumption and improve production efficiency.

## 4. Application of circulating water cooling equipment monitoring system

### 4.1. *Monitoring system interface*

The monitoring system can monitor the operation status of circulating water cooling equipment in real time, including:

- Equipment operation parameters: monitor the key parameters such as inlet and outlet water temperature and frequency of the equipment to ensure that the equipment is running in the best condition.
- Equipment operation faults: real-time detection of equipment faults, and issue timely alarms to facilitate timely investigation and treatment by operators.
- Equipment Operation History: Record the historical operation data of the equipment, which is convenient for analyzing the operation trend and performance change of the equipment.

### 4.2. *Real-time data*

Real-time data mainly includes the current operating status of the equipment, inlet and outlet water temperature, frequency and other information, users can view the monitoring system in real time, the system principle is shown in Figure 4.

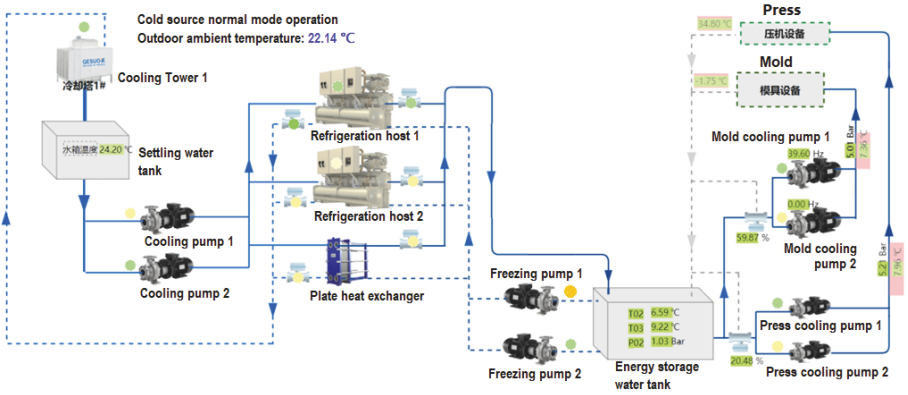



Fig.4 Real-time equipment data detection and display

### 4.3. *Monitoring historical data traceability*

The historical data retrospective function allows users to query the operating data of the equipment in the past period of time, which is convenient for analyzing the performance of the equipment and the cause of failure, as shown in Figure 5. Through the system automatically according to the water load signal, you can automatically adjust, change the frequency of the power supply and control the flow rate and flow of the screw water pump.

Historical data retrospective function allows users to query the operating data of the equipment in the past period of time, which is convenient for analyzing the performance of the equipment and the cause of failure, as shown in Figure 5. Through the system automatically according to the water load signal, you can automatically adjust, change the

frequency of the power supply, control the flow rate and flow of the screw water pump.

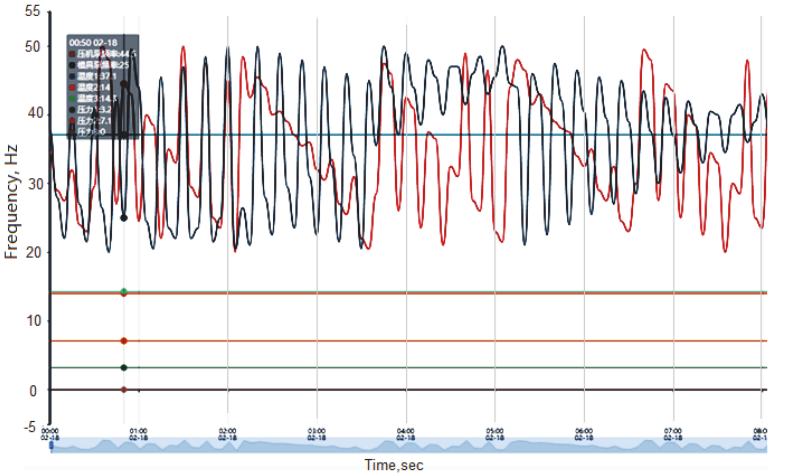



Figure 5 frequency conversion screw pump operating frequency data monitoring

### 4.4. *Mobile monitoring*

The circulating water cooling equipment monitoring system supports mobile APP and WeChat applet, which allows users to check the equipment operation status and data anytime and anywhere via cell phone and realize remote monitoring. At the same time, the system can also send abnormal alarms to remind users to deal with equipment failure in time.

Through the above functions, the circulating water cooling equipment monitoring system can effectively improve the operation efficiency and safety of the equipment, reduce maintenance costs, and provide users with convenient and efficient monitoring solutions.

### 4.5. *Remote setting of some parameters*

Through different parameter settings, it can realize energy-saving control in different environmental seasons, as well as water supply temperature and pressure supply for different process requirements.

The data report of environment, temperature and humidity, pressure and so on provides data support for intelligent control. Through the historical data query, you can check the operating status and parameter changes of each accessory of the equipment before the failure, which is convenient for engineers to investigate and deal with the cause of the failure in time.

### 4.6. *Remote debugging*

The system supports remote debugging function, PLC engineers can not have to go to the scene, at any time anywhere can be remotely overhaul the control program, timely solution

to the user site software problems, greatly reducing the cumulative failure time of the equipment. The system supports remote debugging function, as shown in Figure 6, remote operation log shown in Figure 7. In China on the thermal forming system in the country of Brazil in March for a number of times using the system remote debugging function, can be connected to the global network of any region of the user's equipment to adjust, modify the control program, and timely solution to the user's on-site software program problems, greatly reducing the cumulative failure of the equipment time, but also to save manpower costs.

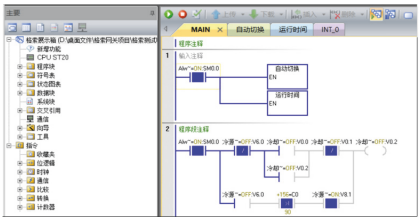


Fig. 6 Remote monitoring operation interface


Fig. 7 Log of remote debugging operation

## 5. Conclusion

Intelligent monitoring system of cooling system in hot stamping plant for automotive parts has achieved remarkable results in practical application. By monitoring and optimizing the status, effect and energy consumption of the cooling system, it realizes the intelligence of the production process and energy saving. The system's three-layer network architecture monitoring model effectively realizes the monitoring of equipment status, intelligent monitoring of cooling effect and energy consumption, which improves the production efficiency and quality of parts and reduces the level of energy consumption. The introduction of mobile monitoring and remote debugging functions further enhances the flexibility and convenience of the system, providing strong support for enterprises to save costs and improve production efficiency. In summary, the intelligent monitoring system has revolutionized the cooling system of hot stamping plants for automotive parts and made an important contribution to the development of the intelligent manufacturing field.

## References

1. Muller CJ Craig IK. Energy reduction for a dual circuit cooling water system using advanced regulatory control. Appl Energy 2016; 171:287-95.
2. Yisheng Zhang, Zijian Wang, Liang Wang. Progress in hot stamping process and equipment for high strength steel sheet. Journal of Plasticity Engineering, 2018, 25(5): 11-23.
3. Xiong Wei. Design of Energy Management System Based on Digital Factory. Chemical Engineering Design Communications,2023,49(12):174-176.
4. Han Hui, Li Bo, Hao Xiaochen, et al. Design and Implementation of Energy Management Systems Based on the Internet of Things. Internet of Things Technology,2015,5(05):44-47.