Health Evaluation Method for Unit of Multi-sand Water Pumping Station
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Abstract. The progress of science and technology has provided strong support for water conservancy modernization. The development of modern water conservancy has put forward new standards and new requirements for the intelligent management of pumping stations. The overhaul management is no longer satisfied with the traditional maintenance mode of the combination of planned maintenance and corrective maintenance. The multi-sand water pumping station unit health evaluation system can effectively evaluate the overall safety level of the pumping station system, and timely find and eliminate equipment hidden dangers. Maintenance provides significant decision support and provides a new type of predictive maintenance mode for the pumping station, which greatly improves the safety and reliability of the unit operation. The pump health status evaluation model is built from the top to the bottom according to the level. Through the analysis of the unit's vibration, swing, temperature, electrical quantity and other indicators, through the end evaluation price standard, the current status of the equipment is evaluated in real time, then push the real-time evaluation status of the current device to the upper layer according to the recursive logic. Combined with the unit fault diagnosis results, the health evaluation results of the pump station units are obtained through priority comparison.

Introduction

The Jingtaichuan electric power pumping project in Gansu Province is a high-lift step pumping station. The water source is the Yellow River water, and contains lots of sediment. When the sediment enters the impeller, the wear of the overcurrent components exacerbates the pump cavitation damage. Pump abrasion will generate vibration and noise, which will lead to pump head drop, efficiency drop, power increase, and even damage to the motor [1]. To evaluate the health status of the units of the multi-sand flow pumping station, it is necessary to pay more attention to the impact of the degree of abrasion of the pump on the unit. Through the changes of pump flow and motor power, the change of unit noise and temperature rise, the monitoring value of unit vibration swing, etc., the performance of the pump should be comprehensively analyzed, and the analysis results are introduced into the overall assessment to predict the occurrence of fault and its development trend. Taking the South-branch No.1 Pumping Station as an example, including eight double-suction centrifugal pumps and electric motors. The transmission and reconstruction of the fiber-optic LAN is used to realize the communication transmission, and the pump station unit health evaluation system is built in the production area.

Network Structure

As shown in Fig.1, it is the hardware composition and software layout structure of the health evaluation system of the South-branch Pumping Station. The system is based on the cloud platform construction, and the platform function node is constructed by the cloud platform virtual server, and the production area data is transmitted to the cloud platform. Among them, the application server is mainly used for data statistics, alarm and status evaluation, and also has the functions of pump performance monitoring and analysis, water valve operation status monitoring and analysis, and cascade pump station optimization scheduling system. The data server is used to store the thinker.
library and the relational database. The web server is used for publishing the diagnostic platform website implemented by the B/S architecture; the communication server is used to accept and send data.

![Diagram of data acquisition and analysis network topology.](image)

Figure 1. South-branch No.1 data acquisition and analysis network topology.

The local public LCU configuration communication management unit is used to collect data of devices such as AC meters, flow meters and DC screens. The data gathered by the local control unit is sent to the pump station computer monitoring system via the network transmission. The data of the monitoring system is sent to the cloud platform via the pump station side communication server, and the data is stored into the time series database of the cloud platform data server. A large number of different types of data are generated during the production and operation of the pumping station. Different applications have great differences in real-time data, data volume and data cycle requirements. The data platform design takes into account the data requirements of different applications of the pumping station[2]. All data is uniformly coded according to KKS coding rules. The data platform implements a unified standard data access interface based on RESTful. The application does not need to consider where the data is stored and how it is stored. All applications obtain the required data through the data platform interface.

The diagnostic platform display layer adopts the B/S mode, and the website is directly published to the cloud web server. The pump station side and the cloud platform side can browse the real-time data and health assessment results of the pumping station through the webpage.
Pump Station Unit Health Evaluation Method

As a complex system, the pumping station unit system involves multiple subsystems that work together and constrain each other. Each subsystem contains many different functions and different types of equipment[3]. The evaluation method takes the main motor and main water pump as research objects, and the electrical, vibration and temperature data are selected to evaluate the health status of the unit[4]. The model is constructed by hierarchical structure analysis, and the health status analysis results are combined with the fault diagnosis results, and the final health evaluation results are given by comparing the priorities. In order to make the pump station unit health evaluation results more clear and easier to grasp, it is divided into four states: normal (green), attention (yellow), abnormal (orange), and dangerous (red), according to the evaluation rules, as shown in Fig.2.

The front page adopts the “top-down” display mode. Entering the page first gives a macro structure of the pump station diagnosis result. When abnormal results are found, click the relevant evaluation icon, and the page will display the diagnosis conclusion step by step, until the lowest node of the diagnosis model, help the relevant staff to identify the device status trends and fault location.

Figure 2. Pump station unit health evaluation interface.

Motor and Pump Status Evaluation

According to the overall structure of the pumping station, the top layer is the unit, the second layer is the main water pump and the main motor, and then it is decomposed into various measuring points, as shown in Fig.3. The health evaluation model algorithm starts from the bottom layer and compares the actual sampled value or calculated value with the evaluation rule of the monitoring point to obtain the conclusion of the node state evaluation, and passes the conclusion to the upper node until the root section “unit”[5].

Terminal Measure Point Score

After the bottom key points are collected, the scores are quantified according to the scoring criteria. The test score rules are as follows:

Analog quantity exceeds the threshold scoring rules:

Each analog measurement point sets a corresponding threshold and deduction standard. When the measured value exceeds the limit, the corresponding score is deducted. If the analog quantity exceeds the threshold, the running time is t, and the total running time is T.

\[ s = \frac{t}{T} \times 100\% \]

If s is greater than the set value S, the score item is deducted from the corresponding score.

Abnormal/alarm classes switch score rule:

There are \( D_n \) switch measuring points under a certain equipment component, such as abnormal temperature/alarm temperature, high temperature of stator winding, etc., and every 1 point action deduction score d, d value is set according to the severity of the event.
After the completion of the key evaluation points, the classification criteria are divided into dangerous, abnormal, attention, and normal four measurement points.

**Equipment Status Evaluation**

Referring to the status evaluation status of the end point, the evaluation of the critical equipment status will be divided into four levels: “first-level status”, “second-level status”, “third-level status” and “normal status”. The specific division rules are as follows:

First-level state: three or more critical measuring points are dangerous;
Second-level state: more than one but less than three measuring points are dangerous;
Third-level state: Any key point abnormal or attention;
Normal status: All key points are normal.

**Pumping Station Health Evaluation System Model**

The existing intelligent remote diagnosis platform can diagnose the pump station equipment. The diagnosis results are divided into four levels, namely “first-level fault”, “second-level fault”, “third-level fault” and “normal equipment”.

Combined with the state evaluation results and fault diagnosis conclusions of the pumping station unit, and after reasonable priority management, the results of the health evaluation of the multi-sand water pumping station unit are analyzed. The health evaluation process of the Multi-sand water pumping station unit is shown in Fig.4.

According to the “short board principle”, the health assessment of the pump depends on the link that performs the worst condition[6], therefore, the priority is defined as: Danger > Exception > Attention > Normal. Assume that the state evaluation result is “Danger”, the fault diagnosis result is “Abnormal” or “Attention”, and the health evaluation result is “Danger”. Assume that the fault diagnosis result is “Abnormal”, the state evaluation result is “Attention” or “normal”, and the health evaluation result is “Abnormal”. And so on.

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**Figure 3. Hierarchical structure.**

**Figure 4. Health evaluation method for multi-sand water pumping station.**
Conclusion

Accurate analysis and evaluation of the health status of the host group of the multi-sand water pumping station is of great significance for the stable and reliable operation of the pump. In this article, a preliminary study on the health evaluation method of the pump is carried out, and there are still some unconsidered and lacking places to wait for improvement. The health assessment of the pump should be a long-term, dynamic process, which will be gradually summarized and continuously improved in the future application of the platform. In the future, after the South-branch No.1 pumping station is connected to the dispatching station, it can play a better role in assisting decision-making.

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References


