Development and Research of Equipment Information Management System of Thermal Power Plant

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Abstract. By using the information of equipment management department of thermal power plant, we analyze the functional requirements detailedly. In function analysis, the system function is divided into several modules which include equipment management, operation management, inspection/giving grease management, two ticket management, plan management, security management, technology management, staff management, material management and OA system. It is based on C/S architecture for system development and construction and it uses Mysql database development. PC client and server development adopted efficient C# programming language, and mobile phone client adopted Android language.

1. Introduction

The equipment information management system is an important part that supports the safe and stable operation of the equipment. It has the functions of collecting equipment status information, analyzing data information, and evaluating equipment status. The equipment information, data collection, equipment standards and planning arrangements are organically combined to realize the advance quantitative prediction and operation evaluation of the equipment operating status.

Most of the thermal power plants are composed of multiple units, so there are many devices that need to be inspected. The traditional information management model requires the cooperation of multiple employees and multiple departments, and has the disadvantages of large workload, inaccuracy, and loss of data statistics [1]. The goal of the equipment information management system is to manage the daily management tasks of the equipment (inspection, giving grease, etc.) in an orderly manner, effectively use the input data, realize the integrated evaluation of equipment, personnel, and spare parts, and accurately understand the equipment operating status [2].

2. Software design and basic framework

The equipment information management system adopts a client/server architecture to facilitate the sharing and transmission. The system is divided into client, server, and mobile client. Adopt Http data transmission protocol, Json format data stream. The basic structure is shown in figure 1.

C/S is a well-known client and server structure. It can achieve the effect of fully utilizing the hardware environment advantages of both ends of the system. Many program processing tasks are processed on the client and then submitted to the server, so that the allocation of tasks to the client and server is optimized, and the communication cost of entire structure achieve the lowest. Most of today's application software systems are two-tier structures of C/S mode [3].

The client uses the Windows system, the server uses the Windows Server system, and the mobile client uses the Android system. The programming development server and client use C# language, use Visual Studio2013, use Winform framework and ADO.net access technology. Mobile client development based on Android Studio, and database apply MySQL database.
3. Basic function introduction

3.1 Data entry class

The data statistics of thermal power plants play an important role in analyzing the causes of accidents and evaluating operational indicators. This system has made scientific records in terms of equipment information, inspection information, and spare parts information.

3.1.1 Equipment information and standard data entry

Personnel with administrator authority entering data on the PC client, including basic equipment information, basic parameters and so on. The PC client can read the data by accessing the server [4].

```csharp
public static int ExecuteNonQuery(string sql, params MySqlParameter[] param)
{
    int n = -1;
    using (MySqlConnection conn = new MySqlConnection(str))
    {
        …;
    }
    return n;
}
```

When the mobile phone App client reads this type of information, the QR code corresponding to the scanning device is taken. Get the data transmitted through Html5.

3.1.2 Inspection/giving grease data entry

Use the mobile client to scan the QR code, identify the encoding number of the device, obtain the item to be inspected (greased), input the item-related data through the mobile phone App client, and transmit it back to the server. Processing in the server is stored in the database [5].

```csharp
public static void JsonMy()
{
    …;
    JavaScriptSerializer js = new JavaScriptSerializer();
    ToJsonMy list = js.DeserializeObject<ToJsonMy>(json);…;
}
```

3.1.3 Two ticket management data entry

Work tickets and operation tickets’s entry of relevant data is crucial. The relevant person initiates the filling in of two tickets; enters the corresponding working hours, team, responsible person, person in charge, waits for long audit value, work plan and place; selects corresponding work notices, warning of dangerous points, etc. [6].

3.1.4 Spare part information data entry

Spare parts information includes basic parameters such as its name, model, manufacturer. When a spare part is entered, the code and correspondence are automatically generated.

```csharp
private void cmb_cg_SelectedIndexChanged(object sender, EventArgs e)
{
    AreaFull areaFull1 = cmb_cg.SelectedItem as AreaFull;
    if (areaFull1 != null)
    {
        string pjcount = …;
        label2.Text = pjcheckid1 + pjcheckid2 + pjcheckid3 + pjcount;
    }
}
```

Figure 1. Basic structure of equipment information management system.
3.2 Process management class

The stability and reliability of design software process approval are necessary. The arrangement of plants, two-vote management, and defect handling are carried out to ensure orderly of work [7-8].

3.2.1 Plan report, notification process

Enacting orderly and reliable plans is an important factor in stabilizing production. In the plan generation process, according to the working time and cycle corresponding to the reading equipment, a work plan for the corresponding equipment is automatically generated, and then the entire power plant is generated, delivered to the corresponding person in charge, and the inspection, giving grease routes are generated. When tasks such as planning and downtime conflict, the person in charge of the relevant equipment will submit the planned change arrangement and submit it to the corresponding person in charge of planning management for completing the plan change [9].

In the planning notification process, the plan is notified advancedly. According to comparison between the planned time and the current system time, the person in charge of the work, the team, the head of the department are alerted in turn to achieve the purpose of the plan assessment.

3.2.2 Check, give grease process

According to scheduled inspections and grease lines, the tasks are completed in turn, the data is recorded on the mobile phone client, and uploaded to the database through the Json format. The content and equipment of each device are checked according to the corresponding dimension code. Through the audit of the specialists and department directors, the completion of the inspection will be evaluated. The inspection and the grease working process are shown in Figure 2.

3.2.3 Two ticket process

The management of two votes (work ticket, operation ticket) is the basis for all construction of the power plant and is an important basis for guaranteeing construction safety. In the process of applying for a work ticket or operation ticket, the person in charge of the team fills in the work ticket, issues it to the person in charge of the shift for review, and checks the value of the duty and issues it to the person in charge of the work. Complete the tasks of the working staff within the specified working hours, complete the closed-loop work ticket. Otherwise proceed with the delay because of the corresponding reasons [10].

3.2.4 Defect processing flow path and spare parts management process

Dealing with corresponding defects in a timely manner is the key to preventing accidents. In the
process of defect processing, team members submit defect applications, which are then reviewed by specialists and department heads to generate defects to be processed, which are handled by relevant maintenance personnel. Stable operation acceptance can eliminate defects.

The adequacy and reliability of spare parts is an important part of the stable operation of the equipment. In the process of spare part entry, the spare part entry slip for entering the spare part information is submitted by the warehouse administrators, which is audited and entered by the relevant professional personnel.

During the process of applying for spare parts, the owner shall submit the delivery order for the corresponding spare part information, which shall be reviewed and approved by relevant workers. When the spare part is insufficient or doesn’t exist, the application for purchase of the spare part needs to be performed. The person in charge of the equipment and inventory determine whether the spare part exists, and if no temporary code is generated, the purchase plan is submitted, and specialist, department director, heads, and warehouse administrators are notified to purchase.

4. Analysis function introduction

4.1 Power plant operation evaluation

The analysis of the acquired contents in the software database is performed to obtain the corresponding equipment evaluation, reliability analysis, abnormal deterioration analysis, and spare parts quality evaluation. The evaluation framework of power plant operation is shown in Figure 3.

![Plant operation evaluation framework](image)

Figure 3. Plant operation evaluation framework.

4.1.1 Equipment status evaluation

After enriching the data collection, the server will evaluate the status of the equipment from various indicators. After each calculation, the coefficients are displayed on the client for display.

Some of the following coefficients are shown below: Planned outage factor (POF), Unplanned outage factor (UOF), Forced outage factor (FOF), Availability factor (AF), Service factor (SF).

\[
POF = \frac{\text{Planned outage hours}}{\text{Statistical period hours}} \tag{1}
\]

\[
AF = \frac{\text{Available hours}}{\text{Statistical period hours}} \tag{2}
\]

\[
SF = \frac{\text{Service hours}}{\text{Statistical period hours}} \tag{3}
\]
4.1.2 Abnormal deterioration assessment

Abnormal deterioration assessment can not only analyze the running status of the equipment, but also can carry out early warning analysis and arrange maintenance tasks. It is mainly divided into: normal rate of equipment inspection data (NO), normal rate of inspection data amplitude (AN).

\[
NO = \frac{\text{Normal data times}}{\text{Total number of inspections}} \times 100\% 
\]

\[
\text{Percentage of amplitude} = \frac{\text{The data–Last data}}{\text{Last data}} 
\]

\[
AN = \frac{\text{Normal percentage of amplitude times}}{\text{Total number of inspections}} \times 100\% 
\]

Taking the measurement point of the induced draft fan as an example, the horizontal and vertical vibration and bearing temperature data were collected. The vibration limit is not more than 6.3mm/s, and the percentage of vibration amplitude is not more than 50%. As shown in Figure 4, the normal rate of horizontal vibration data of bearings is 100%, and the normal rate of amplitude is 93.75%.

![Figure 4. Sampling of vibration data of fan level.](image)

4.1.3 Spare parts quality evaluation and personnel work quality evaluation

We manage the collection of different spare parts data and evaluate their operating time, failure rate, and availability factor. We can compare and evaluate the spare parts of different manufacturers of the same equipment, and we can draw relatively good products. We have certain reference significance in selecting products from different manufacturers. And collect and summarize the corresponding spare parts feedback information to achieve the expert spare parts fault handling system discussed together with the same spare parts problem.

The system will evaluate working ability and work direction of staffs. Achieve a high degree of integration between the mission and the personnel, in order to promote the efficient operation of the entire power plant equipment and normal safe production.

4.2 Equipment data analysis

4.2.1 Equipment Expert Library

The occurrence of equipment failures and defects is difficult to avoid, and the treatment options of various power plants are also different. Then integrate the defect troubleshooting solutions of the same type of equipment to achieve a high degree of information concentration. It can be referred to when dealing with similar issues, and can be handled through consultation and exchange on the issue of intractable diseases.

The establishment of an expert database not only advances the efficient processing of fault defects, but also provides a key reference for the prevention of accidents. It is the trend of the industry 4.0 era, and it is also a powerful guarantee for the safe production of electrical equipment.
4.2.2 Device Association Rules Mining (Apriori)

Application association rule mining algorithm can extract the rules between fault phenomena and fault data, and the fault correlation between various devices for power plant. Provides reference for fault monitoring and prediction analysis. Association rule mining In the case of selecting a transaction set, the failure of the transaction set for devices A, B, C, and D occurs, and the support for the simultaneous failure of devices A and B is \( P(A \cap B) \), and device A fails. The probability of a simultaneous device B failure is confidence, \( P(B|A) \).

The implementation process of association rule mining usually needs to go through the following two steps: 1. Find all frequent item sets according to the support degree. 2. Generate association rules based on confidence. Generate frequent item collection methods:

```cpp
void genarateFrequencelist() {
    int i, j;
    vector<string> f;
    ...
}
```

In the process of generating frequent item sets, if the maximum number of elements in a frequent item set is equal to the maximum number of elements contained in a transaction in a transaction set, or the number is within two, the process can be terminated. And then based on the calculated confidence levels. Filter until all strong association rules are generated [12].

5. Conclusion

The development and application of the thermal power plant equipment information management system effectively integrates various modules, making the equipment management work together efficiently.

(1) Acquiring equipment information and operating status through scanning of two-dimensional codes by mobile phones, realizing online transmission of on-site data and real-time processing of services, and improving the processing efficiency of work affairs;

(2) The internal workflow processing makes the work flow clear and precise, improving the accuracy and efficiency. Scientific management of spare parts, improves the safe operation cycle of the equipment, and reasonably records the service life and operating conditions of the spare parts;

(3) The joint use of PC clients and mobile clients improves the maintenance level of equipment faults, which will make the plant management of power plants more reasonable and effective. It can save maintenance budgets and escorts the safety of the production process.

References


