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Research on Information Organization Method of Power Intelligent Test System Based on CPS

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Abstract. In this paper, we propose the idea of the power intelligent test system by combining the concept of Cyber Physical System. And research the ways to organize information to make the intelligent test system of power is more heterogeneous, high degree of autonomy, adaptability and scalability. At the same time, to achieve high utilization and the Intelligence of the test data.

1. Introduction

In response to the call of the smart grid, the power test information should run through the entire test process, including the collection of test data, preservation and diagnostic analysis. In order to realize the intelligent diagnosis and analysis of intelligent grid test data, it is urgent to study the information organization method in the test process. In order to solve the shortcomings of traditional experimental data recording and processing technology, the concept of power intelligent test system is put forward. The method of information organization in power intelligent test system is studied, and the data is the center. Data classification and statistics can ensure the integrity, accuracy and validity of the test data. It also provides a powerful and complete data base for the realization of intelligent diagnosis and analysis of equipment test data.

In this paper, by explaining the characteristics of the test data in the electric power test and comparing the drawbacks of the traditional experimental data processing technology, this paper introduces the method of hierarchical information organization, improves the utilization rate of the test data by standardizing the storage format and organization method of the test information, Based on the research of physical system, this paper puts forward the research framework of power intelligent test system, and verifies the realization of its function. Finally, it summarizes the research significance of information organization method of power intelligent test system based on CPS.

2. Power Intelligent Test System

2.1.Test Data Characteristics

There are a wide variety of equipment that need to be tested for electricity in the power system. The equipment structure is different and the test items are different. The data size and type of the test are not the same, and the data are not completely independent, but are interrelated to affect the operation of the equipment [1]. Transformer and GIS (including SF6 circuit breaker) as an example [2], transformer and GIS detection items, characteristic parameters, detection of defects such as Table 1 (table for some data).

Table 1 Test item and content

Device	Test item	Parameters	Defect
Transformer	Analysis of dissolved gases in oil	Characteristic gas, micro water	Internal overheating, internal discharge, internal moisture
	High frequency partial discharge detection	Discharge map	Partial Discharge
	Core ground current detection	Core current	Core multi-point grounding
	Infrared thermal image detection	Temperature	Temperature anomaly
GIS（With SF6 circuit breaker）	Ultrasonic partial discharge detection	Local mass	Partial discharge, suspended particles, joints loose
	UHF partial discharge detection	Local mass	Partial discharge, solid insulation within the bubble discharge
	SF6 gas humidity detection	Micro water content	Water exceeded
	SF6 gas decomposition products	Gas composition	Partial Discharge
	SF6 gas leak imaging detection	Laser / infrared imaging	Gas leaks
	SF6 gas purity detection	Gas composition	Detection of purity
	Infrared thermal image detection	temperature	Temperature anomaly

From the above table we can see that different equipment has different test items, different detection items corresponding to different characteristic parameters (ie test data) and detection of defects (ie test results), the same equipment detection defects can also be different test items Out, the same feature parameters can determine the different detection defects. Therefore, the integrated power system equipment, the contents of the test can be seen, the power system equipment test data have the following characteristics [3]:

- data scattered widely: scattered in different equipment;
- large amount of data: the need to collect more data;
- the relationship between the data complex: the data between each other;
- data types: including structured, semi-structured and unstructured.

2.2.Traditional data processing means

The traditional test data is based on the test object, a test data is only used for this test once, the same data in different test items have been collected several times, the use of historical test data again when the query trouble, classification is not clear, And other shortcomings, so follow the traditional data acquisition and analysis methods to deal with data can not meet the intelligent diagnostic requirements. How to make the above information reasonable organization, to facilitate the system more clearly understand the diagnostic test data is the power of intelligent test and test system research focus and key [4].

2.3.Power intelligent test system

Power intelligent test system is an intelligent system, through the construction of the test site and the central side of the exchange between the "transit agent", with the cloud system call center side resources, on-site work to provide support and guidance, and has a certain data analysis , Can achieve "one-click" data upload.

The system diagram of the power intelligent test system is shown in figure1.

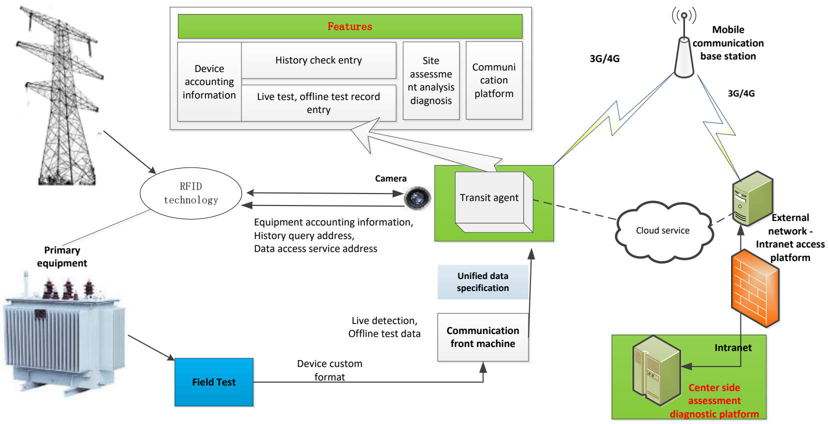

Figure 1 System architecture diagram

Through the establishment of power intelligent test and test system, theoretically, the role of the sensor forward, the information system of physical computing, communication, control the integration of the three functions of the depth of integration into the power system, the computing unit and the physical unit closely The system has the characteristics of controllable, credible and scalable, and can realize the dynamic control and real-time perception of complex system.

3. Research On Information Origanization Method

3.1.Research on hierarchical structure

In order to ensure the orderliness, simplicity and expansibility of the system information, the information organization of the information physical system is adopted, and the information is organized with the hierarchical structure, such as the company - power - station - system - equipment - characteristic parameter, the staff can be based on the actual situation of data to add, modify or delete, to ensure that all information system adaptability and scalability, hierarchical model is shown in figure 2.

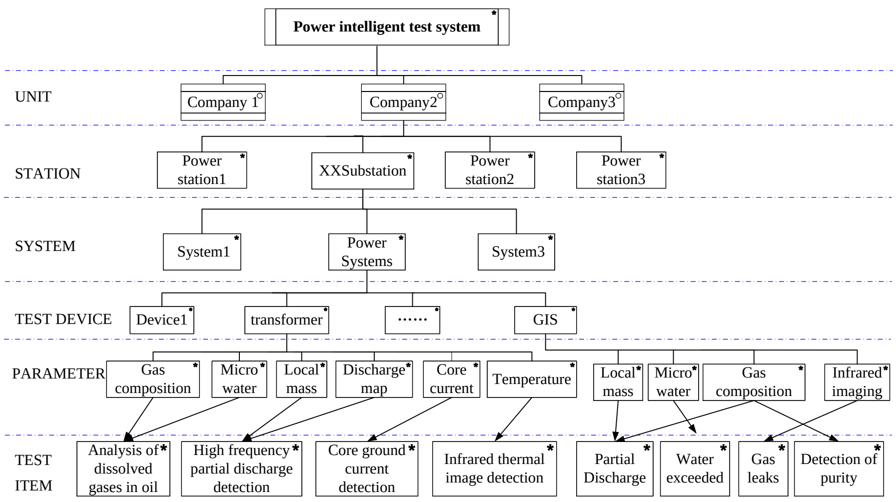

Figure 2 Information structure diagram

On the basis of the hierarchical structure, all the information needed by the comprehensive test of the power intelligent test system is unified and collected by the related technology. When the test results are analyzed, the experimental data can be automatically called according to the existing algorithms, norms or formulas, and the relevant results can be calculated intelligently, and the results

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of the test analysis are also stored hierarchically as the empirical data A similar case reference is provided for subsequent trials. After the data has been used, it can be used as historical data for other test analysis to continue to use, you can also use the same data on the equipment for longitudinal, horizontal statistical analysis and comparison.

In short, the experimental characteristics of the use of hierarchical structure of the unified management and division and then save, can avoid duplication of data collection, to achieve "a collection, multiple use, centralized management, efficient query" target, but also save the test data collection Time, improve work efficiency; can also make full use of the various test data for the operation of the equipment to conduct a more comprehensive, accurate and effective diagnostic analysis.

3.2.Logical model design

Based on the research of the level and content of the test object of the electric power intelligent test system, the information organization logic model of the power intelligent test and test system is carried out according to the characteristics such as the heterogeneity of the information physical system, the high degree of autonomy and the data center. Design, the conceptual structure into a relational model, so that each of the physical relations to meet the requirements of various types of data integrity, but also to meet the basic requirements of each data item minimization. Finally, in combination with the needs of the system, the logic model is further optimized to improve the performance of the database system [5].

In this paper, ER Studio database modeling software for logical model design, using ER Studio design of the power intelligent test test system logic model shown in Figure3.

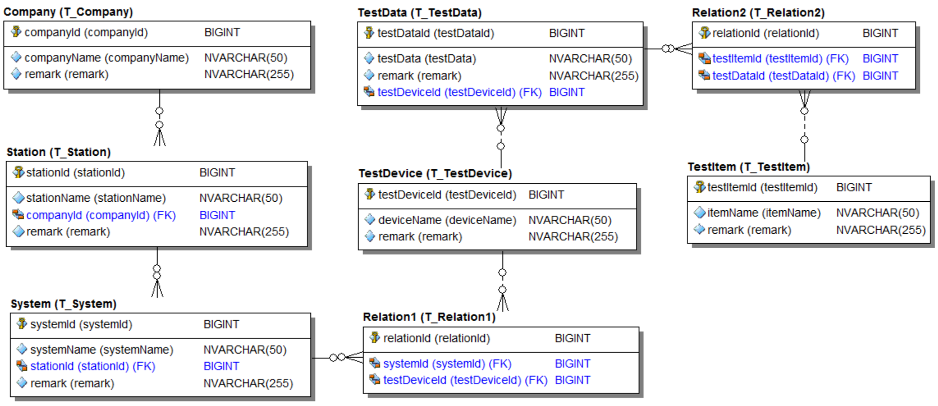

Figure 3 Logical model diagram

Through the design of the information logic model of the power intelligent test and test system, all the data systems involved in the pilot project of the power system are managed in a comprehensive and orderly manner, and the staff can inquire statistics, trend analysis and so on. Provide bottom-end data support.

4. Case Study

4.1.Data analysis

To verify the hierarchical information organization method using transformer oil chromatographic test as an example. The oil chromatographic test mainly analyzes the content of the dissolved gas in the oil, including the total hydrocarbon(TH), C_2H_2, CH_4, C_2H_2, C_2H_6, H_2, CO, CO_2 and other gas components.

This paper selects the data of No.6 transformer of Wusheng Substation in Guang'an City, Sichuan Province as an example to verify the feasibility of hierarchical information organization method. the

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Wusheng 6 transformer 2014 7/8 two months of the gas content of some of the data (In μL / L) is shown in Table 2.

Table 2 Oil chromatographic data

TH	C_2H_2	H_2	CH_4	C_2H_6	C_2H_4	CO	CO_2
132.50	16.40	135.00	52.60	10.80	52.70	228.00	590.00
144.80	16.70	137.00	57.10	11.90	59.10	224.00	628.00
136.00	16.90	144.00	53.20	11.30	54.60	239.00	627.00
132.30	17.10	137.00	53.80	10.20	51.20	218.00	604.00
137.50	17.50	139.00	58.10	11.00	50.90	248.00	605.00
129.50	17.50	120.00	52.00	10.00	50.00	210.00	536.00
118.80	17.80	112.00	46.00	9.00	46.00	190.00	491.00
125.00	18.00	124.00	48.00	10.00	49.00	210.00	520.00
117.60	18.00	123.00	45.00	9.60	45.00	198.00	500.00
126.30	18.30	113.00	47.00	11.00	50.00	195.00	510.00

Table 3 Three ratio method to calculate the results

NO.	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
1	0.3426	0.3994	4.8521

Table 4 Three-ratio method Encoding Rules

Ratio	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
<0.1	0	1	0
0.1-1	1	0	0
1-3	1	2	1
>3	2	2	2

Table 5 List of fault properties

NO.	Fault nature	C_2H_2 $/C_2H_4$	CH_4 $/H_2$	C_2H_4 $/C_2H_6$
1	No fault	0	0	0
2	Partial discharge of low energy density	0	1	0
3	Partial discharge of high energy density	1	1	0
4	Low-energy discharge	1-2	0	1-2
5	High energy discharge	1	0	2
6	Low temperature overheating (<150℃)	0	0	1
7	Low temperature overheating (150-300℃)	0	2	0
8	Medium temperature overheating (300-700℃)	0	2	1
9	High temperature overheating (>700℃)	0	2	2

The August and July data were averaged in accordance with the three ratio method to calculate the calculation results, which was shown in Table 3.

Combining the coding rules as shown in Table 4, we can see C_2H_2/C_2H_4, CH_4/H_2, C_2H_4/C_2H_6 coding analysis of 1,0,2.

From Table 5, we can see that,analysis by the nature of the failure list shows that the failure of the transformer is a high energy discharge

Based on the above calculation process, the oil chromatographic improved three-ratio coding analysis of 1,0,2, to determine the fault belongs to the arc discharge.

Because CO growth is stable (-3% / month), CO content is less than 300μL / L (257μL / L), thus judging the discharge failure does not involve solid insulation, there may be oil flow, suspension discharge, magnetic shielding contact, Bubble discharge, unstable core multi-point grounding, etc. Fault:

- Because C_2H_2 content is less than 40% (14%) of total hydrocarbon content, does not belong to single acetylene growth type failure, so basically can rule out oil flow failure;
- According to the oil chromatographic analysis of high energy discharge, and hydrogen hydrocarbon content of less than 80% (51%), CH_4 total hydrocarbon content of less than 80% (39%), the basic can rule out the oil bubble discharge.

The final cause of the possible failure is: suspension discharge, fuel tank magnetic contact bad, unstable core multi-point grounding.

Using the data measured in Table 2, the power intelligent test system in addition to the use of three ratio method, but also can be used to analyze the David triangle method, compared with the three ratio method, combined with the known norms of total hydrocarbons, C_2H_2, H_2 content of the impact of the judge, the results obtained in the following table.

Table 6 Oil chromatographic data analysis results

Three ratio method	**David Triangle Law**	**TH**	**C_2H_2**	**H_2**
Arc discharge	Overheating and discharge	Normal	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Level 3 deterioration	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Normal	Level 4 deterioration	Level 2 deterioration
Arc discharge	Overheating and discharge	Level 3 deterioration	Level 4 deterioration	Level 2 deterioration
Arc discharge	Overheating and discharge	Level 3 deterioration	Level 4 deterioration	Level 2 deterioration
Arc discharge	Overheating and discharge	Level 3 deterioration	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Normal	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Normal	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Normal	Level 4 deterioration	Normal
Arc discharge	Overheating and discharge	Level 3 deterioration	Level 4 deterioration	Level 2 deterioration

Combining the above analysis results and the results in Table 6, we can see, through the hierarchical storage structure, for the transformer in the gas data is provided by the basis of multiple calls, the initial implementation of the test data "a collection, multiple use, centralized management, efficient query" concept.

4.2.System implementation

The idea of CPS and power intelligent test system integration, proposed hierarchical information organization method to achieve the system's automatic diagnostic analysis function, in order to verify the feasibility of the method can be a simple system development, the system to achieve The basic functions are shown in Figure 4.

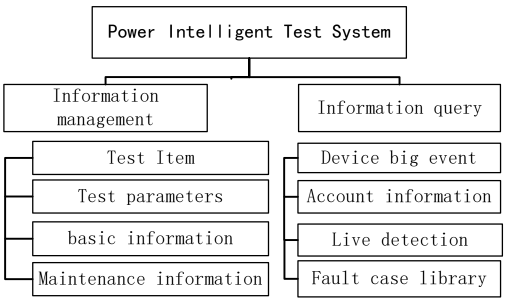

Figure 4 System function design

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The intelligent intelligent test system adopts the modularization thought to carry on the development, the basic function of which is divided into two kinds of modules of information management and information inquiry. Information management is mainly used for the management and maintenance of test information, all data fields are from the design of the data table. The information query module is used to analyze and diversify the data stored in the database.

Information management is mainly based on the experimental data design, which is mainly in accordance with the hierarchical structure of the project information management. The left side of the management page is a tree list, the data information by different levels of division, both for the convenience of staff management, but also to facilitate the statistics of information. Specific examples shown in Figure 5, in each information management page can be added to the data, modify, delete and other functions to ensure that the system has good adaptability and scalability.

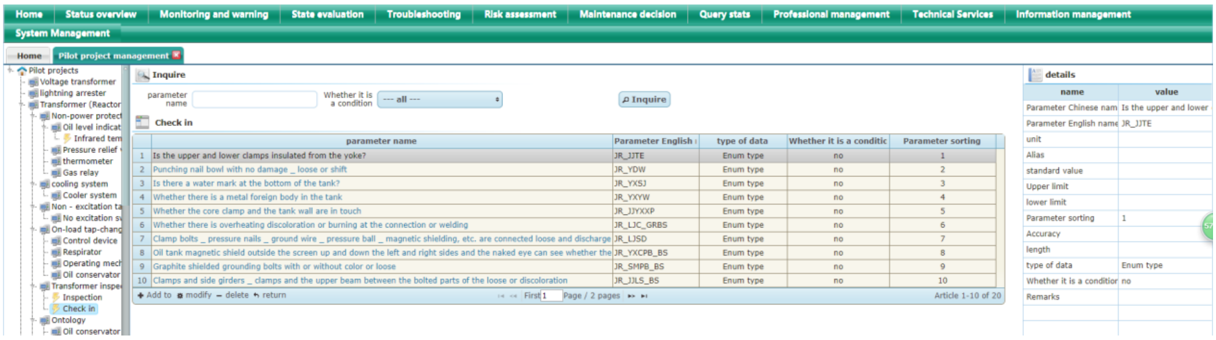

Figure 5 Experimental project management

The information query page mainly displays the information of the equipment of the power station, the memorandum, the test data of the live test, and the standard case database. In the hierarchical structure based on the collection of equipment data, developed a different information query display, as shown in Figure 6 to large equipment, for example, the equipment test results for statistical analysis of the equipment can query all the test results. This example is shown in the form of a timeline chart, or it can be displayed with a fishbone chart, a Gantt chart, or the like.

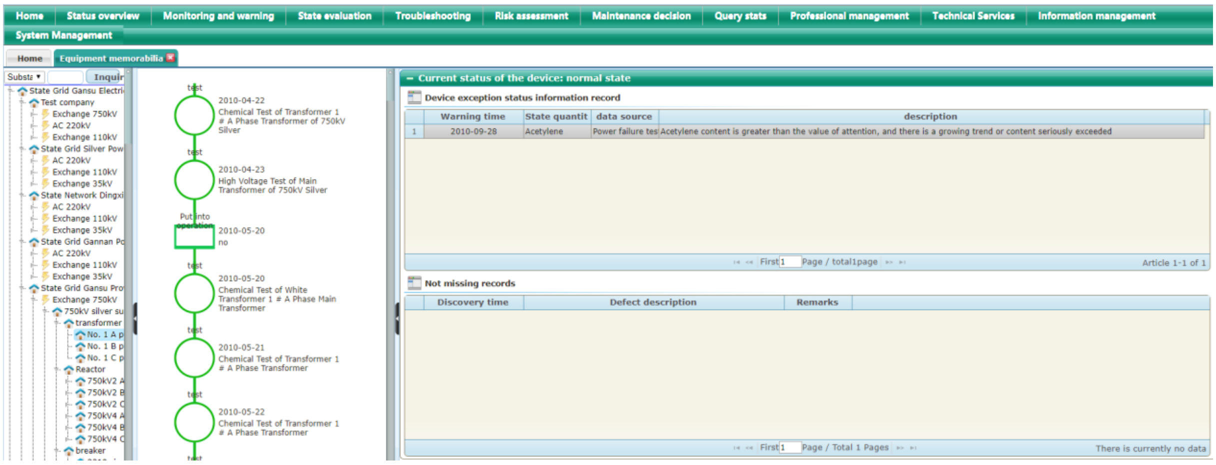

Figure 6 Device big event

As shown in Figures 7, Fault diagnosis combined with the hierarchical information organization method to complete the equipment data collection, storage, and the data for the initial analysis and diagnosis, to provide system and system users and experts of the human-computer interaction interface, the system automatically diagnosed on the basis of improved diagnostic analysis Flow, rich fault tree information. The expert's diagnostic results and test recommendations take effect on the operation and maintenance of the equipment.

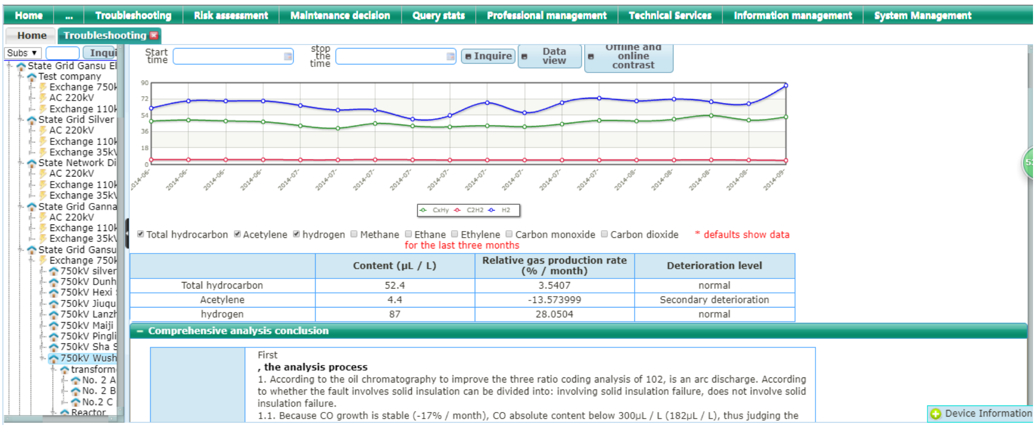

Figure 7 Diagnostic analysis

The system realizes some of the main functions of the system, and through the application of the concept of CPS, it can verify that the data-centric hierarchical information organization can realize the intelligent diagnosis and other functions of the system.

5. Conclusion

In this paper, according to the requirement of developing intelligent power test system, this paper deeply studies the information organization method of power test with the characteristics of data center, heterogeneity and high degree of autonomy of information physics system, and puts forward the hierarchical information organization And the design of the corresponding logical structure model, the model has a good self-adaptability and scalability; and developed a power intelligent test and test system to verify the system information organization of the rationality and feasibility.

By studying the information organization of CPS-based power intelligent test and test system, it provides a good theoretical and practical basis for the acquisition, expansion, preservation, utilization, automatic analysis and intelligent diagnosis of power system test data, which can be realized Intelligent test of power test system.

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