Research on Lean Operation and Maintenance Technology of Intelligent Electric Energy Meter Based on Artificial Intelligence

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Abstract. The existing power metering device does not realize on-line monitoring, operation health evaluation and dynamic inspection of equipment in the process of operation and inspection. The purpose of this paper is to solve the technical problems of online monitoring and evaluation of the operation status of the electric energy metering device, analyze the technical difficulties encountered in the process of realizing the lean operation and maintenance of the electric energy metering device and the supporting technologies available at this stage in detail, and propose a lean operation and inspection technology of the electric energy metering device to improve the working efficiency and level of intelligence management.

1 Introduction

As an important carrier of electric energy accounting, electric energy metering device is the core to ensure the fair, just and accurate sale of electric energy. At present, the mode of regular on-site inspection of electric energy metering devices is inefficient, and the accuracy and real-time performance are still far behind the advanced level of European and American countries; in addition, the operation evaluation system of electric energy metering devices is not perfect. The existing types of electric energy metering devices are various, the operation environment is complex and changeable, there are many uncertainties such as human factors and family defects, and the information obtained by the staff is miscellaneous and numerous, so it is impossible to accurately and efficiently identify the real-time operation state and future state change trend of the electric energy metering device, which greatly slows down the efficiency of operation and maintenance; secondly, there are strong uncertainties in the process of index data collection and expert scoring, which brings challenges to the comprehensive evaluation of the electric energy metering device; finally, in the process of operation and inspection, it is difficult to accurately predict or predict the failure, especially the defect treatment of electric energy metering device, which often results in multiple failure types or false alarms. The level of online lean operation and inspection of electric energy metering device is low, which wastes a lot of time of technical personnel, and the quality of operation and maintenance service is difficult to improve. The above problems have become the "stumbling block" restricting the lean operation and inspection of electric energy metering devices, which need to be solved by technical means.
2 Main technical difficulties

2.1 Research on on-line fault condition monitoring and prediction of electric energy metering device

After the electric energy metering device is put into operation, its actual operation state on the one hand follows the aging rule of electric bath type, on the other hand, with the increase of operation time, the operation data gradually deviates within the acceptance scope of the project, and the deviation has nonlinear characteristics. Based on the small change of operation state data, it is found that the operation state of the electric energy metering device is effectively difficult to be predicted. Therefore, it is a key and difficult point to study the online fault detection and prediction under the condition of small sample data\(^1\).

2.2 Research on comprehensive evaluation index system of electric energy metering device

There are many kinds of existing electric energy metering devices, the operation environment is complex and changeable, and there are many uncertainties such as human factors and family defects\(^2\). In the evaluation process of the operation state of electric energy metering devices, the impact degree of different evaluation indicators is different, and there are strong uncertainties in data collection and expert scoring. Therefore, how to build an objective and comprehensive evaluation index system to support the comprehensive evaluation of the power metering device is a key point and difficulty of this topic.

2.3 Research on online lean operation and inspection technology of electric energy metering device

At present, the operation and maintenance of distribution network mainly adopts two ways of fault and regular maintenance, which are low in automation. The personnel get disorderly information, unable to accurately find the root cause of the problem and solve it in time, and the early warning mechanism is not perfect, especially the large number, scattered disorder and huge data of electric energy metering devices, which bring huge pressure to the operation and maintenance work. The research on-line lean operation and inspection technology, not only needs the technical level, but also needs the comprehensive management level, which is very difficult.

2.4 Study on operation failure mechanism of electric energy metering device

In the defect treatment of electric energy metering device, there are many kinds of failure types or false alarms for the same result. Complex reasons and various manifestations cause the inconsistency of failure information of device operation, greatly increase the operation and inspection workload of electric energy metering device, and seriously affect the function of electric energy information acquisition system. Therefore, according to the analysis of data of relevant characteristics of failure phenomenon of device operation, the study of the failure mechanism of electric energy metering device is a main difficulty of this project.
3 Key technical support

3.1 State evaluation technology based on AHP

The first level index weight is determined by AHP, the second level index weight is determined by entropy weight method, and the evaluation model is constructed by TOPSIS method. The key status of batch operation state of intelligent table is identified by clustering analysis, classification regression and other machine learning algorithms, considering the information of basic files, verification links, operation links and dismantling links of intelligent table comprehensively. The running state of the intelligent table is dynamically tracked, and the influence weight of each state quantity is trained through the historical data regression iteration; the running state evaluation model of the intelligent table is established based on the batch, which realizes the overall evaluation of the batch intelligent table and assists the state change.

3.2 Data depth analysis technology

Data analysis technology includes big data life cycle, big data technology ecology, big data collection and preprocessing, big data storage and management, big data computing mode and system, and big data analysis and visualization. In the life cycle of big data, data collection is in the first step. For different data sets, there may be different structures and patterns, such as files, XML trees, relational tables, etc., which show the heterogeneity of data. The so-called big data computing mode refers to various high-level abstractions or models extracted and established from various big data computing problems and requirements according to different data characteristics and computing characteristics of big data. The in-depth analysis of big data is mainly based on large-scale machine learning technology. Generally speaking, the training process of machine learning model can be reduced to the objective function defined on large-scale training data and realized by a cyclic iterative algorithm. Compared with traditional OLAP, big data analysis based on machine learning has its own unique characteristics.

3.3 Operation failure analysis technology of electric energy metering device

Generally, failure analysis is based on failure mode and phenomenon, through analysis and verification, simulate and reproduce the failure phenomenon, find out the cause of failure, excavate the failure mechanism, and propose countermeasures to prevent re failure. According to the purpose of analysis, failure analysis can be generally divided into narrow sense failure analysis, broad sense failure analysis, failure analysis development status, failure analysis research and failure analysis strategy. The failure analysis of the project focuses on the real-time monitoring data of the electric energy metering device, combined with the actual operation characteristics of the electric energy meter, to study the failure reasons of the electric energy metering device, and the fault tree analysis method is proposed.

3.4 Data cleaning technology for failure of electric energy metering device

Data cleaning refers to the process of re-examining and verifying data, aiming to delete duplicate information, correct existing errors and provide data consistency. Data cleaning can also be seen from the name is to "wash" the "dirty", which refers to the last procedure to find and correct the identifiable wrong data in the data file, including checking data consistency, processing invalid and missing values, etc. Because the data in the database is a
data collection for a certain phenomenon of power distribution terminal failure. These data are extracted from multiple business systems and contain historical data, so that some data are wrong data and some data conflict with each other. These wrong or conflicting data are obviously what we don't want, also known as "dirty data". Therefore, according to certain rules, "dirty data" and "wash away" are data cleaning. The task of data cleaning is to filter the data that does not meet the requirements, and hand the filtering results to data fusion management. The data that does not meet the requirements mainly includes incomplete data (incomplete data), error data and repeated data. In the analysis used in this report, the verification data of electric energy meter with open cover record, the data without verification data and verification time, and the data without word number shall be eliminated.

4 Research on lean operation and maintenance technology of intelligent energy meter

This research aims at online lean operation and inspection of electric energy metering device, takes online monitoring and operation status evaluation of electric energy metering device as the main line, and carries out research from three aspects of theoretical research, system development and device development, so as to achieve the effect of improving inspection efficiency, shortening the time of fault repair, improving customer satisfaction and improving the intelligent level of metering device.

4.1 On line monitoring and rotation strategy of electric energy metering device

In order to further strengthen the operation state management of all kinds of electric energy metering devices, it is necessary to strengthen the whole life cycle management, strengthen the operation data analysis and establish a sound system. Therefore, it is necessary to establish the key state quantity management system of the operation state of the electric energy metering device, construct a method of the operation state analysis of the electric energy metering device based on the big data technology, explore the new method of the online error detection and analysis of the electric energy metering device and the intelligent rotation strategy, so as to realize the online fault detection prediction and optimization of rotation strategy under the condition of the small sample data of the electric energy metering devices of different batches and different manufacturers.

1) The core technology of the key state quantity management system for the operation state of the electric energy metering device is studied.

2) Develop the design scheme of key state quantity management system for operation state of electric energy metering device, mainly including the management of customer and metering device files, inspection plan, organization and authority.

3) Research on the operation state analysis method of power metering device based on big data technology. Using big data storage technology, big data analysis and processing technology and data mining technology to build an intelligent electricity meter running state analysis system model based on big data technology.

4) Combined with the error data obtained from the on-site periodic test, this paper comprehensively evaluates the impact of the complex actual power grid operation environment on the accuracy and reliability of the metering device, analyzes the composition of the state quantity and formulates the weight of each index, so as to form a new state evaluation method for the power metering device.

5) Study on how to realize the accurate replacement of the electric energy meter through the operation batch management, operation sampling management and operation status.
4.2 Accuracy quantitative analysis technology of electric energy metering device

In view of the defects of the original fixed cycle on-site inspection mode, it is necessary to carry out dynamic inspection of power metering devices based on online monitoring information. Therefore, considering the complex and changeable operation environment of the electric energy metering device, it is necessary to explore a comprehensive evaluation method of the operation state of the electric energy metering device, and develop a series of products of the operation monitoring terminal of the electric energy metering device, so as to realize the accurate and quantitative analysis of the failure point, reliability and service life of the online electric energy metering device.

Using big data analysis technology, such as anomaly detection, using a variety of statistical, distance, density of quantitative indicators to describe the degree of alienation between data samples and other samples. There are two kinds of abnormal data in electric energy measurement, one is bad data and the other is distorted data. In view of the equipment failure of the electric energy metering device, it can be divided into two types: abnormal electric energy metering (such as less or no electric energy of the electric energy meter) and damage of the metering device. Measurement anomaly monitoring and analysis is the process monitoring and analysis for the data information of electric energy measurement. It analyzes the collected data comprehensively and forms the monitoring data by statistics. Then, based on the monitoring data, it analyzes the operation status of the metering device and the user equipment, judges the normal operation status of the electric energy measurement equipment, and makes corresponding faults treatment plan.

4.3 Lean management technology for on-line monitoring and rotation cycle of electric energy metering device

Explore the analysis method of operation failure mechanism of electric energy metering device in specific operation environment, research the quantitative analysis method of operation failure rule of electric energy metering device in different operation time and installation area, and develop the online refined operation and inspection platform of electric energy metering device based on Internet of things technology to realize the lean management of online detection and rotation cycle of electric energy metering device.

1) The fusion technology of failure correlation data of electric energy metering device, the cleaning and correction technology of failure data of electric energy metering device and the mining technology of failure data association of electric energy metering device are studied;

2) Analysis of the influencing factor system of power metering device failure, and evaluation the failure characteristics of power metering device.

5 Conclusion

With the deepening of power system reform and the wide application of big data technology, the online assessment of the operation status of power metering devices is facing more and more influential factors, which puts forward higher requirements for its comprehensive and objective assessment; in addition, with the continuous advancement of industrial structure optimization and internationalization process, the proportion of systems and equipment is gradually increasing dominated by high and new technology in the power grid, which puts forward higher requirements for electric energy measurement. The research of lean operation and inspection technology of electric energy metering device can realize the real-time and efficient monitoring and state evaluation of electric energy metering device, and be used for
the fault early warning analysis of device, so as to improve the maintenance efficiency of
electric energy metering device, save the working time of technical personnel, improve the
competitiveness and user satisfaction of power grid company in the electricity market, and
improve the corporate image of power grid company.

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