Study on the discrete analysis method of the factors affecting typical faults of Intelligent Electricity Meter

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Abstract. Intelligent electricity meter represents the development direction of intelligent terminal of energy-saving smart grid end-user in the future. Intelligent electricity meters are widely used in the field, and the development momentum is rapid. In the future, the market demand is more vigorous, and the competition is increasingly fierce. However, in the practical application of electricity meters, faults may occur due to the influence of production enterprises, key components, research and development schemes, quality regulations, age of meters and other factors, even exposed batch quality problems, resulting in measurement disputes and customer complaints. In view of providing power companies and production enterprises with high batch early-warning for intelligent electricity meters to avoid economic losses caused by large-scale failures, based on the statistics of the whole life cycle data of 10 intelligent watt-hour meter manufacturers, this paper analyzes the typical fault types of intelligent watt-hour meter in detail, and obtains the analysis samples and dimensions of the main influencing factors. Based on the analysis method of standard deviation index, the multi-dimensional fault discrete analysis is carried out on the analysis samples, the dimension with the highest dispersion coefficient of fault is mined layer by layer until the smallest element is analyzed, and finally the main influencing factors of fault are obtained. The analysis results are basically consistent with the actual market performance of the production enterprise, which proves the rationality and scientific nature of the set of calculation indexes and discrete analysis method.

1. Introduction
As the intelligent terminal of smart power grid, smart electricity meter is no longer the traditional electricity meter. At present, China is promoting the construction of smart power grid. In 2015, the number of smart meter users in China exceeded 140 million. By the end of 2017, the coverage rate of smart electricity meters in the state grid area had reached 80%, and the coverage rate of smart electricity meters nationwide had reached over 70%. It is expected that the whole coverage of smart electricity meters will be basically realized during the 13th Five-Year Plan period.

Smart meter represents the development direction of intelligent terminal of energy-saving smart grid end-user in the future [1]. To meet the new requirements of modern low-carbon environmental protection and green construction, as well as the widespread application of intelligent electricity
meters, it makes the smart meter market develop rapidly, and the future market demand is more vigorous, and the competition is increasingly fierce. However, in the practical application of electricity meters, they may be affected by production enterprises, key components, research and development schemes, quality regulations, age of meters and other factors, and even expose batch quality problems, resulting in measurement disputes and customer complaints. [2].

In this study, an improved algorithm based on standard deviation value is proposed to mine and analyze the main influencing factors of typical faults of intelligent electricity meters. It covers the faults and associated information of the whole life cycle of the electricity meter, so as to locate the main influencing factors of typical faults rapidly, comprehensively and accurately. To realize the purpose of intelligent analysis and early warning of electricity meters. It promotes the application of discrete analysis method in the electric energy meter industry, helps to improve its operation quality level, and provides power for the sustainable and overall development of China's electric energy meter manufacturing industry.

2. Intelligent electricity meter fault type statistics
In the application process of intelligent electricity meters, there are different types of faults. According to the characteristics of intelligent electricity meters' failure in the whole life cycle, Conduct statistics and classification of the operating fault information, disassembly fault information, archive information of intelligent electricity meters, key components and other information of electricity meters. The failure information of intelligent electricity meters can be divided into eight categories: [3-4]

2.1. Appearance of fault
The external manifestations of such faults mainly include appearance damage, wiring terminal damage, burning meter, key damage, display fault, etc., which are mainly caused by the damage of the internal relay [5-6].

- Appearance damaged. The general performance of the table shell damage, terminal cover damage, seal damage, nameplate damage and other fault phenomena.
- Faulty wiring terminal. The general performance of the terminal seat and terminal damage, screw damage and other fault phenomena.
- Burning meter. Generally, it is the fault phenomenon caused by excessive length or aging of components.
- Key damaged. Generally, it is the damage of the screen key, programming key damage and other fault phenomena.
- Display fault. Generally, the liquid crystal is missing, the display is broken, the display is dim, the liquid crystal is leaking, the display is disorderly, the active power pulse indicator lamp is faulty, etc. This kind of fault is mainly due to the LCD or LCD tube damage. And the backlight color difference, backlight is not bright, backlight long bright and other faults, This kind of fault is mainly due to the backlight circuit components overload work, leading to the shortening of life.

2.2. Measurement fault
This fault is mainly manifested as "inaccurate indication", "unqualified starting", "potentially unqualified" and "out of tolerance of basic error". Among them, the "error out-of-tolerance" fault of the internal program of the smart meter is manifested as stop running, basic current error, perceptual load error out-of-tolerance, automatic zero clearing at the bottom of the meter, etc. The failure phenomenon of "inaccurate indication value" of electricity meters is mainly manifested as reverse active power, reverse reactive power, sudden change of measurement quantity, inaccurate indication value of power, inaccurate indication value of current, inaccurate indication value of voltage, inaccurate indication value of power factor, etc. This kind of failure is mainly caused by the aging of the energy meter, the unreasonable design of the interruption processing of the energy meter, the failure of the diode of the circuit, and the decline of the function of the components.
2.3. Storage failure
This is based on the faults in the internal structure of intelligent electricity meters, which can be divided into two kinds of faults, namely "out-of-tolerance of meter combination error" and "sudden change of electric quantity data". Among them, "the combination error of the meter" is mainly manifested as the current combined active power error of the meter, the current forward active power combination error of the meter, and the current reverse active power combination error of the meter. "Electric quantity data mutation" is mainly manifested as daily electric quantity data mutation, monthly electric quantity data mutation, chip damage, etc., which is mostly caused by the absence of installation process [7-8].

2.4. Communication failure
This is mainly manifested in three aspects: 485 communication fault of smart electricity meter, module communication fault and infrared communication fault:
- RS485 communication failure. Generally, it is caused by the auxiliary terminal RS485 wire connection reverse switch, communication baud rate and other parameters setting errors, table address setting errors, or the occurrence of virtual welding or continuous welding of some components.
- Module class communication failure. It includes carrier communication failure, micro-power wireless communication failure, GPRS communication failure, etc., which is generally caused by carrier module bad contact and damage or insufficient power supply capacity.
- Infrared communication failure. It is usually caused by receiving electricity or by an infrared transmitting tube.

2.5. Fees charged with failure
This is mainly manifested in four aspects: abnormal deduction of electricity charge, failure of recharge, failure of authentication and abnormal control circuit.
- Abnormal deduction of electricity charges. The general performance is the rate of electricity charges deduction abnormal, ladder electricity charges deduction abnormal, prepaid control function failure and other fault phenomena.
- Recharge failed. Generally, it is manifested as the wrong number of power purchase, wrong account number, wrong ESAM verification, wrong card insertion and other fault phenomena.
- Authentication failed. Mainly is the identity authentication failure, the key state error and so on fault phenomena.
- Abnormal control circuit. The main fault phenomena are the abnormal state of pull-off, pull-off and closing.
  This is usually due to problems with the control circuit, such as the relay not working properly and the ESAM chip broken. Operation and maintenance personnel should replace relay or EASM chip in time.

2.6. Alarm clock
When the clock unit of intelligent electricity meters fails, it is mainly reflected in two aspects: time conversion error and clock error. The fault is manifested as time zone error, clock deviation exceeding limit, clock scrambling, etc. Different faults are represented by corresponding exception codes. The reasons for the electricity meter not displaying the clock information correctly can be divided into:
First, the encryption fault causes its automatic control function to be unrecognizable and gives a false alarm. Secondly, the load switch in the electricity meter fails to transmit the information correctly.

2.7. A power failure
In case of power failure, it is mainly manifested as black screen, undervoltage of clock battery, undervoltage of meter reading battery, etc. This is based on the internal structure of the smart meter
during the malfunction, such as insufficient battery capacity, chip damage, etc. This is mostly due to the absence of the installation process.

2.8. Software failures
This is mainly manifested in two aspects of the crash of intelligent electricity meters and abnormal event recording:
- Crashing. The general performance of the card screen of death, the operation of the crash, abnormal restart and other fault phenomena.
- Event log exception. It is generally manifested as abnormal power failure events, abnormal zero clearing events, abnormal open cover events, etc. Generally due to software aging, need to clean, etc., should be timely contact maintenance personnel to deal with.

3. Dimension analysis of influencing factors of intelligent electricity meter failure
Comprehensively analyze the failure types of intelligent electricity meters and analyze the causes of the failures. Combining with the characteristics of the electricity meter industry, the intelligent electricity meter will run through the whole life cycle of the intelligent electricity meter. Covering the eight major links of R&D and design, material procurement, manufacturing, factory delivery, acceptance inspection, warehousing and distribution, installation and operation, dismantling and scrapping, Analyze quantifiable and assessable failure influencing factors. The index dimension of affecting factors of intelligent electricity meter industry failure is measured comprehensively.

As shown in Figure 1, the influence links of faults in the intelligent electricity meter industry are summarized from two aspects, namely the electricity meter industry and the whole life cycle.
Fault analysis is to collect the quality data of the side electricity meters of power companies and the side quality data of the production enterprises, and explore the typical failures of the production enterprises. Longitudinal mining is used to analyze the main influencing factors of typical faults, and horizontal correlation is used to analyze the operating tables involved in typical faults. Avoid the concentrated outbreak of hidden troubles of product quality, and provide support for improving the comprehensive quality level of products. As shown in the figure above, by analyzing the reasons caused by the failure types of electricity meters, the factors affecting the failure can be analyzed from the following seven dimensions:

3.1. **Regional analysis**
Make statistics on the faults of electricity meters in provinces/cities with different supply networks., such as Henan, Gansu, Zhejiang. Analyze the failure rate of electricity meters in each area and prevent the areas with high failure rate.

3.2. **Table of age analysis**
Each running electricity meter has a corresponding age, such as 0-1 year, 1-2 years, 2-3 years, etc. And each electricity meter has a corresponding life span, the longer the service time of the meter, the greater the probability that the meter is prone to failure, the more attention should be paid to it.

3.3. **R & D program analysis**
The research and development of electricity meters are different, such as the level 2 single-phase fee control intelligent electricity meters (saw spring scheme). The electricity meters produced by the research and development scheme will have different use effects, statistics of the use of each R & D program, facilitate the promotion and adjustment of R & D direction.

3.4. **Product gauge analysis**
The type of regulation will have different effects on the meter, such as Level 2 single-phase local charge control intelligent electric energy meter (CPU card - built-in switch). It is convenient to guide the research and development of the product specification by summarizing and analyzing the failure of each product specification type.

3.5. **Analysis of key components**
According to the analysis of the electronic industry, the production failure and market repair of most electric energy meters are caused by component failure, such as battery, load switch, metering chip, liquid crystal display, current transformer, RS-485 chip, microcontroller, etc. Therefore, by analyzing the failure of key components, we can find out the parts and factors of key components that are prone to failure, and then improve the use stability of intelligent energy meter by improving the processing technology.

3.6. **Fault analysis**
There are different phenomena of failure of electric energy meter, such as appearance damage, display failure, recharge failure, burning table, inaccurate indication, etc. By summarizing and analyzing the types of fault phenomena and their failure rates, we can prevent and improve them accordingly.

3.7. **Production enterprise analysis**
There are many manufacturers of power meter components, such as Nanjing dachangbi Electronic Technology Co., Ltd., Ningbo Samsung Medical Electric Co., Ltd., etc. The quality of products shipped by different manufacturers will be different. By summarizing and counting the failures of electric energy meters of each production enterprise, the corresponding production enterprises can be reminded to improve and prevent in time, so as to avoid the high occurrence of batch failures.
To sum up, the failure influencing factors are the analysis index dimensions to ensure the high quality and efficiency of the eight links of the intelligent energy meter. The factors interact with each other, constitute a complete analysis system of fault influencing factors.

4. Study and evaluation of discrete analysis method of intelligent electricity meters

4.1. Study on discrete analysis method of intelligent electricity meters

Firstly, this paper summarizes the operation fault information, file information, key component information, dismantling fault information and other relevant information, and defines the typical fault types, then calculate the discrete value of failure rate in the dimensions of area, table age, product specification, R & D plan, key components, failure phenomenon, production enterprise, etc, take the typical factor with the highest failure rate in the discrete value of dimensional failure rate as the base number, continue to drill down to analyze the remaining dimension fault discrete value, up to the smallest unit of the last dimension, stop RIH analysis, finally, the conclusion of the analysis is summarized, the main influencing factors of typical faults are obtained.

This analysis method covers the fault and correlation information of the whole life cycle of the electric energy meter, the analysis process is characterized by: the basic standard deviation algorithm is used in the process of mining and analyzing the main influencing factors of typical faults, circulating RIH analysis, it can quickly, comprehensively and accurately locate the main influencing factors of typical faults. The workflow of the main analysis is shown in Figure 2.

![Flow chart of discrete analysis method for intelligent electricity meters](image)

As can be seen from the above figure, this analysis method first defines typical faults, according to the region, table age, R & D plan, product specification, key components, failure phenomenon and production enterprise, the failure rate values of each type are classified and counted, reaching a certain threshold is called typical fault. This analysis method is based on the standard difference algorithm to mine and analyze the typical faults formed by the fault watt hour meter, take the regional dimension as an example, calculate the difference between the regional failure rate and the average failure rate of other regions in turn, and calculate the standard deviation of the difference. In the same way, calculate the standard deviation of dimensions such as product planning, table age and R & D scheme, the larger the standard deviation is, the greater the dispersion of failure rate representing this dimension is. Through statistics and comparison of standard deviation of failure rate in different dimensions, take
the highest factor of failure rate of the largest dimension of standard deviation as the base, continue the
discrete analysis of remaining dimensions until the main influencing factors of typical faults are
obtained.

The specific calculation method of discrete analysis includes the following five steps, and the work
to be completed in each step is shown in Figure 3.

![Diagram of Calculation Steps](image)

**Figure 3. Calculation steps of discrete analysis method for intelligent electricity meter**

Step 1. summarize the data: Summarize the relevant data such as operation information, disassembly and replacement information, fault information, R & D plan, meter age, product specification, production enterprise, etc. of the electric energy meter in the whole life cycle.

Step 2. processing data: The information involved in the life cycle of the electric energy meter shall be processed, the relevant information of electricity meters is classified and counted for easy calculation.

Step 3. calculation of failure rate: According to the dimensions of region, aging, R & D plan, product specification, key components, failure phenomenon, production enterprise, etc, count the failure rate information of the smallest unit under the corresponding dimension.

Step 4. discrete analysis: The improved standard deviation algorithm model is used to calculate the standard deviation of each dimension failure rate in step 3, the fault discrete value of standard deviation of fault rate of various dimensions is obtained.

Step 5. analysis results: According to the dimensions of region, table age, R & D plan, product specification, key components, failure phenomenon, production enterprise, compare the fault discrete values of each dimension in step 4. Then take the typical factor with the highest failure rate in the dimension with the highest discrete value as the base number, continue to drill down and analyze the remaining dimensions to the smallest unit of the last dimension, stop the running in analysis and summarize the final conclusion, and draw the main influencing factors of typical faults.

5. **conclusion**

This research is a method based on the improved standard difference algorithm to mine and analyze the main influencing factors of typical faults of intelligent electric energy meter, the analysis scope covers the fault and relevant information of the whole life cycle of the electric energy meter. The analysis process does not need human intervention and saves a lot of human resources. The analytical method is widely used, relying on the life cycle data of electric energy meter, it can locate the main influencing factors of typical faults quickly, comprehensively and accurately, and the operation is simple and practical. The analysis results are convenient for power companies to early warn the batch of hidden dangers and ensure the stability of residents' use, it is beneficial for the production enterprise
to deal with the batch defects in time and make corresponding improvement measures, improve the quality of electricity meter production and enhance the reputation of the enterprise.

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