Talking about the significance of optimizing the condition evaluation standard of small power grid equipment such as voltage transformer

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Abstract. Power grid equipment condition evaluation and condition maintenance is a kind of operation and maintenance means with strong reliability, low cost and high efficiency in power grid equipment operation management. At present, when carrying out state assessment of power grid equipment such as, grounding devices, capacitors, reactors, because of the features of large number, frequent failures, complex and changeable operating environment, etc, existing state evaluation standards have obvious deficiencies, which makes it difficult to meet management needs. Optimizing state evaluation standards, formulating scientific and effective state evaluation guidelines are of great significance for improving equipment safety and ensuring safe and stable operation of power systems.

1 Introduction

With the continuous development of modern power technology, there are more and more means for monitoring the operating status of the main equipment, including live detection, online monitoring, bad working conditions, and historical events of equipment. The amount of information reflects the internal and external operating status of the main equipment of the power grid. Using this information to evaluate the operating status of the equipment is a very effective means of operation and maintenance. At present, when carrying out state

assessment of power grid equipment such as, grounding devices, capacitors, reactors, because of the features of large number, frequent failures, complex and changeable operating environment, etc. [1] Existing condition evaluation system is difficult to find abnormal equipment problems effectively, The existing state assessment system is difficult to effectively detect abnormal equipment problems, which not only easily leads to equipment failure, but also leads to abnormal system voltage fluctuation, thus causing damage to other large power equipment, expanding the scope of the accident, and causing serious economic losses and adverse social impact. [2]

Figure 1. State maintenance decision-making process

2 Technical problems faced by condition assessment of small power grid equipment such as voltage transformers

At present, there are a large number of small power grid equipments such as voltage transformers, capacitors, grounding devices in the power grid system, the amount

of these devices is several times more than that of large equipment such as transformers and GIS, but their attention and technical level of operation and maintenance are far inferior to large equipment. [3] In general, we face the following technical problems when we carry out condition assessments of this small equipment.

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2.1 Poor availability of state quantity

The state quantity of the power grid equipment selected in the existing standards is mainly obtained through human eye observation and traditional electrical tests, and the technical means are relatively simple and backward. it is not only difficult to effectively find equipment operation defects, but also has problems such as long condition evaluation cycle, high cost, and low efficiency when evaluating equipment with strong concealment such as grounding devices. [4]

2.2 The grade standard of the deterioration degree is fuzzy

Among the existing standards, the grading standards for the degree of deterioration of the state quantity of power grid equipment are not clear enough and cannot be effectively quantified, which affects the operability of equipment state evaluation. At the same time, the environmental conditions such as temperature, altitude, and soil have not been considered to affect the operation status of the equipment, and no differentiation clause has been formulated, which affect the accuracy of the evaluation. [5]

2.3 The formulation method of weight coefficient is subjective

The weight coefficients and deduction criteria for the state quantity of the existing evaluation system, which lack a scientific and effective determination method, are mainly based on the subjective judgment of personnel. In addition, in oil immersed transformers and other equipment, there are state quantities such as oil chromatography, frequency response, short circuit impedance, which are both independent and connected. So state assessment should not be carried out independently, we should consider the degree of correlation between state quantities and conduct a comprehensive evaluation. Taking a province in the south as an example, from 2009 to 2017, a total of 562 failures of voltage transformers, capacitors, reactors and other power grid equipment occurred. [6] Only 341 cases were found by the state evaluation with abnormal and serious conditions, which are accounting for only 60.7%. And it caused economic losses of up to 80 million yuan. [7]

3 Innovative work of optimizing the state evaluation system of small power grid equipment such as voltage transformers

In response to the above problems, the researchers improved the effectiveness of the evaluation by studying new detection technologies such as multi-channel grounding grid corrosion positioning and reactor encapsulation detection, use data mining methods to improve evaluation operability, and use artificial learning algorithms to evaluate science. The state evaluation management system has been fully optimized to make the state evaluation more scientific, comprehensive, and easy to operate, which effectively improves the safety and reliability of equipment, reduces the cost of equipment operation and maintenance, and has significant economic benefits. [8]

3.1 For the first time, a state evaluation system with a new detection technology such as multi-channel grounding network corrosion positioning technology as the core is built

In order to optimize the evaluation system, aiming at the problems of single state quantity related technical means and inaccurate state evaluation, researchers research on new live detection technologies such as multi-channel grounding grid corrosion positioning technology, reactor encapsulation detection technology, transformer ultrasonic detection technology, etc, and they use the test results as the state quantity to build an advanced state evaluation system, which can effectively solve the problems of insufficient accuracy, long cycle, high cost and low efficiency of the existing state evaluation.

Table. 1 Partial discharge UHF PRPD data partition table

	Corona discharge	Free metal particle discharge	Insulation void discharge	Floating electrode discharge
Train set	6900	6900	6900	6900
Test set	1725	1725	1725	1725

3.2 For the first time, quantitative grading method for the deterioration degree of state based on big data mining technology is built

In order to solve the problem that the classification criteria of the degree of deterioration of the state quantity is not clear, the researchers used the data correlation multi-copy consistent hash data storage (CMCH) algorithm for data mining for massive samples for the first time, and clustered the degree of deterioration of the state quantity in a high-dimensional space Divide and determine the degradation interval. At the same time, considering the environmental factors such as temperature, altitude, and soil, the parameter intervals in different dimensions are determined and converted into quantitative indicators as the basis for judging the degree of degradation.

Table. 2 The result of classifiers.

	Corona discharge	Free metal particle discharge	Insulation void discharge	Floating electrode discharge	Average accuracy
SVM (s.f.)	86.21%	42.74%	43.68%	46.23%	54.72%
SVM (n.f.)	99.63%	94.55%	89.36%	96.21%	94.94%
BP(s.f.)	91.80%	48.08%	67.25%	66.55%	68.42%

BP(n.f.)	98.74%	93.87%	87.45%	97.56%	94.41%
Random forest(s.f.)	86.38%	56.81%	66.59%	39.38%	62.29%
Random forest(n.f.)	89.16%	97.65%	86.65%	94.77%	92.01%

3.3 For the first time, comprehensive scoring method of state quantity based on artificial neural network and correlation analysis is established

In order to solve the subjective assumptions and lack of relevance of weight coefficient and deduction standard of state quantity , Researchers use artificial neural networks (BPNN) to perform deep learning on typical cases, determine the state quantity weighting coefficients and scoring criteria, and obtain scores for each state quantity. [9] At the same time, the researchers use the apriori algorithm based on the compression matrix for the first time to analyze the correlation of different state quantities, determine the state quantity association, and finally calculate the comprehensive score of the equipment to obtain the evaluation results. [10]

4 Conclusion

After optimizing this series of standard systems, the accuracy of the state evaluation of voltage transformers and other small equipment of power grid-related enterprises has increased from 60% in 2017 to 91.6%, which effectively grasps the operation status of power grid equipment, and takes effective measures in time to avoid equipment damage. At the same time, according to the evaluation results, a reasonable maintenance strategy is formulated to avoid repeated power outages, which greatly improves the efficiency of maintenance and saves maintenance costs. It is estimated that 1.3 billion yuan can be saved in the power industry each year, effectively guaranteeing the safe and stable operation of the national power grid, providing a reliable energy guarantee for the sustained and healthy development of the national economy and the continuous improvement of the people's living standards, with significant economic and social benefits.

The optimized standard system tightly grasps the pulse of the maintenance and development of power grid equipment, and it is an important part of the lean production of the power grid. The standard system not only greatly improves the equipment operation and maintenance level, ensures the safety and reliability of the equipment itself, but also effectively guarantees the reactive power regulation of the power system and the safety and stability of the power system voltage, which not only reduces operating costs, but also improves the corporate brand image. It can also continuously summarize equipment design, manufacturing and operation experience, so as to promote the continuous improvement of the test equipment and technical level of the power industry and promote the continuous development of power grid construction.

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