

PAPER • OPEN ACCESS

Application of Transformer Online Monitoring Data in State Evaluation

To cite this article: Demeng Bai *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **486** 012040

View the [article online](#) for updates and enhancements.

Application of Transformer Online Monitoring Data in State Evaluation

Demeng Bai, Jiafeng Qin, Jian Wang and Chengqi Li

State Grid Shandong Electric Power Research Institute, Jinan

baidemeng0119@126.com

Abstract. The safety, stability and reliability of electrical equipment are directly related to the operation of the electrical system. Discovering various electrical equipment problems and effective treatment of the problem without delay will minimize the probability of electrical equipment failure. In electrical equipment monitoring and maintenance, Application of real-time monitoring is one of the most important elements. Real-time monitoring node can detect equipment failure promptly which will avoid the expansion of accident caused by the long test period or manual inspection. Working time of online monitoring nodes is limited by power consumption of node itself. Application of routing protocol can optimize energy consumption and extend working time of nodes.

Keywords: Online Monitoring, Evaluation.

1. Introduction

In most cases, equipment condition monitoring in power grid is acquired by the staff when the equipment is out of power. It is generally considered that equipment condition assessment is the basis of condition-based maintenance, that is, the accuracy of condition assessment can affect the subsequent maintenance decisions. Based on the results of condition evaluation, maintenance decision-making needs to fully consider the security and economy of the power grid, coordinate the maintenance resources, so as to determine the next time and mode of maintenance, and at the same time make a good maintenance plan in advance[1].

How to accurately and effectively evaluate the status of the transformer in operation is one of the hot issues in current research. At present, many evaluations are based on the evaluation model of the status obtained from routine inspection and preventive test, so as to judge the working status of the transformer. At present, many research work evaluation models only focus on qualitative evaluation, and there is no detailed distinction between the relative merits and demerits, and no accurate and reliable state evaluation system and standards, which are not conducive to the implementation of state assessment and condition maintenance work[2].

2. Current situation

With the development of sensor technology, on-line monitoring is widely used in condition monitoring of power equipment[3]. By using real-time data acquired from on-line monitoring in condition evaluation, a quantitative index system is established by fusing multi-source data, thus fully reflecting the operation status of transformers.



Due to the large number of insulation and other state variables of transformer equipment and the complexity of various influencing factors, so far no unified and scientific state evaluation index system has been established. At the same time, existing index systems usually contain quantitative and qualitative indicators, and no unified and effective quantitative method has been formed. Now some research results have been applied to the comprehensive evaluation of insulation operation status of transformers, but because the uncertainty of evaluation indicators is not taken into account, the accuracy of the evaluation results of insulation operation status of transformers is very low [4-6].

On-line monitoring technology refers to installing customized sensors in specific parts of the equipment without power supply, continuously or regularly sensing the condition of the equipment, and displaying the status of the equipment after certain processing of the monitoring data. Due to the important role of transformer in power grid, the current transformer online monitoring technology is relatively mature, and a large number of transformer online monitoring sensors have been deployed.

At present, the basic framework of the on-line monitoring technology for power transformers can be expressed as shown in the following figure 1.

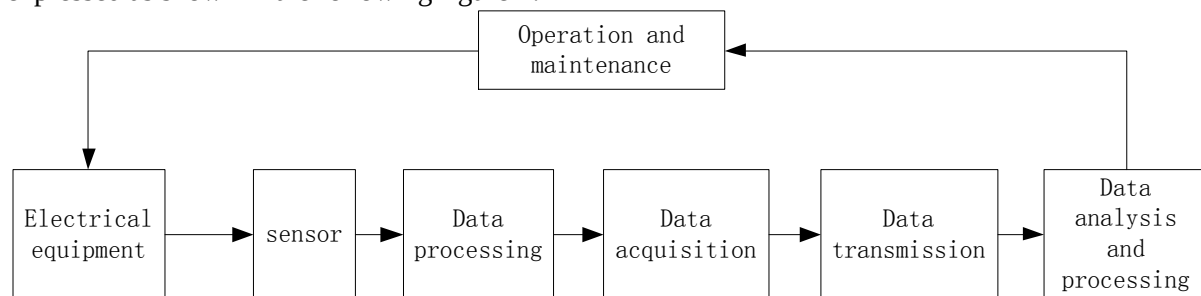


Figure 1. Basic Framework of Online Monitoring Technology

Sensors used to monitor the state variables of power transformers are usually embedded in the transformer or installed on the surface of the transformer shell[7]. The sensors convert all kinds of signals collected into electrical signals for subsequent processing and analysis. As a part of on-line monitoring which contacts directly with transformer body, the performance of sensor will directly determine the effectiveness of the whole on-line monitoring system. Data acquisition system is responsible for collecting electrical signals from sensors[8-9]. Before data acquisition, the signal needs to be preprocessed. The purpose is to adjust the amplitude of the signal and filter the interference signal. After pretreatment, the signal is D/A converted, and then the signal is transmitted to the data processing and analysis system of the main station through optical fiber or wireless transmission.

Transformer is one of the most widely used power equipments in on-line monitoring technology because of its complex structure and numerous accessories. Among many on-line monitoring technologies for power transformers, on-line monitoring technology for dissolved gases in oil is the earliest research and the most mature one in practical application.

At present, the parameters of most on-line monitoring devices are relatively single, without strong pertinence. Generally, only one parameter is monitored by one monitoring device. However, when evaluating the on-line status of transformers, it is necessary to use multiple parameter information to synthetically determine. Therefore, it is usually necessary to use multiple on-line monitoring device information in order to realize data complementation and improve the performance of transformers. Accuracy of information acquisition.

Commonly used on-line monitoring devices are limited to the alarm function of over-limit indicators and do not have intelligence. They also need professional and technical personnel to analyze the original data monitored. Integrative research on monitoring and diagnosis is needed to form an intelligent operation and maintenance system for transformers, which can display the current operation

status of transformers in real time and give corresponding operation and maintenance suggestions according to the on-line monitoring information.

3. Fusion Evaluation Framework of Transformer Online Monitoring Data and Test Data

Transformer equipment in power grid is a very complex system, which is used to represent the state information of transformer operation. A single state information can only reflect the state of one aspect of transformer. For example, transformer winding deformation test can only check whether there is deformation or displacement caused by external force or short circuit; insulation paper polymerization test can only reflect the aging of insulation paper, so as to evaluate its life. Because there are a lot of uncertainties and fuzziness in the relationship between each single state variable, it is difficult to evaluate and diagnose power transformer effectively and accurately only through one or two detection data.

In order to accurately evaluate the operation status of transformer and find its potential faults in time, it is necessary to use the powerful data processing and decision-making ability of multi-dimensional information fusion technology to comprehensively process various monitoring data reflecting all aspects of transformer status. Therefore, it is necessary to screen out comprehensive and reasonable monitoring and evaluation indicators according to various regulations and expert experience, and establish a perfect and feasible condition evaluation system for power transformers. Figure 2 shows power transformer evaluation and diagnosis architecture diagram.

In the data processing module, firstly, using multi-dimensional information fusion technology, referring to various transformer operation and maintenance regulations, expert experience, select appropriate, real and effective monitoring quantity to reflect transformer condition, and establish transformer condition monitoring system. Under the guidance of supervisory system, suitable, economical and effective monitoring technology is selected to carry out data analysis of transformers, and the best monitoring data are analyzed and processed in a unified dimension to establish a set of samples.

In the data assessment module, according to the normalized data transmitted from the data processing module, the evaluation and analysis are carried out. By establishing an appropriate state evaluation method and evaluation system, the current operation status of transformer is analyzed in the acceptable range. If it is within the acceptable range, the corresponding maintenance and repair plan is formulated according to its operation status. If it is beyond the limit, the evaluation will be made. The results and the corresponding data are transmitted to the diagnosis module to diagnose the transformer accurately.

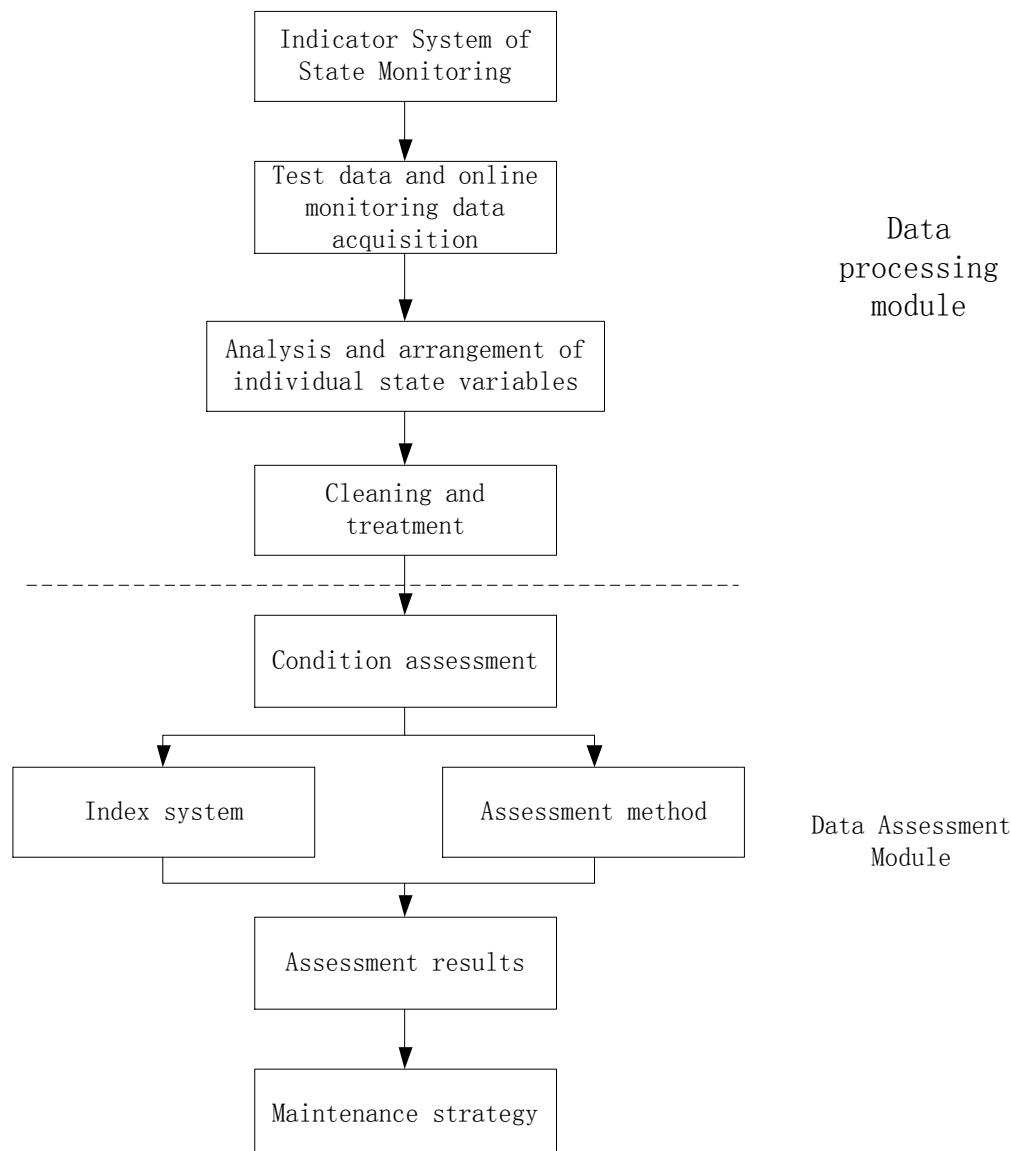


Figure 2. Power Transformer Evaluation and Diagnosis Architecture Diagram

4. Selection of state quantity indicators

Because there are many indexes that can reflect the real-time operation status of transformers, and they reflect the advantages and disadvantages of the operation status of transformers at different levels and degrees. Only by establishing a reasonable and scientific transformer monitoring index system can the power transformer be evaluated and diagnosed more accurately and effectively. Because transformer manufacturers, manufacturing materials, internal structure will be different, especially in the capacity and voltage level differences, will lead to different indicators that can affect the evaluation. In order to evaluate more pertinently, this paper mainly chooses 220kV transformer, which has a large number of equipment data.

Transformer Test Indicators

Transformer test indexes include factory test, routine test and diagnostic test. Frequent tests include infrared detection, dissolved gas analysis in oil, winding resistance, core insulation resistance, winding dielectric loss factor, etc.

Online monitoring indicators

On-line monitoring data is usually high frequency, which can reflect the operation of equipment more quickly. The commonly used indicators are oil chromatographic indicators, micro-water content in oil, partial discharge, winding temperature and winding resistance. Figure 3 shows the deduction process of each state quantity.

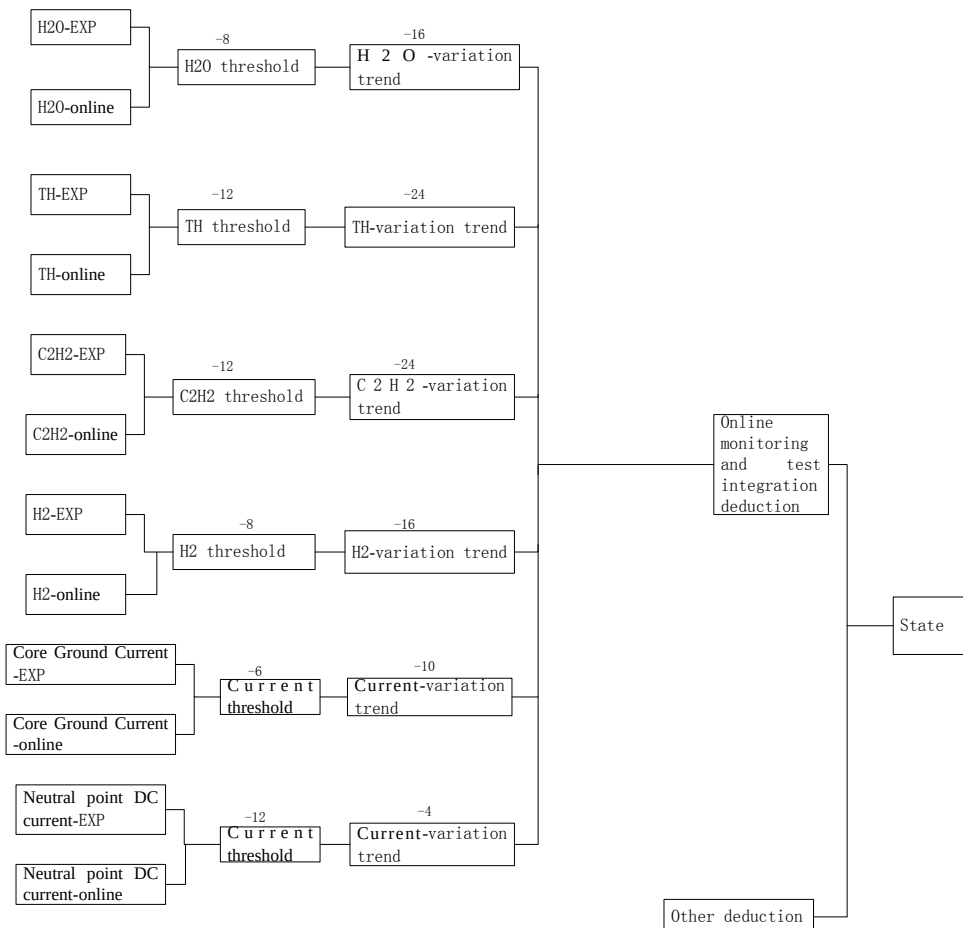


Figure 3. The deduction process of each state quantity

5. A TYPICAL CASE

Taking two 220kV transformers as examples as shown in table 1, the models are SPSF7-150000/220 and SZ11-50000/220, which have been running for 20 and 13 years respectively. The operation and test data of the two transformers are shown in the table.

TABLE 1. Datas of two 220kV transformers

Data type	Core Ground Current	Neutral point DC	H2(ul/l)	C2H2(ul/l)	$\sum$ TH Ci(ul/l)	H2O (mg/L)
Normal test	0.04	0.21	8.7	0	27.1	8
Online	0.02	0.14	12.3	0.2	25.6	11
variation trend	Core Ground Current	Neutral point DC	H2	C2H2	$\sum$ TH Ci	H2O
Online	1%	2%	1%	3%	8%	17%

If using the general evaluation method, the status of two transformers will be evaluated as normal, but after the application of on-line monitoring data, the status of two transformers can be divided into 16 single deductions, which are evaluated as attention status according to the criteria. Equipment operators will also adjust the equipment to a state of attention after on-site inspection and verification, and strengthen later inspection.

6. Conclusion

Power transformer is an important equipment in power grid, its operation status will greatly affect the stability and reliability of power grid. In this paper, the impact of the new technology is analyzed in view of the extensive application of on-line monitoring devices in power grids. The monitoring data are further processed and the on-line monitoring data and test data are integrated and evaluated in-depth, so that the working status of transformer equipment can be more accurately evaluated.

References

- [1] LIAO Ruijin, ZHENG Hanbo, et al. 2011 An integrated decision-making model for condition assessment of power transformers using fuzzy approach and evidential reasoning IEEE Transactions on Power Delivery, 26(2)pp 1111 -18
- [2] DOMINELLI N, RAO A, et al. Artificial Intelligence Applications in the Diagnosis of Power Transformer Incipient Faults, 2006 IEEE Transactions on Power and Energy Magazine, 4(3)pp 24-35
- [3] Su Q, Mi C, Lai L L, et al. A fuzzy dissolved gas analysis method for the diagnosis of multiple incipient faults in a transformer, IEEE Transactions on Power Systems . 2000
- [4] Lee Y, Wahba G, Ackerman S., Classification of satellite radiance data by multicategory support vector machines, Journal of Atmospheric and Oceanic Technology . 2004
- [5] CHENG Zhihua, ZHENG Ruirui, ZHAO Jiyin, et al. Mineral oil-impregnated electrical equipment in service: guide to the interpretation of dissolved and free gases analysis, 2008 Transactions of China Electrotechnical Society, 23 (8)pp 60-66
- [6] LIAO Ruijin, ZHENG Hanbo, et al. A power transformer insulation condition assessment method based on set pair analysis, Automation of Electric Power Systems, 34(21)pp 55 - 60
- [7] ZHANG Yiyi, LIAO Ruijin, et al. Multicategory support vector machines, theory, and application to the classification of microarray data and satellite radiance data, 2012 Transactions of China Electrotechnical Society, 27(5)pp 13-20
- [8] WANG Qin, WEN Fushuan, et al. Research on Transformer Fault Diagnosis Expert System Based on DGA Database, 2009 Automation of Electric Power Systems, 33(7)pp 33-37
- [9] CHENG Jin, ZHONG Yi, et al. Analysis and Treatment of the Inner Fault in a 750 kV Transformer High Voltage Apparatus High Voltage Apparatus 52(2)pp 200-04