Research on Condition-Based Maintenance Technology of Power Equipment Based on Information Fusion Fault Diagnosis Technology

Wei Ya

State Grid Henan Electric Power Company Electric Power Research Institute Customer Service Center, Zhengzhou, 450000, China

Keywords: Information Fusion; Fault Diagnosis; Power Equipment; Condition Based Maintenance

Abstract: With the continuous expansion of the power system, the number of large substations is gradually increasing, and the reliability and technical level of electrical equipment in substations are also increasing. In order to improve the reliability of power supply and high-quality service, it is necessary for enterprises to change the original fixed mode of periodic maintenance and carry out equipment condition maintenance. However, the prerequisite for timely condition-based maintenance is the correct inspection method and discrimination basis for equipment health status. The application of condition-based maintenance technology for power equipment must be based on the overall monitoring of equipment. An accurate reliability model of equipment is established in order to realize on-line monitoring of equipment status and develop an expert system which can be better applied to equipment fault diagnosis.

1. Introduction

With the rapid development of social economy, people's daily life and the production of enterprises are increasing the use of various power equipment, which to a large extent will increase the burden of power equipment and power grid. In order to effectively ensure the normal operation of power equipment economically, safely and stably, it is necessary to strengthen the condition-based maintenance and fault diagnosis of power equipment. How to reasonably arrange the maintenance of power equipment, save the maintenance cost, reduce the maintenance cost, and ensure the high reliability of the system is an important topic for the system operators. At present, China is actively exploring and practicing the condition-based maintenance system. In order to save costs and reduce maintenance costs, and take timely and effective measures to deal with, to improve people's living standards and quality has important significance and role.

2. Evolution of Maintenance System

The evolution of maintenance concept has gone through two stages: afterwards maintenance/failure maintenance (the first industrial revolution in the 18th century) and preventive maintenance (the second industrial revolution in the 19th century). Post-repair, also known as fault repair, is the earliest repair method. This maintenance method takes the functional failure of the equipment as the criterion, and only carries out maintenance when the equipment fails and cannot continue to operate. In the second industrial revolution period, preventive maintenance began to be carried out. After years of development, according to the different technical conditions and objectives of maintenance, preventive maintenance has appeared such maintenance methods as condition-based maintenance, periodic maintenance, reliability-centered maintenance, fault finding, repairing from use to damage, active maintenance and so on. Among them, condition-based maintenance aims at equipment safety, reliable power supply and environmental benefits. In order to ensure the safe and sTable operation of power equipment and reduce the cost of maintenance, state assessment, risk assessment and maintenance strategy are taken as the key points.

China has always adopted the method of regular power outage maintenance for power equipment. Through the formulation of preventive test procedures for power equipment, operators are instructed to conduct power outage tests, maintenance and maintenance for equipment on a regular

  DOI: 10.25236/mmmce.2019.008

basis. Although various pre-test methods can find some equipment defects to some extent, the test voltage is basically far lower than the normal operating voltage of the equipment, so it cannot correctly reflect the operating state of the equipment.For some equipment internal fault or hidden trouble can not be found in time, can not ensure the safe operation of equipment. Since the 1980s, with the progress of electronic technology, sensor technology, optical fiber technology, computer technology, information processing technology have been applied in various fields of economic development, and achieved good practical results.

3. Defects of Traditional Fault Diagnosis Method and Application of Neural Network

3.1 Comparison of different types of neural networks for transformer insulation fault diagnosis

Fault diagnosis of power equipment is a process of searching for various latent fault symptoms and then explaining the causes of these symptoms. For example, when oil-filled transformer has fault precursors or latent faults, some gases will be decomposed from transformer oil. By detecting the composition and content of these gases, the operation status and fault degree of transformer can be preliminarily diagnosed. There are many traditional methods to judge transformer faults by gas chromatography data in oil, such as Rogers method, characteristic gas method and three-ratio method. These methods have solved some problems, but the methods themselves are imperfect to a certain extent. Even for the same set of test data, different diagnostic methods may sometimes lead to different diagnostic results.

3.2 Comparison of Training Performance for Fault Diagnosis of Different Types of Neural Networks

Comparison of Diagnostic Results between Radial Basis Function RBF Network and BP Network Theoretically, RBF Network and BP Network can approximate any continuous nonlinear function. The main difference between the two lies in the use of different action functions. The function of RBFN hidden layer is Gaussian kernel function, which is local. The hidden nodes in BP network use Sigmoid function, whose function value is non-zero in the infinite range of input space, and BP network is used for function approximation.The gradient descent method is used to adjust the weights. This method has some shortcomings, such as slow convergence speed and local minimum, and has some application limitations. RBF network is superior to BP network in this respect. The best approximation ability of RBF network makes it have a good field use value.

In order to compare the training performance of the network, under the same target error, the simulation results are shown in Tables 1 and 2.

Table 2 Comparison of simulation performance of four kinds of neural networks

Network type	Sum of squares of training errors	Number of Hidden Elements	Diagnostic simulation time
BP network	4.8846	31	29.973
RBF Network	0.098142	113	0.241
LVQ pattern classification neural network	53	30	0.18
Probabilistic Neural Network	4	115	0.19

Table 2 Comparison of the Accuracy of Four Neural Network Diagnostic Methods

Network type	Fully in line with reality	Approximate coincidence	Incorrect
BP network	77.26%	0	23.74%
RBF Network	77.26%	4.56%	18.19%
LVQ pattern classification neural network	81.83%	4.56%	13.64%
Probabilistic Neural Network	86.35%	9.19%	4.56%

RBF neural network overcomes some inherent shortcomings of BP network. It has simple

structure, fast convergence speed and shows stronger vitality than BP network. The algorithm of fault pattern recognition using LVQ network is simple and the training speed is fast. Probabilistic neural network is a kind of radial basis function network suiTable for pattern classification.It not only has the function of statistical classification, but also is not limited by conditions such as multivariate normal distribution. In the model studied in this paper, its fault diagnosis accuracy is the highest.

4. Application of Infrared Diagnosis Technology in Electric Power Production

4.1 Multi-expert Diagnostic Information Fusion

Infrared technology is a technology that studies the generation, transmission, conversion, detection and application of infrared radiation in practical work. In 1953, Swedish AGA Company (later AGEMA Company) developed the world's first thermal infrared imager, which was mainly used in military affairs. Subsequently, in 1965, the first commercial thermal imaging system for electrical equipment inspection came out and achieved good benefits. It uses infrared radiation invisible to human eyes as a carrier to transmit information, which can bring people's vision into an invisible world. Infrared technology plays an important role in power production. In order to improve the reliability and quality service of power supply, it is necessary for enterprises to change the fixed mode of periodic maintenance and carry out condition-based maintenance of equipment. The precondition of timely condition-based maintenance is the correct inspection method and judgment basis of equipment health condition. With the application of new technology and technology in operation field, infrared temperature measurement technology is more and more widely used in substation operation. In this way, on-site defects can be found in time under the condition of equipment operation, which provides a basis for the first link of equipment condition-based maintenance information collection system.

When multiple expert systems are used for diagnosis, the diagnosis results obtained by each diagnosis module are different, and how to fuse the diagnosis results of multiple experts is particularly important. The information of transformer fault diagnosis not only comes from the measurement of sensors, but also includes some knowledge, some intermediate results, or the same, similar or different information is called redundant information, cross information and complementary information respectively). On the other hand, the information of sensors in fault diagnosis is the most original information. Using them, we can extract some characteristic information about faults, which is called fault representation.

4.2 Structure of Diagnostic Expert System Based on Information Fusion

Based on the systematic research of transformer insulation fault diagnosis method, and supplemented by many other diagnosis methods, an expert system for transformer insulation fault diagnosis based on information fusion is designed by using information fusion technology. With the continuous expansion of power system scale, the number of large substations is gradually increasing, and the reliability and technical level requirements of substation electrical equipment are also increasing. Especially with the promotion of unattended substation, the requirement of substation automation is getting higher and higher. Since the 1990s, the substation integrated automation system, which integrates relay protection, fault recorder, telecontrol and in-station monitoring, has been successfully developed at home and abroad. It replaces the conventional measurement system of the substation, integrates various devices and protection information of the substation, and improves the automation degree of the substation to a brand-new stage. The real-time operation and remote operation monitoring capability of the dispatching center are greatly improved, which lays a foundation for realizing unattended substation. With the rapid development of computer and communication technology and its application in substation automation, the overall automation level of substation electrical equipment in China has undergone profound changes. Therefore, how to improve the monitoring methods of the existing power grid and help operators to improve their ability to correctly judge and deal with fault conditions is an important research topic for power

workers.

5. Conclusion

Experts predict that the power industry will have greater development in the next century, but boilers, turbine-generator units and transformers, which are major power equipment, will not change much. Therefore, the research on power equipment maintenance technology will have more economic and social benefits. It is imperative to develop power equipment maintenance from planned maintenance to condition-based maintenance. The application of condition-based maintenance technology for power equipment must be based on the overall monitoring of equipment. There are still many problems to be solved on how to establish an accurate reliability model of equipment in order to realize on-line monitoring of equipment status and develop an expert system which can be better applied to equipment fault diagnosis.

References

[1] Gang M, Linru J, Guchao X, et al. A Model of Intelligent Fault Diagnosis of Power Equipment Based on CBR[J]. Mathematical Problems in Engineering, 2015, 2015:1-9.

[2] Tian H, Kang X Y, Zhang J N, et al. Fault Diagnosis of Gearbox Based on Information Fusion Technique [J]. Applied Mechanics and Materials, 2014, 543-547:1083-1086.

[3] Cai B, Liu Y, Fan Q, et al. Multi-source information fusion based fault diagnosis of ground-source heat pump using Bayesian network[J]. Applied Energy, 2014, 114:1-9.

[4] Yang G, Yu S, Wen S. Research on fault diagnosis system of hall for workshop of meta-synthetic engineering based on information fusion[J]. EURASIP Journal on Information Security, 2017, 2017(1):18.

[5] Kyriazis A, Mathioudakis K. Gas Turbine Fault Diagnosis Using Fuzzy-Based Decision Fusion[J]. Journal of Propulsion and Power, 2009, 25(2):335-343.

[6] Liu J, Zhang M, Zuo H, et al. Remaining useful life prognostics for aeroengine based on superstatistics and information fusion[J]. Chinese Journal of Aeronautics, 2014, 27(5):1086-1096.