Research Status of Gas Turbine Fault Diagnosis based on Artificial Intelligence

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Abstract: In recent years, gas turbine has been widely used as an excellent power equipment. But at the same time, with the continuous development of gas turbine technology, problems and challenges are emerging in endlessly, among which the loss caused by gas turbine fault is the most difficult problem to solve at present, so efficient and accurate fault diagnosis is an important link in the development of gas turbine technology. And the rapid development of artificial intelligence methods in recent years, for the fault diagnosis of gas turbine provides a new solution, this article mainly introduces the various artificial intelligence methods widely used in fault diagnosis, the application of artificial intelligence method in the gas turbine is analyzed and the advantages and disadvantages of the application of fault diagnosis, and prospects the development direction of this technology in the future.

1. Introduction

In recent years, as a new type of power equipment, gas turbine has been widely used due to its advantages of compact structure, small volume, rapid start-up and shutdown, variable operating conditions and high thermal efficiency. But at the same time, also because of its high internal temperature during operation, the system is more complicated, in the work also exist such problems as high failure rate, can't predict in advance the fault, if not timely detection and treatment, will reduce the reliability of the equipment, loss of production function, and cause huge economic losses, even lead to machine apart major accidents. Therefore, it is of great significance to predict and deal with faults in time.

2. Principle and Status of Fault Diagnosis

Fault diagnosis is used to reflect the situation of technology equipment in use process status, can distinguish fault types of equipment, through the research of the relationship between the fault features, to judge whether running state fails, what kind of specific failure occurs, through study of fault symptoms and fault characteristics to determine the equipment reliability and availability of global or local. The occurrence of fault is a process of gradual change, and certain symptoms will be revealed before the fault is completely generated. Therefore, fault diagnosis can be used to detect faults in advance, which is conducive to the safe operation of the equipment [1].

In the traditional method, the fault treatment of gas turbine adopts the method of regular maintenance, that is, the maintenance and replacement cycle is determined by the working time of the main components of gas turbine, and the maintenance is carried out according to the interrupted work life determined by the manufacturer. Up to now, the maintenance mode is still in China by means of major maintenance, the main drawback of this approach is that only according to the statistics law of running time as maintenance basis, and cannot effectively prevent those who have no direct relationship with the use time of failure, at the same time, also ignore the gas turbine running environment and conditions of individual differences, resulting in the corresponding maintenance. And through the use of advanced fault diagnosis technology can accurately and efficiently evaluate the state of the gas turbine, exceptions can be found as soon as possible, on the

one hand, on the other hand can timely deal with gas turbine failure, effectively prevent the catastrophic accidents caused by the fault development, in addition can also reasonable and scientific arrangement of maintenance time, save maintenance costs, improve equipment service life effectively. Therefore, it is of great significance for the safety and economy of gas turbine operation to adopt a new method to effectively diagnose the fault of gas turbine and reasonably arrange the operation and maintenance plan on this basis.

3. At Present, Main Artificial Intelligence Methods are Applied in Fault Diagnosis

In recent years, due to the rapid development of computer technology, many efficient and accurate algorithms have provided new solutions for the development of fault diagnosis technology. Based on artificial intelligence diagnosis method does not need to diagnosis objects have a precise mathematical description or set up detailed physical models, and can according to the reaction in the diagnosis of running state monitoring data object to study, so as to realize the automatic identification and prediction of the unknown state, such as neural network diagnosis method, support vector machine (SVM) diagnosis, evolution intelligent diagnosis, diagnosis expert system, fuzzy fault diagnosis, information fusion diagnosis method, etc. The data-oriented approach provides a good solution to the problem of fault diagnosis.

3.1 Expert System Diagnosis

Expert system is a knowledge base built by domain experts based on accumulated experience in long-term practice, and then fault diagnosis is conducted by a set of computer programs designed by imitating human experts' speculation and decision process [2].Fault diagnosis method based on expert system has many advantages, such as do not need to complete is based on the analysis of the physical model is set up, only need to use the knowledge in the field of heuristic knowledge for reasoning diagnosis, the diagnosis is simple, intuitive and easy to accepted, so the fault diagnosis is used in many areas, has a good diagnosis effect. However, the method based on expert system also has some defects. First of all, the experience in the knowledge base of expert system is limited, and the diagnosis result is inevitably inaccurate, unsupported and incomplete. The diagnosis accuracy is closely related to the knowledge level of expert experience in the knowledge base. At the same time, the development of expert system is also difficult and requires a lot of work.

3.2 Neural Network Diagnosis

Fault diagnosis system based on neural network is a "black box" system, which can complete diagnosis based on fault data without a clear understanding of fault mechanism. Moreover, the capacity of neural network is large, which can solve a large number of fault mode classification problems [3].

Artificial neural network is an important branch of artificial intelligence algorithms, it is the core of running through the analysis of the human brain neural network structure to build a simulation of the human thinking, decision making, behavior of artificial neural network algorithm, is essentially through the simulation of the neurons to establish a nonlinear network structure features, and then based on the study of large amounts of data, find the relationship between the state of the system previously hidden fault and the fault, at the same time also do not need a deeper understanding of the mechanism of failure, this method does not need a mathematic model of the system, can according to the state of the system data, set up effective, rapid and accurate prediction model, has the very good fault tolerance, with the ability of memory and association, it can quickly classify known faults and realize effective classification for some unknown faults by virtue of its associative ability, which is a function difficult to realize by other diagnostic methods.

However, in practical application, artificial neural network also has some problems. First of all, it is impossible to know the mechanism of fault occurrence. Secondly, the establishment of an accurate neural network model requires a large number of fault-related accurate data as well as the complete pre-fault state parameters of the whole system. These data are very important for the accuracy of the

established neural network and are also difficult to obtain. Finally, the training time of neural network is very long, and the establishment cycle is also very long. In the case of few or incomplete data, inaccurate diagnosis such as local optimal solution is easy to occur. At the same time, due to the unclear fault mechanism, it is difficult to judge whether the diagnosis result is correct or not.

3.3 Support Vector Machine Diagnostics

Support vector machine (SVM) is a kind of machine learning algorithm, using the statistical learning theory and support vector machine (SVM) is to establish a good set of machine learning theory and method under the condition of small sample, its core idea is to learn the machine should be compatible with limited training samples, both the strict theoretical basis, and can better solve the small sample, nonlinear, high dimension and local minimum point and so on practical problems, has a good learning performance and generalization ability, and therefore they are widely used in fault diagnosis of [4].But at the same time, there are also some problems such as the difficulty in classifying abnormal data and the slow convergence speed in algorithm learning, which are the focus of current research. Moreover, this kind of method is only valid for the specific data studied by the researcher and is not universally applicable.

3.4 Information Fusion Diagnostics

With the rapid development of sensor technology, a variety of information systems have emerged. In these systems, due to the requirements of information diversity, information capacity and information processing speed, the information fusion technology comes into being [5].Multi-sensor information fusion refers to the multi-level, multi-faceted and multi-layered processing of data from multiple sensors, so as to produce new and meaningful information that cannot be obtained by any single sensor [6].

Multi-source information fusion technology can fuse all kinds of information collected by various sensors in the system, so that more accurate and complete diagnostic results can be obtained by using this technology. Through automatic analysis and synthesis of multi-source information to obtain more reliable conclusions. In the fault diagnosis method based on information fusion, the feature extraction of signal is realized by various signal processing methods, and the information fusion can be realized by artificial intelligence methods such as neural network, fuzzy logic or expert system, so it focuses on the advantages of signal processing method and machine learning-based processing method [7].

4. Advantages and Disadvantages of Artificial Intelligence Method in Gas Turbine Fault Diagnosis

4.1 The Advantages of Artificial Intelligence Methods

Artificial intelligence is a newly emerging fault diagnosis method in recent years. Generally, the fault diagnosis method based on artificial intelligence has been widely applied in this field because it is good at simulating the process of human processing problems, easy to consider human experience and has certain learning ability [8].But for the gas turbine, which is a very complex power equipment with poor working conditions, the application of this method for fault diagnosis has certain advantages.

Compared with traditional fault diagnosis, the advantages of gas turbine fault diagnosis based on artificial intelligence can be summarized as follows:(1) able to simulate the thinking mode of human to deal with the problem of fault diagnosis (2) without a clear understanding of the fault mechanism can accurately predict the fault;(3) it can be combined with easily obtained sensor data to improve the efficiency of fault diagnosis;(4) the unknown fault also has a certain ability to predict;(5) easy to use by maintenance personnel;(6) diagnostic results are more accurate and reliable.

4.2 The Disadvantages of Artificial Intelligence Methods

Although artificial intelligence method has many advantages in fault diagnosis of gas turbine, it also has some problems. First, the establishment of artificial intelligence model requires a large number of faults and pre-fault data, which is difficult to obtain in a short time, and the cost of obtaining these data is also very high. Secondly, the accuracy of diagnosis is too dependent on the algorithm, which has a high requirement on the algorithm.

The shortcomings of artificial intelligence method in gas turbine fault diagnosis are as follows: (1) the large amount of data needed to build artificial intelligence model is difficult to obtain or has high cost;(2) high requirements on the algorithm, if the algorithm is not applicable to the problem, then the training model is easy to appear local optimal solution or difficult convergence problem;(3) it is impossible to know the fault mechanism, prevent the fault, and perfect the whole gas turbine system according to the fault mechanism;(4) compared with the traditional method, the cost of early investment is higher, there is no good economy.

5. Conclusion

On the whole, in the current rapid development of computer technology, software technology, artificial intelligence technology is also developing very fast, this technique is widely used, and the development prospects are very good, but the technology is still some deficiencies, in technology development and utilization, technology promotion, as well as some problems, in terms of technology is not mature enough. In order to improve the fault diagnosis technology based on artificial intelligence as soon as possible, we should develop a practical fault diagnosis system software based on artificial intelligence according to the actual needs of engineering, so that the technology can really be applied and bring value. At the same time, due to the complexity and diversity of learning problems and the working principle of the computer of restriction and limitation, in the artificial intelligence method of fault diagnosis accuracy is still no breakthrough progress, therefore, USES the advanced theory and algorithm updates on issues such as the rules of knowledge acquisition, a breakthrough, improve the learning ability, is an important development direction in the future [9].Gas turbine technology is not only a representative technology of efficient energy utilization by human beings, but also a high-tech product symbolizing the level of industrial development. If progress can be made in gas turbine fault diagnosis, it is bound to make progress in gas turbine technology.

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