

Analysis of key techniques of condition monitoring and fault diagnosis of mechanical system

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Abstract. In the rapid development of social economy and science and technology, the mechanical field has brought more problems, such as some large generator equipment during the work of the problem will affect the overall work efficiency and quality, so the relevant state detection and fault diagnosis technology is very important. Nowadays, Chinese scholars are actively studying the mechanical system condition monitoring and fault diagnosis technology, while integrating existing technical theories and gradually forming a relatively complete application system. The emergence of artificial intelligence also provides a new idea for equipment fault maintenance. Therefore, after studying the status of Chinese mechanical system status monitoring and fault diagnosis research, this paper, according to the common fault diagnosis methods, takes the large complex mechanical system as an example to analyze the case, and finally judges the application value of condition monitoring and fault diagnosis technology.

Keywords: mechanical system; Condition monitoring; Fault diagnosis; Signal processing technology; Fuzzy diagnosis.

1. Introduction

In the construction of modern society, mechanical system has been widely applied in many departments of national economy, and it is an important sign of our country's industrial modernization and intelligentization. From the perspective of overall development, how to ensure the safe operation of mechanical systems has a positive impact on improving product quality, reducing application costs, order and protecting the environment. However, the probability of safety failure in the application of mechanical systems is extremely high, which will not only threaten the technological development and innovation in the mechanical field, but also cause uncontrollable safety consequences. As the application equipment presents the characteristics of complexity and large scale, the working time and efficiency requirements are increasingly high, leading to corrosion aging, equipment deformation, work fatigue, friction damage and other problems often occur in most mechanical systems. Therefore, domestic and foreign scholars have strengthened the research on the condition monitoring and fault diagnosis technology of mechanical systems. Expect to continuously optimize our current technical means in practice exploration. [1.2.3]

In essence, condition monitoring and fault diagnosis technology, as an emerging discipline of modern equipment management, mainly serves the lifelong management of mechanical systems. Specific research includes fault diagnosis, condition monitoring, system operation, decision maintenance, trend forecast and other contents. Different types of sensors will be used to detect and analyze the physical data and chemical information of the working state of equipment. In order to accurately grasp the working state of the equipment, and then to the experts in the detection process, master the relevant value changes, use the experience of the equipment has been diagnosed for reasoning judgment, quickly find the location of the safety fault and the main causes, and then develop effective treatment measures. The mechanical fault prevention Group was established in the United States in the mid-1960s. The practical research contents include fault definition, bearing fault, field monitoring, fault prediction, fault prevention, oil spectrum analysis and many other contents. At present, a large number of systems have been developed for formal application. In the late 1960s, Europe also put forward relevant research topics, among which the British Machine Health monitoring Center first proposed the study of fault diagnosis, and in the early 1980s founded Wolfson Industrial Maintenance company, mainly for fault diagnosis research and consultation;

Other European countries have also made excellent achievements in the research of equipment diagnosis technology. For example, Finland has developed a new automatic magic monitoring and diagnosis system based on the hydraulic system of Marine diesel engine. Japan's mechanical fault diagnosis technology has been applied and developed rapidly in the civil industry. For example, some enterprises have launched the nuclear reactor diagnosis management system, and some enterprises have developed railway electromechanical diagnosis system. But in the analysis of mechanical system condition monitoring and fault diagnosis technique, mainly applied the relevant theory and technology in electric power, metallurgy, petrochemical and other industries, until the 1990s, the relevant technical theory was rapidly infiltrated into every field of national economy. At present, only from the perspective of electric power system, the technical system of condition monitoring and fault diagnosis has reached nearly a set. Therefore, on the basis of understanding the status quo of application development of condition monitoring and fault diagnosis technology at home and abroad, according to the mechanism research and application technology of fault diagnosis, taking condition monitoring and fault diagnosis of large complex mechanical system as an example, this paper comprehensively explores the technical methods and effective schemes of practical application, in order to provide effective guarantee for the construction and application of mechanical system in the new era. [4.5.6]

2. Method

2.1 Large complex mechanical system

From the perspective of practical application, large complex mechanical systems have nonlinear, time-varying and other characteristics, often appear multiple damage or multiple failures coexist phenomenon, traditional simple working condition monitoring and fault diagnosis system only need to process the original data, after obtaining signal characteristics for statistical judgment, it can not meet the needs of large complex mechanical systems research. Therefore, in order to better deal with the state problems of large complex mechanical systems, some scholars focused on the mechanical system fault dynamics model and the transfer function matrix between multi-fault sources and multi-sensors, in-depth analysis of the complex mechanical system partition criteria, and regard it as the basic condition of multi-sensor grouping optimization, so as to improve the storage content of effective information in the system as much as possible. Meanwhile, based on the research of multi-sensor measurement data processing, expert knowledge and fault model, the theoretical framework of hybrid classifier based on online parallel simulation is proposed, and the application structure of fault detection and diagnosis method as shown in FIG. 1 below is constructed. [7.8.9]

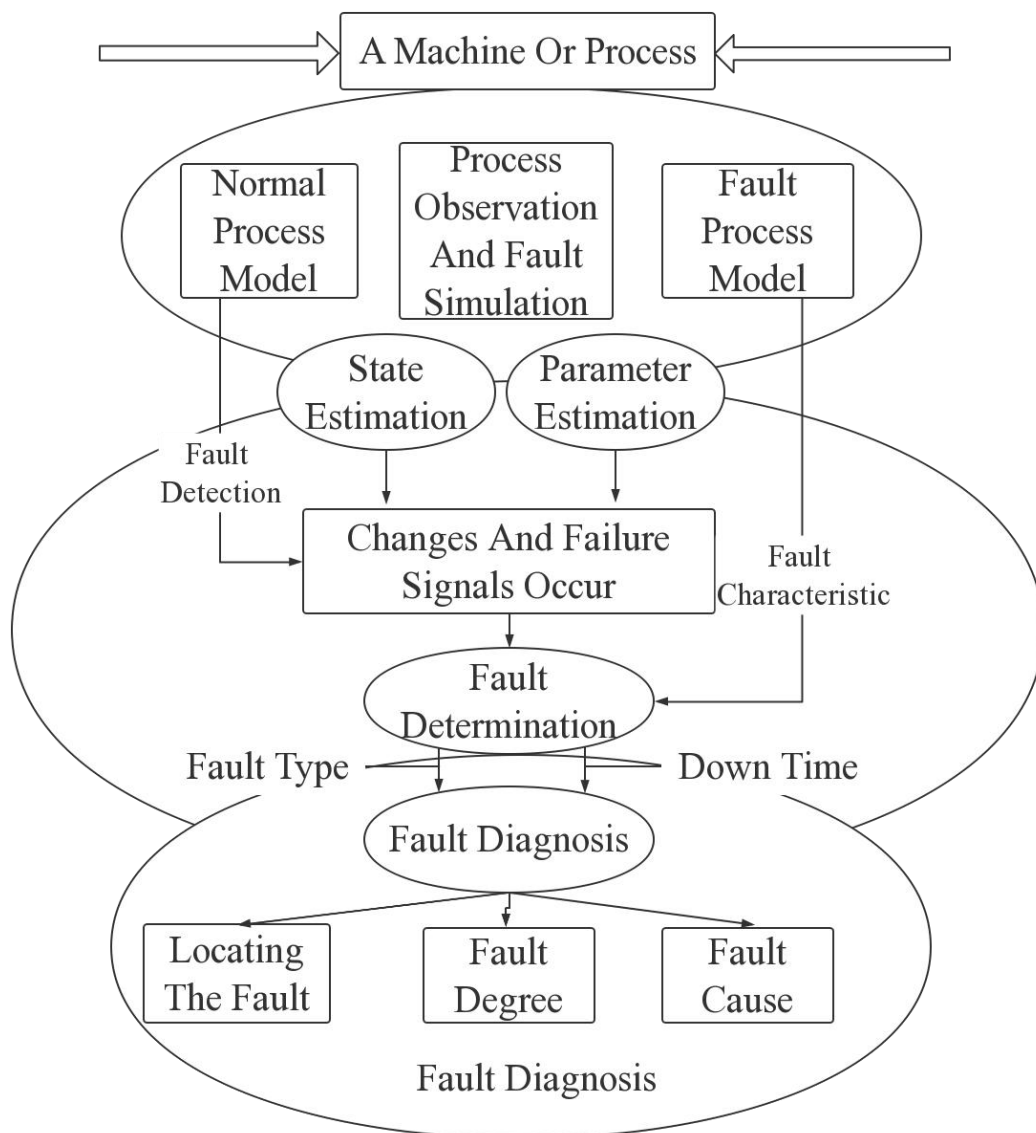


Figure 1 General structure frame diagram

Based on the analysis of the above figure, we can see that on the one hand, accurate data model, neural network model, fuzzy control table and knowledge base should be combined with each other to provide perfect spatial variable relations for the mechanical system and form a composite model network. On the other hand, effective training and scientific correction should be carried out during machine operation by means of online identification, observation data analysis, fault simulation and theoretical analysis. Since some parameters in the system cannot be measured directly, indirect measurement technology should be used for processing during the work, and statistical analysis, fuzzy mathematics, stochastic theory, theoretical calculation and other methods should be combined for integrated research. Finally, the application scheme as shown in Figure 2 below is formed: [10.11.12]

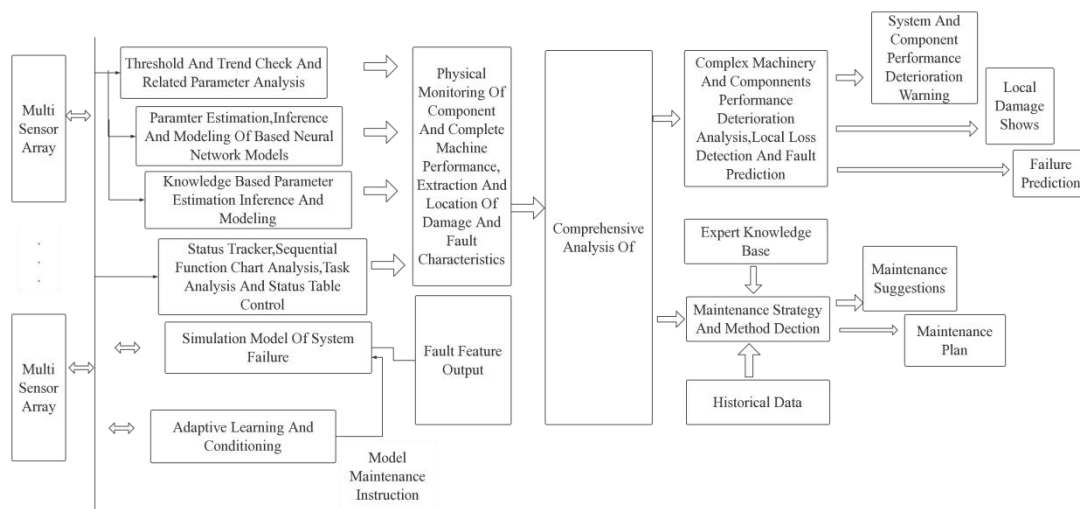


Figure 2. Structure diagram of software scheme for fault diagnosis of large complex machinery

Based on the analysis of the figure above, it can be seen that there are many operation problems of large complex mechanical systems mastered at present, most of which still need to be studied and dealt with by combining theoretical knowledge and practical cases, so as to be widely used in the industrial field.

2.2 Application methods of condition monitoring and fault diagnosis

First, signal processing technology. The technical means of signal processing and feature extraction in fault diagnosis mainly apply the signal processing technology in the general sense to carry out operations. It is necessary to master the original signal of monitoring system scientifically to provide effective basis for subsequent diagnosis and analysis. Nowadays, there are many diagnostic methods with signal processing and feature extraction as the core, such as amplitude range feature method, time difference feature method, waveform feature diagnosis method, information feature method, among which spectrum analysis is the most widely used. Although our country has increased the research and management of this field, a large number of theoretical methods emerged in the market, but the real-time monitoring needs to be strengthened.

Secondly, fuzzy diagnosis. As the working state of equipment continues to change, the expression of empirical knowledge is uncertain, so some scholars add fuzzy concepts when studying the state, monitoring and fault diagnosis technology of mechanical system. In essence, fuzzy diagnosis is based on the mapping relationship between symptom space and fault state space, using symptoms to diagnose specific faults, which is a new discipline in the current scientific research field. Relevant theoretical knowledge and practical cases are not mature, and in the future development, visitors and scholars are needed to master relevant data information for in-depth research. [13.14.15]

Third, expert system. The design of this system can simulate the working mode of experts in the field, which is the core content of artificial intelligence research in the new era, and has achieved excellent results in practical application research. Due to the uncertain reasoning in the expert system, there are many problems in the applied research. For example, the prior knowledge is obtained with the cooperation of experts in the field, but the practical knowledge is often difficult to be expressed in language, and each expert field has different views on the same issue, which leads to many contradictions in the practical application research. The essence of expert system is to reason effectively according to specific rules, but from the perspective of current application, the relevant logic theory is not mature, and the practical research has not put forward complete fuzzy reasoning theory and semantic logic theory.

Finally, pattern recognition. This method classifies specific things according to their interrelated characteristics. The feature array of each sample corresponds to a point in the feature space, which is called the pattern space. By quantitatively calculating the distance of the sample in the space, the

feature with low error rate is proposed, and the extraction method and classification criteria can realize effective classification.

3. Result analysis

In this paper, after defining the main content of the mechanical system condition monitoring and fault diagnosis technology, taking the loader equipment as an example, according to the fault safety frequently occurred during the operation of diagnosis and detection, in order to verify the application of condition monitoring and fault diagnosis technology research value. Based on the analysis of the intelligent monitoring and diagnosis principle shown in Figure 3 below, it can be seen that the construction of intelligent monitoring and diagnosis system based on loaders requires the acquisition and processing of vibration, temperature, pressure and other signals in some sensitive locations, and the working state of loaders can be judged according to the characteristic parameters extracted from the signals.

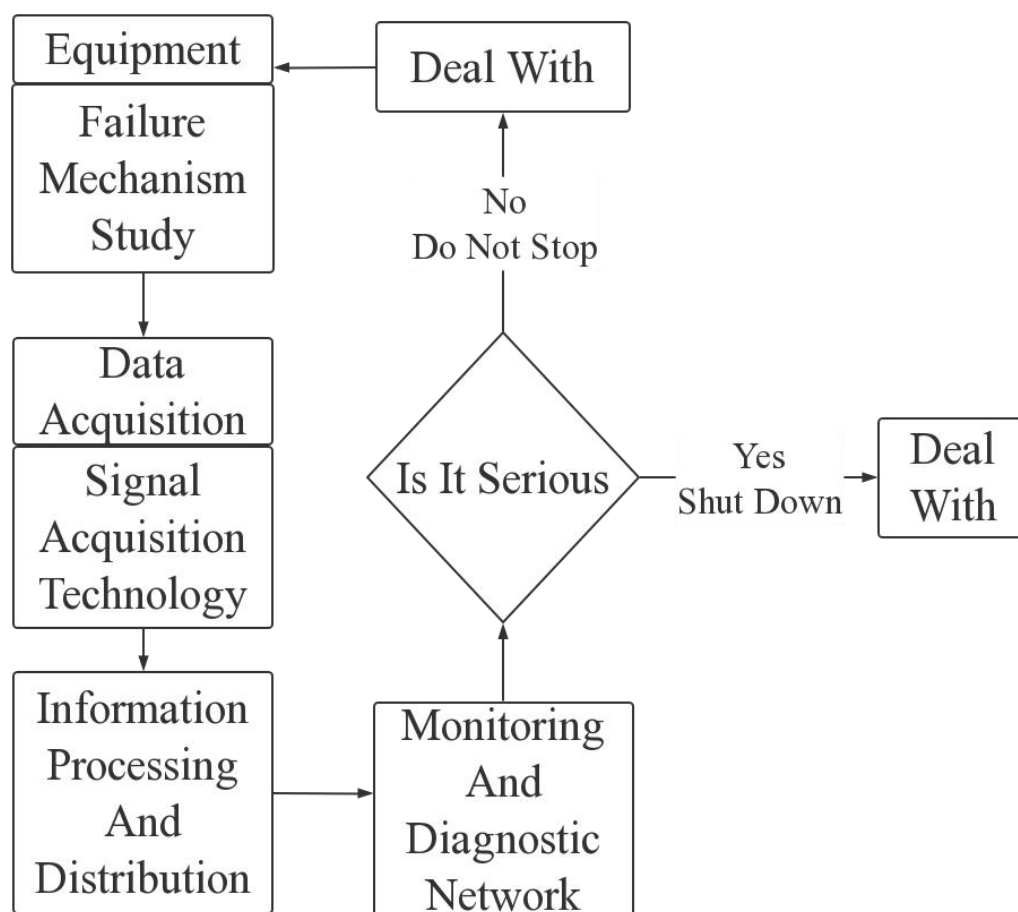


FIG. 3 Schematic diagram of intelligent monitoring and diagnosis technology

Combined with the principle shown in the figure above, the sample training network is first learned, and the sample data is weighted and optimized, so that all data information changes in the specified network space. Since vibration is the main characteristic of the loader's abnormal condition, it is necessary to correctly judge the vibration signal and the cause of the fault in the process of monitoring and diagnosis. The specific results are shown in Table 1 below:

Table 1 Vibration failure cause analysis of loader

Fault sample number	frequency band	Eigenvalues of different faults					
		imbalance/	In-cylinder	Piston impact	Inertia force of	Loose nut	Friction between

		loss of balance	pressure		moving member		moving and static parts
1	0.01-0.4 0f	0.00	0.00	0.00	0.10	0.00	0.00
2	0.41-0.5 0f	0.00	0.20	0.00	0.10	0.10	0.00
3	0.51-0.9 9f	0.00	0.00	0.10	0.90	0.50	0.00
4	f	0.80	0.40	0.90	0.20	0.00	0.00
5	2f	0.10	0.60	0.00	0.00	0.00	0.00
6	3-5f	0.05	0.10	0.00	0.00	0.00	0.10
7	>5f	0.00	0.00	0.10	0.00	0.00	0.00

After identifying the vibration failure and causes of the loader, the artificial neural network model is used for prediction and analysis, and the results shown in Table 2 can be obtained after multiple training:

Table 2 Experimental results

Corresponding node		imbalance/ loss of balance	In-cylinder pressure	Piston impact	Inertia force of moving member	Loose nut	Friction between moving and static parts
output node	1	0.9778	0.0058	0.0000	0.0067	0.0000	0.0009
	2	0.0055	0.9899	0.0022	0.0000	0.0026	0.0000
	3	0.0038	0.0003	0.9909	0.0079	0.0008	0.0078
	4	0.0065	0.0066	0.0080	0.9886	0.0087	0.0064
	5	0.0000	0.0098	0.0005	0.0021	0.9920	0.0006
	6	0.0010	0.0018	0.0015	0.0006	0.0003	0.9884

According to the data analysis in the above table, for the corresponding input sample and target template, the corresponding faulty node value in the output mode is close to 1, while the non-faulty node value is close to 0. The experimental results show that the artificial neural network can effectively simulate the parallel classification structure of human beings, and has the characteristics of distribution and parallel in data processing and analysis. It is very suitable to deal with the fault monitoring and diagnosis of large and complex mechanical systems. Therefore, in the future, Chinese scientific researchers should combine artificial intelligence algorithm to improve the existing mechanical system status, monitoring and fault diagnosis technology, in-depth exploration to master more valuable data information, correct comparison and analysis of the original data and output data, and improve the effectiveness of fault diagnosis and analysis while mastering the types and main causes of faults in turn. It provides technical guarantee for the safe and stable operation of mechanical system.

4. Conclusion

To sum up, with the rapid development of information technology, a large number of scientific researches have been applied to the condition monitoring and fault diagnosis of mechanical systems. For example, the emerging neural network technology and data fusion technology in recent years have made excellent achievements in the research of machine fault diagnosis. Therefore, on the basis of grasping the operation problems of mechanical systems, our country should pay attention to the theoretical basis and innovation direction of the monitoring and fault diagnosis technology from

different levels and many disciplines, so as to provide effective basis for national economic construction in the new period.

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