Analysis of Fault Diagnosis Methods of High-power Permanent Magnet Synchronous Motor

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Abstract: High-power motor is widely used in actual production and life, and motor failure will seriously affect the efficiency and safety of the equipment, and normal production and life. Therefore, it is necessary to strengthen the fault judgment of the motor, quickly locate the fault and analyze through integrated means, and improve the subsequent maintenance methods. The article will take the permanent magnet synchronous motor of an electric vehicle as an example to discuss the analysis of the fault diagnosis method of the high-power motor.

1. Introduction

The consumption of resources and environmental pollution by automobiles is becoming more and more serious. New energy automobiles have become popular with environmental protection and low pollution. Electric automobiles are the main force of new energy automobiles. At present, high-power permanent magnet synchronous motor is mostly used as a drive. The stable and reliable operation is seriously related to the vehicle and personal safety. Therefore, the failure of the motor is a problem that cannot be underestimated. Design and maintenance personnel should clarify the reliability index of the system, and ensure the stable output through isolation design, over-current and over-voltage protection design, and important circuit component protection design.

2. Overview of high-power permanent magnet synchronous motor

The high-power permanent magnet synchronous motor can quickly realize basic operations such as acceleration, deceleration, and commutation with high speed and torque for electric vehicles. It is the power source of electric vehicles. The permanent magnet synchronous motor drive system is composed of a drive control module, an energy management module, a signal acquisition module, and a communication module. By collecting data on the current voltage, three-phase AC current and voltage signals, power and speed of the motor drive system, electrical signals can be analyzed to diagnose and alarm.

From design, production to maintenance, a complete and transparent information sharing system should be established. At present, fault diagnosis management tends to realize internal fault location through electronic information technology, micro-processing technology and sensor technology. Dynamic management of the operation of high-power permanent magnet synchronous motor ensures integrated and intelligent development through sensors remote control, comprehensive data transmission, voltage and current signals, fault alarms and a series of functions. It can identify the weak links and continuously optimize the internal electromagnetic compatibility and derating design, protection and component selection.
3. Fault diagnosis of permanent magnet synchronous motor

The fault of high-power permanent magnet synchronous motor is caused by many aspects. The maintenance personnel should make clear the cause of the motor fault, strengthen the daily maintenance measures, clarify the internal manufacturing and structure, and strengthen the early-stage control. There are the following problems in operation and fault maintenance of high-power permanent magnet synchronous motor.

3.1. Main motor fault

Loss of stator winding and short circuit are common faults. High-power permanent magnet synchronous motor will suffer vibration wear. When the external stress is too large or insulation measures are not in place, the stator windings may be burnt out. In addition, in the early design, due to the unreasonable structure and insufficient top binding and too few fulcrum in quality, the stator winding is not stable enough and the outlet joint is unwelded, thus causing coil fusing or short circuit, which seriously endangers the safety of the motor.

The magnetic field of permanent magnet synchronous motor is generated by permanent magnet material. With the use time and high temperature, permanent magnet material may lose its magnetic field and weaken the magnetic field of the motor, or even lose. It makes unable to operate normally. The failure of permanent magnet synchronous motor is also one of the main faults.

At the same time, the eccentric rotor and bearing failure is also a common fault of permanent magnet synchronous motor. It shows in high-power permanent magnet synchronous motor in the vibration, sound. It can cause further wear and damage in the early failure and must be solved.

3.2. Poor working environment

The working environment of most high-power permanent magnet synchronous motor is poor with long operation time. The motor starts and adjusts speed and commutes frequently, which seriously affects the service life of the motor. For example, parts in the power cabin of an electric vehicle are dense and poorly ventilated with a large amount of dust. It is easy to cause the internal temperature of the motor to rise and further reduce the insulation performance, and even cause the line to burn down. Moreover, the rise of temperature will easily lead to the occurrence of demagnetization, which will cause great damage to the environment. During the operation of electric vehicles, vibration is easy to occur such as uneven surface. Strong vibration is easy to cause cracks and others in bearings and mechanical components of electric motor, which will also pose a threat to the connection of electrical components.

3.3. Data integration difficulties

There are a lot of data generated by permanent magnet synchronous motor in the operation of electric vehicles, and the internal voltage and current are not matched, which will also lead to the loss of collection. Motor fault diagnosis is based on the vibration, current voltage, electromotive force signal changes and judgment, so the acquisition of electrical signals is difficult to increase the timeliness and accuracy of fault diagnosis. The early stage of the electrical signal characteristics is small, and collection and judgment are more complex.

3.4. Trouble locating

When the permanent magnet synchronous motor has minor problems, it is difficult to observe and detect the faults. In the case of abnormal heating and vibration, there may already be multi-point faults in the internal system with a heavy fault. There is overlap and crossover between the manifestations and causes of the mechanical and electrical faults. Permanent magnet synchronous motor for electric vehicles is unstable with difficult daily maintenance, excessive replacement cost, and lack of emergency management measures with a large number of potential safety hazards, which inadvertently increase the risk of use. Therefore, the motor fault diagnosis should focus on the detection, location and maintenance of the early fault.
4. Analysis of fault diagnosis methods for high-power permanent magnet synchronous motor

4.1. Strengthen the analysis of the central control system

The central control system of high-power permanent magnet synchronous motor is composed of controller and permanent magnet synchronous motor, which is developing towards light weight, integration and intelligence. As the core of the control system, the controller contains a large number of components and circuit information such as photoelectric encoder, signal conditioning device, CAN bus communication chip. Technicians should make use of the current mature technology to identify the problems existing in the design of high-power permanent magnet synchronous motor, comprehensively utilize the voltage sensor and photoelectric encoder, improve the integrated processing of electrical signals, and directly input the processed electrical signals into the DSP controller for operation and processing. It is needed to strengthen the internal automatic processing mechanism when the equipment failure. The first time when the signal input to DSP for systematic processing directly generates alarm signal. Through the definition, operation and maintenance in the early stage, the full life cycle management of high-power permanent magnet synchronous motor is formed.

For example, the internal bus current is strengthened to form a three-phase current monitoring mechanism. To continuously optimize calculation model and the code to improve the reliability, then fault analysis control focuses on high module. It can form a certain fault-tolerant mechanism, comprehensively consider the disassembly, welding, replacement and other requirements of components, clarify the failure rate and mode, and set the maximum value of current and instantaneous stress reasonably. In the selection of components, the model and service life should be matched according to the external to ensure the safe operation of the high-power permanent magnet synchronous motor and expand its application scope. The coupling relation between voltage upper and lower limit is defined to improve data transmission efficiency and avoid no-load current. The following figure is the schematic diagram of the control system.

![Schematic diagram of permanent magnet synchronous motor control system](image)

Figure. 1 Schematic diagram of permanent magnet synchronous motor control system

4.2. The realization of fault data analysis

Data analysis is the main method for fault location of high-power permanent magnet synchronous motor. When the fault occurs, the internal characteristic parameters will inevitably change, resulting in a series of fault data. Experimental and empirical data make judgment and comprehensive use of
computer modeling and calculation carry out data analysis.

4.2.1. Statistical method of data
Statistical methods require a large amount of data, including laboratory and actual data. Laboratory data is easy to obtain, but the actual fault data is subject to the number of fault motor, the frequency of fault types and the effectiveness of data collection. In addition, data information is not shared, and awareness of fault data collection is weak, resulting in a small amount of actual data. Due to some differences between the laboratory and the working environment, continuous parameter modification of experimental data must be carried out according to the actual environment to obtain the most objective data. Statistical analysis of data can be extracted with representative characteristics. The establishment of a database can help identify and find motor faults.

4.2.2. Similarity prediction method
The similar method predicts and analyzes the structure of existing products, the form and cause of failure. And the characteristics of the failure determine the actual performance and potential failure modes of their own products. It finds out the weak links in operation and the factors that affect reliability factors optimize the internal structure, circuit and magnetic system. However, this method has higher requirements for similar products and multiple couplings in a large amount of historical data.

4.3. Improve internal maintenance management mechanism
There are many influencing factors during the operation of high-power permanent magnet synchronous motor, and the motor design and operation rules must be strictly implemented. In the design, reasonable cooling measures are taken to prevent the motor from overheating and loss of magnetization. The protective components are reasonably selected to effectively prevent disconnection, burnout, and unstable operation caused by open and short circuit, etc., and reasonable shock absorbers are installed to extend the service life. The surrounding environment is kept dry and well ventilated to effectively prevent harmful substances such as oil and water vapor from entering the motor. It needs to improve the real-time overhaul mechanism, regularly maintain and overhaul the motor, and establish data-based operating status based on actual conditions.

It needs to supervise the entire motor design, production, sales, and maintenance, establish a transparent fault database, and track the operating status of the motor, thereby forming a huge information resource to support data analysis and realize data sharing to locate each item with high efficiency and low cost. The permanent magnet synchronous motor limits simple maintenance, replacement of the motor and sets up the whole life cycle and concludes experience from the daily maintenance and gathering information to serve the entire power of the motor.

5. Conclusion
As the power source of electric vehicles, the high-power permanent magnet synchronous motor is a key factor to ensure the safe, reliable and stable operation of electric vehicles. It is particularly important to conduct fault analysis and the detection and maintenance of the initial motor fault. With the continuous improvement of the integration and intelligence of motor drive systems, the collection and data processing of fault characteristic information will also become more complete, and fault detection and maintenance will be easier to achieve. motor fault diagnosis and testing require not only technological innovation and improvement, but also professional grass-roots personnel, who participate in the entire life cycle of the motor, and provide supporting data for motor fault diagnosis.

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