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Analysis of Common Problems in Three-phase Asynchronous Motors

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Abstract*:* The operation of the drive motor consumes about 50% of China's electricity, indicating its wide application. The application scenarios of electric motors include industrial and agricultural production and household appliances, and they are the most common gas equipment. Among them, cage asynchronous motors are the most widely used. They have simple structure, convenient starting, small size, reliable operation, durability, and easy maintenance and repair. In order to ensure the safe operation and energy conservation of asynchronous motors, electrical personnel must master the basic knowledge of safe operation of asynchronous motors, understand the safety assessment of asynchronous motors, and achieve timely detection and elimination of motor accident hazards as much as possible. This article analyzes the selection, fault analysis, and safe operation of three-phase asynchronous motors, as well as the causes and consequences of various faults.

Keywords Asynchronous motor, Fault, Winding, Current, Motor overheating

INTRODUCTION

Three-phase asynchronous motors, commonly known as induction motors, are a type of motor that operates on a 380V three-phase AC power supply with a phase difference of 120 degrees. These motors are characterized by the slip rate phenomenon, where the rotating magnetic fields of the rotor and stator rotate in the same direction but at different speeds, hence the term "asynchronous." When the three-phase stator windings of an electric motor are supplied with a symmetrical alternating current, a rotating magnetic field is generated. This rotating magnetic field interacts with the rotor winding, inducing a current in the rotor winding, which is a closed circuit [Diyoke, et. al., 2016].

The current-carrying rotor conductor generates an electromagnetic force under the influence of the stator's rotating magnetic field. This force forms electromagnetic torque on the motor shaft, driving the motor to rotate [Adekitan, 2018]. The direction of the motor's rotation aligns with that of the rotating magnetic field.

The principle of operation of these motors is based on electromagnetic induction, a process where an induced current is generated within a conductor when it intersects magnetic lines in a magnetic field. The combined effect of the induced current and the magnetic field produces a driving force on the motor rotor, enabling its rotation. This interaction is fundamental to the functionality of induction motors and underscores their widespread application in various industrial and commercial settings [Makarov, et. al., 2022].

Three-phase asynchronous motors are renowned for their robustness, simplicity, and efficiency. They are widely used in applications ranging from small household appliances to large industrial machinery. Their ability to operate without the need for direct electrical connections to the rotor (unlike other types of motors) reduces maintenance requirements and enhances durability.

Furthermore, advancements in motor design and control technologies have significantly improved the performance and energy efficiency of three-phase asynchronous motors. Innovations such as variable frequency drives (VFDs) allow for precise control of motor speed and torque, optimizing energy consumption and reducing operational costs.

In summary, three-phase asynchronous motors are essential components in modern electrical engineering, providing reliable and efficient power conversion. Understanding their operational principles and advancements is crucial for developing more efficient and sustainable electrical systems.

SELECTION OF ASYNCHRONOUS MOTORS

Approximately 60% of electric motors in our country operate under load conditions below 60% of the design rated load. In this state, up to 30% of the electric motor's power consumption is wasted. Therefore, it is necessary to select suitable electric motors for production machines. The selection of electric motors includes determining the rated voltage, rated speed, structure type and rated power of the motor, mainly considering the following four aspects:

(1) It is required that the rated voltage of the selected motor matches the power supply voltage.

(2) The selected motor should meet the requirements set forth by the tractor production machinery..

(3) The structure type of the electric motor should meet the requirements of the surrounding environment.

(4) Select the correct capacity of the motor. The capacity of the electric motor must match the load size of the production machine, taking into account the operation mode of the production machine and its continuous and intermittent patterns. If the selection is too small, premature damage may occur; if the selection is too large, the cost will increase.

COMMON FAULTS AND ANALYSIS OF ASYNCHRONOUS MOTORS

Motors can fail during operation for a variety of reasons that can be categorized as mechanical and electrical.

(1) Mechanical failures include frequency sweeping, vibration, overheating and damage to bearings. The air gap between the stator and rotor of the asynchronous motor is very small, which can easily cause collision between the stator and rotor. Generally, the different shafts of the seat, end cap and rotor will cause the bore to clear due to the wear and deformation of the end cap shaft bore, or the wear and deformation of the end cap stops and seat stops. Vibration may be caused by the motor itself, poor transmission equipment or mechanical load end drive. Specific cases should be analyzed specifically. Vibration caused by the motor itself is mainly due to poor rotor dynamic balance, poor bearings, bent shafts or different shafts in the end caps, seat and rotor, or uneven motor mounting bases, poor installation and loose fasteners. Vibration produces noise and additional loads. Cracked or corroded inner and outer rings of bearings; broken or loose ball bearings; friction between the inner bore of the outer bearing cover and the shaft, or over-tightening of the bearing by pressing the outer cover against the bearing, can lead to overheating of the bearings.

(2) Electrical faults include stator windings running out of phase, stator windings reversed, three-phase current imbalance, shorting and grounding of windings, overheating of windings, rotor bars broken, open circuits, etc.

a. Phase loss is one of the common faults. An open circuit in any of the three phases of the power supply can cause the motor to run out of phase. Phase loss operation can be caused by melted fuses in the circuit, poor contact with switch contacts or wire connectors, and other causes. A three-phase asynchronous motor with a missing phase will stall (fail to start) if started from a stopped condition. The stalled rotor current of the motor is much higher than the normal operating current, so in this case, leaving the power supply on for too long or repeatedly starting the power supply can cause the motor to burn out. When a running motor is out of phase, such as when the load torque is very small. If the load is heavy and the running time is too long, the motor winding will burn out.

b. If the front and rear ends of the three-phase winding are incorrectly connected, there will be a serious imbalance of the three-phase current, a decrease in the rotational speed, a sharp increase in temperature, an increase in vibration, and a sudden change in noise when the power is turned on. If the protective device does not work, the motor winding can easily be burned. Therefore, it is necessary to distinguish between the first and last terminals of the motor before turning on the power to run.

c. Three-phase current unbalance fault is usually caused by the motor external power supply voltage unbalance; internal causes are mainly due to the winding turn-to-turn short circuit or motor rewinding and maintenance of the coil turns or wiring is not correct.

(3) Both grounded windings and short-circuits can lead to excessive currents. Winding grounding is often referred to as "case collision". The main reasons for winding grounding are: motor not used for a long time, the environment is humid, sunshine and rain, long-term overload operation, exposure to harmful gas erosion, so that the insulation performance is degraded, the insulation resistance is lowered; or due to metal foreign objects falling into the machine, resulting in insulation damage. Winding grounding will make the motor shell charged, easy to cause personal electric shock accident. You can use a megohmmeter or calibration lamp to check the ground fault. Short-circuit faults such as inter-turn short circuit, inter-pole group short circuit and inter-phase short circuit can be detected by lowering the supply voltage of the stator winding to measure the current or measuring its DC resistance.

(4) The main cause of motor overheating is excessive load drag, but overvoltage or undervoltage can also cause the motor to overheat. Severe overheating can cause a smell of burnt insulation inside the motor. If it is not treated in time or the protection device does not work, it is easy to burn the motor.

(5) When the aluminum conductor of a motor rotor breaks or the winding of a wire-wound motor rotor breaks, it results in an abnormal stator current with periodic high and low variations, as well as fluctuating noise and vibration. The heavier the load, the more pronounced this phenomenon becomes.

MOTOR OPERATION

Before the motor is operated, the assembly of all parts of the motor should be checked and wired according to the requirements of the motor nameplate. Measure the insulation resistance, the winding insulation resistance should meet the requirements. When rotating the rotating part of the motor manually, it should be flexible and free of jamming.

To ensure the safe and normal operation of asynchronous motors, first of all, we should choose economical and practical motors according to the actual situation, familiarize ourselves with the causes of various failures and treatment measures, and regularly inspect and maintain the motors. If problems are found, they should be dealt with in time.

(1) Operating parameters: Generally, the allowable voltage fluctuation of a motor is ± 10% of the rated voltage, and the difference in three-phase voltage should not exceed 5%; the allowable current imbalance value of each phase shall not exceed 10%.

(2) The protection of electric motors requires the proper configuration of control devices such as low-voltage circuit breakers, contactors, fuses, and thermal relays to ensure safe operation of the motor. In addition, the motor enclosure should be reliably grounded or earthed depending on the operating mode of the grid.

(3) Routine maintenance and upkeep: The motor should be kept in good condition with all accessories intact and its surroundings kept clean. Regular maintenance and servicing of the motor is an important task to ensure its safe operation. Routine maintenance includes removal of external dust and oil, monitoring for abnormal noises and regular lubricant changes. Motor temperature rise, odor and vibration should be noted during inspection. A normally operating motor should have a light and even sound, no murmurs or special noises, no noticeable vibration, and the speed should reach the rated speed. The three-phase current should be basically balanced.

CONCLUSION

Three-phase asynchronous motors are integral components in various industrial, agricultural, and household applications due to their robustness, efficiency, and ease of maintenance. This paper has explored the fundamental principles of three-phase asynchronous motors, highlighting their operational mechanics, common faults, and best practices for selection and maintenance.

Understanding the slip rate, which defines the asynchronous nature of these motors, is crucial for comprehending their operation. The rotating magnetic field generated by the symmetrical three-phase AC power supply interacts with the rotor, inducing currents that create the electromagnetic torque necessary for motor operation.

The selection of appropriate motors for specific applications is essential to optimize performance and energy efficiency. Proper matching of the motor's rated voltage, speed, structure type, and power capacity with the load requirements is critical to prevent premature failures and excessive energy consumption.

Common faults in three-phase asynchronous motors, including mechanical issues like vibration and bearing damage, and electrical problems such as phase loss, current imbalance, and winding short circuits, can significantly impact motor performance. Understanding these faults, their causes, and their effects enables timely detection and rectification, thus ensuring reliable motor operation.

Routine maintenance and the implementation of proper protection measures are indispensable for the safe and efficient operation of these motors. Regular inspections, adherence to operating parameters, and the use of control devices such as circuit breakers and thermal relays help prevent accidents and extend motor lifespan.

In conclusion, mastering the principles of three-phase asynchronous motors, coupled with diligent maintenance and correct selection practices, can significantly enhance their performance and longevity. This knowledge is vital for electrical personnel and engineers who aim to ensure the safe, efficient, and sustainable operation of these ubiquitous machines.

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