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GB/T 24625-2024

Guide for the design and application of synchronous motors for converter supply

变频器供电同步电动机设计与应用指南

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1 Scope

GB/T 24625-2024 is the Chinese guide to designing and applying synchronous motors fed from converters. Converter-fed synchronous machines occupy the top of the drives market, in mine hoists, rolling mills, large compressors, ship propulsion and increasingly in high-efficiency industrial drives with permanent magnet or synchronous reluctance rotors, and the converter changes almost every design assumption: the supply carries harmonics that heat the machine and stress the insulation, the common mode voltage drives bearing currents, the excitation and control are shared between machine and converter, and the machine may be required to run at speeds and torques a line-fed one never sees. The guide covers the machine and drive as a system: the selection and rating, the additional losses and the thermal design, the insulation system and the voltage stress at the terminals, the bearing currents and their mitigation, the torsional interaction with the load, the excitation and control, the protection and the testing and commissioning. It takes effect on 1 April 2025.

This document specifies the ratings, structural types, performance requirements, cooling

methods, test methods and acceptance rules for three-phase or multi-phase electrically excited synchronous motors and permanent magnet synchronous motors powered by inverters, including requirements for inverters. This document applies to synchronous motors driven by frequency converters.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 755-2019, Rotating electrical machines -- Rating and performance

GB/T 997-2022, Classification of types of construction, mounting arrangements and terminal box position (IM Code) for rotating electrical machines

GB/T 1029, Test procedures for three-phase synchronous machines

GB/T 1971-2021, Rotating electrical machines -- Terminal markings and direction of rotation

GB/T 1993-1993, Cooling methods for rotating electrical machines

GB/T 4942-2021, Degrees of protection provided by the integral design of rotating electrical machines (IP code) -- Classification

GB/T 10068-2020, Mechanical vibration of certain machines with shaft heights 56 mm and higher -- Measurement, evaluation and limits of vibration severity

GB/T 10069.1-2006, Measurement of airborne noise emitted by rotating electrical machines and the noise limits -- Part

1.Method for the measurement of airborne noise emitted by rotating electrical machines

GB/T 10069.3-2008, Measurement of airborne noise emitted by rotating electrical machines and the noise limits -- Part

3 Noise limits

a) The inverter is generally configured according to the continuous load current capacity, short-time load current capacity and peak current capacity. In the selection process, the size of the specification, the peak and instantaneous value of the current, the RMS value of the motor current and the operating mode of the system should be properly controlled.

b) When the motor and control system are used for loads where torque or frequency may change suddenly, the current size should be selected taking into account the maximum transient current peak value caused by the sudden change.

c) When the motor's operating speed is required to change, if the power frequency changes more than the motor's speed, the effective current or peak current output by the control system may exceed the steady-state requirement.

d) When the motor is running at low speed or overloaded, the motor loss increases and the efficiency decreases, so the power supply should ensure the operating requirements of the motor.

e) The du/dt value of the inverter output is not greater than 3 kV/μs, and the common mode voltage is not greater than 1 kV. If there are special requirements, they can be negotiated separately.

f) Frequency converters can be divided into two types. voltage source type and current source type. For AC-DC-AC frequency converters, if the intermediate DC link is connected in parallel with a filter capacitor, it is a voltage source type. If the intermediate DC link is connected in series with a filter inductor, it is a current source type. AC-AC frequency converters do not have an obvious DC intermediate link, but they also have voltage source type and current source type to meet the needs of the load. Usually, the internal resistance of AC-AC frequency converters is very small, and most of them are voltage source type.

4.2 Design of synchronous motor powered by inverter When designing and selecting three-phase or multi-phase variable frequency synchronous motors, the following factors need to be considered.

a) Unless otherwise specified, the motor shall be rated at continuous duty (S1). The rated value is the shaft power output by the motor at rated speed and rated voltage. The definition of the base rated value is to specify the voltage, speed, power or torque of the motor at point 3 in Figure 1 so that it meets the conditions at that point.

b) The short-term overload capacity for occasional use refers to the ability of the motor to continuously withstand a load exceeding the rated load within a specified time when an accident rarely occurs or an emergency occurs. The short-term overload capacity for frequent use refers to the ability of the motor to repeatedly requirements of the agreement.

g) Because at a certain operating frequency of some types of inverters, the RMS value of the current input to the motor contains a considerable amount of harmonic current peaks and transient currents. Therefore, under full load, the total RMS value of the motor current is greater than the current corresponding to running under a sine wave power supply.

h) The effect of cogging torque should be reduced when designing the motor.

i) The corresponding harmonic content in the voltage or current of the inverter- powered motor is different from that when it is running on a sinusoidal power supply. It is important to analyze the torque reduction caused by harmonics and the impact of oscillating torque on the basic operating performance of the drive. Only by understanding the frequency spectrum of the inverter output current and/or voltage can the motor manufacturer calculate

the details of the additional torque (especially oscillating torque) and losses generated during the operation of the motor and the impact of harmonics on the temperature rise of the windings. This is very different from the design of the effective part of the motor within the scope of

GB/T 755-2019, so that each reduction factor is determined before the selection. When using intermittent, periodic, and variable load working systems, the time quota is a continuous quota based on the thermal effects encountered in actual use.

j) Technical information communication should be considered when selecting inverters and motors, see Annex A.

4.3 Noise and vibration of synchronous motors powered by inverters

4.3.1 Factors affecting noise and vibration of inverter-powered synchronous motors The motor and the driven equipment have natural resonant frequencies in radial, axial and different torsional modes. When frequency modulation control is applied to the motor, the system will be excited by the electromagnetic harmonics emitted by the inverter, which will affect the noise level, vibration level and torsional response of the transmission system. System design needs to consider these effects to ensure the normal operation of the transmission system. When designing such motors, motor manufacturers should optimize the design to reduce noise and vibration, but factors other than the motor need to be considered comprehensively. The noise and vibration of the motor are related to the following factors.

a) electromagnetic design;

b) inverter type;

c) motor frame structure, resonance of rotating parts and oil film stiffness;

d) mass size, equipment integrity and foundation structure;

e) load and shaft connection method;

f) air duct or external cooling device noise;

g) vibration effect of ventilation device and main motor body.

4.3.2 Noise and vibration assessment of synchronous motors powered by inverters The allowable vibration value of the motor shall comply with the following requirements.

a) The speed should not exceed the maximum allowable value specified in

GB/T 10068-2020 for speeds of 600 r/min and above;

b) The double amplitude vibration value should not exceed

0.075 mm for speeds below 600 r/min. Normally, the noise of a motor should not exceed the