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Small power motors - Part 21: General test methods

小功率电动机 第 21 部分: 通用试验方法

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Small power motors - Part 21: General test methods

1 Scope

This Part of GB/T 5171 specifies terms and definitions, symbols involved in general test methods for small power motors, basic requirements for the test, test preparation, temperature rise test, efficiency determination, as well as locked-rotor test and other test methods.

This Part is applicable to the products defined in GB/T 5171.1.

The special test items and methods of various types of small power motors that are not specified in this Part need to be supplemented in the test method standards for this type of small power motors.

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 755, *Rotating electrical machines - Rating and performance*

GB/T 1958, *Geometrical Product Specifications (GPS) - Geometrical tolerance - Verification*

GB/T 2423 (all parts), *Environmental testing - Part 2: Test methods*

GB/T 2828.1, *Sampling procedures for inspection by attributes - Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

GB/T 4942.1, *Degrees of Protection Provided by the Integral Design of Rotating Electrical Machined (IP Code) - Classification*

GB/T 5171.1, *Small Power Motors - Part 1: General Technical Requirements*

GB/T 10069.1, *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 12113-2003, *Methods of measurement of touch current and protective*

[GB/T 2900.25-2008, definition 411-53-28]

3.1.5 locked-rotor test

a test to determine the locked-rotor torque and the locked-rotor current, when the motor is energized and the rotor is blocked

[GB/T 2900.25-2008, definition 411-53-32]

3.1.6 over-speed test

a test carried out on the motor to determine whether the motor rotor can meet the specified overspeed requirements

[GB/T 2900.25-2008, definition 411-53-39]

3.1.7 short-time over-torque test

a test to determine the ability of the motor to withstand the specified over-torque multiples within a specified time

[GB/T 2900.27-2008, definition 9.7]

3.1.8 accidental over-current test

a test to determine the ability of the motor to withstand the specified overcurrent multiples within a specified time

[GB/T 2900.27-2008, definition 9.9]

3.1.9 operating time limit test

a test to determine the normal operation period that the manufacturer guarantees to the user under the specified conditions

[GB/T 2900.27-2008, definition 9.12]

3.1.10 no-load test

a test without effective mechanical output on the shaft when the motor is running

3.1.11 line-to-line resistance

the arithmetic average of the resistance between the terminals of each two-phase power supply connection of a multi-phase AC motor

NOTE 1: For Y-connection three-phase motors, the phase resistance is 0.5 times the line-to-line resistance. For Δ-connection three-phase motors, the phase resistance is 1.5 times

P_c - Constant loss (W);

P_{fe} - Iron consumption (W);

P_{fw} - Friction and wind resistance loss (W);

P_{fw0} - Friction and windage loss (W) at synchronous speed;

P_k - Locked-rotor input power (W);

P_{LL} - Additional load loss (W);

P_{Lr} - Stray loss (W);

P_r - Rotor winding loss (W);

$P_{r,\theta}$ - Rotor winding loss (W) corrected to 25°C reference cooling medium temperature;

P_s - Stator winding loss (W);

$P_{s,\theta}$ - Stator winding loss (W) corrected to 25°C reference cooling medium temperature;

P_T - Total loss (W);

P_0 - No-load input power (W);

P_1 - Input power (W);

$P_{1,\theta}$ - Input power (W) corrected to 25°C reference cooling medium temperature;

P_2 - Output power (W);

P_{2c} - Corrected output power (W);

p - Number of pole pairs;

Q - Gravity of code and container (N);

R - Winding resistance;

$R_{ll,0}$ - Interpolated winding resistance (Ω) during no-load test (each voltage point);

R_0 - Winding resistance (Ω) during no-load test;

R_1 – Cold-state winding resistance (Ω);

R_2 - In the temperature rise test, the winding resistance measured after the

n - Harmonic order (does not include the multiples of 3 and 3 for three-phase AC motors);

k=13.

When conducting temperature rise and efficiency tests, the voltage tolerance of the AC power supply for the test shall not be greater than 0.5%. The frequency fluctuation of the AC power supply shall be within ±0.1% of the rated frequency. The average power supply frequency shall be within ±0.1% of the test frequency.

4.2.2 Three-phase AC power supply

For three-phase AC power supply, in addition to meeting the requirements in 4.2.1, the negative sequence component of the three-phase voltage system shall be less than 0.5% of the positive sequence component, and the influence of zero sequence component shall be eliminated. The negative sequence component of the measuring current system can be used to replace the negative sequence component of the measuring voltage system. The negative sequence component of the current system shall not exceed 2.5% of the positive sequence component.

4.2.3 DC power supply

The DC power supply equipment used in the test shall not exceed 0.5% of the nominal source voltage and the output voltage tolerance of each output under half-rated load. For each output, within the specified load range and under the most unfavorable supply voltage, the load regulation rate is not more than 0.2%.

4.3 Use of measuring instruments

4.3.1 General

The ambient conditions during the test shall be within the range recommended by the equipment manufacturer. If applicable, temperature corrections shall be made to the measured values according to the manufacturer's equipment instructions.

Digital measuring instruments shall be used whenever possible.

Since the accuracy of analog measuring instruments is usually expressed as a percentage of full scale, the range of the measuring instrument selected during the test shall be as small as possible as the actual value. The observation value shall be within one-third of the instrument range to the full-scale range.

The range of the measuring instrument, especially the current sensor, shall be adapted to the power of the motor being tested.

Parasitic loads shall be minimized through shaft alignment adjustments and the use of flexible couplings.

4.3.4 Measurement of rotating speed

4.3.4.1 General

The indication error of the speed measuring instrument shall be less than ±0.1% of the speed range or less than 1r/min. Take the one with the smallest error between the two.

For asynchronous motors, the induction coil method or flash method can also be used to measure the slip rate to replace the speed measurement.

The measurement methods of motor speed (slip rate) mainly include:

- Digital speed (or slip) measuring instrument;
- Induction coil method;
- Measuring slip ratio by speed measuring instrument;
- Digital frequency meter;
- Stroboscopic test method.

If the induction coil method or the stroboscopic test method is used to directly measure the slip rate, the power supply shall be the power supply for the tested motor. It is not recommended to use direct mechanical contact method that affects the running state of the motor.

4.3.4.2 Digital speed (or slip rate) measuring instrument method

Install a photoelectric reflective mark, transmissive grating disc or magneto-electric induction device that does not generate significant load when the motor rotates on the rotating shaft. Transform the speed signal into pulse signal by photoelectric sensor or magnetoelectric sensor. The measuring instrument directly displays the speed (or slip rate) of the tested motor.

4.3.4.3 Induction coil method

For asynchronous motors, a multi-turn coil with iron core can be placed on the motor casing. And connect with magnetoelectric galvanometer or cathode oscilloscope. During the test, use a stopwatch to measure the time t (s) required for the full swing of the galvanometer pointer or the oscilloscope waveform for N times. The slip rate s is calculated according to formula (3).

thermometers and alcohol thermometers), semiconductor thermometers, and non-embedded thermocouples or resistance thermometers.

When used to measure the temperature of the parts of the motor, the thermometer shall be close to the surface of the measured point. To measure the temperature of the surface of the contact point, the heat conduction from the measured point to the thermometer shall be as good as possible. Use thermal insulation material to cover the temperature measurement part of the thermometer, so as to avoid the influence of the surrounding cooling medium.

When used to measure the temperature of parts with strong alternating or moving magnetic fields, mercury thermometers shall not be used.

4.3.6.3 Thermocouple method

This method is recommended for the measurement of surface temperature of motor parts. It is not recommended to use this method to measure the temperature of the winding.

When using a thermocouple to measure the temperature of the winding, it shall consider: because the thermocouple reading lags behind the temperature change of the winding, when the motor is powered off, the temperature of the thermocouple may continue to rise. Therefore, the temperature of the motor winding shall record its maximum temperature. The temperature may be reached after power failure.

The specifications for the selection, preparation, arrangement, installation and connection of thermocouples are shown in Annex C.

4.3.6.4 Resistance method

The resistance method determines the temperature of the winding based on the relationship that the resistance of the winding increases correspondingly after the temperature rises. What it measures is the average temperature of the winding.

Resistance method includes direct measurement method and live measurement method (see 6.5.3 and 6.5.4).

4.3.7 Determination of winding resistance

4.3.7.1 General

Winding resistance R can be determined by appropriate methods such as double-arm bridge, single-arm bridge or DC voltmeter-ammeter method.

For permanent magnet DC motors, R is the total resistance of all coils that load

When measuring the winding insulation resistance, if the beginning and end of each winding circuit have been led out of the casing, then the insulation group of each winding circuit to the casing and the windings shall be measured separately. If the winding has been connected inside the motor, when only the wire end is drawn out, measure the insulation resistance of the wire end to the casing.

For capacitor motors, the capacitor shall be connected to the secondary winding circuit (unless otherwise agreed).

After the insulation resistance measurement is over, the winding shall be discharged to the ground.

5.2 Determination of cold-state winding temperature θ_1 and cold-state winding resistance R_1

Put the motor indoors for a period of time. Use a thermometer to measure the temperature of the end of the motor winding or the iron core. When the difference between the measured temperature and the temperature of the cooling medium does not exceed 2K, then the measured temperature is the temperature of the cold-state winding θ_1. If the temperature of the winding end or the iron core cannot be measured, the temperature of the casing is allowed to replace it.

While measuring the cold-state winding temperature θ_1, measure the cold-state winding resistance R_1, see 4.3.7.

6 Temperature rise test

6.1 Overview

The purpose of the temperature rise test is to determine the temperature rise of windings and certain parts of the motor that are higher than the temperature of the cooling medium when the motor is running under specified load conditions. The temperature measurement method is selected according to 4.3 and the relevant provisions of this Clause.

6.2 General description

Measures shall be taken during the test to minimize the change in the temperature of the cooling medium.

The tested motor shall be protected to block the influence of airflow generated by other machinery or the surrounding environment on the tested motor. Generally, a very slight airflow is enough to cause a large deviation in the results of the temperature rise test. Environmental conditions that cause rapid changes

6.5 Temperature rise test method

6.5.1 Determination of load

6.5.1.1 Overview

The motor shall be able to run under its rated load or less than its rated load. The motor that can run at multiple speeds shall be able to run at the minimum, intermediate and maximum speeds with a rated load. During this process, all parts of the motor shall not reach too high temperature.

For voltage regulating motors that work in a voltage range and motors with multiple working conditions, the temperature rise test shall be carried out under the most unfavorable conditions that may occur in normal use.

For motors with thermal protector or thermal fuse without fixed installation position, during rated load temperature rise test and no-load temperature rise test, the installation position of the motor shall be such that the thermal protector or thermal fuse is in a position with the highest possible temperature (usually in the upper position of the motor winding). During the test, the thermal protector or thermal fuse is not allowed to operate.

6.5.1.2 Motors with clear rated operating point

This kind of motors use direct method. Apply a rated load to the motor under test through a dynamometer (or a load motor with a torque measuring instrument). Test under rated frequency and rated voltage.

For single-phase asynchronous motors running with capacitors, the temperature rise test shall be assessed at the point of maximum loss. The maximum loss point is determined by testing among the rated point, the no-load point, and the intermediate speed points of the above two points.

For capacitor-running asynchronous motors and dual-value capacitor asynchronous motors, the temperature rise at no load shall also be measured.

6.5.1.3 Motors with actual load

This type of motor has actual load during normal operation, and these actual loads have a greater impact on the temperature rise of the motor. Therefore, when the temperature rise test is performed, it is necessary to carry the actual load and perform the test at the rated frequency and rated voltage.

6.5.2 Duration of various motor temperature rise tests

6.5.2.1 Maximum continuous rating (or S1 working system) motor

The test shall be continued until all parts of the motor reach a thermally stable

6.5.2.6 Locked-rotor temperature rise test

For single-phase asynchronous motors with capacitor start and resistance start, the locked-rotor temperature rise test shall also be carried out.

The tested motor shall quickly block the rotor in the hot state or after the temperature rise test is over. Apply a rated voltage. Maintain 5s. Immediately measure the resistance of the primary and secondary windings to obtain the temperature rise of the windings.

6.5.3 Determination of the winding resistance R_2 and temperature of each part of motor after the motor is stopped

After the temperature rise test is over, the power shall be cut off immediately. Carefully arrange the test procedures and the appropriate number of test personnel. Measure the winding resistance readings and the temperature of each part of the motor as soon as possible.

From the moment of power failure, if the winding resistance and temperature are measured within 15s after the power is cut off, then use this resistance value to calculate the winding temperature rise. The measured temperature of each part of the motor does not need to be corrected.

If it cannot be measured within 15s, additional readings shall be taken as soon as possible at intervals of 20s~60s. Plot these readings as a function of time. Use extrapolation to correct to the moment of power failure. That is, measure resistance R or temperature θ and corresponding time t. There shall be no less than 5 points. Draw R=f(t) or θ=f(t) curve on graph paper or semi-logarithmic graph paper, as shown in Figure 3. The extension curve intersects the vertical axis. Its intersection point is the resistance value or temperature value at the moment of power failure.

9.2 Short-time over-torque test

The short-time over-torque test shall be carried out at rated voltage and rated frequency.

During the test, the motor gradually increases the load in the hot state. The over-torque multiple and time are in accordance with GB/T 5171.1 or the product standard of this type of motor.

9.3 Determination of maximum torque

9.3.1 Overview

There are two methods to measure the maximum torque:

- Dynamometer method;

- Torque measuring instrument method.

When measuring, it shall be carried out at rated voltage. If the test voltage cannot reach the rated voltage, the test voltage shall be controlled within the range of 0.9~1.1 times the rated voltage. The measured maximum torque value shall be converted according to 9.3.4.

During the test, the tested motor shall be prevented from overheating and affecting the accuracy of the measurement.

The terminal voltage of the tested motor shall be measured on its outlet terminal.

9.3.2 Torque measuring instrument method

When measuring the maximum torque with the torque measuring instrument method, the torque and speed characteristic curve of the tested motor shall be measured. The maximum torque is calculated from the curve.

The torque and speed characteristic curve can be manually drawn after point-by-point determination. It can also be drawn directly with an automatic recorder. The number of measured points shall meet the needs of correctly obtaining various torques (maximum torque, minimum torque, synchronous torque and locked-rotor torque). In the vicinity of these torques, the measurement points shall be as dense as possible.

The characteristics of the load equipment shall be able to measure the entire torque-speed characteristic curve. Adjustment is easy. Operation is stable. Data is reliable.

When using DC motor as load, the tested motor is connected with a torque measuring instrument and a DC motor. The DC motor is separately excited. Its

- Torque measuring instrument method.

During the measurement, the tested motor shall be close to the actual cold state. The measurement is carried out at the rated frequency and rated voltage. If the test voltage cannot reach the rated voltage, when the test voltage is within the range of 0.95~1.05 times the rated voltage, the minimum torque is converted according to 9.4.4.

During the test, the tested motor shall be prevented from overheating and affecting the accuracy of the measurement.

The terminal voltage of the tested motor shall be measured on its outlet terminal.

9.4.2 Torque measuring instrument method

When measuring the minimum torque with the torque measuring instrument method, the speed shall be gradually increased from the locked-rotor state. Measure the torque and speed characteristic curve of the tested motor. The minimum torque is obtained from the curve.

During the test, the direction of the tested motor and the load DC motor can be the same or opposite. First, make the DC motor run at a very low speed. Then start the tested motor at or close to the rated voltage. Increase or gradually reduce the load of the tested motor until its rated speed. Other test methods and requirements are the same as 9.3.3.

9.4.3 Dynamometer method

Use a dynamometer as the load of the tested motor. The minimum torque is read from the dynamometer.

During the test, connect the tested motor with the coupling of the dynamometer. First, connect the tested motor to a low voltage. Adjust the terminal voltage (or excitation current) of the dynamometer, so as to determine the intermediate speed at which the tested motor has the minimum torque (at a certain speed, the unit can operate stably at this speed without increasing speed). Disconnect the power to the tested motor. Adjust the power supply voltage (or excitation current) of the dynamometer to make the speed approximately 1/3 of the intermediate speed. Then increase the power supply voltage of the motor to the rated value and then turn it on. Quickly adjust the power supply voltage (or excitation current) of the dynamometer until the dynamometer reading of the accelerating dynamometer shows the minimum value. Read this value.

9.4.4 Conversion of minimum torque value

The minimum torque is converted according to formula (45):

9.8 Determination of vibration

The determination of motor vibration is carried out according to the provisions of JB/T 10490.

9.9 Electric strength test

9.9.1 General test requirements

Before the test, it shall determine the insulation resistance of the winding. If it is necessary to carry out over-speed test, short-term over-torque test or accidental over-current test, this test shall be carried out after these tests. If a temperature rise test is required, it shall be performed immediately after the temperature rise test.

The test shall be carried out when the motor is stationary.

The test voltage is applied between the tested winding and the casing and between the windings. For interconnected multiphase windings, if the beginning and end of each phase are not led out separately, it can be tested as a separate circuit.

9.9.2 Test voltage

The frequency of the test voltage is 50Hz. The waveform is an actual sine wave. The capacity of the test equipment is not less than 0.5kVA. The test voltage (effective value) is $1000V+2U_{rms,max}$. But the minimum is 1500V. For insulated windings of motors with rated voltages below 100V, the test voltage (effective value) is $500V+2U_{rms,max}$. $U_{rms,max}$ is the maximum effective value of operating voltage.

9.9.3 Trip current

No breakdown shall occur in the electric strength test. When the current exceeds 10mA in the test circuit, it is assumed that breakdown has occurred. For electric strength test after damp heat test, when the current exceeds 30mA in the test circuit, it is assumed that breakdown has occurred.

NOTE: A current sensor is installed in the test circuit, which trips when the current exceeds the limit.

9.9.4 Test time

During the test, the applied voltage shall not exceed half of the full value of the test voltage. Gradually increase to the full value of the test voltage. The time for the test voltage to increase from half value to full value shall not be less than 10s. The full voltage test time shall last for 1 min. When performing inspection

segments at an angle of 180 degrees. The test peak voltage of the motor with a rated voltage of 220V is not less than 1100V. The peak value of the impulse voltage test of other rated voltage motors is determined by 5 times U_N (U_N is the rated voltage of the motor), but the minimum is 500V.

The test method of the impact test of the motor is carried out according to GB/T 22719.1.

b) Short-term voltage increase test:

The test motor runs at no load at 130% rated voltage. Last 3min (capacitor running motor is 1min). During the test, the power frequency can be increased to 110% of the rated value (except for capacitor-operated motors). But it shall not exceed the speed specified in the overspeed test.

During the test, observe whether the motor has a breakdown such as smoke.

9.12 Leakage current test at working temperature

The motor is powered by 1.06 times the rated voltage. Operate under rated load or actual load conditions.

If the motor is equipped with a radio interference filter, it shall be disconnected before the test.

The leakage current is measured by the measurement network described in Figure 4 in GB/T 12113-2003. The measurement is carried out between any pole of the power supply and the accessible metal parts connected to the metal foil. The area of the connected metal foil does not exceed 20cm×10cm. It is in contact with the accessible surface of the insulating material.

The voltmeter shown in Figure 4 in GB/T 12113-2003 shall be able to measure the true effective value of the voltage.

For single-phase motors, the measurement circuit is shown in Figure 9. Turn the selector switch to each position of a and b to measure the leakage current.

phase motor at working temperature

In Figure 9 and Figure 10:

a, b, c: single pole single throw switch;

L_1, L_2, L_3: three-phase power cord;

N: neutral line;

C: Figure 4 measurement network in GB/T 12113-2003.

9.13 Accidental overcurrent test

The accidental overcurrent test is suitable for motors with protection devices. The over-current capability of rotating electrical machines is specified in order to match the electrical machines with control and protection devices.

The accidental overcurrent test shall be carried out at rated voltage and rated frequency.

During the test, the motor gradually increases the load in the hot state. Make the motor current reach the specified overcurrent within the specified time. The overcurrent limit and time are in accordance with GB/T 5171.1 or the product standard of this type of motor.

During the test, the protection device shall not act.

9.14 Over-speed test

If there are no other provisions in the technical conditions of various types of motors, the over-speed test is allowed to be carried out in a cold state.

The assembly quality of the motor shall be carefully checked before the over-speed test, especially the assembly quality of the rotating part. Prevent debris or parts from flying out when the speed increases.

Corresponding safety protection measures shall be taken during the over-speed test. The control of the tested motor or the measurement of its vibration, speed, temperature and other parameters when needed shall adopt remote measurement methods.

During the test, increase the speed of the motor to the speed specified in GB/T 5171.1 or the technical conditions of each type of motor. Last for 2min.

The method of overspeed can be selected according to the type of motor, such as:

During the test, the change of input voltage is distributed in units of 8h: the upper limit of voltage is 8h, the nominal value is 8h, the lower limit of voltage is 8h, the nominal value is 8h, and so on.

For bidirectional motors, the rotation direction is changed every unit time.

The unit time can also be adjusted according to actual needs, but the longest shall not exceed 24h.

For short-time working system (S2) motors, run for a given time under rated load, and then stop and cut off energy. The energy cut-off time shall be enough to cool the motor to within 2K of the cooling medium.

9.19.2 Test procedures

9.19.2.1 Sampling

A certain number of samples are randomly selected from the motors that have passed the exit-factory inspection. The number of samples is determined according to the following test plan.

9.19.2.2 Test plan

9.19.2.2.1 Single-eight system test plan

Extract 8 motors. All have been tested until the specified operating time limit.

If the number of rejected units does not exceed 2, the test is considered nonconforming.

9.19.2.2.2 Double three-system test plan

Extract 6 motors. Take 3 motors as a group, two groups in total. First test a group of 3 motors. Test until the specified operating time limit.

If all are accepted, the test is considered conforming. If there are two or more rejected, the test is considered nonconforming. If one motor fails, try another group of 3 motors. Test until the specified operating time limit. If there are no more failures, the test is considered conforming. In any case, as long as there are 2 or more rejected in total, the test is considered nonconforming.

NOTE: The determination of the single-eight system test plan and the double-three system test plan is objectively based on the use of basically the same statistical characteristics (acceptance quality limit: 10%) for the limited number of electric motors.

9.19.2.2.3 Other test plans

Other methods specified in GB/T 2828.1 can also be used. The acceptance

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