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Rolling bearings - Test and assessment for life and reliability

滚动轴承 寿命可靠性试验及评定方法

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Table of Contents

Rolling bearings - Test and assessment for life and reliability

1 Scope

This document describes the routine test for life and reliability and assessment methods of general-purpose rolling bearings with bearing inner diameters (d) of 5mm~180mm on testing equipment.

This document is suitable for product quality acceptance, product quality comparative analysis and evaluation of users who have requirements for rolling bearing life and reliability. It is also suitable for verification testing, project acceptance, assessment and evaluation by the bearing industry and third-party certification agencies, and internal testing of the manufacturing plant.

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 275-2015, *Rolling bearings -- Fits*

GB/T 6391-2010, *Rolling bearings -- Dynamic load ratings and rating life*

GB/T 6930, *Rolling bearings -- Vocabulary*

GB 11118.1-2011, *Hydraulic fluids of L-HL, L-HM, L-HV, L-HS and L-HG type*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 6391-2010 and GB/T 6930 as well as the followings apply.

3.1 test for life

A test conducted to estimate or verify product life.

3.2 test for reliability

A test conducted to measure, evaluate, analyze and improve product reliability levels.

3.3 failures of rolling bearing

Rolling bearings are unable to meet predetermined design performance requirements due to defects or damage.

3.4 figure estimation

A method of parameter estimation with the help of Weibull probability plots.

3.5 best liner invariant estimation

A numerical calculation method that uses tables to estimate parameters using the best linear invariant estimate.

3.6 sequential method

A method of analyzing and judging test data one by one based on sequential tests.

3.7 confidence interval

The estimated interval of the population parameter constructed from the sample statistic is numerically equal to the difference between the upper confidence limit and the lower confidence limit of the parameter estimate.

3.8 conformity assessment

Demonstration that specified requirements related to a product, process, system, person or organization are met.

[Source: GB/T 27000-2023,3.1, modified]

4 Symbols

The following symbols apply to this document.

b: Shape parameter, slope parameter of Weibull distribution, indicating the degree of dispersion of bearing life or the stability of bearing life quality

C: Basic dynamic load rating, N

C_l: Best linear invariant estimation coefficient

D_l: Best linear invariant estimation coefficient

d: Bearing inner diameter, mm

F_a: Axial load, N

F_r: Radial load, N

α: Accepted risk or significance level;1-α is the confidence level

β: Failure risk

η: Proportional coefficient

μ_α: Acceptance threshold coefficient

μ_β: Rejection threshold coefficient

ν: Scale parameter, the characteristic life of Weibull distribution, which is the bearing life when the failure probability F (L) =0.632, h

5 Principle of test for life and reliability

Test the same batch of bearing samples under the same test conditions. Count the number of revolutions or time that the bearing can operate normally. Apply the corresponding evaluation method to process the test data to determine the life reliability parameters of this batch of bearing products.

6 Test classification

6.1 Tests are divided according to test methods and test purposes.

6.2 According to the test method, the classification is as follows.

a) Complete test method: a set of bearing samples are tested to failure.

b) Censoring test method: a set of bearing samples are tested to a predetermined time or to partial failure. Censoring test methods are further subdivided into the following three types:

1) Timed censoring test: a set of bearing samples are tested and the test is stopped at a predetermined time;

2) Fixed-number censoring test: a set of bearing samples is tested until the predetermined number of rejected sets is reached; generally, the number of rejected sets shall not be less than 2/3 of the bearing sample size (at least 6 sets shall be guaranteed);

3) Group elimination test: a set of bearing samples are randomly divided into groups, and the test is stopped until one rejected sample appears in each set.

c) Sequential test: a set of bearing samples are used to judge the samples that are stopped according to the rules one after another. Generally, the number of rejected sets does not exceed 5 sets.

6.3 According to the purpose of the test, the classification is as follows:

a) Verification test: a test used for product acceptance by users and verification by third-party certification agencies. Generally, censoring tests or sequential tests are used;

b) Periodic test: for bearings used in mass production, manufacturers must provide testing to users on a regular basis. The quality requirements are the same as verification testing;

c) Qualification test: a test that needs to be carried out when the bearing structure, material, and process are changed. Generally, a complete test or a truncation test is used.

7 Test equipment

7.1 General requirements

7.1.1 The test equipment shall be a bearing life testing machine whose performance parameters can meet the usage requirements or performance assessment capabilities and which have been regularly calibrated. The test equipment shall have some necessary monitoring means during the test process, such as monitoring of rotation speed, load, temperature, vibration, lubrication and other parameters.

7.1.2 The same batch of bearing samples shall be tested on testing equipment with the same main structure and performance parameters.

7.1.3 Comparative tests of bearing samples of the same structural type and the same outer dimensions shall be conducted on test equipment with the same main structure and performance parameters.

7.2 Tolerance zone requirements for test spindles and bearing housing holes that fit with bearings

7.2.1 When the inner ring of the bearing rotates and the outer ring is fixed, the tolerance zone of the test spindle and the bearing seat hole that matches the bearing is recommended to be selected according to Table 1.

7.2.2 When the bearing is subjected to a large radial load, the interference between the inner ring of the bearing and the test spindle shall be appropriately increased while ensuring the working clearance of the bearing to prevent relative sliding between the inner ring of the bearing and the test spindle during operation.

7.2.3 For bearings operating in other ways, the fit shall be determined through consultation with the user.

9.4.1.3 Lubricating oil quantity

The oil supply amount shall be able to ensure sufficient lubrication of the bearing samples during the test.

9.4.2 Grease lubrication

9.4.2.1 When testing grease-lubricated bearings, the lubricating oil circuit of the test bearing shall be closed.

9.4.2.2 The grease used for testing open grease-lubricated bearings shall be determined in consultation with the user. During the test process, the bearing temperature changes shall be monitored and the grease loss shall be checked. Add grease when necessary to avoid affecting the lubrication effect.

10 Test steps

10.1 Test preparation

10.1.1 Pre-installation inspection

Before the test, the number and size of the main parts of the test shall be reviewed and inspected to ensure that there is no interference between the parts. Review and inspect the dimensions of the test spindle and bearing seat holes that match the inner and outer rings of the bearing to ensure that they meet the technical requirements of relevant drawings and documents.

10.1.2 Installation

10.1.2.1 Installation of bearing inner ring and test spindle

The installation of the bearing inner ring and the test spindle generally uses press mounting, but hot mounting can also be used. The heating temperature of sealed bearings generally does not exceed 80℃. The heating temperature of open bearings generally does not exceed 100℃. The installation force shall not be transmitted through the rolling elements during installation.

10.1.2.2 Installation of bearing outer ring and bearing seat hole

To install the bearing outer ring and the bearing seat hole, push the bearing gently and install it in place.

10.2 Test equipment debugging and calibration

10.2.1 After the test body and the test equipment are assembled, rotate the test spindle. The test spindle shall rotate flexibly and there shall be no blockage. All systems of the test equipment can work normally.

10.2.2 Use a calibrated tachometer to check the test speed and control the error within ±2% of the set value.

10.2.3 Use calibrated force sensors, weights, pressure gauges and other instruments to check the test load so that the error is controlled within ±2% of the set value.

10.2.4 For tests with temperature requirements, the temperature measuring instrument shall be calibrated.

10.3 Running-in test

For oil lubricated bearing testing, the lubricating oil circuit shall be opened and the test bearing shall be fully lubricated. Oil-lubricated or grease-lubricated bearings shall first apply a small amount of load, and then start the testing machine to start the bearing. When applying combined loads, the axial load shall be applied first and then the radial load. Under normal circumstances, the load and speed shall be slowly increased to the set value within 3 h. When the test load is large or the temperature rise changes rapidly, the running-in time shall be appropriately extended. Generally, it is no more than 24 h.

10.4 Formal test

After the running-in test, conduct the formal test. Record the monitoring data and test time during the test. The rotation speed, load and temperature shall be controlled within the required range.

10.5 Data collection

Sample failure during the test due to reasons other than the bearing itself (such as equipment reasons, human reasons, accidents, etc.) shall not be included in the normal failure data.

Record the original test data. Keep data complete and correct. Test time statistics shall generally be accurate to minutes (min). When the user has needs, it can be determined through consultation with the user.

10.6 Termination of test

The test shall be stopped when the test reaches the predetermined time or the bearing fails.

10.7 Inspection after test

After the test is completed, the sample shall be inspected to determine whether the sample has rejected. If necessary, the cause analysis of typical failure samples can be carried out in the test report.

Failures include:

11.4 Conformity assessment

11.4.1 The conformity assessment parameter index, $L_{10t}/L_{10h} \geq Z'$, is accepted, among which $Z' = 1.4$ for ball bearings, $Z' = 1.2$ for roller bearings and aligning ball bearings.

11.4.2 According to the quality requirements, conformity assessment shall be carried out according to the following rules:

a) Verification test: the verification test is accepted when the accepted life is reached;

b) Qualification test: the qualification test is accepted if it reaches 3 times the accepted life-span.

12 Test report

The test report shall generally include the following aspects.

a) Sample description:

1) Sample source;

2) Sample type and sample parameters;

3) Sample quantity;

4) Sample test time;

5) Attach comparative photos of the samples before and after the test if necessary.

b) The standard number used in the test.

c) Test method:

1) The test conditions shall include the bearing rotation method, loading conditions, lubrication method, etc.;

2) Add a description of the test environment if necessary.

d) Test results:

1) Make a judgment or conclusion on whether the test samples and test data meet the requirements;

2) Description of test samples and abnormal phenomena observed during the test;

3) During the long-life test, the test report shall also give the multiple of the accepted life or the multiple of the basic rated life.

A.2.3 Parameter interval estimation

A.2.3.1 According to the serial number i and sample size N =12, look up Table A.2 and Table A.3 to find the corresponding 5% confidence limit and 95% confidence limit, as shown in Table A.4.

A.2.3.2 The abscissa is the test time L. The ordinate is the 5% confidence limit corresponding to each failure data. Plot points on the Weibull distribution plot. Connect the points with smooth curves.

A.2.3.3 The abscissa is the test time L. The ordinate is the 95% confidence limit corresponding to each failure data. Plot points on the Weibull distribution plot. Connect the points with smooth curves.

A.2.3.4 The area between the two curves on the distribution chart is the 90% confidence interval of some characteristic parameters, as shown in Figure A.2. Find the 90% confidence interval (52h, 190h) of the basic rated value of test for life L_{10t}.

A.2.4 Conformity assessment

L_{10t}/L_{10h} <1.4, so the life of this batch of bearing samples is judged to be rejected.

A.3 Figure estimation processing for fixed number censoring test data

A.3.1 Test data

Deep groove ball bearings produced by a manufacturer: L_{10h} =100 h, N =12 sets. At the end of the test, 12 data are obtained: no failure at 70 h, failure at 80 h, failure at 110 h, failure at 155 h, failure at 170 h, no failure at 180 h, failure at 220 h, failure at 240 h, no failure at 280 h, failure at 300 h, failure at 380 h, and no failure at 500 h.

A.3.2 Parameter point estimation

A.3.2.1 Sort the 12 test data from small to large. Record the sample test state.

A.3.2.2 Correct the serial number of the first invalid data:

$$I_1 = \frac{N+1}{N+2-i} \qquad \text{(A.1)}$$

Where,

I_1 - The correction value of the first rejected data sequence number;

i - The sequence number of the first rejected data in all data.

A.3.2.3 Correct the sequence number of the i-th rejected data:

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