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# Precision Gear Transmission for Robot - Test Method

机器人用精密齿轮传动装置 试验方法

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# Precision Gear Transmission for Robot - Test Method

## 1 Scope

This Standard specifies the basic requirements for test pieces, test equipment, installation and debugging, torque efficiency test, transmission precision test, service life test, bending moment rigidity test and data processing of bench test of precision gear transmission for robot.

This Standard is applicable to bench test of precision gear transmissions (such as: harmonic gear reducers, planetary cycloid reducers and cycloid pin gear reducers) for robots in general industrial environment.

## 2 Normative References

The following documents are indispensable to the application of this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 2828.1 *Sampling Procedures for Inspection by Attribute - Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-lot Inspection*

GB/T 2828.11 *Sampling Procedures for Inspection By Attribute - Part 11: Procedures for Assessment of Declared Quality Levels for Small Population*

GB/T 6404.1 *Acceptance Code for Gear Units - Part 1: Test Code for Airborne Sound*

## 3 Terms and Definitions

The following terms and definitions are applicable to this document.

### 3.1 No-load Running Torque

No-load running torque refers to the input torque at different stable speeds at the no-load output end, while starting the input end.

**NOTE:** no-load running torque may also be applied to the expression of speed - torque curve.

### 3.2 Starting Torque

Starting torque refers to the torque required at the moment when there is no load on the output end, and the input end is slowly reversed, to the start of the output end.

comply with the product design requirements and be accompanied by inspection records.

# 5 Test Equipment

## 5.1 Test Equipment of Torque and Speed

**5.1.1** It is used for test items, such as: no-load, loaded, overloaded, no-load running torque, starting torque and mechanical efficiency; the basic composition is shown in Figure 1 (the angle sensor may not be installed).

**5.1.2** The mode of driving and loading is not restricted and shall be able to maintain stable operation. Under the rated speed, the fluctuation of the driving speed shall not exceed ± 1 r/min; the fluctuation of the load torque shall not exceed ± 1.5% FS.

**5.1.3** It shall be able to start in forward, reverse and with load; the position adjustment component shall be able to be deadlocked.

**5.1.4** The specifications, measuring range and precision of the instruments and meters shall be compatible with the test requirements; the system errors shall be obtained through calibration and theoretical calculation. During the test, data shall be automatically recorded.

## 5.2 Test Equipment of Transmission Precision

**5.2.1** It is used for test items, such as: torsional rigidity, lost motion and transmission error; the basic composition is shown in Figure 1. On the input and output ends of the test piece, respectively install a set of angle sensors and speed torque sensors to directly measure the input and output torsional angles, torque and speed of the test piece. It shall be ensured that the connection between the test piece and the angle sensors is synchronized.

**5.2.2** The mode of driving and loading is not restricted and shall be able to maintain stable operation. Under the rated speed, the fluctuation of the driving speed shall not exceed ± 1 r/min; the fluctuation of the load torque shall not exceed ± 1.5% FS. The torsional angle measurement error shall not be greater than 1/3 of the transmission error of the test piece.

**5.2.3** It shall be able to start in forward, reverse and with load; the position adjustment component shall be able to be deadlocked. The torsional brake component shall reliably function (in other words, there shall be no looseness in the braking state, and no friction in the loosened state).

**5.2.4** The specifications, measuring range and precision of the instruments and meters shall be compatible with the test requirements; the system errors shall be obtained through calibration and theoretical calculation. During the test, data shall be

2---installation supporting system;

3---work platform.

**Figure 4 -- Schematic Diagram of Test Equipment of Bending Moment Rigidity**

**5.4.2** The specifications, measuring range and precision of the instruments and meters shall be compatible with the test requirements; the system errors shall be obtained through calibration and theoretical calculation. Test parameters include axial and radial load force, and output axis deflection angle. Use a force sensor to respectively measure the axial and radial load; use an angle measuring instrument to directly measure the deflection angle of the output axis, or, use a displacement sensor to measure the deflection displacement, then, calculate the deflection angle.

### 5.5 Test Equipment of Temperature and Noise

**5.5.1** The temperature measurement of the shell of the test piece shall preferentially adopt a patch-type temperature sensor.

**5.5.2** The noise test instrument and test method shall comply with the stipulations of GB/T 6404.1.

## 6 Installation and Debugging

After the installation of a test piece is completed, it shall comply with the following requirements:

---The connection between the test piece and the various parts of the test equipment shall be reliable; the rigidity shall be ensured; the adjustment links shall be reduced; the system errors shall be cut down.

---The coaxiality between the input and output axes of the test piece and the adjacent equipment shall be not greater than 0.02 mm; it shall be ensured that the system is flexibly operated.

## 7 Torque and Efficiency Test and Data Processing

### 7.1 No-load Test

Under the rated speed, respectively operate in the forward and reverse directions for no less than 30 min. During the test process, observe and record:

---Whether the various connectors and fasteners are loosened;

---Whether the various seals and joints manifest oil leakage and penetration;

After the load test is completed, DO NOT unload; continue to operate at 2.5 times the rated torque for 10 min; at 4 times the rated torque, operate for 2 s ~ 5 s.

# 8 Transmission Precision Test and Data Processing

## 8.1 Torsional Rigidity

**8.1.1** Fix the input end; gradually load the output end to the rated torque, then, unload it, and then, in the reverse direction, gradually load to the rated torque, then, unload it. Record the torque and torsional angle value corresponding to the output end. In the meanwhile, draw the hysteresis curve, as it is shown in Figure 6. During the test, it shall be ensured that there is no backlash in each connection part. If there is a backlash, then, before the test, it needs to be accurately measured; in the final result, the backlash of the connection parts shall be corrected as a system error.

**8.1.2** From zero, load to the rated load, then, from the rated load, drop to zero. The sampling quantity of output torque and torsional angle shall respectively be not less than 100 points; the same for reverse loading. The test data shall be recorded based on the positive and negative increases of angular displacement.

**8.1.3** The torsional rigidity value is calculated from the hysteresis curve. The torsional rigidity value shall be fitted in sections in accordance with the hysteresis curve. Generally speaking, in accordance with different slopes, the unidirectional loading and unloading curve may be divided into 2 to 3 sections, or, it may be divided in accordance with the test demands of the test piece. Perform the least squares linear fitting on each section of loading and unloading data set; obtain the slope of the section $k$ = a/b; the reciprocal of the value $k$ is the torsional rigidity within the torque range of the section.

## 8.2 Lost Motion

**8.2.1** The test procedure and method of lost motion are the same as torsional rigidity. The result shall be calculated in accordance with the hysteresis curve and the definition of lost motion.

**8.2.2** On the hysteresis curve, when the x-coordinate is +3% rated torque, the average value of the two torsional angle values in the corresponding forward curve is $\theta_1$; when the x-coordinate is -3% rated torque, the average value of the two torsional angle values in the corresponding reverse curve is $\theta_2$; the difference between $\theta_1$ and $\theta_2$ is the lost motion of the test piece.

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