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NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 43200-2023

Performance and related test methods of mechatronic joints for robots

机器人一体化关节性能及试验方法

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1 Scope

GB/T 43200-2023 specifies the performance of integrated mechatronic joints for robots and the methods of testing it. The modular joint - motor, harmonic or cycloidal reducer, brake, encoders and drive electronics in one housing - is what made collaborative and legged robots buildable by companies that are not motion control specialists, and it is bought as a component, so its torque, backlash, stiffness, backdrivability and thermal behaviour have to be comparable between suppliers. The standard sets the performance characteristics and then the test methods: the test environment, equipment and fixtures, and the mechanical, electrical, control and other performance tests, with an informative annex giving examples of joint compositions. It applies to the joints of collaborative and legged robots and took effect on 1 April 2024.

This document specifies the performance of mechatronic joints (hereinafter referred to as joints) for robots and describe the related test methods. This document applies to the joints of collaborative robots and legged robots; other robot joints shall refer to this document for guidance.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including

any amendments) applies.

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 16439-2009, General specification for AC servo system

GB/T 35089-2018, Precision gear transmission for robot - Test method

GB/T 39266-2020, Mechanical environment reliability requirements and test methods for industrial robots

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 mechatronic joint A drive module with independent functions, consisting of motor, reducer, encoder, driver, etc. [Source: GB/T 38560-2020, 3.2, modified] The ratio of the difference between the maximum and minimum instantaneous torque of the joint to the sum of the maximum and minimum instantaneous torque of the joint when the joint is running in steady state under constant load. [Source: GB/T 16439-2009, 3.10, modified]

4 Performance

The joint's performance is as follows, and its performance shall meet the requirements of the product standard.

a) Mechanical performance. 1) Backdriving torque; 2) Allowable moment load; 3) Allowable torque during acceleration or deceleration; 4) Joint inertia; 5) Mechanical stiffness; 6) Backlash; 7) Static servo stiffness; 8) Static rated braking torque; 9) Dynamic rated braking torque; 10) Safety torque off.

b) Electrical performance. 1) Rated power; 2) Rated speed; 3) Rated torque; 4) Efficiency; 5) Maximum permitted speed; 6) Instantaneous maximum torque; 7) Torque constant; 8) Torque density; 9) Power density.

c) Control performance. 1) Absolute positioning accuracy; 2) Repetitive positioning accuracy; 3) Torque control accuracy; 4) Position response time of a positive step input; 5) Position response time of a negative step input; 6) Speed response time of a positive step input; 7) Speed response time of a negative step input; 8) Torque response time of a positive step input; 9) Torque response time of a negative step input; 10) Location bandwidth; 11) Speed bandwidth; 12) Torque bandwidth; 13) Range of rotation angle; 14) Speed ripple coefficient; 15) Torque ripple coefficient.

d) Other performance. 1) Vibration; 2) Impact; 3) Noise.

5 Test methods

5.1 Test environment Unless otherwise specified, all tests shall be conducted under the following conditions. -- Temperature. 15 °C ~ 35 °C; -- Relative humidity. 25% ~ 75%; -- Atmospheric pressure. 86 kPa ~ 106 kPa.

5.2 Test equipment

5.2.1 Test power supply The voltage of the DC test power supply shall be within ±10% of the rated voltage specified in the joint product standard, and the ripple voltage shall not exceed ±1%; the AC test power supply shall be (220±11) V, and the frequency shall be (50±1) Hz.

5.2.2 Test instruments The accuracy requirements for test instruments are as follows: -- Voltmeter, accuracy not lower than grade 0.5; -- Ammeter, accuracy not lower than grade 0.5; -- Power analyzer, accuracy not lower than grade 0.5; -- Angle sensor, accuracy not less than ±2 arcsec (arcseconds); -- Speed sensor, error shall be less than ±0.1% of the speed range or less than 1 r/min (revolutions per minute); -- Torque sensor, accuracy not lower than grade 0.5; -- Temperature measuring instrument, accuracy not lower than ±1 °C; -- Force gauge, accuracy not lower than grade 1; -- Weight, accuracy not lower than grade M3; -- Resistance measuring instrument, accuracy not less than grade 0.2; -- Sound level meter, accuracy not less than ±1 dB.

5.3 Test device Unless otherwise specified, the test device is shown in Figure

1.An example of joint components is shown in Appendix A. Before the performance test, the joints shall be assembled and wired correctly.

5.4.7 Static servo stiffness When the joint is working in position control mode - if there is a brake, the brake shall be in a non-braking condition - load the output end. First slowly load from 0 in one direction to TN; then slowly load in the opposite direction to -TN; then slowly load in the positive direction to TN; finally, slowly unload. Record the output end rotation angle change value corresponding to different load torques during this process, and draw the hysteresis curve, as shown in Figure 3. In the hysteresis curve, the ratio of the load torque to the corresponding elastic deformation angle, i.e., b/a in Figure 3, is the static servo stiffness, where b is half of the rated torque and a is the difference between the angle corresponding to the rated torque on the median line and the angle corresponding to 50% of the rated torque.

5.4.8 Static rated braking torque When the joint is under braking conditions, slowly and uniformly increase the torque applied to the joint output end to the specified static rated braking torque, and check the angular displacement of the joint output end to see if it exceeds ±1°.

5.4.9 Dynamic rated braking torque When the joint is running under no-load and rated

speed, gradually increase the torque at the joint output end to the specified dynamic rated braking torque. Once the joint rotation speed stabilizes, and the internal brake is activated, observe the joint to check if it can brake normally and stop rotating.

5.4.10 Safety torque off When the joint is running normally, enable the safety torque off signal to determine whether the joint has stopped and the output shaft has entered the free state.