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Torsional and Pinching Dynamic Characteristics Testing of Rubber Vibration Isolators [JIS K6385]

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User Benefits

- Dynamic characteristic tests based on JIS K6385 can be performed.
- Frequency sweep tests automatically measure dynamic characteristic values at each frequency.
- Tests in both torsional and pinching directions can be performed simply by changing the jig.

■ Introduction

Rubber vibration isolators are a product designed to prevent or mitigate the transmission of vibration and shock and are widely used in various fields such as transportation equipment, construction, and industrial machinery.

JIS K6385 "Rubber vibration isolators - Testing methods" specifies several test methods and terms for evaluating the performance of rubber vibration isolators[1]. Among these, tests in the torsional direction around the central axis and tests in the torsional direction around an arbitrary axis perpendicular to the central axis (pinching test) are defined for cylindrical rubber vibration isolators. Cylindrical rubber vibration isolators are used for supporting and coupling vibration sources such as engines and motors, and play an important role in reducing noise and stabilizing performance. When mounted on a vehicle, loads are applied in both the torsional and pinching directions, so it is necessary to evaluate the characteristics of each.

This article introduces examples of dynamic characteristic tests in the torsional and pinching directions for cylindrical rubber vibration isolators.

International standards corresponding to JIS K6385 have not been established at present.

■ Specimen Information

Cylindrical rubber vibration isolators, which are generally available on the market, were used as the test pieces. Fig. 1 shows a photograph of a test piece, and Table 1 shows the test piece information.

Fig. 1 Photograph of a Specimen

Table 1 Specimen Information

Material	: Rubber conforming to JIS K 6386 Type A
Outer Diameter	: 33 mm
Inner Diameter	: 14 mm
Total Length	: 31 mm
Allowable Torsion Angle	: 5 deg
Torsional Static Spring Constant	: 0.45 N•m/deg (reference value)

■ Test Equipment

Since the torsional and pinching directions are about rotational axes, they cannot be tested with a general tensile testing machine with a linear axis. The combined axial force and torsion testing machine EHF-EV/TV was used in these tests.

Fig. 2 shows a photograph of the equipment, and Table 2 shows the equipment information. In this test, the small-capacity load cells shown in Table 2 were used in accordance with the strength of the specimen.

This machine can control not only torsion but also axial force at the same time. In these tests, the axial force direction was controlled by maintaining the position.

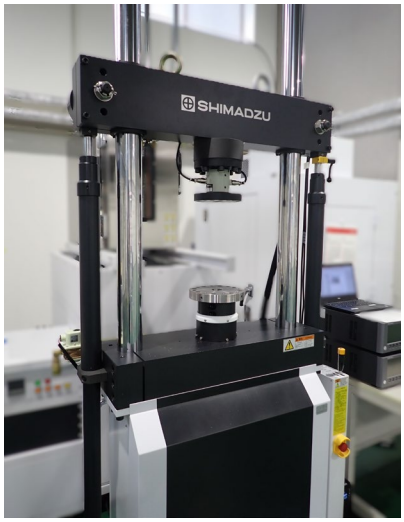


Fig. 2 Axial Force and Torsion Testing Machine
EHF-EV100kN/TV1kN•m

Table 2 Equipment Information

Testing equipment	: Axial Force and Torsion Testing Machine EHF-EV100 kN/TV 1kN•m
Grips	: Torsional and pinching dedicated jig
Small Capacity Load Cell	: Biaxial 10 kN/100 N•m
Software	: Frequency sweep, Resonance tracking Software

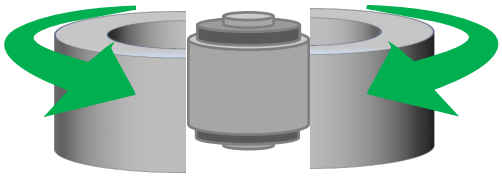
The test conditions are shown in Table 3. The conditions were the same for both the torsion test and the pinching test. This test corresponds to the non-resonance method of the dynamic characteristic test in JIS K6385. Frequency sweep refers to the automatic sequential change of the excitation frequency during the test. By using frequency sweep, the characteristics of the specimen obtained by changing the frequency can be obtained continuously.

In JIS K6385, if not specified between the parties involved, the test conditions are to be carried out at an average deflection of 2 mm with an amplitude of ±0.5 mm and an excitation frequency of 15 Hz, or with an amplitude of ±0.05 mm and an excitation frequency of 100 Hz. However, there is no specification for the torsional direction and the pinching direction. Therefore, in order to investigate the dependence of the dynamic characteristics of the specimen on the excitation frequency in the torsional direction and the pinching direction, the frequency was changed stepwise in the range of 3 to 20 Hz.

Table 3 Test Conditions

Testing Mode	:	Frequency sweep
Control Transducer	:	Angle
Wave Form	:	Sine wave
Test Frequency	:	3 to 20 Hz (Change with time at step intervals)
Amplitude	:	0 ± 5°
Test Temperature	:	Room temperature (24 °C)

The jigs were designed specifically for torsion and pinching tests. Figs. 3 and 4 show the jigs holding the specimens for torsion and pinching tests, respectively.



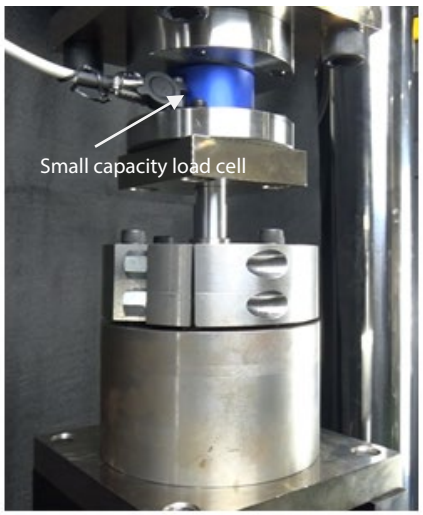
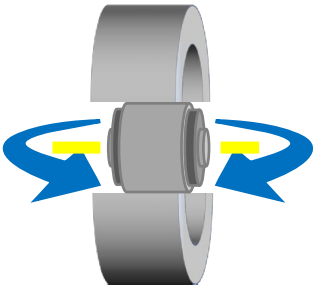


Fig. 3 Torsion Test



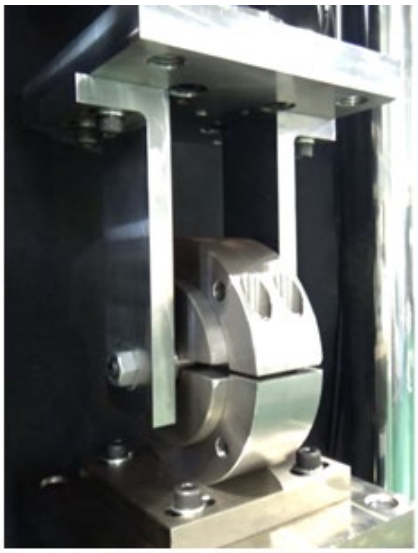


Fig. 4 Pinching Test

■ Test Results

Figs. 5 to 8 show the test results. These are the cycle peak value graph and time waveform graph for each test. The torque is shown in blue and angle is shown in light blue.

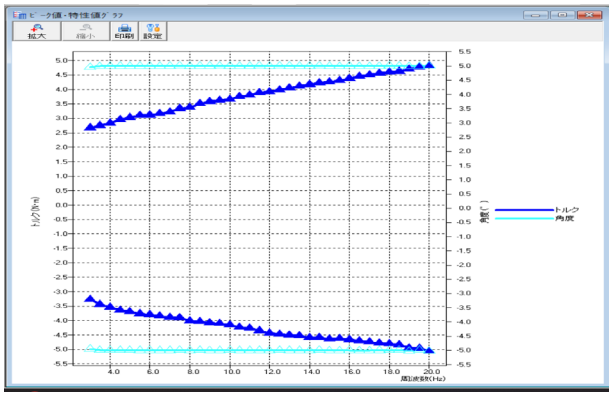


Fig. 5 Cycle Peak Value Graph for Torsion Test

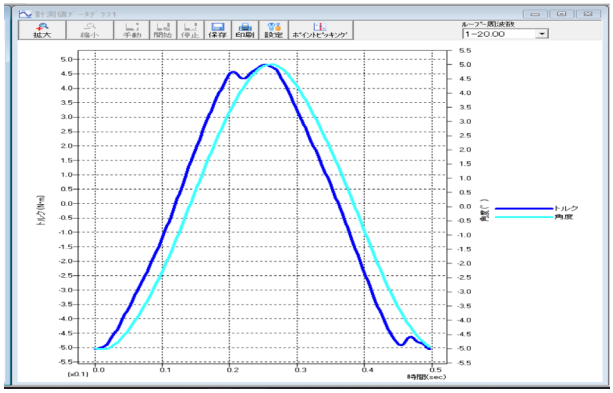


Fig. 6 Time Waveform Graph (at 20 Hz) for Torsion Test

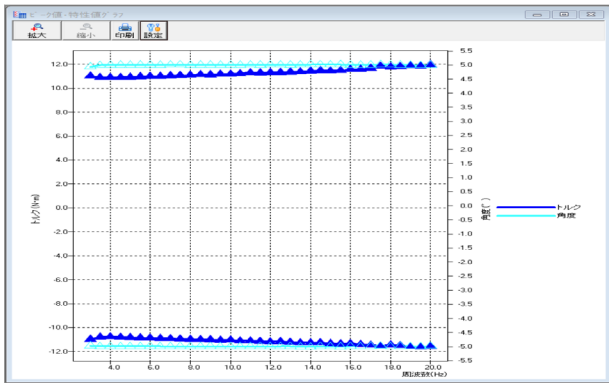


Fig. 7 Cycle Peak Value Graph of Pinching Test

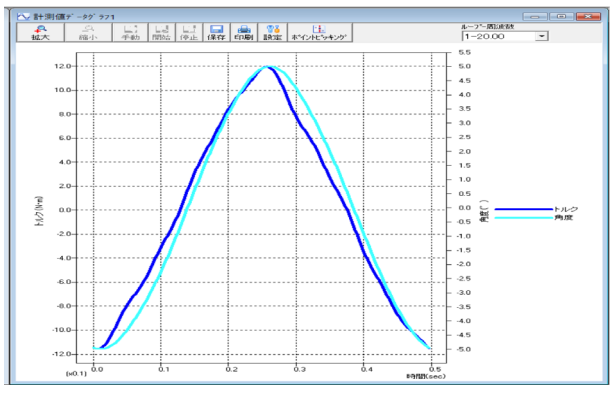


Fig. 8 Time Waveform Graph (at 20 Hz) for Pinching Test

The test results were converted to text files and analyzed. Figs. 9 and 10 show the torque angle diagram at each excitation frequency. In the torsion test, the torque increases as the excitation frequency increases. In the pinching test, the torque is stable regardless of the excitation frequency.

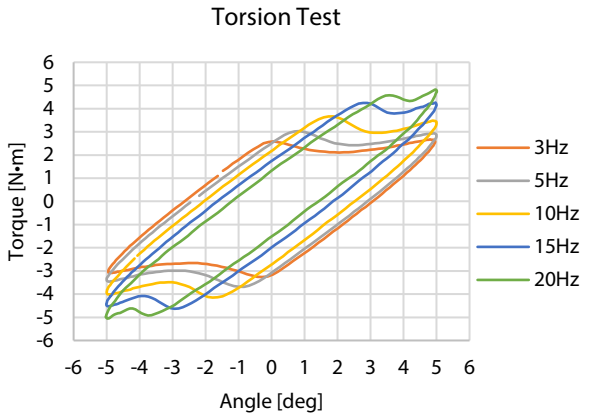


Fig. 9 Torque Angle Diagram of Torsion Test

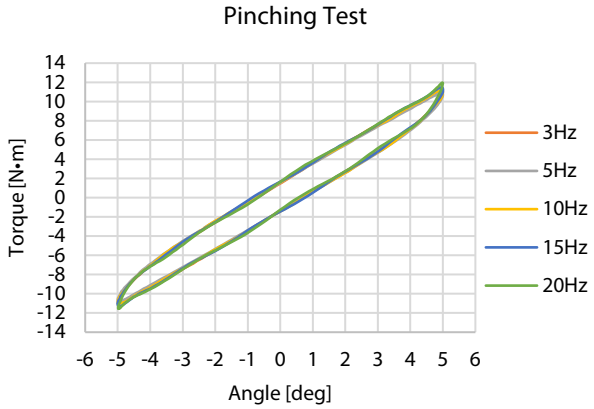


Fig. 10 Torque Angle Diagram of Pinching Test

The area of the hysteresis curve in the torque angle diagram is the energy loss. This is defined in the JIS K 6385 reference standard JIS K6394[2]. Shimadzu's frequency sweep test and resonance frequency tracking test software have a function to calculate the energy at each frequency step.

Fig. 11 shows the energy graph. It can be seen that the torsion test is more affected by the change of excitation frequency than the pinching test.

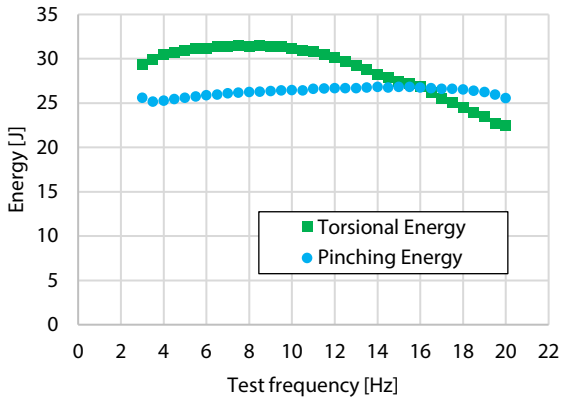
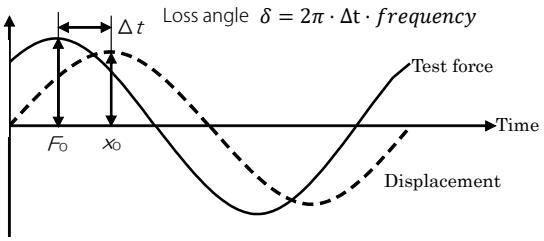


Fig. 11 Energy - Test Frequency Graph

■ Calculation of Various Dynamic Characteristic Values

JIS K 6385 specifies calculation methods for various dynamic characteristic values, referring to JIS K6394. Absolute spring constant, storage spring constant, loss spring constant, damping factor, and loss factor are each calculated from Formulas 1 to 5 respectively. Like energy, these can be calculated by frequency sweep test and resonance frequency tracking test software. For torsion and pinching tests, test force is converted into torque and displacement into angle.

The international standard corresponding to JIS K6394 is ISO 4664-1.



Absolute spring constant	$\lvert K^* \rvert = \frac{F_0}{x_0}$	Formula 1
Storage spring constant	$K' = \lvert K^* \rvert \cos\delta$	Formula 2
Loss spring constant	$K'' = \lvert K^* \rvert \sin\delta$	Formula 3
Damping factor	$c = \frac{K''}{2\pi \cdot frequency}$	Formula 4
Loss factor	$Lt = \frac{K''}{K'}$	Formula 5

The values of various dynamic characteristics vary depending on the excitation frequency. Based on the test results of the frequency sweep test, the changes of various dynamic characteristics were plotted against change of the excitation frequency.

Fig. 12 shows the graph of the spring constant. It can be seen that the absolute spring constant and storage spring constant changed less in the torsion test than in the pinching test.

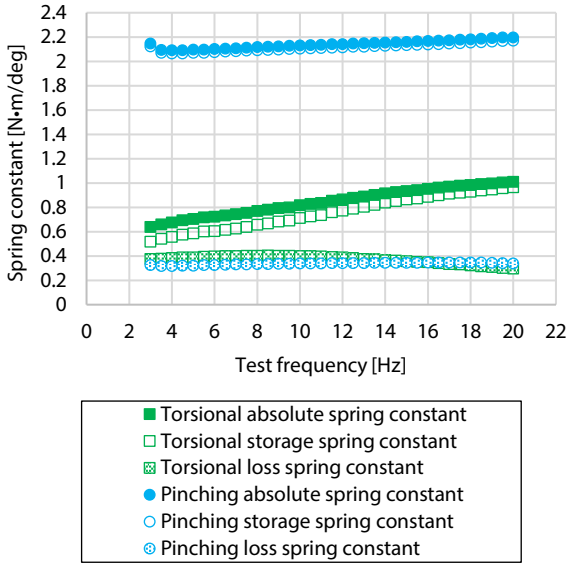


Fig. 12 Spring Constant - Test Frequency Graph

Fig. 13 shows the graph of the damping factor. Similar curves are drawn for both torsion and pinching tests.

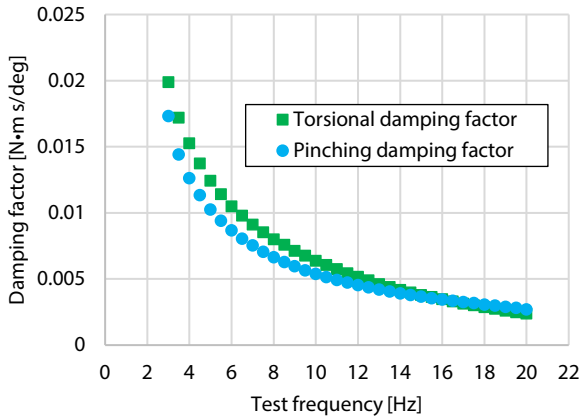


Fig. 13 Test Frequency – Damping Factor Graph

Fig. 14 shows the loss factor graph. It can be seen that the loss factor of the pinching test is stable regardless of the frequency, while the loss factor of the torsion test is greatly affected by the frequency change.

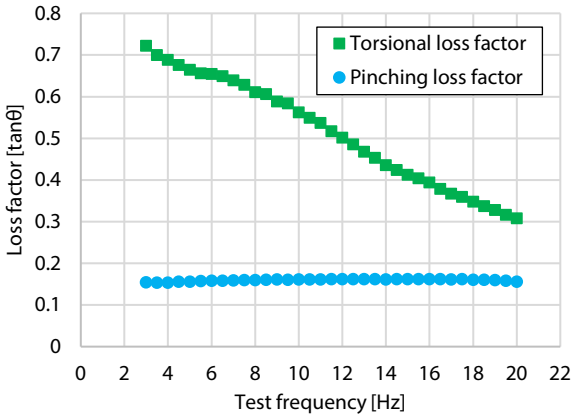


Fig. 14 Test Frequency – Loss Factor Graph

■ Conclusion

Using a combined axial force and torsion testing machine, torsional and pinching dynamic characteristic tests were conducted on cylindrical type vibration isolators based on JIS K6385. By using the frequency sweep test software, it was possible to quickly confirm the dependence of various dynamic characteristic values on the excitation frequency.

<References>

1) Rubber vibration isolators - Testing Methods JIS K6385-2012
2) Rubber, vulcanized or thermoplastic – Determination of dynamic properties–General guidance JIS K6394-2007

01-01035-EN First Edition: Oct 2025

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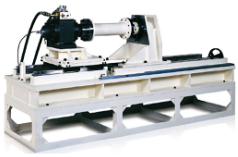

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