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Three Researchers in JSME Award in 2003

Encourage Talent and Contribute to the Society through the Planning of Various Events

Hiroya Taguchi

President, JSME
Hitachi, Ltd.

Introduction

The "8th ROBOT GRAND PRIX" exhibit entitled "Mechano World -from karakuri (traditional Japanese moving puppet) to robot-", was presented at the *Sasashima Satelite exhibition*, 2005 World Expo, Aichi, Japan, (March 18 to 21, 2005) by the Robotics and Mechatronics Division of the Japan Society of Mechanical Engineers (JSME) and JSME Tokai Branch worked in co-operation with Nagoya City.

Continued on page 2

Advanced technology of spiral bevel and hypoid gears

Shogo Kato

Professor
Setsunan Univercity

Introduction

Spiral bevel and hypoid gears, which are used as the final reduction gears of vehicles, have very long history. However the procedure of the design and manufacturing have been stayed in the primitive stage. On my opinion, the main reason is that any measuring method of gear tooth surfaces had not existed before my invention. I invented the measuring method(1) of gear tooth surface of spiral bevel and hypoid

Continued on page 3

Servo track writing of HDDs using magnetic printing technology

Kaoru Matsuoka

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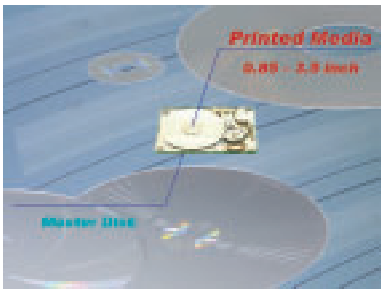
Introduction

As the recording density of hard disk drives (HDDs) is rapidly increasing, the current method of servo track writing by using a conventional servo track writer has become more costly and technically difficult [1]. To cope with these problems, a new magnetic contact duplication technology using a lithographically patterned master disk has been proposed [2], [3].

In this article,the author



Continued on page 6

Vibration isolation system using zero-power magnetic suspension

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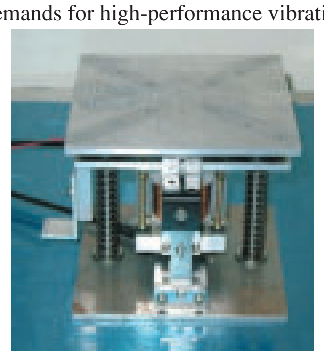
Introduction

Demands for high-performance vibration isolation systems have been increasing in various scientific and industrial fields. There are two kinds of vibration to be reduced by vibration isolation system. One is vibration transmitted from ground through suspension. The other is vibration caused by disturbance acting on the isolation table (direct disturbance).



Continued on page 9

Encourage Talent and Contribute to the Society through the Planning of Various Events

Hiroya Taguchi
President, JSME
Hitachi, Ltd.

Continued from page 1This was the fist time for the JSME to work with a World Expo. The City of Nagoya displayed and demonstrated eight *dashi-karakuris*, which are recognized as important cultural assets. JSME demonstrated performing Street Artist robots, and had children experience numerous experiments in order to attract their interest and gain the understanding. It was a co-starring performance by old mechanics (traditional *karakuri*) and new mechanics (Street Artist Robot made with today's high technology).

The roots of today's high technology mechatronics comes from the *karakuri*. The lecture by Dr. Ichiro Tsutsumi, professor at Polytechnic University, explained the inside mechanism of the *karakuri*. The entirey audience, from children to adults, showed high interest in his explanation and observed with great interesy. Also the lecture, "Why swings swing?" by Dr. Koji Kimura, Professor at Tokyo Institute of Technology, explained the principle of a pendulum through humorous experiments which increased the understanding of the audiences.

A member of the society for the preservation of *karakuri* told me, "We now face difficulties in funding, and human resources to teach young engineers the knowledge of repair, preservation and operation of *karakuri*." When we look at the state of mechanical engineers and technology of production, we find ourselves facing similar problems. Through *karakuri*, I realized the importance of preserving cultural assets and commemorative machines, and the urgent need in training young personnel.

The mission for JSME is to encourage and to increase the interest of the next generation towards mechanics and technology of production through events with various new idea and devoted efforts by JSME members including student JSME members. This year, we plan to further publicize the efforts of our members towards personnel training and contributions to the society through the support and promotions of various events.

Lastly,I would, like to express my gratitude and ask for further support from the staff of Nagoya City and co-sponsored corporations.

Co-sponsored Groups :
JSME Tokai Branch, JSME Robotics and Mechatronics Division, Nagoya University, Nagoya Institute of Technology, Chubu University, Tokyo Institute of Technology, Waseda University, Japan Mechanism Arts Association, Harmonic Drive Systems, Inc., Shimadzu Corporation, Denso Corporation, Yamaha Motor Co., Ltd

Organized Committee of Mechano World:
Kikuo Kishimoto, Executive Board Directer,Public Relations,JSME (Tokyo Institute of Technology), Masafumi

Fig.1 Photo of Karakuris (built in 1822～1835)

Fig.2 Explanation for mechanism of karakuri

Fig.3 Soccer robot

Fig.4 Experiment of water fluid in PET bottle

Katsuta, Executive Board Directer,Public Relations,JSME (Waseda University), Keisuke Tanaka, Executive Board Directer,Engineering Activities,JSME (Nagoya University), Hiroshi Ishikawa Executive Board Directer,General Affairs,JSME (Kagawa University), Takushi Saito (Tokyo Institute of Technology), Ichiro Tsutsumi (Polytechnic University), Koji Kimura (Tokyo Institute of Technology), Yoshikazu Suematsu (Nagoya University)
Organizing Committee of 8th ROBOT GRAND PRIX:
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Advanced technology of spiral bevel and hypoid gears

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Continued from page 1 gears at first in the world. It is the epoch-making technique and has opened the gate toward the analytical investigation of the gears. Now efficient gear checkers based on my invention are available around the world. I invented the other techniques, which inspect the transmission error of gear pairs under load and the software, which assists design and manufacturing of the gears. Using these new techniques we are producing quality gears.

1. Gear tooth surface measurement and it's applications
The traditional procedure to evaluate gear tooth surface is the tooth bearing check(Fig.1). It is very clear that it can only trivial information and is useless to manufacture quality gears. Really speaking most gear manufactures are relying on this method even now. The gear tooth checker(2)(3) based on my invention is shown in fig.2. Transverse profiles (maximum 29) and lengthwise profiles (maximum 9) are measured on the lines as shown in fig.3. As for the reference of the measurement, the surface created by the tooth cutting condition is used for the gear and the surface generated by the gear reference surface is used for the pinion. Fig.5 shows measured data of the gear pair after lapping. Five transverse profiles and one lengthwise profile are measured. The mean area of transverse profiles and lengthwise profile of the gear express fairly flat pattern. The protrusions at both end of transverse profiles are made by lapping process and it's height shows the removal amount of lapping, which is useful for lapping process control. In fig.5, the transverse profiles of the pinion have also flat shape. On the other side the lengthwise profile of the pinion has fairly amount of crowning, which is given to avoid edge contact. The relative profiles can be obtained by adding both errors of the gear and pinion simply. The transverse profile of mean position expresses fairly flat pattern and this suggests this gear pair has a fairly good conjugateness.

Fig.1 Tooth bearing


Fig.2 Gear tooth checker

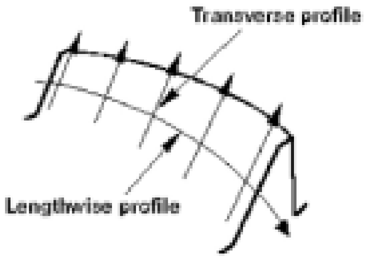


Fig.3 measured lines

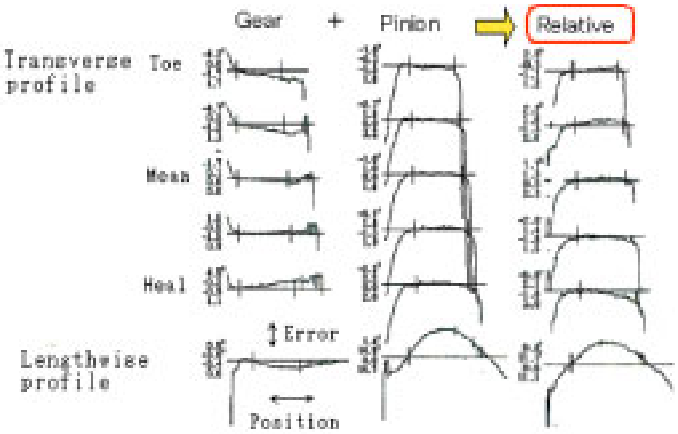
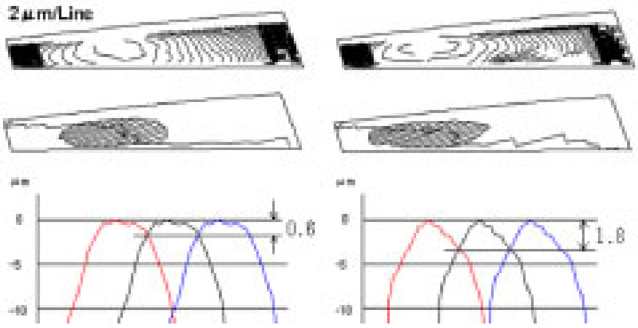


Fig.4 Tooth profile data



(a) Quiet gear (b) Noisy gear

Fig.5 Tooth contact analysis

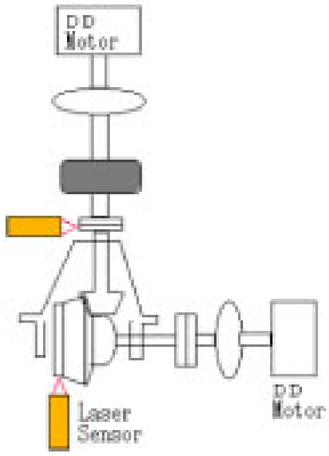


Fig.6 Transmission error tester for gear unit

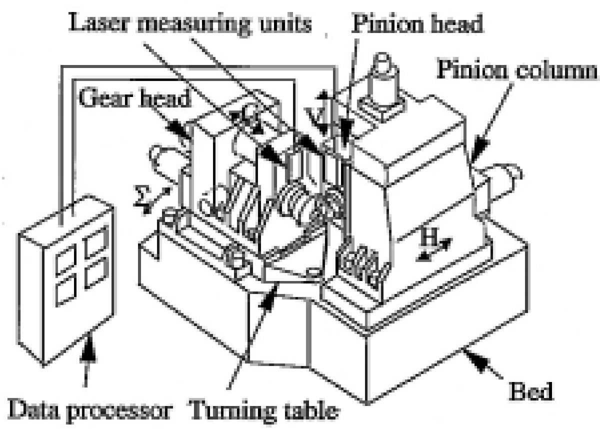


Fig.7 Transmission error tester of gear pair

The features described above are just the same as involute gears. So the experienced engineers in involute gears are able to understand the measured data very easily. On the other hand, so called 3D coordinate measurement system of bevel and hypoid gears(4), which was developed after my invention by Gleason and Carl Zeiss, does not have those features and is useless to analyze gear surfaces, which are generally complicated. Therefore I do not admit the system as a gear checker.
Then I have developed the program, which makes a contour map of error, a tooth bearing and a motion graph as shown in fig.5 from the relative data. The error of the quiet gear in the profile direction is smaller than that of the noisy gear, and it causes the smaller variation of motion graph. Furthermore we developed the technique to calculate the tooth contact analysis under load condition(5)(6)(7).

2. Transmission error tester under load condition
To make quiet gears an accurate measurement of transmission error under load, which is the origin of gear noise, is an essential technique. Some techniques were presented. However they are not sufficient in accuracy of measurement or torque capacity. In the case of vibration test obtained data is relative (it is affected by the mechanical system) and it is differ from surface error in the scale. I developed the measuring techniques shown in fig.6(8) and fig.7(3). Because the gear rotational movements are

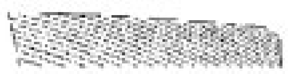
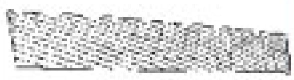
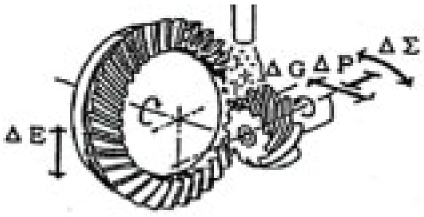
Drive side		Cutter Dia.= 5 inch	Cutter Dia.= 6 inch
Error map by misalignment	PMD +0.1 mm		
	Offset +0.1 mm		
Tooth Bearing	No Load		
	under Load H=-0.1mm V=-0.16mm		

Table 1 Effect of cutter diameter on tooth bearing shift



	⊿Σ	⊿P	Tooth Bearing
Toe	50min.	-0.1mm	
Center	0	0	
Heal	-80	-0.1	

Table 2 Study of lapping machine setting

detected by laser sensors at near position from gear mesh, very accurate measurement is achieved. Steady torque (maximum 1200NM at gear axis) and smooth rotation are given by the direct drive motors. The analysis ability is 5 micro-radian.

3. Assistant software for design and manufacturing

The design of bevel and hypoid gears has been limited by the guidance made by machine tool makers. Because of the many freedoms in the design, I believe the possibility to get better gears. For the tool to search the best design, I developed the assistant software(7), which predicts gear performance exactly. Table 1 is one example, which shows the effect of cutter radius, one of design parameters, on the tooth bearing under load condition. The cutter radius effects surface errors caused by the misalignment as shown in the upper figures. As for the tooth bearing under load, the one of 6 inch cutter gear reach to large end of the tooth, but the one of 5 inch cutter gear has some space to the end. This means that 5 cutter gear has more strength than 6 inch cutter gear. Furthermore the stress of gears in this condition can be calculated.

To make good gears it is very important to set machine tools correctly. This operation has been entrusted to skilled operators and has some limitation in the quality. The assistant software is effective to break the limitation. Table 2 shows one example of it's application. In the lapping procedure, which finishes the tooth surface after heat treatment, the tooth bearing is shifted between the toe position and the heal position. By using the software, the machine settings to shift the tooth bearing at the desired position can be obtained.

4. Conclusion

The developed techniques above mentioned are the state of the art in bevel and hypoid gears. We can produce much better gears by using those.

Reference

(1) Measuring method of hypoid gear tooth profiles, Kato, Akamatu, SAE Technical paper, No.810105, 1981
(2) Measurement of hypoid gear tooth profiles, Oguma, Kato et al, Application machinery, vol.33, No.5, p96-101, 1992

(3) Development of Revolutionary Measuring Methods of Hypoid-Gears, Kato, Kubo, International Conference on Gears, VDI Berichte, Nr. 1230, p1053-1065, 1996
(4) Computer aided inspection of bevel and hypoid gears, Krenzer, Knebel, SAE Technical paper, No.831266, 1983
(5) Checker of 3D Form Accuracy of Hypoid & Bevel Gear Teeth for the New Generation of Quality Control, Saito, Kato et al, AGMA Technical Paper 98FTM7, 1998
(6) Tooth root stress analysis of hypoid gears, Wang, Kubo, Kato et al, Trans. JSME, Vol. 66, No.652,p221-227, 2000-12
(7) Performance Analysis of Hypoid Gears by Tooth Flank Form Measurement, Takeda, Wang, Kubo, Kato et al, The JSME International Conference on Motion and Power Transmissions, p595-601, 2001
(8) Analysis of the effect of cutting dimensions on the performance of hypoid gears manufactured by the face hobbing process, Kato, Kubo, 4th World Congress on Gearing and Power Transmission, 1999
(9) Measuring method of transmission error of final reduction gearboxes and gear noise occurrence mechanism, Kato, Nomura, Trans. JSME, Vol.69, No.688, p230-235, 2003-12

Servo track writing of HDDs using magnetic printing technology

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Continued from page 1 first reviews the basic scheme of magnetic printing technology. Then, the author discusses the reliability of the printing process for its applicability to the product drives, including development of the master disk production process and magnetic printing process, in particular, from the viewpoint of the issue of master-slave contact [4].

Basic principle and advantages

Fig. 1 shows a schematic illustration of the duplication method. On the master disk, a ferromagnetic film patterned according to the information signal to be printed on slave disks is processed by a lithography technique. After the master disk is placed facing a DC-erased magnetic disk, i.e., slave disk, an external field is applied to the master disk. Then, owing to the shielding effect of the individual patterned magnetic film on the master, flux leaks and reverses the initial magnetization on the slave disk at the section between the neighboring patterned films, and magnetic signal information according to the magnetic film pattern on the master is printed onto the slave disk [2].

Unlike the anhysteretic process of the conventional contact duplication method for magnetic tapes [5], [6], this method can provide a very effective way of printing signals on highly coercive hard disk media. For one reason, since the signal information stored on the master is not a magnetization pattern, but provided as a physical shape pattern of the magnetic films, the master information never disappears when a large external field is applied to the master during the printing process. Also, the magnetic film on the master is not necessarily required to be so coercive as the slave medium, but is allowed to be a more permeable soft magnetic film with a higher magnetic moment, thus ensuring sufficient recording capability.

This duplication method can also provide a very productive and inexpensive method for the servo track writing process of HDDs, because it is essentially an areal lump-sum recording, while the current servo track writing process is a linear recording based on the relative movement between the head and the disk.

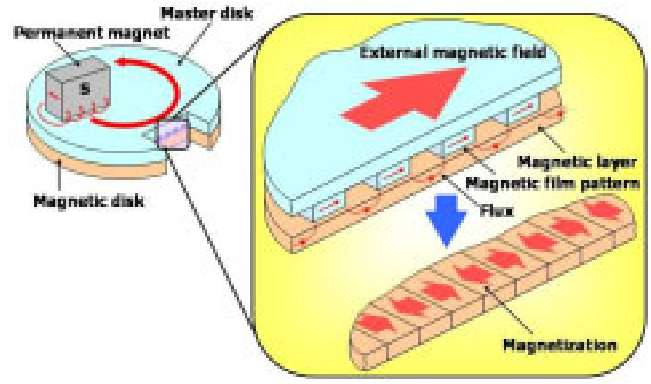

Figure 1. Magnetic duplication method using a lithographically patterned master disk

Self-servo-writing method using magnetically printed reference signal

If the product servo track signal pattern currently used in the drives is to be directly printed on the disk, productivity and cost performance would be optimally improved. However, in such a case, there are two major issues to be solved. One is that there remains a certain amount of

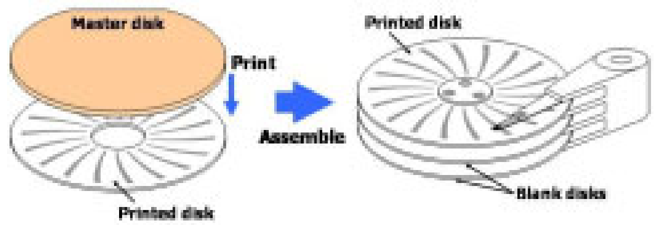

Figure 2. Self-servo-writing method using magnetically printed reference signal

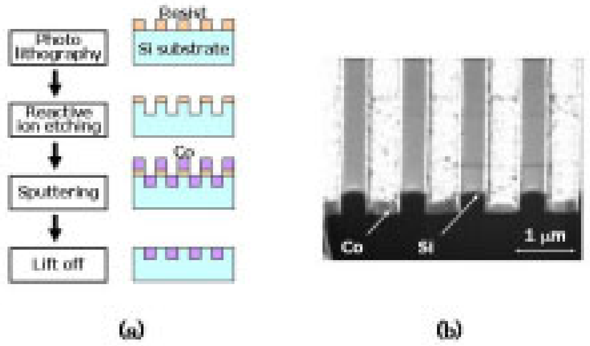

Figure 3. (a) Master disk process flow; (b) SEM photo of master disk surface

eccentricity in the printed pattern with respect to the disk rotation center. The other is that even the most up-to-date lithography system with high resolution would suffer from the small feature size (approximately 0.1 μm) of reasonably dense product servo track signal pattern. So in the actual drive process, practically introduced is the self-servo-writing method using the printed signal pattern [7] as shown in Fig. 2.

First, a low density reference signal pattern is printed on a magnetic disk surface. After installing the printed disk with normal non-printed disks in the drive, the inductive heads installed self-servo-write and generate the high density product servo track signal pattern by referencing the printed signal pattern for positioning the heads. Pattern eccentricity can be minimized in the generated product pattern because it can be compensated during the self-servo-writing process. Also, in the reference pattern signal density can be considerably relaxed so that the conventional photo mask lithography process can easily process the pattern.

The self-servo-writing method still has many advantages regarding productivity and cost, since the process essentially deals with sealed drives and does not require expensive servo track writers and a clean room area to place them in.

Printing process reliability proof for practical implementation to the product drives

For practical implementation of magnetic printing technology to the product drives, the most serious concerns had been printed signal uniformity, master disk durability and slave media damage (physically or chemically) from the viewpoint of the issue of master-slave contact. In order to achieve sufficient practicability and reliability for commercial production of HDDs using the magnetic printing technology, the following items were mainly studied.

A. Master Disk Production Process

Fig. 3(a) shows the lithography process flow for the master disk production. First, a resist mask pattern according to the servo track signals to be printed on magnetic disks is formed on a silicon substrate by using a lithography technique. Then, the surface of the silicon substrate is

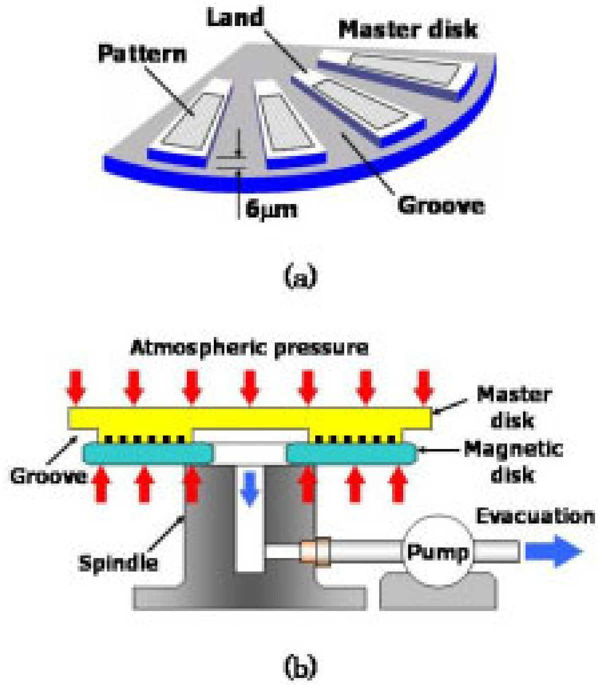

Figure 4. (a) Master disk surface; (b) Contact method between the master disk and slave disk surfaces

etched by reactive ion etching (RIE), and a cobalt film is sputter-deposited so that the film is buried into the etched section. After removing the resist layer and any unnecessary cobalt layer on the resist, the embedded cobalt film pattern according to the servo track signal is complete as shown in Fig. 3(b). This kind of structure is advantageous with respect to master disk durability since it can reduce the stress put on the magnetic film by the close contact between the two rigid disks. The cobalt film thickness is typically set at 0.3 μm to 0.5 μm for printing on current highly-coercive media.

B. Surface area contact between two rigid disks

Achieving full surface area contact between two rigid disks, i.e., a master disk and slave disk, is a serious issue. If the contact state is not secure enough, the printed signal deteriorates due to the spacing loss between the two disk surfaces.

Fig. 4 shows schematic illustrations of the method for achieving close and full surface contact between the master disk and slave disk surfaces. On the master disk, as shown in Fig. 4(a), a groove structure is provided between the neighboring servo pattern wedges. In the magnetic printing stage shown in Fig. 4(b), this groove structure functions as an air channel for evacuating the air between the master disk and slave disk, thus resulting in full surface area contact between them.

The printed signal amplitude modulation was found to be less than 10% in the disk radius region of 20 mm to 47 mm of the 95 mm disks, indicating that uniform printed signal quality is achievable over the entire user data area of the disk.

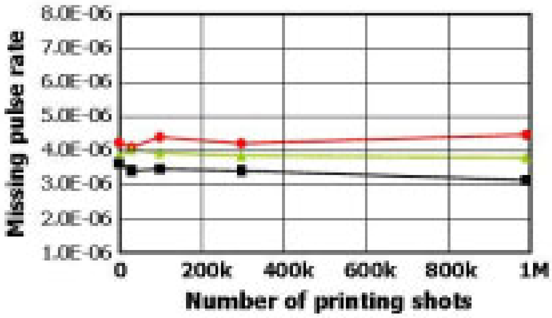

Figure 5. Missing pulse rate of the printed signal as a function of the number of printing shots

C. Physical or chemical damage proof of master disk and slave disk

Master disk durability against close contact between the two rigid disks, i.e., the master disk and slave disk, was evaluated from the missing pulse rate of the printed signal. If serious damage, such as exfoliation of the ferromagnetic film pattern, occurs to the master disk, the number of signal dropouts will increase. Fig. 5 shows the missing pulse rate as a function of the number of printing shots evaluated for three master disks of the same kind. It can be seen that, for all the three master disks, missing pulse rate remains constant from the initial state up to 1 million shots of printing, indicating that the master disk with the structure shown in Fig. 3 is durable over 1 million pieces of printed media production.

From organic and inorganic contamination test results of the printed disk, in comparison with the non-printed disk, it is also indicated that the contact printing operation itself does not induce chemical contamination when both the printing process and the ambient conditions are adequately controlled.

Summary

A new magnetic contact duplication technology using a lithographically patterned master disk has been proposed and the following outcomes were obtained regarding the issues for practical implementation of the technology to produce HDDs.

The air channel structure provided on the master disk surface allowed close and full surface contact between the master and slave disks, yielding very small amplitude modulation of the printed signal.

The master disk produced with the presented process was found durable over 1 million printing shots without any serious damage to the lithographically patterned ferromagnetic film.

Organic and inorganic contamination tests show that the contact printing operation does not induce increased contamination on the printed disks.

The presented magnetic duplication technology can provide a very effective and inexpensive way for the servo track writing of HDDs, and is a promising candidate for realizing productive and cost effective mass production processing of future high density HDDs.

References

[1] Y. Uematsu, et al., “Development of the pushpin free STW.” Digests of APMRC2000, WB3-01 (2000).
[2] T. Ishida, et al., “Printed media technology for an effective and inexpensive servo track writing of HDDs,” IEEE Trans. Magn., Vol. 37, pp. 1875-1877 (2001).
[3] T. Ishida, et al., “Demodulation of servo tracking signals printed with a lithographically patterned master disk,” IEEE Trans. Magn., Vol. 37, pp. 1412-1415 (2001).
[4] T. Ishida, et al., “Magnetic printing technology - application to HDD,” IEEE Trans. Magn., Vol. 39, pp. 628-632 (2003).
[5] H. Sugaya, et al., “Magnetic tape duplication by contact printing at short wavelengths,” IEEE Trans. Magn., Vol. 5, pp. 437-441 (1969).
[6] F. Kobayashi, et al., “Theoretical analysis of contact printing on magnetic tape,” IEEE Trans. Magn., Vol. 7, pp. 244-248 (1971).
[7] B. Baker, et al., “Self-writing of servo patterns based on printed reference pattern in rotating disk drive,” U.S. Patent 6,304,407 (2001).

Vibration isolation system using zero-power magnetic suspension

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Continued from page 1 Lower stiffness of suspension is better for reducing the former while higher stiffness is better for suppressing the latter. A trade-off between them is inevitable in conventional passive-type vibration isolation systems so that their performances are limited.

We propose a novel approach to breaking through the trade-off [1]. The proposed vibration isolation system uses zero-power magnetic suspension system for generating negative stiffness. It is connected with a normal spring in series for the realization of infinite stiffness against direct disturbance.

Zero-power Magnetic Suspension

Zero-power magnetic suspension uses a hybrid magnet consisting of electromagnet and permanent magnet. The electromagnet is controlled for the steady deviation of the coil current to converge to zero. Its unique characteristic is that it behaves as if it has a negative stiffness. When an external force is applied to the mass in normal mass-spring systems, the mass moves to the direction of the applied force as shown in Fig.1a. In contrast, the suspended object moves to a new equilibrium position located in the direction opposite to the applied force in the zero-power magnetic suspension system as shown in Fig.1b. The zero-power magnetic suspension system, therefore, has negative stiffness in a static sense.

Vibration Isolation System

Infinite stiffness can be realized by connecting a normal spring with a spring that has negative stiffness. When two springs with spring constants of k_1 and k_2 are connected in series as shown by Fig.2a, the total stiffness k_C is given by

$$k_C = \frac{k_1 k_2}{k_1 + k_2} \qquad (1)$$

This equation shows that the total stiffness becomes lower than that of each spring when normal springs are connected. However, if one of the springs has negative stiffness that satisfies

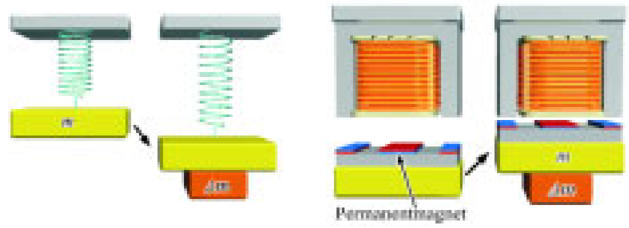
$$k_1 = -k_2, \qquad (2)$$

the resultant stiffness becomes infinite, that is

$$|k_C| = \infty \qquad (3)$$

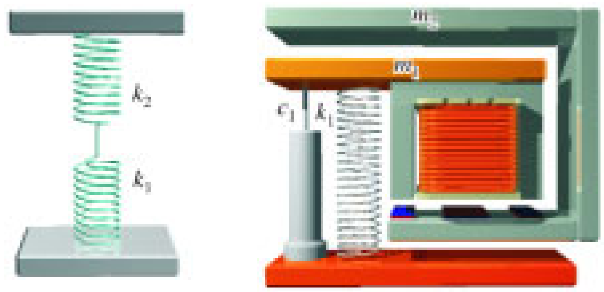
This research applies this principle to vibration isolation systems for generating high stiffness for direct disturbance.

Figure 2b shows the configuration of one of the proposed vibration isolation systems. A middle mass m_1 is connected to the base through a spring k_1 and a damper c_1 that



(a) normal spring (b) zero-power suspension

Fig.1 Comparison of zero-power magnetic suspension with a normal spring



(a) Series spring (b) Basic structure

Fig.2 Vibration isolation system using zero-power magnetic suspension

work as a conventional vibration isolator. An electromagnet for zero-power magnetic suspension is fixed to the middle mass. The part of an isolation table m_2 facing the electromagnet is made of soft iron material confining magnetic fields produced by permanent magnets for zero-power magnetic suspension.

This system can reduce vibration transmitted from ground by setting k_1 small and at the same time have infinite stiffness against direct disturbance by setting the amplitude of negative stiffness equal to k_1. To put the latter more concretely, it is assumed that the table is subject to a downward force. Then the gap between the electromagnet and the table becomes smaller by the zero-power control; in other words, the table would move upwards if the middle mass were fixed. Meanwhile, the middle mass moves downwards because of the increase of the electromagnetic force. The decrease of the gap is cancelled by the downward displacement of the middle mass. Thus the isolation table is maintained at the same position as before.

Experiment

Figure 3 is a photo of the developed apparatus for experimental study. The middle and isolation tables are guided to be in translation in the vertical direction by linear bearings. An electromagnet is fixed to the middle table corresponding to m_1 in Fig.3. Permanent magnets providing bias flux are made of NdFeB materials. They are built in the target iron of the isolation table.

Two kinds of experiments were carried out. The first is for estimating the negative stiffness of the zero-power magnetic suspension and the other is for measuring the displacement of the isolation table for direct disturbance.

Figure 4 shows the results of the first experiment. The middle table is fixed during measurement. The upward displacement of the isolation table is plotted to the mass of weights added to the isolation table. The mass of the table m is set to be

(a)700[g], (b)1310[g], (c)1700[g].

Since the additional forces produced by weights are down-

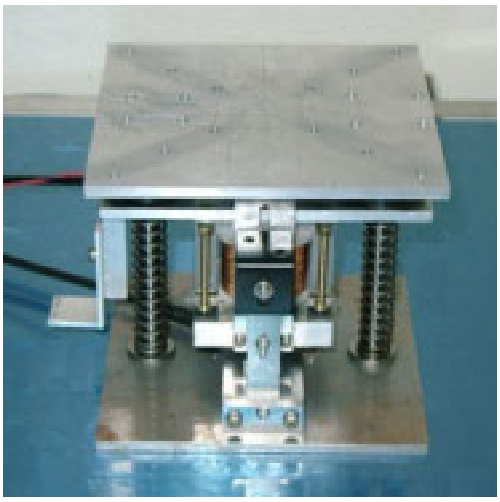


Fig.3 Photo of the experimental apparatus

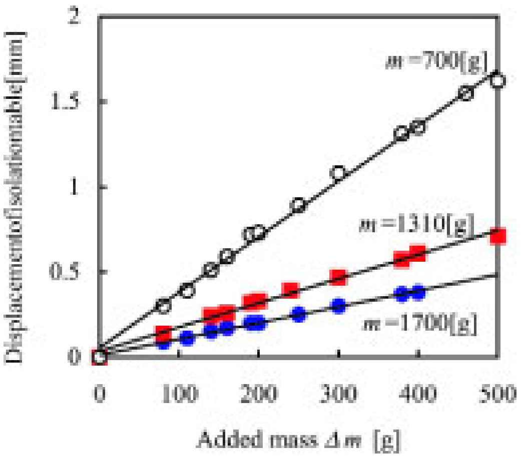


Fig.4 Load-displacement characteristics of the zero-power magnetic suspension system

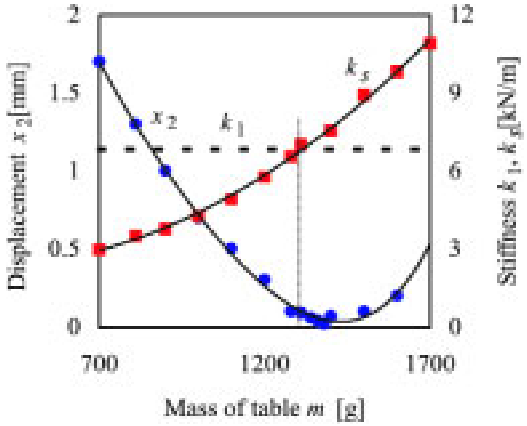


Fig.5 Displacement of the isolation table when the mass of the isolation table is varied; the stiffness of the mechanical spring and that of the magnetic suspension system are also shown.

ward, the stiffness of the magnetic suspension is clearly negative. The relation between displacement and external force is linear when added weights are small. It is also found that the magnitude of stiffness becomes larger as the mass of the table increases.

In the second experiment, the middle table, suspended by springs, is movable and weights are added to the isolation table again. Figure 5 shows the relative displacement of the isolation table to the base. The stiffness of suspension of the middle table k_1 and the magnitude of the negative stiffness of magnetic suspension k_s are also plotted in this figure. It is found from this figure that the displacement of the isolation table $|x_2|$ is very small when $k_1 = k_s(m \cong 1380[g])$. The estimated stiffness between the isolation table and the base is 490[kN/m] in this region, which is about 70 times k_1 and $k_s(\cong 6.8[kN/m])$. This result demonstrates well that combining a zero-power magnetic suspension with a normal spring can generate high stiffness against static direct disturbance acting on the isolation table.

Conclusion Remarks

The serial connection of a normal spring and a zero-power suspension system enables the isolation system to have low stiffness for vibration from the ground and infinite stiffness against direct disturbance. This concept is applicable to vibration isolation system that uses linear actuator instead of hybrid magnet in suspension [2].

References

[1]Mizuno, T. and Yoshitomi, R.: Vibration Isolation System Using Zero-Power Magnetic Suspension (1st Report, Principles and Basic Experiments), Trans. JSME, C, 68, 673, (2002), 2599, (in Japanese).

[2]Mizuno, T., Toumiya, T. and Takasaki, M., Vibration Isolation System Using Negative Stiffness, JSME International Journal, Series C, Vol.46, No.3, (2003), 807.

MEETING CALENDAR

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DATE	CONFERENCES	LOCATION
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