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Abstracts
Résumés

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Noncontact Manipulation Using Linear PM Drive Mechanism - Rotation Control for Spherical Object -

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1. Introduction

So far, for avoid sample contamination there are more and more requirements of environment in science experiments and manufacturing. Hence, noncontact manipulation is being developed. Compare with contact manipulation, there are no contamination, less friction and elimination of lubricants in noncontact manipulation. Our purpose is using a permanent magnet suspension mechanism to develop noncontact micromanipulation system. It can be applied in such fields in which ultra-clean environment is needed to avoid sample contamination, such as semiconductor processing and biotechnology experiments, etc.

In this investigation, a suspension system in which the suspended object is manipulated in the horizontal plane is built. It makes a spherical object rotate along the suspension axis without mechanical contacts. In this paper, the principle of suspension and rotation of this system is explained and experimental examination is performence.

2. Rotation Mechanism

2.1. Prototype Rotation System

Use SI(MKS)The suspension system with a permanent magnet and linear actuator is already proposed [1]. The method for stabilization is adjusting the air gap for control of the attractive force. A PM (permanent magnet) is driven by a linear actuator and the air gap is controlled. In comparison to the electrical control method of electromagnetic suspension systems, this suspension method is supposed as a mechanical noncontact suspension system.

A rotation mechanism can be build using same way. A prototype system is shown in Figure 1. An spherical object is suspended in the central position of prototype. From the figure we can see that there are five VCM actuators, which drive the five PMs respectively. The position of the magnet is sensed by means of eddy current

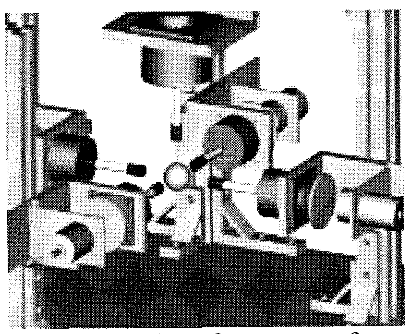

Figure 1: Illustration of prototype of rotation mechanism

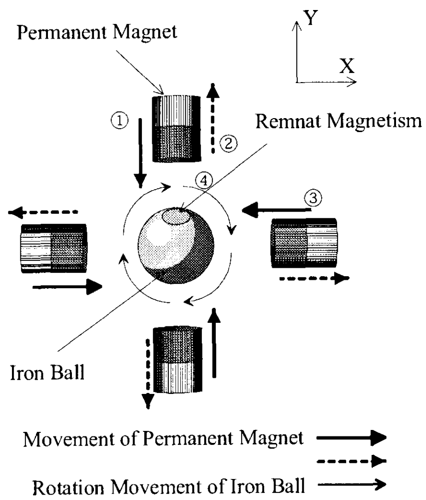

Figure 2: Strategy for rotation

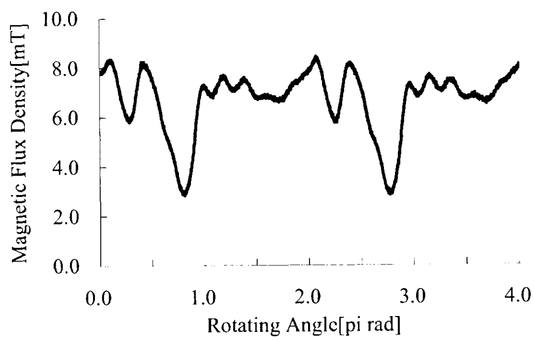

Figure 3 : Remnant magnetism on equator of spherical object

sensor. When the iron ball is suspended, through control the motion of upper magnet the height of iron ball can be adjusted to make the iron ball and four horizontal magnets in the same horizontal plane. And through control the approaching order of four horizontal magnets we can make the iron ball rotate along suspension axis.

2.2. Principle of Rotation Mechanism

Figure 2 shows the control strategy for rotation of the object with linear PM drive mechanisms. This figure shows the horizontal section including the object. The object is located in the centre position, and four magnets are located in right angles around the object.

The suspended object is a ferromagnetic material, and there is remnant magnetism on the surface of it. When the object is suspended, the influence of remnant magnetism is mostly in the vertical direction of suspension. However, there is still remnant magnetism. Figure 3 shows flux density on the equator of the spherical object during levitation. As shown in the figure, we can see the minimum point. And when a PM in the horizontal plane approaches the object, the object of the minimum point faces to the PM. And when the PM withdraws and the next PM magnet approaches, the object rotates 90 degrees. When the magnet approaches the iron ball alternatively, the iron ball can be rotated along the suspension axis.

3. Experimental Examination

3.1. Control System

Figure 4 shows the configuration of control system for rotation. This system consists from four position feedback control system. In each system, a reference position signal which phase is 90 degrees difference from next system. This phase difference keeps the approaching order of PMs and the object rotates with synchronous motions of PMs.

3.2. Experimental results

Figure 5 shows the results of rotational speeds of the object when various frequency reference signals are applied. The diagonal line indicates the case that the object speed is synchronous with input frequency. Actual speed are little slow from synchronous motion. The reason is that the remnant magnetism minimum point is moves as the object rotates. When input is over 1 Hz, it can be seen asynchronous motion.

Figure 6 shows the result of rotational speed when reference frequency is a ramp input. The speed follows input frequency with vibration. We can see, however, about 1 Hz the object stop rotating.

4. Conclusion

As the one step of the development of the noncontact manipulation, a noncontact rotation mechanism with linear actuators and PMs has been developed. The mechanism consists of four linear actuated magnets. And the remnant magnetization of the spherical object is utilized.

Summary of this paper are

1. A noncontact spinning control method using remnant magnetization was developed.

2. An experiment examination was carried out and it was succeeded.

References

[1] K. Oka and T. Higuchi, "Magnetic levitation system by reluctance control", Int. J. Applied Electromagnetics and Materials, vol. 4-1, pp. 369-375, 1994

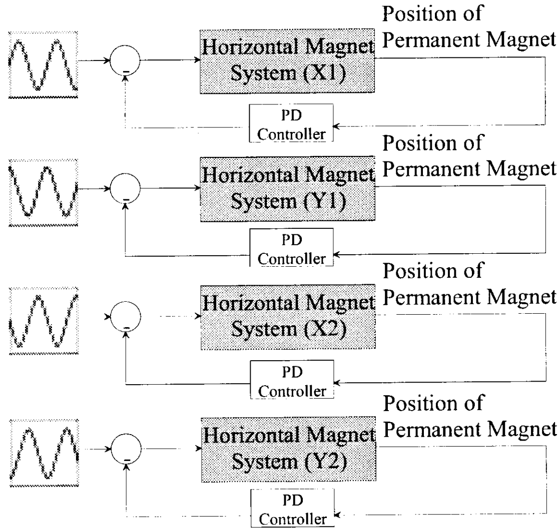

Figure 4: Control system for rotation

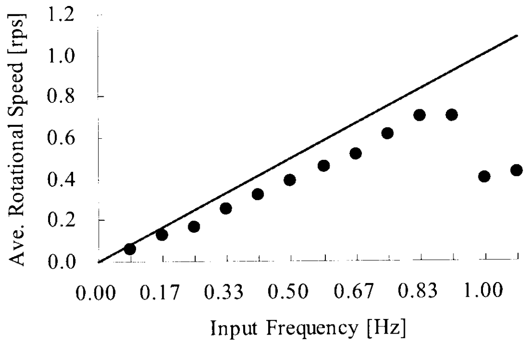

Figure 5: Experimental result of rotational speed about input frequency of PM

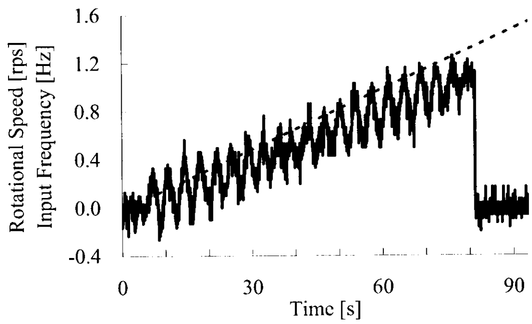

Figure 6: Experimental result of rotational speed when input is ramp