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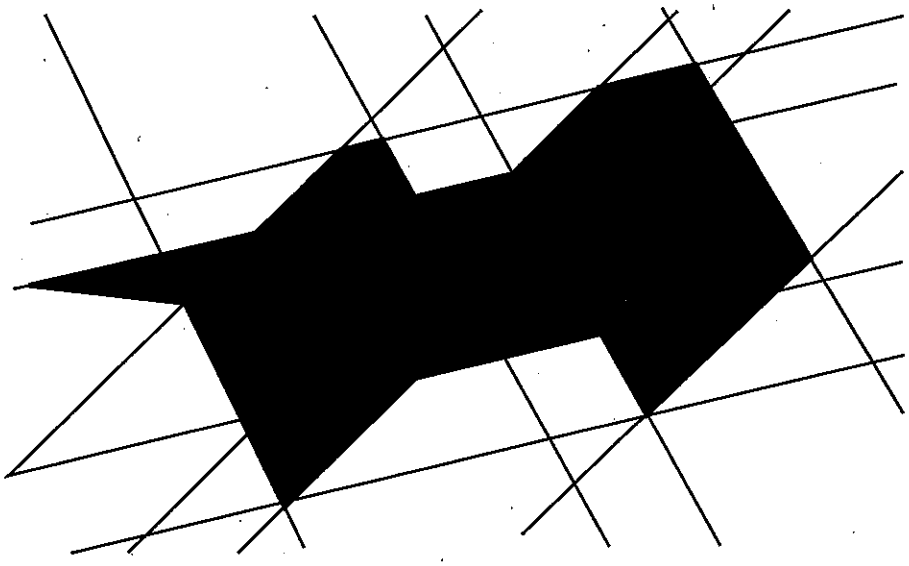

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2-DOF Permanent Maglev System

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1. Introduction

There are many magnetic suspension systems that have been developed via electro-magnets [1]. However, in the multi-DOF (degree of freedom) micromanipulation, the huge volume and heat generation of electric coil are the shortcomings of electro-magnetic suspension system. In this paper, we introduce a 2 DOF suspension system in which we use permanent magnets and actuator to substitute electro-magnet for reducing the volume and heat generation of the system. It is also one step of multi-DOF micromanipulation.

2. Principle of suspension system

The principle of a permanent magnets suspension system is shown in Fig.1. A ferromagnetic body is suspended via an attractive force from a permanent magnet positioned above. The magnet is driven with an actuator. The direction of levitation is vertical, and the magnet and the object move only in this direction. The equilibrium position is determined in terms of a balance between the gravity force and the magnet force.

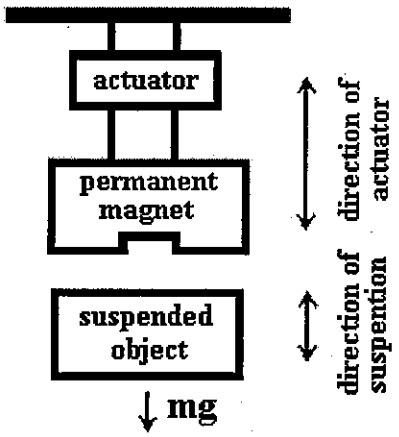

Figure 1. Outline of suspension mechanism

If the actuator does not actively control the magnet's position, the levitated object will either fall or adhere to the magnet. However servo-control of the actuator can make this system stable. Because there is a smaller attractive force for a larger air gap between the permanent magnet and object, the actuator drives the magnet upwards in response to object movement from its equilibrium position towards the magnet. Similarly, the actuator drives the magnet downwards in response to object movement away from the magnet. In this way, the object can be stably suspended without contact [2]-[4].

A photograph of a prototype of a 2 DOF suspension system is shown in Fig. 2. The movements of the magnets and the iron ball are sensed using the gap sensors and the photo sensor, respectively.

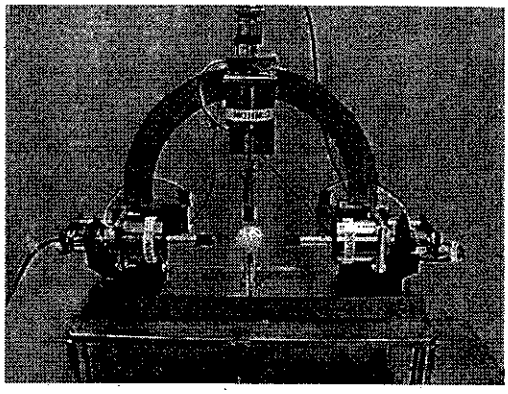

Figure 2. The prototype of suspension system

3. Analysis of system

As shown in Fig. 2, it is considered that the motions of the iron ball and the magnets divide into the vertical and the horizontal direction movement. It is consumed that two motions are individual each other. The analysis of vertical motion has been already investigated [1]. Here, the horizontal motions , which involve the motions of an iron ball and two permanent magnets driven by actuators, are mainly investigated. Fig. 3. shows the modal of horizontal motion of system.

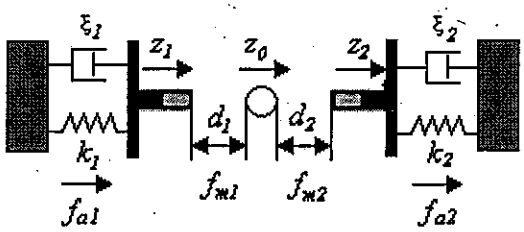

Figure 3. the modal of horizontal motion

Reference:

[1] K. Oka, T. Higuchi, "Magnetic levitation system by reluctance control- levitation by motion control of permanent magnet", Int. J. of Applied Electromagnetics in Materials, 4, 1994, pp. 369-375