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Magnetic Suspension System by Flux Path Control Using Rotary Actuator

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Abstract. This paper proposes a magnetic suspension system using a permanent magnet and a rotary motor. In this suspension system, the suspension force is controlled by varying the angle of the permanent magnet driven by the actuator so as to change the magnetic flux path. This system can generate a zero attractive force, change the polarity of the stator poles and realize zero power control for any suspension position.

1 Introduction

Magnetic suspension is technology for supporting an object by means of a magnetic force. So far, many kinds of magnetic levitation systems have been proposed and developed. These magnetic levitation systems use different methods to control the suspension force. Two important type of systems are electromagnetic suspension systems, which control the coil current so as to change the magnetic force in order to levitate an object stably [1]; and magnetic levitation systems, which use permanent magnets control the magnetic reluctance so as to vary the suspension force in order to achieve stable suspension. Moreover, there are two methods for controlling magnetic reluctance: changing the air gap by moving the permanent magnet [2] and varying the flux by changing the flux path of the magnetic circuit.

This paper proposes a magnetic suspension system that controls the suspension force by varying the flux path using a permanent disk magnet and a rotary actuator. This magnetic suspension system can generate a zero suspension force, change the polarity of the stator poles and realize zero power control for any suspension position.

2 Suspension Principle

The suspension principle of this magnetic suspension system can be understood from Figure 1, a schematic diagram showing a permanent disk magnet, two aspectant F-type iron cores and a rectangular suspension object. Figure 1(a) shows that the magnetic poles of the magnet are aligned in the vertical direction. The magnetic flux comes from the N pole and is absorbed into the S pole through the iron core. Because no flux is flowing through the suspension object, there is no attractive force. However, Figure 1(b) shows that after the magnet has rotated a certain angle, some of the flux flows through the suspension object, and attractive force is generated.

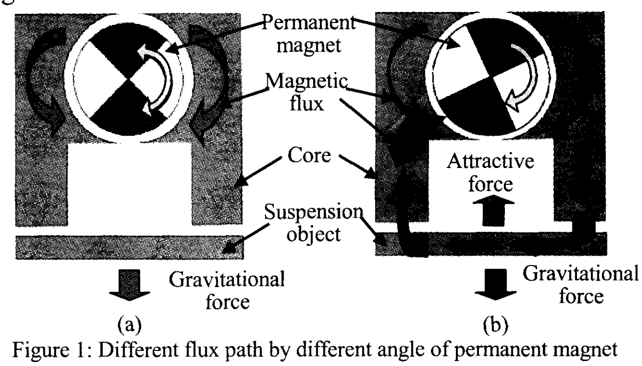

Figure 1: Different flux path by different angle of permanent magnet

3 Prototype of Magnetic Suspension System

A prototype of the proposed magnetic suspension system was constructed, as shown in Figure 1. This prototype consists mainly of a permanent disk magnet, a rotary actuator containing a gear reductor and an encoder, a pair of aspectant F-type permalloy cores, a rectangular permalloy suspension object and two eddy current sensors. The permanent disk magnet was magnetized so that its two magnetic poles lay in the radial direction.

4 Basic Examination and Suspension Experiment

To examine the characteristics of the suspension system, many basic experiments were performed. The magnetic flux densities of the magnet were measured through one rotation using a gauss-meter at different distances from the magnet. The resultting flux density curves resemble sine curves at all points, and smaller distance yielded greater flux density. The magnetic flux densities between the permalloy cores and the suspension object were measured as well. A graph of the relationship between flux density and the rotation angle of the magnet resembles a sine curve as well; this system can generate a zero attractive force and change the polarity of the stator poles. Moreover, because of flux leakage, the attractive forces of the two cores are different even when they are in the same position and same angle.

In order to overcome the difference between the attractive forces of the two cores, the suspension object was installed on a linear rail. The suspension experiments were carried out using this suspension system. Figure 2 shows the results for a 0.1 mm stepwise downward movement of the suspension object. The results indicate that the suspension object can be levitated stably and the system can realize zero power control.

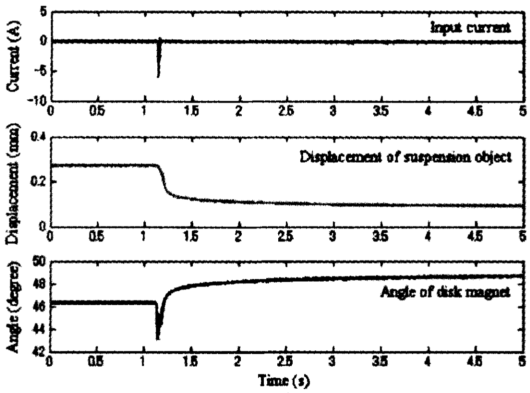

Figure 2: Experimental results with a step

5 Conclusion

The magnetic suspension system proposed here controls the suspension force by varying the flux path by means of a permanent magnet and a rotary motor. The results of a basis study of the relationship between magnet rotation angle and resultant flux and some suspension experiments indicate that this system can levitate the suspension object stably, generate a zero suspension force, change the polarity of the stator poles and realize zero power control for any suspension position.

References

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