Characteristic Analysis based on Analytical Method in Non-Contact Magnet Gear

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Abstract **- This paper proposes the analysis method for finding characteristics of non-contact magnet gears by using the Biot-Sarvart law. The permanent magnet of the magnet gear is changed into the equivalent magnetization surface current, such as current-carrying circuit. Then, the flux density is calculated by the Biot-Sarvart law from the current in a closed circuit. The proposed method is more easy and simply than the 3-dimensional Finite Element Method to calculate the characteristic of the magnet gear. The analysis results are compared with experiments.**

INSTRUCTION

Conventional gear systems raise dust due to contact. Some special gear mechanisms, however, ought to keep the workplaces very clean such as in semiconductor manufacturing. Therefore, a no-contact gear mechanism is demanded for the reason. A no-contact magnet gear using permanent magnets could be an attractive transmission mechanism for conveyor systems because it does not make any dust. It consists of driven and driving skewed permanent magnets, like the helical type gear shape. Two axes of upper and lower magnets intersect each other perpendicularly and the no-contact magnet gear has a small air-gap.

It is necessary to investigate the influence of important parameters on the performance of the magnet gear [1]. The popular method for 3-D electromagnetic problems is 3-D Finite Element Method. The method is still powerful, but has some disadvantages. One of them takes a lot of time to solve the electromagnetic field. Consequently, a simpler method is required to analyze the 3-D electromagnetic field and characteristic of the magnet gear. In this paper, the simpler method based on Biot-Sarvart law is proposed to solve the 3-D electromagnetic problem [2]. From the proposed method, characteristics of the magnet gear are calculated very easily, accurately, and simply.

ANALYSIS METHOD AND RESULTS

The permanent magnets of the magnet gear are changed into the equivalent magnetization surface current density, such as current-carrying circuit. Then the permanent magnet is like a rectangular sheet with a lineal circumferential current density. The flux density is calculated by using the Biot-Sarvart law. Finally, the Lorentz force to find the magnetic torque from the calculated flux density is used.

Step1) Mesh generation of permanent magnet

Step2) Calculation of equivalent magnetization current in each element

Step3) Selection of elements and determination of the flux density at a selected point caused by all source elements that carry a magnetization current by applying the Biot-Sarvart law as follows:

$$d\vec{B} = \frac{\mu_0 I}{4\pi}\left(\frac{d\vec{l} \times \vec{a}_R}{R^2}\right) \quad (1)$$

Step4) calculation of the force by the Lorentz force from the flux density, the magnetization current, which is expressed as:

$$d\vec{F} = I d\vec{l} \times d\vec{B} \quad (2)$$

Step5) repeat from Step 3 to Step 5 for all elements

From the above procedures, the total torque of the magnet gear is obtained by the sum of torque acting on each element.

Fig. 1 shows the analysis model of the non-contact magnet gear. The permanent magnet has 6-poles and its skew angle is 45(deg.). Fig. 2 shows the comparison of the flux density around the air-gap in the magnet gear according to the analysis methods. The magnetic torque measured is 3.5(kgf.cm), which is similar to the calculated torque of 3.6(kgf.cm).

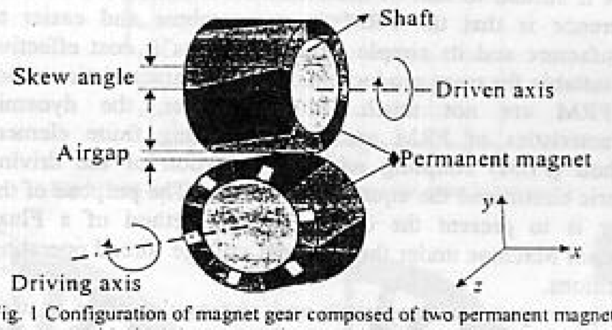

Fig. 1 Configuration of magnet gear composed of two permanent magnets with skew (upper: passive gear, lower: running gear)

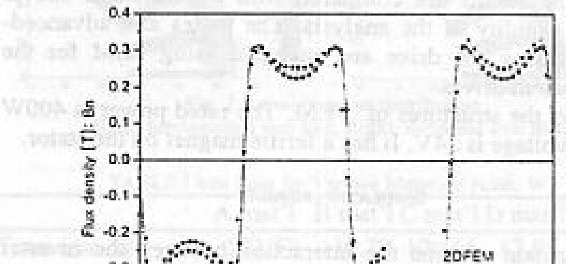

Fig. 2 Comparison of flux density in airgap according to analysis methods

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