TORQUE PROPERTIES ANALYSIS OF MAGNETIC HARMONIC GEAR WITH STACKABLE STRUCTURE

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Abstract The magnetic harmonic gear has been studied because of its high magnet use efficiency. However, the magnetic harmonic gears are difficult to assemble. So, a new type of the magnetic harmonic gear was proposed. This magnetic gear has the stackable structure and is assembled easily. Thus far, it was studied its characteristics. In this study, we deal with dynamic torque properties of the proposed magnetic gear. As a result, the cause of torque properties are considered by frequency analysis.

1. Introduction

The magnetic harmonic gears (MHG) are studied because they have the high torque density and large transmission torque [1-4]. Fig.1 shows the structure of the MHG. It is structured of the three parts (an outer, a center and an inner). The outer and the inner consist of magnets. The center consists of pole pieces. The center has a role to modulate the magnetic flux. The authors study the MHG that has the stackable structure [4]. In this magnetic gear, the inner and outer have the two types of layers. It can adjust the transmission torque by changing the number of stuck.

The purpose of this study is to analysis a dynamic torque property by the frequency analysis. In this paper, we use a prototype and deal with the dynamic characteristics of it.

2. The MHG with stackable structure

In the MHG with stackable structure, the outer and the inner has two types of layers. Fig.2 shows the new structure. Layer1 (L1) is a set of radially magnetized segment magnets arranged on the circumference. The magnetic flux is directed in the radial direction and is directly related to the transmission of the rotation in this layer. Layer2 (L2) is a set of axially magnetized segment magnets arranged on the circumference. In L1 and L2, adjacent magnets are magnetized in opposite direction. In the outer and the inner, a Halbach array is formed by alternately stacking L1 and L2 (Fig.3).

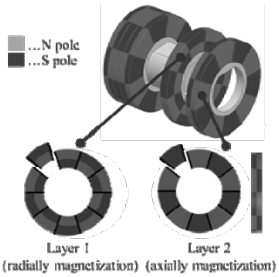


Fig.1. Magnetic harmonic gear

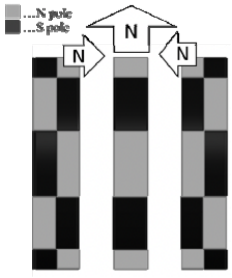


Fig.2. Stackable structure

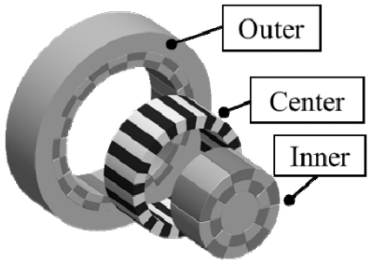


Fig.3. Halbach array

Table 1. Dimension of the magnetic gear

	outer	center	inner
No. of pole pair / pole pieces	13	16	3
The size of magnets for Layer1 [mm]	10×7×3	-	R30×R27×7×60°
The size of magnets for Layer2 [mm]	10×5×3	-	R30×R27×5×60°
The size of the pole pieces [mm]	-	R41×R31×11.25°×7	-
Outside and inside diameter [mm]	Φ120-Φ84	Φ82-Φ62	Φ60

Table 1 shows the dimension of the prototype. Fig.4 shows the parts of the MHG and prototype. In the prototype, the inner is an input and the outer is an output

3. Experiment

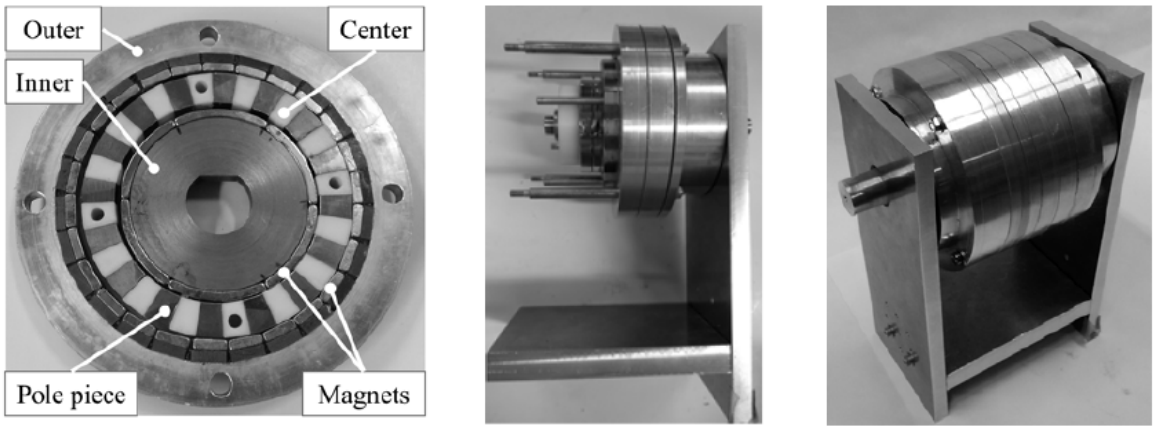
We measured input and output torque while rotating input shaft constantly and loading output shaft 3 Nm. Setting rotational speed from 50 rpm to 1000 rpm. The measurement data calculated by FFT to analyze

the frequency spectrum of the torque. The sampling frequency was 1,000Hz, and the measurement time was 8.192 seconds.

Fig.5 shows the FFT analysis of a dynamic torque. Fig.5 (a) shows input-side torque included rotational component proportional to rotational speed of outer from 1st-order to 3rd-order and high-order frequency spectrum proportional to rotational speed. Fig.5 (b) shows output-side torque included rotational component proportional to rotational speed of outer from 1st-order and 2nd-order.

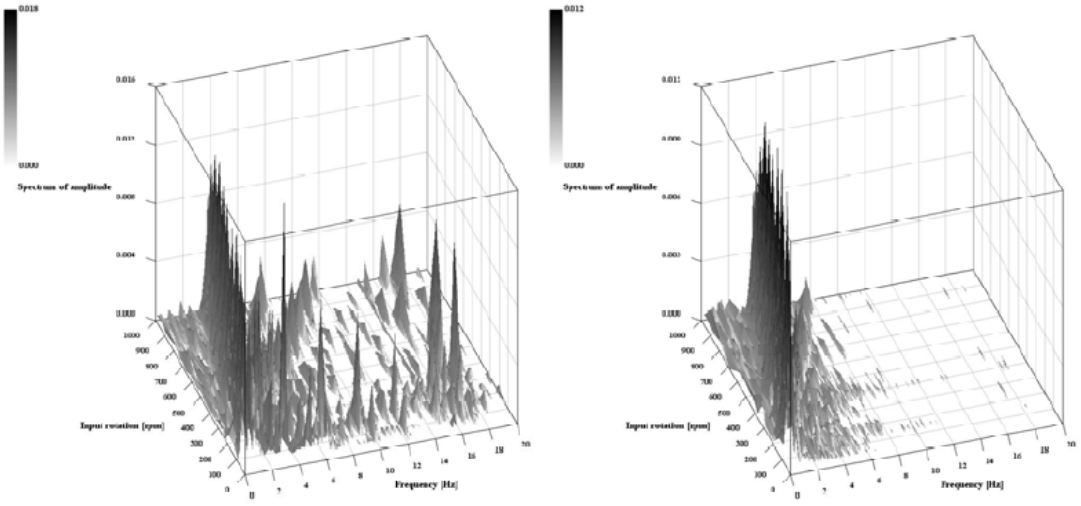
Conclusion

In this report, we revealed some dynamic torque properties of the stackable MHG by frequency a nalysis.



(a) Parts of magnetic gear (b) Stacking (c) Magnetic gear

Fig.4 Prototype



(a) Input side (b) Output side

Fig.5 FFT Analysis of a dynamic torque

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