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# Magnet Pole Cover를 이용한 BLCD Motor 코깅 토크 저감에 관한 연구

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# Reducing the Cogging Torque in BLDC Motor by Using a Magnet Pole Cover

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**Abstract** - 최근 널리 사용되고 있는 BLDC Motor는 코깅 토크 문제점을 가지고 있다. 본 연구에서는 4극 24슬롯 BLDC Motor를 Flux 2D로 시뮬레이션 하였고, 문제점을 파악하여 Magnet Pole Cover를 이용한 모터를 설계 하고 분석 하였다.

## 1. Introduction

Brushless permanent-magnet (PM) DC motors are widely used in the industrial applications. They have some good characteristics such as high efficiency, high power-density, easy speed control, low size comparing with conventional machines, low noise and vibration compare with other kinds of motors. But, in these BLDC motors, the main disadvantage is the torque ripple which is inherent in their design. This ripple can lead to mechanical vibration, acoustic noise, and driven system problems. So to minimizing this ripple is very important in designing a PM motor.

One of the major contributors to torque ripples is the cogging torque which is the interaction of the permanent-magnet and the stator slots. Several methods have been proposed to reduce the cogging torque, for example, pole ratio adjustment method, permanent magnet asymmetry arrangement method, semi-closed slots method and a variation of residual magnetization distribution in the PM method.

In this paper, taking a 4-pole 24-slot BLDC motor as an example we introduce a method that is we add a magnet pole cover.

## 2. Basic Theory

It is all known that the cogging torque is the interaction between the permanent magnets and the motor slots. After adding this cover, which is the thin layer in Fig. 2, the flux density in the stator yoke is different from the original motor and this will cause the reluctance changing. So the cogging torque is reduced. We take a 4-pole 24-slot BLDC motor as an example. First we introduce the structure of the motor. The structure of the original motor is showed in Fig. 1.

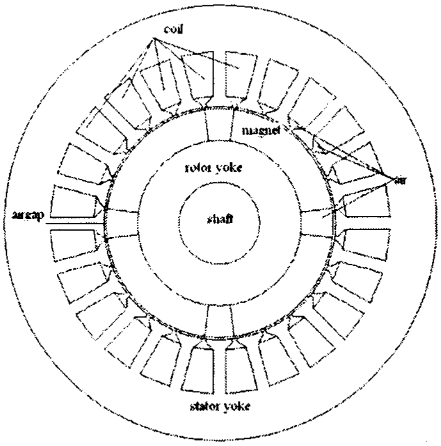


Fig. 1 Structure of original motor

Each part is shown in the Fig. 1. The air gap is 0.503mm, When we add the magnet pole cover, the structure of the redesigned motor is shown in the following figure.

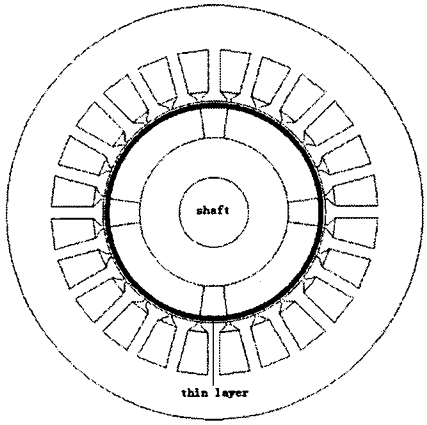


Fig. 2 The structure of redesigned motor

In Fig. 2, the black region is the added cover.

we keep the air gap 0.503mm, in order not to enlarge the motor's size, the shaft is shortened. For example, if we want that the cover is 1mm, we shorten the shaft radius 1mm. By this method we can keep the stator yoke and rotor yoke the same value.

We set the thickness of the cover be these following values: 0.5mm, 0.6mm, 0.7mm, 0.8mm, 1.2mm, 1.6mm, 2.0mm and 2.4mm. And the same time, the value of saturated flux density of this cover we presume are 0.4T, 0.5T, 0.6T, 0.8T, 1.0T, 1.2T, 1.6T, 1.99T and 2.4T. So there are 72 different combinations. By these 72 cogging torque results we can find the discipline.

### 3. Simulation Results

The cogging torque of the original motor is in Fig. 3. Because there is only 1/4 part of the motor when we simulated it by using Flux 2D, the actual value of the cogging torque is 4 times bigger than the value in Fig. 3.

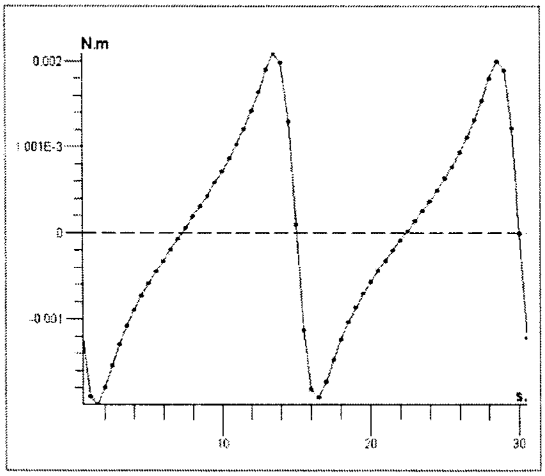


Fig. 3 Cogging torque of original motor.

In Fig. 3, the maximum value is 0.00209895N*m, the minimum value is -0.0019868N*m, the peak-to-peak value is 0.00408575N*m. So the cogging torque should be 0.00408575* 4, which is 0.016343N*m.

For the redesigned motor, here we only take two group results in Fig. 4 and Fig. 6. In this two group, the thickness of the cover is a constant value 0.8mm and 1.6mm, respectively. The variable is the saturated flux density of the cover. Fig. 5 and Fig. 7 are the detailed reduction value about the cogging torque.

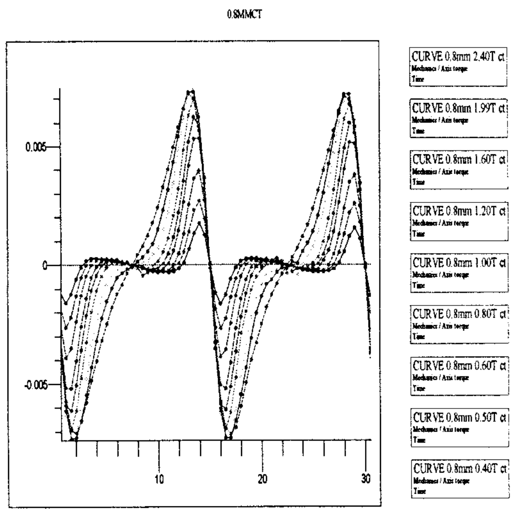


Fig. 4 0.8mm Cogging torque of magnet pole cover

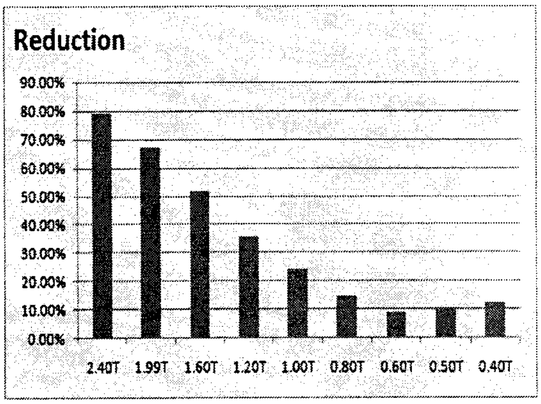


Fig. 5 0.8mm Cogging torque reduction

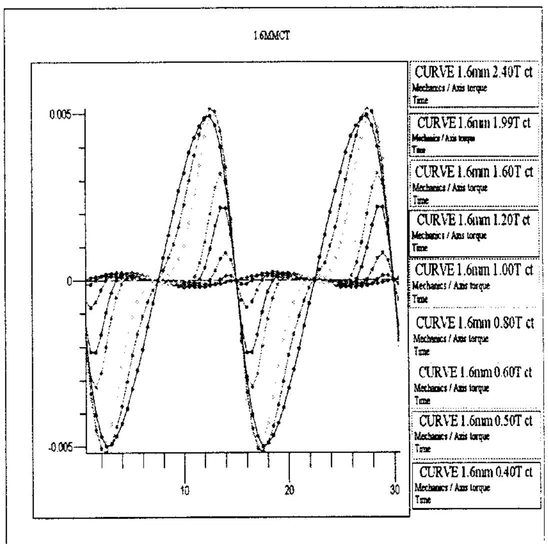


Fig.6 1.6mm Cogging torque of magnet pole cover

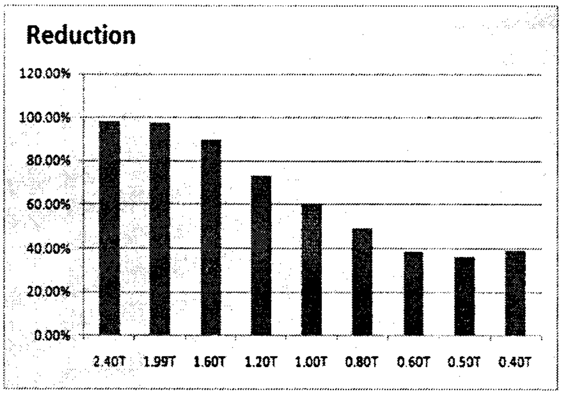


Fig. 7 1.6mm Cogging torque reduction

Form the cogging torque results we can find that after adding this cover, the cogging torque is reduced obviously.

## 4. Conclusion

In this paper, we introduced a method--manget pole cover--to reduce the cogging torque.

Form all these 72 cogging torque results, generally speaking, we can find that for the same thickness of the cover, the bigger the saturated flux density is, the smaller the cogging torque is and for the same saturated flux density, the bigger the thickness is, the smaller the cogging torque is. But there is one problem when the cover is too thick and the saturated flux density is too big, such as thickness is 2.4mm and saturated flux density is 2.4T, the flux density in the air gap will be very small, then the main torque of the motor will be reduced, this is what we do not want to happen. So we should consider this problem when to choose the thickness and the material of the cover.

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