Design and Characteristic Analysis of Skeleton type Single-Phase Brushless DC Motor Using Finite Element Method

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Abstract — **This paper deals with the design of Skeleton type single-phase Brushless DC motor (SBLDC) to eliminate the dead-zone and to protect the inflow of dust. As the results, it is proved by the finite element method and experimental results that the improved shape is very effective to solve these problems.**

INTRODUCTION

Single-phase motors are widely used in industrial and household applications. The reason is that the operation is fed directly from the commercial single-phase voltage source. Recently, SBLDCs have substituted for single-phase induction motor with shaded pole to drive the evaporator fan of refrigerator because the latter has low efficiency characteristics. They have many advantages in economical efficiency that means simple motor construction and low cost driver topology with only two power switches.

The detent groove shape and the link part of stator core in the SBLDC, as shown in Fig.1, have influence on the toque profile such as torque ripple and reverse torque zone, so that the investigation of these parameters is needed [1]. This paper deals with the design and characteristics analysis of SBLDC for driving the evaporator fan of a refrigerator. The analysis method is the electromagnetic finite element method coupled with the driving circuit [2].

DESIGN AND RESULT

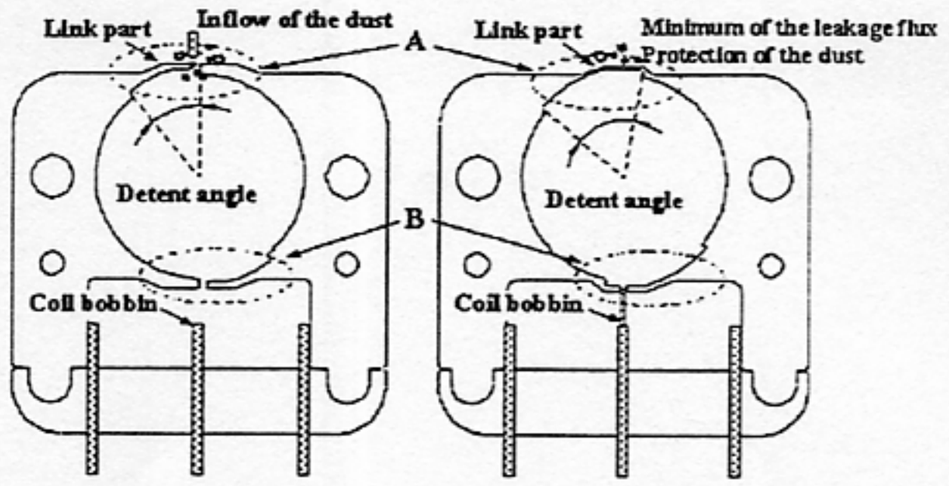
The dead-zone, where the torque cannot be developed exists in the SBLDC, leads to the starting problem. In order to get rid of the dead-zone it is possible to choose a detent groove that has asymmetric air gap. The stator core with the detent groove produces the cogging torque that helps to reduce the dead zone. Therefore, a proper angle and width of the detent groove is determined from analysis results to increase the starting torque.

The stator core of the conventional model has the opened link part to reduce the flux leakage driven by the permanent magnet but the motor is able to be lock due to the inflow of dust through the opened link part, as illustrated in Fig. 1(a). If the link part is closed, the EMF waveform distortion is generated owing to the increase of flux leakage and deteriorates the motor characteristics. Hence, it is important to determine the appropriate shape of link in SBLDC to make the improved EMF waveform and cover of the dust from surroundings. This paper proposes the new stator structure to solve the above-mentioned problem. Fig. 1(b) shows the proposed shape of stator core.

The upper link part is closed and the lower one opened.

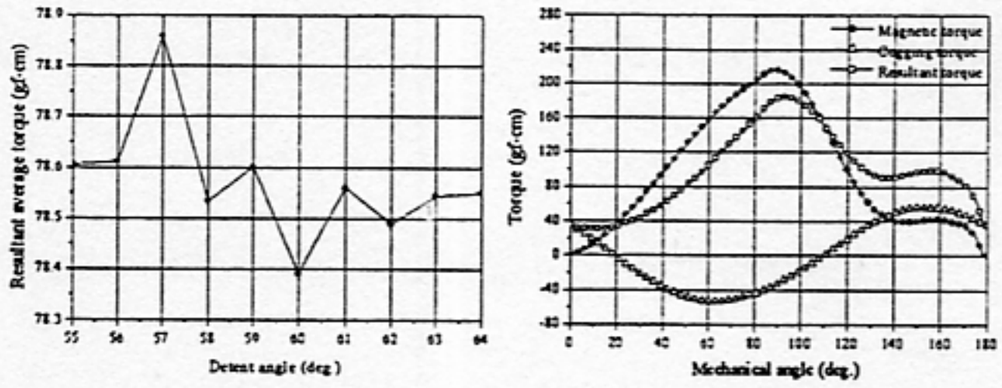
The minimum flux leakage and the protection of dust are accomplished by the closed link part as the thin structure, as presented on Fig. 1(b). In the case of the lower link part, its open width is filled with the coil bobbin to prevent the inflow of dust.

Fig. 2(a) shows the variation of resultant torque varying with detent angle. The resultant average toque has a peak value at 57 degree. The torque profile of the improved model is shown in Fig. 2(b). In Table I, the comparison of both torque data shows good agreement between the conventional model and the improved model.



(a) Conventional model (b) Improved model

Fig. 1 Comparison with core shape



(a) Resultant torque (b) Torque profile

Fig. 2 The analysis result of the improved model

Table I. Comparison with experimental results of the two models

	Initial model	Improved model
Back-emf (V_{rms}/krpm)	9.6	8.9

REFERENCES

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[2] J.R. Hendershot Jr., Timothy J. E. Miller, *Design of Brushless Permanent-Magnet Motors*, Magna Physics Publishing and Clarendon Press, 1994.