# Influence of Magnet Shape on Cogging Torque and Efficiency in Surface-Mounted Permanent MagnetBrushless DC Motor


## 李志勇、陳盛基

E-mail: 9607816@mail.dyu.edu.tw



**ABSTRACT**

The magnetic material and the power electronic technologies have been developing fast in recent years. Therefore, brushless DC motors (BLDCM) are not only miniaturized and lighter weight, but also have high power density. Nowadays, induction motors are being replaced by BLDCM, due to the latter possesses high efficiency and high torque advantages. Presently, some new products use BLDCM, such as air conditioning, machine tool, OA machine, sewing machine and so on. For a slotted permanent-magnet machine, the cogging torque is inherent, irrelevant to driving current, which is caused by the interaction between the permanent magnet and slotting on the stator or rotor of the motor, it might affect the quality of terminal product. This paper studies the influence of magnet shape on cogging torque and efficiency by means of changing pole-arc to pole-pitch ratio and arc-offset of magnet through finite element method. Also, a comparison between the analytically predicted results will be discussed.



Keywords : Brushless Motor, Permanent Magnet, Cogging, Torque, Efficiency


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**REFERENCES**


[1] 許溢适，〝實用電動機設計手冊〞，文笙書局，民國八十五年十二月。。

[2] 顏文鴻/鄒應嶼，“泛用型永磁與感應交流伺服驅動器之研製”第十七屆電力工程研討會，民國八十五年十一月。

[3] 趙貴祥，"DC無刷電動機與控制電路"，文笙書局，民國八十四年七月。

[4] Hitachi, Ltd., High voltage monolithic IC ECN3067 datasheet, 1999. http://www.hitachi.com.

[5] 中國鋼鐵股份有限公司,“C931794中鋼電磁鋼片中文型錄P5 /C931841中鋼電磁鋼片特性圖型P48”,2007 [6] 賴耿陽，”永久磁鐵技術實務”，復漢出版社，民國九十年十一月。

[7] J.R. Hendershot and T.J.E Miller,“Design of Brushless Permanent Magnet Motors”,Magna Physics Publishing and Clarendon Press ,1994.

[8] D.C. Hanselman,“Brushless Permanent-Magnet Motor Design”, McGraw-Hill, New York, 1994.

[9] C.Studer, A .Keyhani, T.Sebastian, S .K .Murthy, " Study of Cogging Torque in Permanent Magnet Machines " ,IEEE IAS Annual Meeting, 1997.
[10] R.P. Deodhar, D.A. staton, T.M.Jahns , T.J.E.Miller. " Prediction of Cogging Torque Using the Flux-MMF Diagram Technique " ,IEEE Transactions on Industry Applications, Vol. 32, No. 3,pp.569-576,1996.
[11] J.F. Gieras, Fellow, " Analytical Approach to Cogging Torque Calculation of PM Brushless Motors " ,IEEE Transactions on Industry Applications, Vol.40 ,No.5, pp. 1310-1316,2004.
[12] N. Bianchi and S. Bolognani, " Design Techniques for Reducing the Cogging Torque in Surface-Mounted PM Motors " ,IEEE Transactions on Industry Applications, Vol.38 , No. 5, pp.1259- 1265,2002 [13] Z.Q. Zhu and D. Howe, " Influence of Design Parameters on Cogging Torque in Permanent Magnet Machines " ,IEEE Transactions on Energy Conversion, Vol. 15, No. 4, pp.407- 412, 2000.
[14] S. Ruangsinchaiwanich, Z.Q. Zhu, D. Howe, " Influence of magnet shape on cogging torque and back-emf waveform in permanent magnet machines,Electrical Machines and Systems " , Proceedings of the 8th Int. Conf. Vol. 1, pp. 284-289, 2005.
[15] Ansoft Corporation, Maxwell 2D Field Simulation, Release Notes. 1995 [16] Ansoft Corporation, RMxprt, Release Notes. 2004