UNIVERSITI PUTRA MALAYSIA

REDUCTION OF TOTAL HARMONIC REDUCTION IN TORQUE CHARACTERISTICS IN TWO-PHASE SIDE BY SIDE BRUSHLESS DC MOTOR

NG SENG SHIN

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By

NG SENG SHIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of the Requirements for the Degree of Master of Science

January 2013

Dedication

TO
MY BELOVED PARENTS, MY BROTHER, MY FAMILY AND MY FRIENDS.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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January 2013

Chairman : Assoc. Prof. NorhisamMisron, PhD

Faculty : Engineering

This research deals with the reduction of total harmonic distortion (THD) in torque characteristics for the improvement of torque ripple in two-phase side by side brushless DC motor. The sinusoidal waveform in torque characteristic create uniform flux distribution that produces smooth speed rotation.

By creating an uniform flux distribution, the torque ripple produced by the motor is reduced. To reduce the torque ripple, the flux density distribution in the gap must be adjusted. It gives a more balanced flux density distribution in the motor. The ideal situation is that the developed torque being higher with low torque ripple value. By variation of various parameters, the flux flows inside the motor changes. The final aim is to get sinusoidal waveform and reduce the torque ripple as much as possible. Simulation studies to evaluate the aspects of the flux distribution inside the machine and the torque characteristic are presented.

There are studies to reduce the cogging torque produced by the brushless DC motor. By reducing the cogging torque, the THD of the torque characteristic can be reduced. In those previous researches, the combination of each pole of different structure is not being discussed before. Thus, the combination method introduced in this research is a new technique that can further reduce the THD of the torque waveform produced by the motor.

In this study, the structure of individual single phase brushless DC motor is adjusted to get near sinusoidal waveform in the torque characteristic which has low THD value. Combination of different pole structure motor is presented to get the lowest THD in torque characteristic possible. Then, two phase side by side brushless DC motor is presented to reduce the torque ripple produced by the motor. The simulation result in the original model is verified by experimental result.

Simulation analysis using finite element method (FEM) is performed to analyze the magnetic circuit on various shapes of rotor and stator. The analysis parameters include the magnetic field flux, the cogging force and the developed torque. The optimum model is derived. In the end, the torque ripple generated by the original motor is reduced by 70.5% compared with the torque ripple produced by the optimized motor. So, the proper choice of parameters is important in getting sinusoidal waveform and reduce the torque ripple produced by the motor.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENGURANGAN HEROTAN HARMONIK DALAM CIRI DAYA KILAS DALAM MOTOR DC DUA FASA TANPA BERUS SEBELAH- SEBELAHAN

Oleh

NG SENG SHIN

Januari 2013

Pengerusi : Prof. Madya Norhisam Misron, PhD

Fakulti : Kejuruteraan

Kajian ini bagi mengurangkan herotan harmonik (THD)dalam ciri daya kilas ke atasdaya riak dalam motor DC dua fasa tanpa berus sebelah-sebelahan. Bentuk gelombang sinus dalam ciri daya mewujudkan taburan fluks seragam yang menghasilkan kelajuan putaran yang lancar.

Dengan pengagihan ketumpatan fluks yang lebih seimbang, dayariak yang dihasilkan oleh motor dapat dikurangkan. Untuk mengurangkan dayariak, taburan ketumpatan fluks dalam jurang mestilah diimbangkan. Ia memberikan ketumpatan fluks pengagihan yang lebih seimbang dalam motor. Situasi yang ideal adalah menghasilkan daya kilas yang lebih tinggi dan daya riak yang dihasilkan oleh motor adalah lebih rendah. Jadi, dengan perubahan pelbagai parameter di motor, aliran fluks yang dihasilkan dalam motor turut berubah. Matlamat akhir adalah untuk mendapatkan bentuk gelombang sinusoidal dan mengurangkan daya riak seberapa

banyak yang mungkin. Kajian simulasi untuk menilai aspek taburan fluks di dalam mesin dan ciri-ciri daya cogging akan dibentangkan..

Terdapat kajian untuk mengurangkan daya riak yang dihasilkan oleh motor DC tanpa berus. Dengan mengurangkan daya riak, THD daripada ciri daya kilas boleh dikurangkan. Dalam kajian sebelum ini, gabungan setiap tiang struktur yang berbeza tidak dibincangkan sebelum ini. Oleh itu, kaedah gabungan yang diperkenalkan dalam kajian ini adalah teknik baru yang boleh terus mengurangkan THD daripada hasil gelombang daya kilas oleh motor.

Dalam projek ini, stuktur motor tanpa berus fasa satu diubah bagi mendapatkan gelombang sinusoidal dalam daya kilas yang mempunyai THD yang rendah. Kombinasi struktur polarmotor yang berbeza diperkenalkan bagi mendapatkan daya kilas THD terendah. Selepas itu, motor DC dua fasa tanpa berus sebelah-sebelahan diperkenalkan bagi merendahkan daya riak dalam motor. Keputusan simulasi disahkan oleh keputusan eksperimen.

Analisis simulasi menggunakan kaedah unsur terhingga (FEM) dilakukan untuk menganalisis litar magnet pada pelbagai bentuk pemutar dan pemegun. Parameter analisis termasuk fluks medan magnet, daya cogging dan daya kilas yang dihasilkan. Model optimum dibangunkan. Pada akhirnya, riak tork yang dijanakan oleh motor asal dikurangkan sebanyak 70.5% berbanding dengan riak tork yang dihasilkan oleh motor dioptimumkan.Jadi, pilihan parameter yang betul akan berkesan dalam mendapatkan gelombang sinusoidal dan mengurangkan dayariak yang dihasilkan oleh motor.

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.

I certify that a Thesis Examination Committee has met on 30 January 2013 to conduct the final examination of Ng Seng Shin on his thesis entitled " Reduction of Total Harmonic Reduction in Torque Characteristic in Two-Phase Side By Side Brushless DC Motor " in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the Thesis Examination Committee were as follows:

Ishak b Aris, PhD
Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

Hashim b Hizam, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Internal Examiner)

Chandima Gomes, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Internal Examiner)

Abdul Halim b Mohamed Yatim, PhD
Professor
Faculty of Engineering
University TeknologiMalaysia
Malaysia
(External Examiner)

_____

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of University Putra Malaysiaand has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

NorhisamMisron, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

Noor Izzri b Abd. Wahab, PhD
Senior Lecturer
Faculty of Engineering
University Putra Malaysia
(Member)

_____

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

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NG SENG SHIN

Date: 30 January 2013

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