UNIVERSITI PUTRA MALAYSIA

DESIGN OF DOUBLE STATOR ARC TYPE PERMANENT MAGNET GENERATOR FOR PALM OIL MECHANICAL CUTTER APPLICATION

SUHAIRI RIZUAN BIN CHE AHMAD

DESIGN OF DOUBLE STATOR ARC TYPE PERMANENT MAGNET GENERATOR FOR PALM OIL MECHANICAL CUTTER APPLICATION

By

SUHAIRI RIZUAN BIN CHE AHMAD

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

MARCH 2012

Dedication

TO FATMA MULYANI, MY BELOVED WIFE, FATMA NUR IMAN, MY BELOVED DAUGHTER, CHE AHMAD SENIK AND ZAINAB SAID, MY BELOVED PARENTS, MY SISTERS, MY BROTHERS, MY FAMILY AND MY FRIENDS.

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

DESIGN OF DOUBLE STATOR ARC TYPE PERMANENT MAGNET GENERATOR FOR PALM OIL MECHANICAL CUTTER APPLICATION

By

SUHAIRI RIZUAN BIN CHE AHMAD

MARCH 2012

Chairman : Assoc. Prof. Eng. Norhisam Misron, PhD

Faculty : Engineering

Over the past few years, the usage and demand of portable generators are very high. In accordance with its lightweight, small size, easy to carry anywhere and can provide high power; it becomes necessary for everyone to have it. There are various types of portable generators in the market, but mostly for use in homes, commercial and industrial. Only a few of them are design for agriculture application. Therefore, a portable power supply with a small size and lightweight of Permanent Magnet Generator (PMG) for the agricultural sector is proposed.

In this research, the Permanent Magnet Generator (PMG) will be applied as a part of new palm oil mechanical cutter system. A lot of research regarding previous work that has been done by others and the characteristic and performance of the PMG is described in literature. However, none of them focus on PMGs intended to be used for agricultural application whereas the typical requirement is of high-power

capability, small and ease of use. Recently, there were some existing products developed for palm oil mechanical cutter. Due to the drawbacks of the existing mechanical cutter are extra weight and limited height. The improvement of this mechanical cutter by using PMG to supply the mechanical motor that will convert rotational to linear motion for harvesting works.

The new system of palm oil mechanical cutter employs the Permanent Magnet Generator (PMG) which is can operates in a single-phase, slot type with a double stator, and with arc type permanent magnet that embedded in the rotor. This PMG aimed to produce 500W at a speed 3000 revolution per minute (rpm). This PMG will attach with a single cylinder two stroke engine (*Stihl* KM 85) with 0.95kW capacity. The engine will act as a prime mover to this PMG. At the same time, in order to evaluate on the best possible PMG that can be used for this application, new design and analysis on the developed PMG is required. This thesis addresses the above issue and discusses the choice of PMG for used in palm oil mechanical cutter application.

A Permanent Magnet Generator is designed with a double stator, and the rotor consists of arc type permanent magnet in order to maximize its usage of flux. This new design of generators are fabricated and tested experimentally to see their output power capability. The design optimization is done by varying the size of permanent magnet, it is to ensure the magnetic flux density is considered to determine the amount of hysteresis and eddy current losses and thus the effects of the total output power that can be generated by the PMG. As a conclusion, the proposed design produced the highest output power and efficiency that can be used for palm oil mechanical cutter system.

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

REKA BENTUK TERHADAP PENJANA KUASA MAGNET KEKAL JENIS LENGKUK DUA STATOR UNTUK APLIKASI PADA PEMOTONG MEKANIKAL KELAPA SAWIT

Oleh

SUHAIRI RIZUAN BIN CHE AHMAD

MAC 2012

Pengerusi : Prof. Madya Eng. Norhisam Misron, PhD

Fakulti : Kejuruteraan

Sejak beberapa tahun kebelakangan ini, penggunaan dan permintaan untuk penjana mudah alih adalah sangat tinggi. Selaras dengan saiz yang ringan, kecil, mudah untuk dibawa ke mana-mana dan boleh memberi kuasa yang tinggi, ia menjadi keperluan untuk semua orang memilikinya. Terdapat pelbagai jenis penjana mudah alih di pasaran, tetapi kebanyakannya untuk kegunaan di rumah, komersil dan industri. Tetapi, hanya sedikit yang telah digunakan dalam bidang pertanian. Oleh sebab itu, bekalan kuasa mudah alih dengan saiz yang kecil dan ringan Penjana Magnet Kekal (PMG) bagi kegunaan sektor pertanian adalah dicadangkan.

Dalam kajian ini, Penjana Magnet Kekal (PMG) akan digunakan sebagai sebahagian daripada sistem pemotong mekanikal kelapa sawit. Beberapa penyelidikan yang dijalankan sebelum ini untuk menganalisis ciri-ciri dan prestasi PMG telah diterangkan dalam kajian literatur. Walau bagaimanapun, tiada satu pun di antara

mereka memfokuskan PMG dalam bidang pertanian yang memerlukan keupayaan kuasa tinggi, bersaiz kecil dan senang digunakan. Sebelum ini, terdapat beberapa produk pemotong mekanikal kelapa sawit yang telah dibangunkan dan dihasilkan. Walau bagaimanapun, kuasa keluaran yang dihasilkan tidak cukup untuk melaksanakan tugas yang diberi. Antara kelemahan pemotong mekanikal yang sedia ada adalah berat yang berlebihan dan capaian yang terhad. Peningkatan prestasi pemotong mekanikal dengan menggunakan bekalan kuasa daripada PMG untuk dibekalkan motor elektrik yang akan menukar gerakan putaran kepada gerakan linear untuk kerja-kerja penuaian

.

Sistem baru pemotong mekanikal kelapa sawit yang dibangunkan menggunakan Penjana Magnet Kekal (PMG) yang boleh beroperasi dalam fasa tunggal, jenis slot dengan pemegun berganda, dan dengan menggunakan magnet kekal jenis lengkuk yang terdapat dalam pemutar. PMG ini bertujuan untuk menghasilkan 500W pada kelajuan 3000 pusingan per minit (rpm). PMG ini akan disertakan dengan enjin satu silinder dua lejang (*Stihl* KM 85) dengan kapasiti 0.95kW. Enjin ini akan bertindak sebagai penggerak utama kepada PMG ini. Pada masa yang sama, dalam usaha untuk menilai PMG terbaik yang boleh digunakan untuk aplikasi ini, reka bentuk yang baru dan analisis pada PMG telah dijalankan. Tesis ini menangani isu di atas dan membincangkan pilihan PMG untuk digunakan dalam aplikasi pemotong mekanikal kelapa sawit.

Penjana Magnet Kekal direka dengan pemegun dua, dan pemutar terdiri daripada jenis arka magnet kekal bagi memaksimumkan penggunaan fluks. Reka bentuk penjana baru ini yang direka dan diuji secara eksperimen untuk melihat keupayaan

kuasa keluarannya. Pengoptimuman reka bentuk dilakukan dengan mengubah saiz magnet kekal, ianya bertujuan untuk memastikan fluks magnet yang terhasil dan menentukan jumlah kehilangan histerisis dan arus pusar yang memberi kesan kepada jumlah kuasa keluaran yang boleh dijana oleh PMG. Sebagai kesimpulannya, cadangan reka bentuk baru PMG menghasilkan output kuasa dan kecekapan yang tinggi berbanding diamana ianya dapat digunakan pada pemotong mekanikal kelapa sawit.

ACKNOWLEDGEMENTS

All praise to supreme Almighty Allah s.w.t. the only creator, cherisher, sustainer and efficient assembler of the world and galaxies whose blessings and kindness have enabled the author to accomplish this project successfully.

The author also would like to take this opportunity to gratefully acknowledge the guidance, advice, support and encouragement he received from his supervisor, Assoc. Prof. Dr. Norhisam Misron who keeps advising and commenting throughout this project until it turns to real success. Great appreciations are expressed to Prof. Dr. Ishak Aris and Dr. Amran Mohd Radzi for their valuable remarks, help, advice and encouragement.

Furthermore, the author would like to give special thanks to En. Abdul Razak Jelani of Malaysian Palm Oil Berhad for his support in sponsoring the project. The author also would like to say deepest thanks to Raja Nor Firdaus, Siti Khodijah, Norafiza for their kind assistance and guidance. Appreciation also to the Faculty of Engineering for providing the facilities and the components required for undertaking this project.

I certify that an examination committee met on (month, date year) to conduct the final examination of Suhairi Rizuan Bin Che Ahmad on his thesis entitled "Design of Double Stator Arc Type Permanent Magnet Generator for Palm Oil Mechanical Cutter Application" 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 examination committee are as follows:

Suhaidi Shafie, PhD
Senior Lecturer
Faculty of Graduate Studies
Universiti Putra Malaysia
(Chairman)

Hashim Hizam, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Chandima Gomes, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Nasrudin Abd. Rahim, PhD
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(External Examiner)

_____

BUJANG KIM HUAT, Ph.D
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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

Norhisam Misron, PhD Eng.
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

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

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

SUHAIRI RIZUAN CHE AHMAD

Date: 9 March 2012

TABLE OF CONTENTS