UNIVERSITI PUTRA MALAYSIA

SPEED ESTIMATION FOR A CAPACITOR DRIVE INDUCTION COIL LAUNCHER

SEYED ALI MIRATASHI YAZDI

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By

SEYED ALI MIRATASHI YAZDI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2012

DEDICATION

To my Parents

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

SPEED ESTIMATION FOR A CAPACITOR DRIVE INDUCTION COIL LAUNCHER

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Chairman: Syed Javaid Iqbal, PhD

Faculty: Engineering

The essential concept of the Capacitor drive traveling wave linear induction coil launcher is based on the principal of the classical linear induction electric machines. The literatures present the model of the launcher based on the circuits equations. The equations describe the currents and voltages of the coils and capacitors bank and interactive force between the coils in every time step of launching.

The main launcher power components are drive and projectile coils, capacitor bank and thyristors.The resistances of the coils and their changes due to the temperature have been considered in the previous research but for pure copper and aluminum. The characteristics of the capacitors and thyristors have not been considered because the capacitors and thyristors resistances are so smaller than coils resistance, and have been neglected in previous research. The thyristors have simple characteristics and have small voltage drop and power loss but there are many different kinds of

capacitors in the market and each model have different resistance and thermal specifications.

A simulation program was coded to determine output velocity of the projectile and other important parameters of the launcher in terms of inputs. The inputs are mass of the projectile, temperature of the launcher components and capacitors bank voltages. The model equations have been improved by considering the temperature characteristics of the capacitors and coils with impure copper and aluminum. The curve fittings method has been used for extracting the equation from the capacitors datasheets

The results show that the coils resistance have very important role in launcher performance. So they have to be calculated precisely and added to the model. The differences between simulation model outputs with considering capacitors and thyristors characteristics and without considering them are so small and this confirmed previous research.

In practical applications, one of the basic necessities of the every launcher is to determine the muzzle speed before shooting in short period of time. Therefore, there is a need to estimate initial voltage of the capacitors bank to reach the desired muzzle speed. There is a lack of a method that could estimate the initial voltage of the capacitors bank for specific muzzle speed. So a new system needed with the following inputs, the temperature of projectile, the mass of the projectile, the desired speed and the output is the capacitors bank voltage. In fact, a speed estimator is required to calculate proper input capacitors voltage in order to reach the desired muzzle speed. A novel method was applied by using intelligent systems for speed estimation and the results have been verified by the prototype launcher.

In this research the temperature effect on each parts of the launcher tested separately and it was verified that for the small size launchers the coils have the important role in temperature effect on the launcher performance and capacitors have not considerable role. Also the speed estimator model is a new application of neural network based systems and the test results approved that is a powerful tool for improving the launcher capabilities.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

ANGGARAN HALAJU UNTUK PELANCAR GEGELUNG DORONGAN KAPASITOR

Oleh

SEYED ALI MIRATASHI YAZDI

Ogos 2012

Pengerusi: **Syed Javaid Iqbal, PhD**

Fakulti: **Kejuruteraan**

Konsep terpenting bagi pelancar gegelung aruhan linear gelombang bergerak berpacu kapasitor adalah berasaskan prinsip mesin elektrik induksi linear klasik. Bahan rujukan memaparkan model pelancar tersebut berdasarkan persamaan-persamaan litar. Persamaan-persamaan tersebut menggambarkan arus dan voltan dalam gegelung dan bank kapasitor dan daya interaktif di antara gegelung dalam setiap detik waktu pelancaran.

Komponen-komponen kuasa utama pelancar adalah gegelung pemacu dan peluru, bank kapasitor dan thyristor-thyristor. Rintangan gegelung serta perubahan nilai akibat suhu telah dipertimbangkan dalam kajian sebelumnya tetapi hanya untuk kuprum dan aluminium tulen. Sifat kapasitor dan thyristor belum lagi dikira kerana rintangan kapasitor dan thyristor jauh lebih kecil daripada rintangan gegelung, dan telah diabaikan dalam kajian sebelumnya. Thyristor mempunyai sifat yang mudah

serta penurunan voltan dan kehilangan kuasa yang kecil tetapi terdapat banyak jenis kapasitor dalam pasaran dan setiap model mempunyai rintangan dan spesifikasi termal yang berbeza.

Aturcara simulasi telah dikodkan untuk menentukan halaju output peluru serta parameter-parameter utama pelancar dari segi input-input. Input-inputnya adalah jisim peluru, suhu komponen pelancar dan voltan bank kapasitor. Persamaan-persamaan model tersebut telah diperbaiki dengan mengambil kira karakteristik suhu kapasitor-kapasitor dan gegelung kuprum dan aluminium yang tidak tulen. Kaedah penyesuaian keluk telah digunakan untuk mendapatkan persamaan daripada risalah-risalah data kapasitor.

Hasilnya menunjukkan bahawa rintangan gegelung mempunyai peranan yang penting dalam prestasi pelancar. Oleh itu, nilai-nilai itu harus dikira dengan tepat dan ditambah kepada model. Perbezaan di antara output model simulasi dengan mengambil kira sifat-sifat kapasitor dan thyristor dan tanpa mengambil kira sifat-sifat tersebut adalah sangat kecil, dan ini mengesahkan kajian sebelumnya.

Dalam aplikasi praktikal, salah satu keperluan asas setiap pelancar adalah untuk menentukan halaju muncung sebelum tembakan dalam jangka masa yang singkat. Oleh itu, terdapat keperluan untuk menentukan voltan permulaan bank kapasitor untuk mencapai halaju muncung yang diingini. Terdapat kekurangan kaedah untuk menentukan voltan bank kapasitor untuk halaju muncung yang tertentu. Maka suatu sistem yang baru diperlukan dengan input yang berikut, suhu peluru, jisim peluru, halaju yang diingini dan outputnya adalah voltan bank kapasitor. Malah, penganggaran halaju diperlukan untuk mengira input voltan kapasitor untuk mencapai halaju muncung yang diingini. Suatu kaedah yang baru telah digunakan dengan menggunakan sistem cerdik untuk penganggaran halaju dan hasilnya telah disahkan menggunakan pelancar prototaip.

Dalam kajian ini kesan suhu terhadap setiap bahagian pelancar telah diuji secara berasingan dan telah disahkan bahawa bagi pelancar saiz kecil, gegelung mempunyai peranan penting dalam kesan suhu terhadap prestasi pelancar dan suhu kapasitor tidak mempunyai peranan yang penting. Selain itu, model penganggar halaju merupakan suatu aplikasi baru sistem berasaskan jaringan neural dan hasil kajian membuktikan bahawa ia adalah alat yang sangat mampu untuk membaiki keupayaan pelancar.

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APPROVAL

I certify that a Thesis Examination Committee has met on 7th August 2012 to conduct the final examination of **SEYED ALI MIRATASHI YAZDI** on his thesis entitled "**Speed Estimation for a Capacitor Drive Induction Coil Launcher**" 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 Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Norman b. Mariun, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Norhisam b. Misron, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Raja Mohd Kamil b. Raja Ahmad, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Muhammad Khaleeq ur Rahman, PhD
Professor
Faculty of Science
University Of Engineering and Technology Lahore
Pakistan
(External Examiner)

____

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

Date: ____________

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

Syed Javaid Iqbal, PhD
Professor
Faculty of Science
University of Engineering and Technology Lahore
(Chairman)

Mohammad Hamiruce b. Marhaban, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Member)

Samsul Bahari b. Mohd Noor, PhD
Associate Professor
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 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 institution.

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SEYED ALI MIRATASHI YAZDI

Date: 7 August 2012

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