FIELD ESTIMATION OF INDUCTION MOTOR PERFORMANCE USING DYNAMOMETER METHOD AND EQUIVALENT CIRCUIT METHOD

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A thesis submitted
In fulfillment of the requirements for the award of the
Degree of Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering
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NOVEMBER 2008

I declare that this report on "Field Estimation of Induction Motor Performance Using Dynamometer Method and Equivalent Circuit Method" is the result of my own project except for works which have been cited in the references. The report has not been accepted any degree and not concurrently submitted in candidature of any other degree.

Signature : ....

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To my beloved parents Mr. Mohd Ariff & Mrs. Zaitun,
fiancée Tengku Ani Sofeea,
brother Mohd Izwan & sister Nurul Ayuni

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ABSTRACT

Three phase AC induction motors are ideal for most industrial and agricultural applications because of their simple construction, low maintenance and robustness in field conditions. With varying load requirements, the performance of the motor also varies in terms of torque, efficiency and power factor. The induction motor's performance characteristics provide important information to the motor designer and also to the actual users for evaluating operating costs and monitoring motor performance under actual load conditions. Realizing the importance of motor performance information in practice, this project aimed to investigate and improve the standard motor tests that predict motor performance so that it can be done quickly, easily and accurately.

The first method is based on the dynamometer approach and the second is concerned with obtaining the motor's equivalent circuit parameters from basic tests. The performance of the motor in terms of torque, efficiency and power factor is then calculated from the equivalent circuit. The validity of the test methodology was verified by comparing the results of analysis with data of a motor from a catalogue with the results of dynamometer instrument in the laboratory.

Also carried out in this project was motor performance analysis using GUI performance calculator which was developed using Matlab software. The results from the methods used were then compared in term of ease of implementation and accuracy achieved.

ABSTRAK

Motor tiga fasa banyak digunakan di dalam aktiviti perindustrian dan juga pertanian atas faktor ketahanan, keupaayaan melakukan sesuatu kerja dalam apa jua keadaan. Dengan mengubah keperluan beban keatas motor, ia turut mempengaruhi keupayaan motor yang turut berubah dari segi nisbah kecekapan, tork dan faktor kuasa. Ciri-ciri keupayaan motor menyalurkan maklumat penting kepada pengguna dan juga pencipta motor untuk tujuan penjimatan kos operasi dan juga penilaian keupayaan motor semasa beban sebenar dikenakan keatasnya. Ruang kerja bagi projek ini adalah untuk mengkaji ciri-ciri keupayaan motor dengan mudah, cekap dan tepat. Kaedah pertama dan kedua telah dipilih setelah pengkajian dilakukan dan diperincikan.

Atas kesedaran akan kepentingan motor aruhan, tesis ini bermatlamat untuk mencari parameter litar kesamaan berdasarkan maklumat perincian yang dibekalkan oleh pengilang motor. Keupayaan motor ini boleh dikaji dalam bentuk tork, nisbah kecekapan dan faktor kuasa yang dianalisis dari litar kesamaan. Tesis ini juga turut menyentuh langkah-langkah mendapatkan maklumat dari maklumat perician dan juga perbandingan terhadap keputusan kajian dari meter dinamo di dalam makmal. Keputusan kedua-dua kaedah telah dibandingkan dalam bentuk nisbah kecekapan. Kajian ini juga turut melibatkan penciptaan simulasi menganalisis keupayaan motor mengunakan perisian MATLAB. Secara keseluruhannya kaedah satu dan kaedah dua telah mencapai kejayaan. Projek ini mempunyai potensi besar dalam membantu penjimatan tenaga.

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LIST OF SYMBOLS/ ABBREVIATIONS

Symbols:

μ	-	Micro (10^6)
Ω	-	Ohm
f	-	Frequency (*Hz*)
π	-	Pi (180)
ϕ	-	Flux
ω	-	Omega
φ	-	Phase displacement
η	-	Efficiency
s	-	Slip
S	-	Apparent Power
R	-	Resistor
T	-	Torque
n	-	Speed
m	-	mili (10^{-3})
M	-	Mega (10^6)
I	-	Current
X	-	Reactance
p	-	Pole
P	-	Power
A	-	Ampere
V	-	Voltage
t	-	Time
Z	-	Impedance

Abbreviations:

AC (a.c)	-	Alternating Current
DC (d.c)	-	Direct Current
e.m.f	-	Electric Magnetic Force
TSC	-	Torque Speed Characteristic
LN	-	Lucas Nulle
KV	-	Kilo-Volt
IEEE	-	Electrical and Electronic Engineer
PCOS	-	Pole Change Over Switch
CSI	-	Current Source Inverter
RCL	-	Rotor Core Losses
GUI	-	Graphical User Interface
AG	-	Air Gap
sync	-	Synchronous
async	-	Asynchronous
kV	-	Kilo-Volt
ACC	-	Acceleration
DEC	-	Deceleration

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CHAPTER I

INTRODUCTION

1.1 Induction Motor Performance Analysis and Control

In a three phase induction motor, there are many methods pertinent to measure motor performance characteristic or field efficiency evaluation in the literature and new methods are appearing every year. In order to calculate the performance of a three-phase induction motor, using the well known equivalent circuit, it is necessary to know the value of the equivalent circuit parameters. The most well known method for parameter determination of three-phase induction motors uses no-load and locked-rotor tests. [1]

There may be various reasons for the desire of testing an induction motor in the field, such as consideration of exchanging out of date or worn motors with new, or checking the efficiency after rewinding. Determination of efficiency is essentially a simple procedure. However, depending on the required degree of accuracy, in the field it may be an involved process. Particularly the output power is hard to detect. One of established procedures is therefore to look at the torque-speed characteristic (TCS) graph according to indirect methods by measuring the equivalent circuit and load test to estimate the motor performance. For the general summary, the behavior and performance of the motor can be interpreted in term of efficiency, power factor, slip, magnetizing current, and peak torque. Each of these can impact the suitability of a motor design for the demands of variable speed application.

1.2 Types of induction motor testing

1.2.1 Braking Method

This method is based on IEEE standard 112 A. The motor is loaded by means of a mechanical brake which a capable of being adjusted to provide the desired torque loading. Care shall be exercised in the construction and use of the brake and brake pulley. The "tare", if present, shall be carefully determined and compensate for [3].

1.2.2 Dynamometer Method

The dynamometer system is intended to be used as a test instrument to test the speed and torque capabilities of a motor and controller combination. The dynamometer is based on the IEEE standard 112 B. Dynamometers are electro-mechanical instruments used to place a controlled mechanical load on torque-producing devices such as motors. They are used to characterize motor torque as a function of speed. A dynamometer (dyno) is a basic electro-mechanical instrument used in the development of motors and motor drives. A dyno is a controlled, mechanical, rotational load. It controls either speed or torque and measures both. With a dyno, the torque-speed curves of motors can be plotted, and their motor-drives can be tested over the intended operating range. Dynos