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

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PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

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

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In the name of Allah, the most Gracious and most Compassionate

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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.

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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.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	THESIS STATUS CONFIRMATION	
	SUPERVISOR'S CONFIRMATION	
	TITLE	ii
	TESTIMONY	iii
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE OF CONTENTS	viii
	LIST OF FIGURES	xiii
	LIST OF TABLES	xv
	LIST OF SYMBOLS / ABBREVIATIONS	xvii
	LIST OF APPENDIXES	xix
CHAPTER 1	**INTRODUCTION**	1
	1.1 Induction Motor Performance Analysis and Control	1
	1.2 Type of Induction Motor Testing	2
	1.2.1 Braking Method	2
	1.2.2 Dynamometer Method	2
	1.2.3 Duplicate Machines Method	3

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

		1.2.4 Input Measurement Method	3
		1.2.5 Equivalent Circuit Method	3
	1.3	Background of the Study	5
	1.4	Problem statement	6
	1.5	Aim of the study	6
	1.6	Objectives of the study	7
	1.7	Research Scopes	7
	1.8	Report Outline	8
CHAPTER II	**LITERATURE REVIEW**		9
	2.1	Induction Motor	9
	2.2	Types of Induction Motor	14
		2.2.1 Three Phase Induction Motor with Squirrel Cage Rotor	14
		2.2.2 Dahlander Motor	16
		2.2.3 Three Phase Induction Motor with Separate Windings	18
	2.3	Method 1: Theory of Dynamometer Analysis	20
		2.3.1 Characteristics Test	20
		2.3.2 Machine Performance Characteristics	20
	2.4	Method 2: Theory of Equivalent Circuit Analysis	22
		2.4.1 Equivalent Circuit	22
		2.4.2 Machine Performance Characteristics	25
	2.5	Review of Important Research Works on Motor Performance Analysis	31

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER III	METHODOLOGY		33
	3.1	Introduction	33
	3.2	Method 1	33
		3.2.1 Introduction	34
		3.2.2 Research flow	34
		3.2.3 LN Dynamometer System Instruction Manual	36
		3.2.4 General Overview of LN System	36
		3.2.5 Basic Operating Modes	38
		3.2.5.1 Torque Control	38
		3.2.5.2 Speed Control	40
		3.2.5.3 Inertia Wheel	41
		3.2.5.4 Step-Position	42
		3.2.6 How to Operate the Dynamometer system	43
		3.2.7 Physical Connection of the Controller Computer	44
		3.2.8 Setting the Controller Computer	46
		3.2.8.1 Starting the Program	46
		3.2.8.2 Procedure of handling	47
		3.2.9 Important menu function of ActiveASMA Software	53
		3.2.9.1 The File Menu	53
		3.2.9.2 The Setting Menu	54
		3.2.9.3 The Operating Mode Menu	54
		3.2.9.4 The View Menu	55
		3.2.9.5 The Chart (Motor Characteristic) Menu	56
		3.2.9.6 The Chart (Oscilloscope) Menu	57
		3.2.9.7 The Exercise Menu	57
		3.2.9.8 The Help Menu	58

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

3.3	Method 2	59
	3.3.1 Introduction	59
	3.3.2 Research flow	60
	3.3.3 No Load Test	61
	3.3.3.1 Introduction	61
	3.3.3.2 Procedures	61
	3.3.3.3 Typical test Report	62
	3.3.4 Locked Rotor Test	63
	3.3.4.1 Introduction	63
	3.3.4.2 Procedures	54
	3.3.4.3 Typical Test Report	64
	3.3.5 DC Resistance Test	65
	3.3.5.1 Introduction	65
	3.3.5.2 Procedures	65
	3.3.5.3 Typical Test Report	66
	3.3.6 GUI Performance Calculator	67
	3.3.6.1 Introduction	67
	3.3.6.2 Procedures	67
3.4	Testing Implementation	70
CHAPTER IV	**RESULTS AND DISCUSSIONS**	71
4.1	Result of Separately Excited Motor (High Speed)	72
	4.1.1 Characteristic Test	72
	4.1.2 GUI Analysis	74
	4.1.3 Comparison Testing with Characteristic Test and GUI Calculator	75
4.2	Result of Separately Exited Motor (Low Speed)	77
	4.2.1 Characteristic Test	77
	4.2.2 GUI Analysis	79

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

	4.2.3	Comparison Testing with Characteristic Test and GUI calculator	80
4.3		Result of Dahlander Motor (Low Speed)	82
	4.2.1	Characteristic Test	82
	4.2.2	GUI Analysis	84
	4.2.3	Comparison Testing with Characteristic Test and GUI Calculator	85
CHAPTER V		**CONCLUSIONS**	87
REFERENCES			89
APPENDIXES			91

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Induction Motor Components	10
2.2	Torque-Speed Characteristic for Squirrel-Cage Induction Motor	11
2.3	Connection Star/Delta	14
2.4	Run-up characteristics	15
2.5	Connection Delta/Double Star	16
2.6	Run-up characteristics	17
2.7	Connection Star/Star	18
2.8	Per-phase equivalent circuit	22
2.9	Thevenin equivalent Circuit	26
3.1	LN Test Bench for Induction Machines	34
3.2	Flowchart of research work for characteristic analysis using dynamometer	35
3.3	Layout of Digital Control Unit for Servo-Brake	35
3.4	Connection to setting controller computer to Dynamometer system	44
3.5	Wiring Connection for Characteristic Test	45
3.6	Starting of ActiveASMA window display	47
3.7	Monitor-Data Display screen	48
3.8	Display Bar for characteristic selection	49
3.9	Monitor-Characteristic Test Data Display screen	50

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

3.10	Characteristic test data display screen for speed control test	51
3.11	Characteristic test data display screen with text	52
3.12	Flowchart of research work for performance analysis using equivalent circuit method	60
3.13	No load test physical connection	62
3.14	Locked rotor test physical connection	64
3.15	Physical measurement connection for star/delta connection	68
3.16	Snap shot of the GUI of the performance calculator	68
3.17	Snap shot of the GUI of the performance calculator showing calculation	69
4.1	Characteristics test for Separately Excited Motor when PCOS =1	72
4.2	GUI analysis for Separately Excited Motor when PCOS = 1	74
4.3	Characteristics test for Seperately Excited Motor when PCOS =2	77
4.4	GUI analysis for Separately Excited Motor when PCOS = 2	79
4.5	Characteristics test for Dahlander Motor when PCOS = 1	82
4.6	GUI analysis for Dahlander Motor When PCOS = 1	84

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Commercial available motor with separate winding	19
3.1	Summaries command associated of file menu	54
3.2	Summaries command associated of setting menu	54
3.3	Summaries command associated of operating mode menu	55
3.4	Summaries command associated of view menu	55
3.5	Summaries command associated of chart menu	56
3.6	Summaries command associated of help menu	58
3.7	No Load test report	62
3.8	Locked Rotor test report	64
3.9	DC resistance test report	66
4.1	Data of characteristic test for Separately Excited Motor when PCOS = 1	73
4.2	GUI analysis for Sepeately Excited Motor when PCOS = 1	75
4.3	Comparison Testing with Characteristic test and GUI calculator	76
4.4	Data of characteristic test for Separately Excited	

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

	Motor when PCOS = 2	78
4.5	GUI analysis for Sepeately Excited Motor when PCOS = 2	80
4.6	Comparison Testing with Characteristic test and GUI calculator	81
4.7	Data of characteristic test for Dahlander Motor when PCOS = 1	83
4.8	GUI analysis for Dahlander Excited Motor when PCOS = 1	85
4.9	Comparison Testing with Characteristic test and GUI calculator	86

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

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

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

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

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF APPENDIXES

APPENDIX	ITEM	PAGE
A	SPECIFICATION, DATA FOR LN SERVO DRIVE-BRAKE SYSTEM	91
B	SPECIFICATION DATA FOR MOTOR UNDER TEST	99
C	STANDARD TESTING REPORT	103
D	MATLAB CODE	106

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

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

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

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

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

are to motors and motor drives as oscilloscopes are to electronics – a basic test instrument [2].

1.2.3 Duplicate Machines Method

This method determining efficiency may be used when duplicate machines are available and based on the IEEE standard 112C. The two machines are coupled together and electrically connected to two sources of power, the frequency of one being adjustable. One machine is operated as a motor at rated voltage and frequency, and the other is driven as a generator at rated voltage per Hertz, but at lower frequency, to produce the desired load [3].

1.2.4 Input measurement Method

This method is based on the Ontario hydro version of the IEEE standard 112 method E. This method estimates efficiency at varying loads from the measurement of the cold stator resistance, voltage, current, power factor and rpm (measured with a speed sensor) [3].

1.1.5 Equivalent Circuit Method

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 based on IEEE standard 112 method F. The parameter determination of three-

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

phase induction motors uses no-load and locked-rotor tests. From the parameter obtained, equivalent circuit can be replace into the network to the left of the reflected components by Thevenin equivalent source and hence simplify the determination of torque and power equation. Finally, the complete torque-speed curve of a motor can be determined by selecting various values of slip and solving the circuit equation.

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

1.3 Background of the Study

Industrial automation has placed increasing demands on induction motor drives and the tasks performed by these machines are becoming ever more complex. The knowledge about the performance characteristics and fault mode behavior of such systems can be extremely useful from the standpoint of improved system design, protection and fault-tolerant control. However, the testing of the drives of electrical motors is not yet subject to standards, although motor drives with the same general design may differ significantly in performance [15].

The present work describes an experimental investigation of motor performance based on IEEE Std 112 B and IEEE Std 122 F. Here the dynamometer test and equivalent circuit test used to analyze the motor behavior and performance. The good features of these methods give the following advantages:

i. These tests are commonly used by higher learning institution and provide less risk rather than other types of test.
ii. These tests can be integrated with up-to-date computer hardware and software tool since most educational system company concentrate on this field test.
iii. The torque-speed characteristic curve easily obtained by this types of test
iv. The procedures in order to run these tests are simple.
v. The result obtained are easily analyzed and can be as teaching tools, support the classroom teaching by enabling the instructor, through the computer-generated graphics, to illustrate easily steady-state operation of the motor under various loading condition.
vi. The computational tools as a part of test enhance laboratory experiments enhance laboratory experience by providing students with the opportunity to verify the result of laboratory experiments and compare them with those obtained by computer simulations.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

1.4 Problem statement

The methods for determination of motor performance of induction motor can be summarized as follows [10]: name plate method, slip method, equivalent circuit method, segregated loss method, and shaft torque method. On field test one may estimate the efficiency based on information from the nameplate which a few problems may occur. First, the nameplate efficiencies of a given motor can be evaluated according to different standards. Second, some manufacturers and vendors may be incorrectly proposing an easily applied calculation which gives an approximation of motor efficiency, based on motor nameplate information. Third, the motor may have been rewound. The limitations of the slip method are that it does not recognize actual current losses which vary at loaded and no-load conditions, and the calculations rely upon the value indicated on the motor nameplate for speed (rpm) at full load which is an average for groups of similar motors tested by the manufacturer. The advantage of equivalent circuit method is that the performance of a motor can be predicted at any load when the impedance values are known. There are different approaches for obtaining the impedance values, which is the purpose of this paper. The segregated loss method estimates the magnitudes of the fives losses, namely: stator copper loss, rotor copper loss, core loss, stray load loss, and friction and windage loss. The most straightforward method is to measure the output power directly from the shaft without any need to calculate losses. The shaft torque method offers the most accurate field efficiency evaluation method, however, it is also high intrusive.

1.5 Aim of the study

The aim of this study is to learn to use the LN servo-brake system and the Graphical User Interface (GUI) for performance analysis from equivalent circuit.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

1.6 Objectives of the study

The objectives of this study are:

i. To familiarize with the LN Servo Drive / Brake system operation.
ii. To study the ActiveASMA program software that controls the Servo Drive / Brake System.
iii. To study standard test for motor performance.
iv. To learn to connect the Lucas Nulle Servo Drive with the induction motor.
v. To observe the effects on motor performance under different Under LN system and also by motor equivalent circuit method predict by Graphical User Interface (GUI).

1.7 Project Scopes

In this project, ActiveASMA program software will be used for monitoring the motor performance characteristic. The proposed Lucas Nulle Servo Drive / Brake system application for performance characteristic will be simulated by using ActiveASMA program software. The Lucas Nulle Test Bench will be tested and simulated with three difference capacities of asynchronous motor. Next, the main purpose of this study is to observe the motor performance under different method known as motor equivalent circuit method and analyzed by Graphical User Interface (GUI).

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

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