PERFORMANCE CHARACTERISTICS OF INVERTER DRIVEN SYNCHRONOUS MOTOR

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SESI PENGAJIAN: 2008/2009

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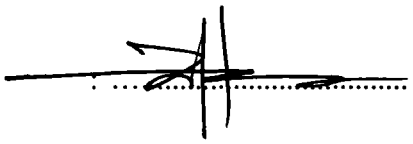
Signature : 

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PERFORMANCE CHARACTERISTICS OF INVERTER DRIVEN SYNCHRONOUS MOTOR

MAHYUZIE BIN JENAL

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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MAY 2009

I declare that this report on "Performance Characteristics of Inverter Driven Synchronous Motor" 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.

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Date : MAY 2009

For my dearest wife Nazalina,

My beloved sons M.Luqman Al-Hakim and M.Uwais Afiq,

My beloved daughters Nuraniqah Humaira and Nurqamarina Husna.

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ABSTRACT

Three phase synchronous motor has a wide range of applications. Its constant-speed operation (even under load variation and voltage fluctuation) and high efficiency make it most suitable for constant-speed, continuous-running drives such as motor-generator sets, air compressors, centrifugal pumps, blowers, crushers and many types of continuous-processing mills. However, this motor is not a self-started type. There are many methods implemented in order to bring up the motor's speed to the required limit. One of the approaches is by using variable-frequency supply starter that is used in this project work. Realizing the importance of motor performance information in practice, this project aimed to carry out the standard motor tests and observe the characteristics. Two main methods are applied in this particular system where one of them is by running up the synchronous motor conventionally. "Prime mover" is coupled to the motor and drives it to the desired speed before supplying electrical sources. The other method is by using variable-frequency (inverter) supply connected to the synchronous motor and run the motor accordingly. A number of experiments are set up either with and without the inverter to analyze and compare their performance characteristics. The results are reported and discussed in this work.

ABSTRAK

Motor segerak tiga fasa memiliki aplikasi penggunaan yang sangat meluas. Operasi kelajuan yang tetapnya (walau pun beroperasi dibawah nilai beban yang pelbagai dan ketidakstbilan voltan) dan kecekapan yang tinggi membuatkannya adalah yang paling sesuai bagi pemacu dari jenis kelajuan-tetap dan memerlukan operasi yang berterusan seperti set motor-penjana, pam empar, peniup , mesin penghancur dan lain-lain kategori industri yang berkaitan. Walaubagaimanapun, motor ini bukanlah dari jenis yang boleh digerakkan dengan hanya memberikan bekalan elektrik. Terdapat banyak kaedah yang digunakan untuk menggerak motor daripada keadaan rehat kepada tahap kelajuan yang dikehendaki. Salah satu daripadanya adalah dengan menggunakan bekalan pemula pembolehubah frekuensi yang juga telah digunakan didalam kerja ini. Atas kesedaran akan kepentingan motor segerak, tesis ini bermatlamat untuk melaksanakan beberapa ujikaji dan pemerhatian keatas karektor prestasinya. Dua kaedah telah digunapakai didalam sistem ini diman salah satu daripadanya adalah memacu motor secara konvensional. "Penggerak utama' disambung kepada motor dan memacunya kepada kelajuan yang dikehendaki sebelum sumber elektrik dibekalkan. Satu lagi kaedah adalah dengan menyambungkan bekalan pembolehubah frekuensi (penyongsang) kepada motor segerak dan memacunya. Beberapa set ujikaji dijalankan sama ada menggunakan penyongsang atau tidak telah dijalankan untuk menganalisis dan membandingkan karektor prestasi motor tersebut. Hasilnya telah diapor dan dibincangkan didalam kerja ini.

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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
δ	-	Torque angle
η	-	Efficiency
s	-	Slip
S	-	Apparent Power
Ra	-	Armature Resistor
T	-	Torque
n	-	Speed
m	-	mili (10^{-3})
M	-	Mega (10^6)
I	-	Current
Xs	-	Synchronous Reactance
p	-	Pole
P	-	Power
A	-	Ampere
E	-	Generated Voltage
V	-	Voltage
t	-	Time
Z	-	Impedance

Abbreviations:

AC (a.c)	-	Alternating Current
DC (d.c)	-	Direct Current
e.m.f	-	Electric Magnetic Force
m.m.f	-	Magnetomotive force
LN	-	Lucas Nulle
KV	-	Kilo-Volt
IEEE	-	Electrical and Electronic Engineer
FKEE	-	Fakulti Kejuruteraan Elektrik & Elektronik
UTHM	-	Universiti Tun Hussein Onn Malaysia
VSI	-	Voltage Source Inverter
CSI	-	Current Source Inverter
VVVVF	-	Variable Voltage Variable Frequency
BJT	-	Bipolar Junction Transistor
TTL	-	Transistor-transistor Logic
MOS	-	Metal Oxide Semiconductor
CMOS	-	Complementary Metal Oxide Semiconductor
SCR	-	Silicon Controlled Rectifier
IGBT	-	Insulated Gate Bipolar Transistor
PWM	-	Pulse Width Modulation
THD	-	Total Harmonic Distortion
sync	-	Synchronous
ACC	-	Acceleration
DEC	-	Deceleration

LIST OF APPENDIXES

CHAPTER II

LITERATURE REVIEW

This chapter will review past literature and discuss about operating characteristics of synchronous motor. The elements of speed control will be briefly discussed as well as the application for three phase synchronous motor. Finally, all the reviewed literature will be summarized.

2.1 Synchronous Motor

Synchronous means *to occur at regular or fixed intervals*. An AC Synchronous Motor is an electrical motor that rotates at a fixed speed, regardless of any increase or decrease in load. The motor will keep its fixes speed regardless of the torque required up until it reaches its stall torque rating. If the load becomes greater than the motor's stall torque, the AC Synchronous Motor will not slow down until it reaches a point at which it will stall and stop turning. The AC Synchronous motor is an effective way to obtain a fixed speed at a very low motor system cost [10]. No expensive driver or amplifier is

necessary. Most synchronous motors are used where precise timing and constant speed are required.

AC Synchronous Motors range in size from sub-fractional horsepower to over 10,000 horsepower. Smaller synchronous motors can be found in household devices such as clocks, timers, fans and cassette players, and as stepper motors in computer disk drives and printers. Larger synchronous motors are used in process industries and drive equipment such as compressors. Large synchronous motors most commonly employ a three-phase system. The smaller AC Synchronous Motors commonly use a single-phase system. The three-phase AC Synchronous Motor is the focus of this study.

Basically, according to the shape of the field, synchronous motor may be classified as cylindrical-rotor (non-salient pole) motor (Figure 2.1) and salient-pole machines (Figure 2.2).

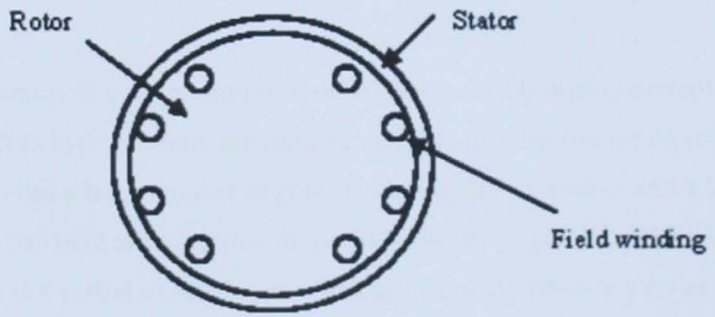

Figure 2.1: Basic construction of cylindrical-rotor synchronous motor type