EFFECT OF ROTOR BAR SIZE ON THREE PHASE INDUCTION MOTOR PERFORMANCE

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EFFECT OF ROTOR BAR SIZE ON THREE PHASE INDUCTION MOTOR PERFORMANCE

by

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LIST OF ABBREVIATIONS

AC	Alternating Current
ASD	Adjustable Speed Drive
AES	Annual Energy Saving
B	Magnetic Flux Density
DC	Direct Current
EDM	Electrical Discharge Machining
FEM	Finite Element Method
H	Magnetic Field Intensity
HP	Horse Power
IEC	International Electrotechnical Commission
IEEE	Institute Electric and Electronic Engineering
IM	Induction Motor
LF	Load Factor
NEMA	National Electrical Manufacturers Association
F&W	Friction and Windage
RCL	Rotor Copper Loss
RPM	Revolutions Per Minute
SCL	Stator Copper Loss
SESCO	Sarawak Electricity Supply Corporation
SESB	Sabah Electricity Supply Sendirian Berhad
SEU	Energy Consumed per unit physical product
TNB	Tenaga Nasional Berhad
TCS	Total Cost Saving

Kesan Saiz Bar Pemutar Terhadap Prestasi Motor Aruhan Tiga Fasa

ABSTRAK

Penyelidikan ini adalah tentang kesan saiz bar pemutar terhadap prestasi motor induksi tiga fasa. Penyelidikan telah dijalankan dalam dua bentuk, iaitu dengan menggunakan perisian FEM dan eksperimen makmal yang dijalankan pada tiga fabrikasi model perkakasan pemutar. Kajian menggunakan FEM perisian melibatkan tiga (3) saiz iaitu 6 mm, 8 mm dan 10 mm, ukuran diameter bar pemutar. Perisian FEM, Motorsolve, adalah perisian mesra pengguna yang membenarkan simulasi dilaksanakan dengan cepat dan tepat. Perbandingan hasil keputusan dari simulasi perisian kemudian dibandingkan dari segi maklumat plat nama seperti arus, kuasa keluaran dan faktor kuasa, parameter-parameter litar setara, tork, kecekapan, kuasa masukan, kuasa keluaran, kerugian dan ketumpatan fluks magnet. Bahagian kedua ialah pembinaan tiga rotor motor induksi dengan saiz bar pemutar 6 mm, 8 mm dan 10 mm. Pembinaan bermula dengan penyediaan blok kepingan keluli bukan ira dan kemudian diikuti dengan proses memotong menggunakan mesin pemotong wayar EDM, kepingan yang telah dipotong kemudian dikimpal dan diikuti dengan memasukkan bar pemutar tembaga, dan akhir sekali adalah pemasangan kedua-dua gelang hujung dan aci pemutar. Peringkat seterusnya adalah menjalankan eksperimen makmal seperti ujian tanpa beban, ujian pemutar disekat, dan kaedah ujian rintangan arus terus (AT) pada tiga model rotor yang direka. Maklumat voltan, arus dan kuasa yang didapati membolehkan pengiraan matematik dilakukan untuk menentukan kecekapan motor aruhan, kerugian dan faktor kuasa, θ. Keputusan dari kedua-dua siasatan menunjukkan bahawa kenaikan diameter bar pemutar akan meningkatkan arus, kuasa keluaran, faktor kuasa, kerugian dan tork pada kelajuan terkadar tetapi mengurangkan tork permulaan. Dari segi kecekapan motor aruhan, keputusan menunjukkan bahawa saiz bar pemutar yang berbeza memberikan kecekapan yang berbeza. Perubahan dari 6 mm hingga 8 mm diameter bar pemutar meningkat kecekapan tetapi perubahan dari 8 mm hingga 10 mm diameter bar pemutar akan mengurangkan kecekapan motor aruhan. Ini adalah kerana kenaikan saiz bar pemutar daripada 6 mm hingga 8 mm telah menurunkan peratusan kerugian berbanding kuasa masukan manakala kenaikan selanjutnya daripada 8 mm hingga 10 mm saiz bar pemutar meningkatkan peratusan kerugian berbanding kuasa masukan.

Effect of Rotor Bars Size on Three Phase Induction Motor Performance

ABSTRACT

This investigation is to determine the effect of rotor bar size to performance of three phase induction motor. The research was conducted in two forms, namely by using the FEM software and laboratory experiments that conducted on three fabricated rotor hardware models. The study using FEM software involves three (3) sizes, 6 mm, 8 mm and 10 mm, of rotor bar diameter. A user-friendly FEM software named Motorsolve, allowed simulation to be performed quickly and accurately. Comparison of the results from the software simulation then compared in terms of information on the name plate such as current, output power and power factor, equivalent circuit parameters, torque, efficiency, power input, power output, losses and magnetic flux density. The second part is the construction of three induction motor rotors with rotor bar size 6 mm, 8 mm and 10 mm. Construction starts with preparation of a block of non-grain steel laminations and then followed by cutting process using EDM wire cutting machine, the cut laminations then welded and followed by insertion of copper rotor bars, and finally is installation of both end rings and rotor's shaft. The next stage is to carry out laboratory experiments such as no-load test, blocked rotor test, and direct current (DC) resistance test methods on the three rotor models that were fabricated. The information of voltage, current and power gathered allows mathematical calculation to determine the induction motor efficiency, losses and power factor, θ. Results from both investigations shows that the increment in rotor bar diameter will increase the current, power output, power factor, losses and torque at rated speed but decrease the starting torque. Results show that different sizes of rotor bar given different efficiency. Changes from 6 mm to 8 mm of rotor bar diameter increased the efficiency but changes from 8 mm to 10 mm of rotor bar diameter will decreased an induction motor efficiency. This is because increment the rotor bar size from 6 mm to 8 mm had decreased the percentage of losses to power input while further increment from 8 mm to 10 mm rotor bar size increased the percentage of losses to power input.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The AC induction motor is used more than any other means to power industrial equipment. It became an important class of electric machines which apply in so many industry and usage. Motors are taking the biggest portion of electricity consumption in most industries where more than 85% of them are induction motors (Theodore W., 2006). What makes this type of motor very popular because they require less maintenance and its smaller size compared to the horse power produced. The three phase induction motor has no switching or commutation of circuits that make it possible to be used at very high voltage. The other advantage of induction motor is cost of production is low and simple. Additionally, induction motors are highly reliable and relatively have high efficiency. Moreover, the wide range powers induction motors, which is from hundreds of watts to megawatts, satisfies the production needs of most industrial processes. This is due to the use of motors of this type not only for ordinary use but also to the extreme and dangerous. In general, the use of induction motors, including pumps, conveyors, machine tools, centrifugal machines, presses, Elevators, Grain Elevators packaging equipment, Shredders, and equipment for coal plants (Aderiano M.,2006).

According to study by U.S. Department of Energy, as for 1991, the number of electric motors in the 1 – 120 hp range was more than 125 million, and they consumed 53-58% of the total electric energy generated. This huge consumption of generated

power became the reason that we could save electricity by increase the efficiency of motors. In many years, motor design was toward smaller and lighter body in order to lower the production cost but this approach is gradually change by giving more intention to efficiency and power factor

Malaysia is heading towards the developed countries are also experiencing rapid growth in the industry. The use of induction motors is increasing from year to year which would certainly increase the use of power generated at power plants. Thus, small energy saving by individual induction motor will help in reducing the amount of energy consumed as a whole which can be directed for the use of other.

Although studies have been carried out to produce a more efficient induction motors, but the focus is more on the material and rotor bar shape itself. There were no significant studies on the size of the rotor bars which can also affect the overall efficiency of an induction motor. A marginal increase in efficiency will have a major impact on overall energy consumption based on huge numbers of current induction motors in use.

1.2 Aims and Objectives

The aim of the thesis is to investigate the effect of different rotor bar size towards the 0.5hp induction motor performances. The objective of this research can be summarized as follows:

i. Design and simulation of three phase based on 0.5hp AC induction motor using Finite Element Method software, Motorsolve version 2.3 for three different sizes of rotor bars.

ii. To construct three induction motor rotors with different sizes of rotor bar diameter, 6 mm, 8 mm and 10 mm.

iii. To compare induction motor performance and characteristics by using FEM software analysis and laboratory experiments between three different size of rotor bars, 6 mm, 8 mm and 10 mm diameter sizes.

iv. To investigate the effect of 6mm, 8 mm and 10 mm rotor bar diameter sizes on induction motor efficiency and total losses such as stator copper loss, rotor loss, core loss, friction & windage losses and stray load loss.

1.3 Scope of Project

The scope of this study includes a relatively large area. Each stage of this scope is very important in order to produce a complete research.

The first stage is to create motor models with three different sizes of rotor bar using FEM software. The FEM software that used in this research is Motorsolve Ver. 2.3. The model of the designed motor is based on a 0.5 HP induction motor. The software simulations will conduct all calculations related to the power losses, efficiency, torque, magnetic flux density, speed of the motor. It will show how changes in the rotor bar size will affect the overall efficiency of an induction motor.

The next stage is to build three rotors with three different sizes of rotor bar. Each rotor will be studied using the same stator where the comparison will be made in several experiments. In the experiments, all tests related to the efficiency of the motor will be carried out, including no load test, the DC resistance and blocked rotor test. All of these tests results will enable parameters and power losses calculation in an induction motor to determine the motor efficiency. The final stage is to compare the efficiency of

both the motors and discuss how the changes of rotor bar sizes will influence an induction motor performance.

1.4 Problem Statement

The usage of induction motors are in a very large scale nowadays, this situation has given researcher an idea to study further on how to increase the efficiency of an induction motor that could be able to save energy. This is because demand for energy is increasing rapidly due to the rapid growth of technology that resulted more factories and plants were built. Energy conservation from a single motor may be considered very small, but because of the number of motor usage, the conservation of energy has become very significant.

Based on the fact that an investigation should be conducted on how the efficiency of an induction motor could be improved, changes in the size of the rotor bar for a motor is believed to provide different efficiency. As such a study should be done whether the efficiency can be improved by increasing or reducing the size of the rotor bars.

1.5 Project Overview

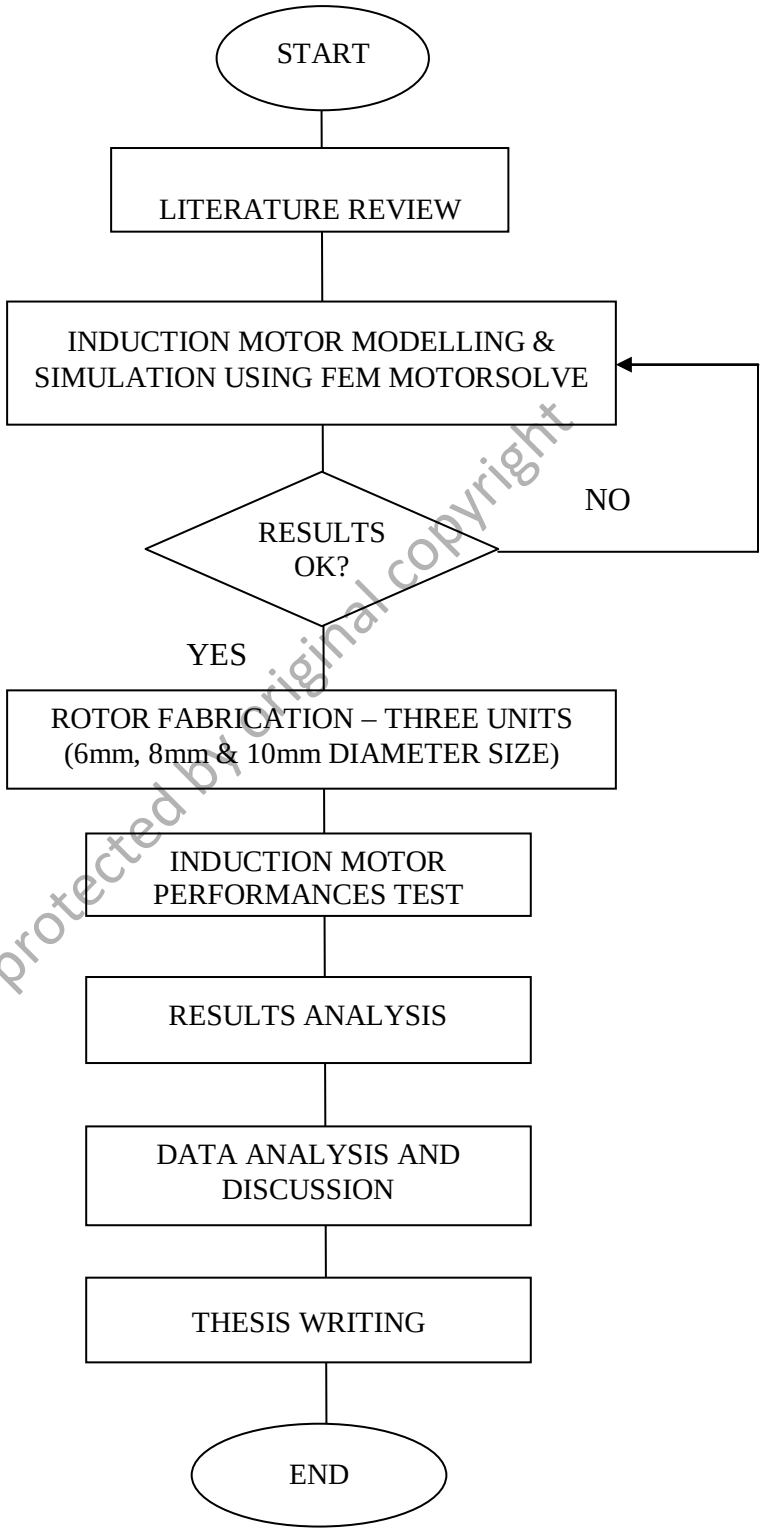

Figure 1.1: Flow Chart of Project Overview

1.6 Thesis Synopsis

Thesis will be divided into five parts, namely, introduction, literature review, Implementation of Methodologies, results and discussion and finally the conclusion.

The first chapter states on introduction, Aims and objectives, research scope, problem statement, project overview and thesis writing.

Chapter two discusses the literature review based on induction motor performance, types of experiment carried out by other researcher around the globe. The aspect of research concept of induction motor such as losses, the induction motor test such as no load, DC resistance, and block rotor test, literature on load factor evaluation is stated as well.

Chapter three which is the methodology chapter is divided to two main sections. The first section is research using FEM software and how the analysis is done using the software. The second section is more on how to fabricate actual hardware rotor that commenced with steel laminations cutting to complete rotor fabrication process. This will followed by the laboratory tests such as the no load, blocked rotor and DC resistance test.

Chapter four contains results and discussion from simulation of Motorsolve Ver 2.3 and comparison between the rotors with different sizes of rotor bars, the laboratory experimental analysis between two sizes of rotor diameter bar in terms of loss segregation and efficiency measurement. This topic will discuss the results obtained from software simulation and experiment using the hardware models. Induction motor model selected is based on 0.5 HP, 3 phase and 4 poles motor. Part simulation will examine from all angles, including losses in the motor, torque, flux density and finally