UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRIK

FINAL YEAR PROJECT REPORT

GEOMETRY DISCRETIZATION OPTIMIZATION FOR
FIELD MODELLING OF INSET PMSM
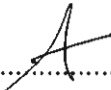
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2011/2012

"I hereby declare that I have read through this report entitle "Geometry Discretization Optimization for Field Modeling of Inset PMSM" and found that is has comply the partial fulfilment for awarding the degree of "Bachelor of Electrical Engineering (Industrial Power)"

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Date   :   25/6/2012

"I declare that this report entitle *"GEOMETRY DISCRETIZATION OPTIMIZATION FOR FIELD MODELLING OF INSET PMSM"* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date   :   2/7/2012

ABSTRACT

This project discusses about the geometry discretization for field modelling of Inset PMSM. In permanent magnet machine, leakage may have a major impact on the air gap fluxes. The phenomena in the air gap are use to estimate torques characteristic. Torque, back emf and flux density are the three variable that affect by the modelling the geometry discretization when the estimation process in performed in DMRM software. This study is required to improve torque waveform estimation by construct a suitable geometry discretization. This PMSM model is simulate in DMRM software which provides the mechanism that able to analyze the electrical motor performance. These three major factors are emphasized in this study in with aims to obtain at least 30% validation result compared to finale element package software. Important issues such as geometry modelling rules, output waveform analysis and result validation with the commercial final element software are described.

ABSTRAK

Karya ini membincangkan tentang pendiskretan geometri untuk pemodelan bidang Inset PMSM. Dalam magnet kekal mesin, kebocoran mungkin mempunyai kesan yang besar kepada fluks ruang udara. Fenomena dalam ruang udara digunakan untuk menganggarkan ciri tork. Tork,back emf dan ketumpatan fluks adalah tiga faktor yang berubah disebabkan oleh pemodelan geometri pendiskretan apabila proses anggaran yang dilakukan dalam perisian DMRM. Kajian ini adalah untuk meningkatkan anggaran daya kilas bentuk gelombang dengan membina pendiskretan geometri yang sesuai. Model PMSM disimulasikan dalam perisian DMRM yang menyediakan mekanisme yang mampu untuk menganalisis prestasi motor elektrik. Ketiga-tiga faktor utama yang ditekankan dalam kajian ini bertujuan untuk mendapatkan pengesahan hasil sekurang-kurangnya 30% berbanding dengan unsur pakej perisian yang sebenar. Isu-isu penting seperti kaedah-kaedah pemodelan geometri, output analisis bentuk gelombang dan pengesahan hasil akhir dengan perisian komersial diterangkan.

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Introduction

1.1 Project background

This study is required to improve torque waveform estimation by construct a suitable geometry discretization for permanent magnet synchronous motor (PMSM). This PMSM model is simulate in DMRM software which provides the mechanism that able to analyze the electrical motor performance. Torque, back emf and flux density are the three major factors are emphasized in this study in with aims to obtain at least 30% validation result compared to finale element package software.

1.2 Project Objective

There are three main objectives in this project which are:

i. To construct suitable geometry discretization as input to DMRM software for inset type PMSM.

ii. To improve the torque waveform estimation by mean of geometry segmentation for Inset PMSM in DMRM software.

iii.   To achieve at least 30% different of result compared to finale element package software.

1.2 Problem Statement

Based on future work in reference [1], reluctance mesh on the air gap can be modified to accommodate the heavily saturated iron. More subtle reluctance to provide greater net of flux path can be found to model this condition. The process of creating the elements of air gap by means overlapping area can be increase by using the overlap that can be determined from the curved that generate from finite element model (FEM). This may be particularly useful when managing HF injection and incremental inductance which associated with saturated saliency in the machine. This study is performing to solve this issue.

1.3 Scopes of Project

In many study, there are some limits and constrain of the project that makes the project achievable, in this project the scopes are:

i.   The focus only on Inset PMSM

ii.   18-slots 6-poles inset and 24-slots 20-poles inset PMSM is use in this study

iii.   DMRM software is provided and used as it is (no modification required)

iv.   Back emf, torque and flux density are the variables that considered in this paper.

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CHAPTER 2

Literature Review

2.1 Permanent Magnet Synchronous Motor (PMSM)

AC motor consists of permanent magnet motor, induction motor, traditional synchronous motor and reluctance motor. Permanent magnet motor can be divided by two type that is permanent magnet synchronous motor (sinusoidal emf) and brushless DC motor (trapezoidal emf). There are three type of permanent magnet synchronous motor (PMSM) that is surface PMSM, inset and interior PMSM.

The magnet of the surface-mounted PMSM are attached to the surface of the rotor whereas those of the interior PMSM motor are buried inside and inset PMSM is an alternative form of surface-mount where the space between magnets is filled with magnet material acting to retain the magnet. The locations of the magnets in a PMSM determine the level of mechanical robustness, saliency path, field weakening and torque generation [1].

Compared with the traditional electric excitation motor, the permanent magnet synchronous motors (PMSM) have reliable operation, simple structure, high power factor, and many other advantages. The PMSM is extremely suitable for the drive system of electric vehicles. If the PMSM had been made the magnetism of the permanent magnet would be changed difficulty. Some researches about the motor structure were done in recent years. The

good achievements are obtained in increasing the low-speed torque and expanding the constant-power operation range [2].

2.2 Modelling PMSM

Nowadays, the need for designing tools for permanent magnet (PM) motor are increasing due to the rise of demands for high efficiency motor in the industry. The tools that provide reliable information on loss distribution is crucial, especially or the designing the efficiency of the motor. There are three methods that can be use to decide a strategy for a fast and reliable motor, that method such as finite-element method, magnetic equivalent circuit and empirical methods.

2.2.1 Finite Element Modelling

The finite element modelling is a numerical analysis or numerical technique to obtain approximate solution of linear and nonlinear partial differential numerical method [1]. This method used mesh network to model the magnetic circuit into many fine elements. The disadvantage of this method is it takes a long calculation time even it is very flexible for new design that consist new shapes.

2.2.2 Empirical, Conventional Method

Empirical, conventional modelling methods rely heavily on the existence of a body of experimental experience, obtained by testing known designs [3]. The reliable results cannot be given to the new design that is being tried using this method but for industrial designs, this method is useful for analysing small changes.

2.2.3 Magnetic Equivalent Circuit (MEC)

This method is the combination of both methods that state above that can support steady-state and dynamic simulations. MEC modelling was selected for further investigation as it seemed a good technique providing high speed and acceptable accuracy compared to FEM and empirical method [3].

2.3 MEC and Field Modelling

The cost and the time required to set-up an experimental rig can be saved by using MEC or known as field modelling. There are some field modelling methods such as Dynamic Mesh Reluctance Model (DMRM), the reluctance network (RelNet) method, and Finite Element Method (FEM).

2.3.1 Dynamic Mesh Reluctance Model (DMRM)

DMRM can be considered as a compromise between FEM and lumped parameter models. Its advantages are the relatively low computing time and an acceptable accuracy, achieved through a division of the geometry that is coarser than in FE models. DMRM approach, gives the same modeling functionality as the FEM. This includes linear and non linear iron and the analysis of space and time harmonics and their resulting impact on torque ripple, flux linkage and back EMF [1].

2.3.2 Reluctance Network (RelNet) Model

The RelNet method is known to be a good compromise between computation time and precision. The reluctance network approach uses the magnetoelectric analogy where reluctance replaces resistances. These reluctances are either time dependent (vary with the saturation) or position dependent (air-gap) reluctances. Among these reluctances, the most delicate are the ones modelling the air-gap where high accuracy is required [4].

2.3.3 Finite Element Method (FEM)

The Finite Element method of modeling machines has no restriction on the direction of direction of flux through any element. The machine magnetic circuit is modeled by a mesh of fine element. The FE method is very flexible as few assumptions are made as to the direction of flux flow, thus allowing for the study of new designs incorporating new shapes. However, the long simulation times make the FE method practically incapable of modeling the machine dynamics and the interactions between the control system and the machine's physical properties [5].

2.4 DMRM Software

There is some similarity between FEM and DMRM such as impact on flux linkage, back emf and torque ripple. DMRM use less time to simulate and less memory used compared to FEM that use large number of element. The DMRM user interface provide a flexibility for the user to easily change and modify the machine's physical geometry and control parameters to investigate the combined effect of motor geometry and control on machine performance. There are some disadvantages of DMRM that obviously been seen when the study is perform. The user placing the mesh in the directions of the important flux path in the machine, the ability of the coarse mesh of the reluctance network to yield results of reasonably good accuracy can be achieved. Based on the user experience on type of machine the good results can be obtain due to the prediction of the flux distribution relies on the electrical machine.

CHAPTER 3

Methodology

This chapter discussed about the methodology of this project. There is some numbers which refer to separate section which every section is develop individually and combined to complete this project. Each section needs to be understood to ensure that success design can be carried out. The methods in this project are discussed in the following sections.


3.1 Overview

This project is all about the modelling the Inset PMSM by using DMRM software and Matlab simulation. The DMRM software is provided and use as it is, whereas Matlab simulation is use to produce torque and back emf graph and compare it with the actual graph. Figure 3.1 shows the flow chart of this project. In the beginning, before the starting of the project, the understanding about the literature review of permanent magnet and field modelling is crucial. This is the highlight of all the method before the flux direction and movement around the PMSM structure can be determine and analyze. Then, find the available technique and choose suitable one or design a new technique and define the geometry discretization rules for inset PMSM before test it in DMRM file.
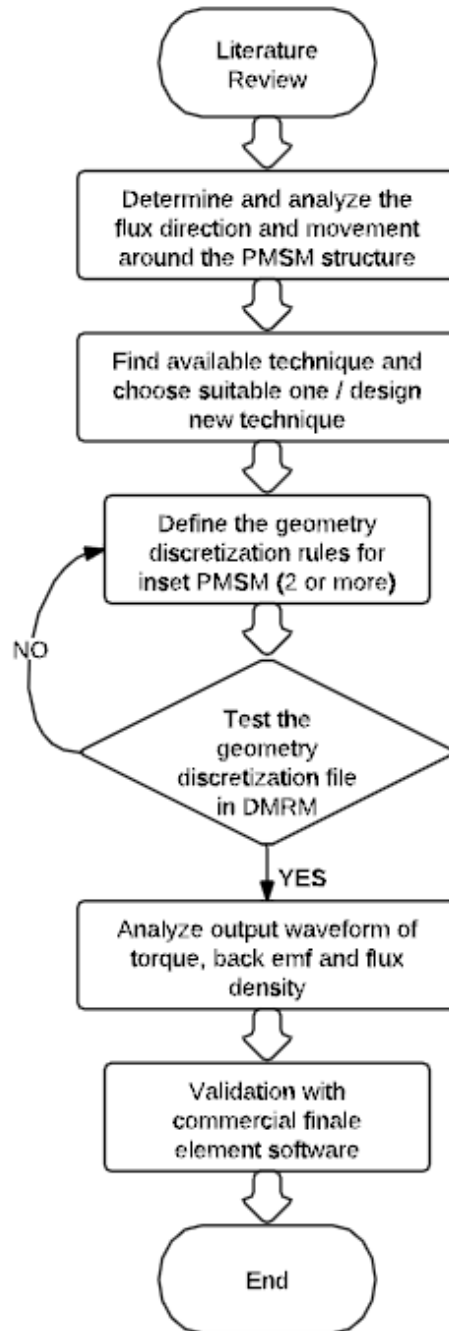
Figure3.1: flow chart of the project

3.2 Detail of Method

After the topic of the project already confirmed with the lecturer, searching of the journal that relate to this project is start. Some journal that related to this project is studied and understands and the points that can be used in this project are compiling in the literature review part. The structure of PMSM part then studied before the flux direction and movement can be determine and analyze to ensure the process while doing this project running smoothly. Then, the process proceeds to find the available technique to model the structure in the PMSM. The geometry discretization rules for this project is define by doing only seven configuration element as the starting to analyze the torque and back emf in the DMRM file that combine with the Matlab software that help to produce the waveform. The modelling of structure and the value of motor used in this project is shown below.
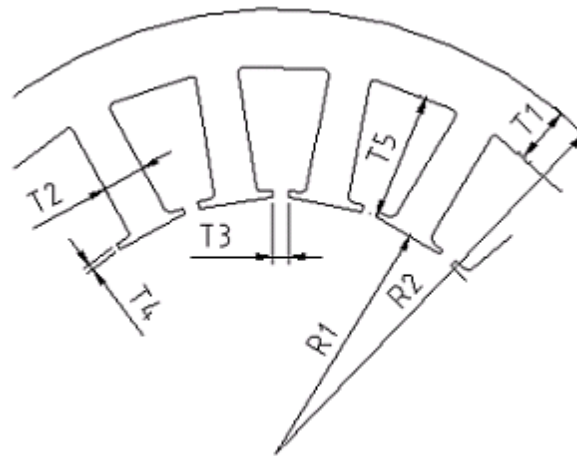
Figure3.2: dimensions of the stator geometry
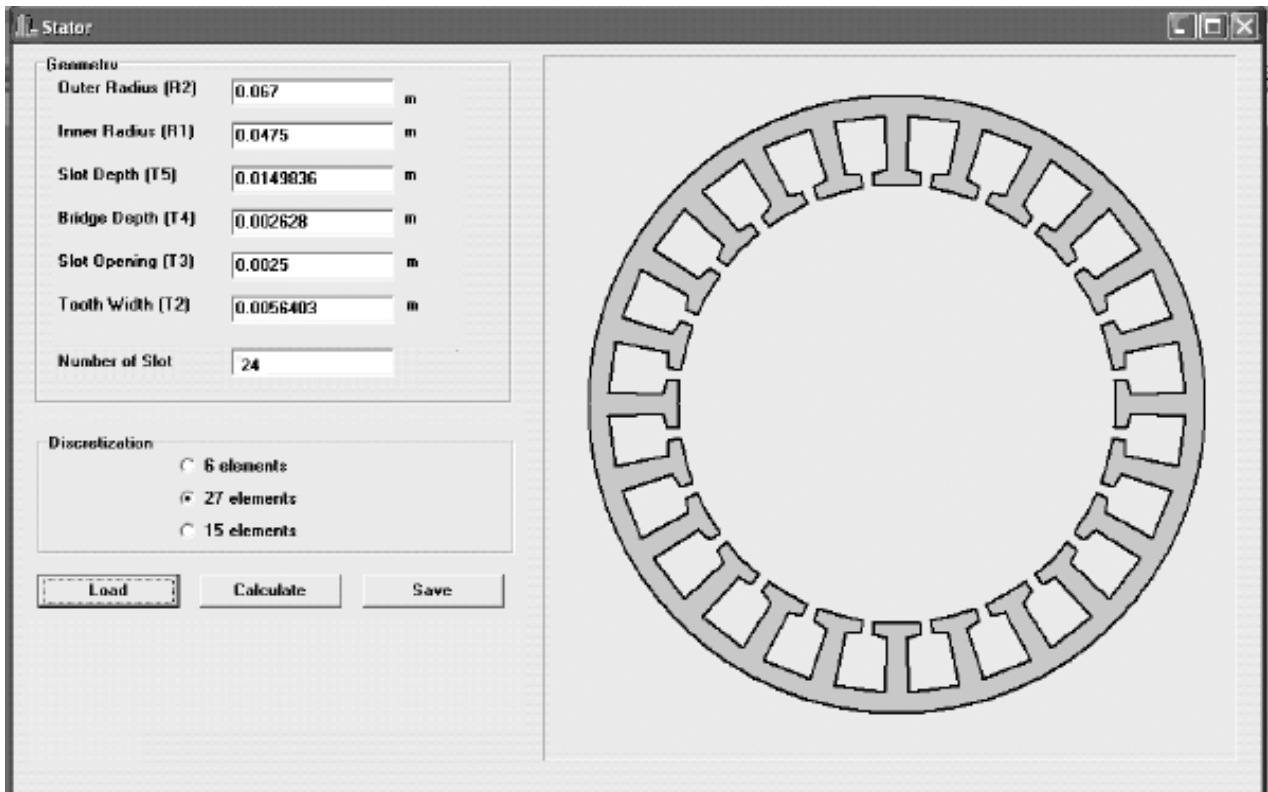
Figure3.3: the stator configuration unit

3.3 Modelling the iron part

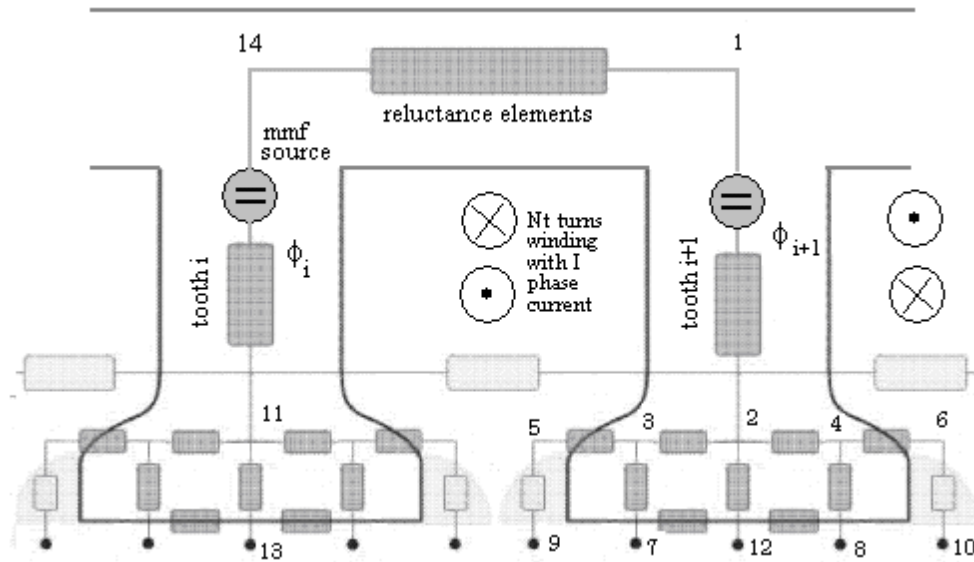Based on the figure 3.2 above, a table for stator for inset PMSM can be created using the value in the table 1 below:

Figure3.4: stator modelling

Table 1: Dimension to create reluctance mesh element for the stator

Nodes		Length, l	Width, w	Depth, d
0	1	(2*π*R2) / num. of slot	back iron depth	core length
0	2	sloth depth – bridge depth	tooth width	core length
2	16	bridge depth	tooth pitch	core length
1	3	sloth depth – bridge depth	tooth width	core length
3	17	bridge depth	tooth pitch	core length
2	3	(tooth pitch/2) + slot opening	tooth width	core length
16	17	slot opening	bridge depth	core length

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