1.Introduction

In this study, synchronous reluctance machine (SynRM) design is detailed. General structure of SynRM is given firstly. Reluctance concept will be detailed. Working principle of this machine is detailed as well.

SynRM was developed in 1930s firstly. However, it suffers from high torque ripple, low power factor and poor high speed performance. After dramatical increase in magnet prices and development in power electronics devices, researchers pay attention to SynRM design again due to the benefits as follows:

* High efficiency (due to absence of field)
* Low cost (due to absence of PMs)
* High torque ratio

In this study, overall design will be presented and Finite Element Analysis will be performed. Syr-e which is optimization tool for SynRM will be used by the author. Syr-e uses FEMM and MATLAB/OCTAVE paralelly. By using GUI in MATLAB, design parameters can be determined and optimized by using FEMM numerically. Beside this, any design with defined parameters can be drawn and simulated by using this program.

2.Design process

2.1. Design Parameters

In this study, 22 kW and 1500 rpm machine with 2 pole pairs will be designed. It is driven by 50 Hz. By calculating, output torque of the desired machine is 140 N.m. In this design, all parameters are determined step by step in following parts. Rated voltage of the machine is 400 Volt line to line.

2.2. Machine Constant

In order to calculate machine constant, approximate electrical loading and magnetic loading should be chosen. Electrical loading is chosen as 40 kA/m and magnetic loading is chosen as 0.8 Tesla. Then machine constant can be calculated as follows

,where fill factor of the winding is taken 0.96. This value is compared the table given in lecture notes and it is sensible.

2.3. Determining air gap clearance, rotor diameter and stack length

In order to determine air gap clearance, the formula given in lecture notes will be used and it is calculated as follows:

This value is actually generally used value for synchronous machines. It can be manufactured and it increases saliency ratio (Ld/Lq) of the machine and correspondingly increase torque constant of the machine.

After that, in order to calculate rotor diameter, let’s alculate sheer stress of the machine as follows:

Then, desired torque for the machine is 140 N.m and it is calculated as follows:

In this case, l is chosen as 160 mm and corresponding rotor diameter is calculated as 156 mm.

2.4. Determining of Winding Parameters

Before determining slot number in the machine, slot per phase per pole (q) should be determined. Then total slot number can be calculated easily. If q is taken 1, winding factor is higher. However, in order to decrease effects of harmonics, q should be taken higher. For this case, q is taken 4 due to the geometric constraints.

In order to define turn number in each slot, back emf formula is used. Flux per pole can be determined by using magnetic loading determined above and pole area calculated by using rotor diameter and stack length of the machine. Flux per pole can be calculated as follows:

Then frequency of the machine is 50 Hertz and winding factor is taken 0.96. So, by using back emf equation, turn per phase can be calculated as follows:

There are 16 slots for each phase and for each slot is taken 9 (68/8=8.5).