Development of a Reluctance Mesh Generator

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The usage of reluctance networks for predicting the performance of electrical machines and electromagnetic devices has become a very convenient solution. Although reluctance networks are not as accurate as the finite element method, they give acceptable results. Reluctance networks has been used for the initial sizing of electrical machines during its optimization process. It is interesting to note that reluctance networks are very useful, but there is not published work on the generator of reluctance networks. This paper presents the development of a software for generating reluctances and its associated magnetic network. The software is designed to create elements and nodes with its appropriate data structure that is then used to numerically solve the problem. The complete software will be presented in the full paper version.

***Index Terms*—Reluctance network, magnetostatic, mesh generator.**

I. Introduction

The solution of electromagnetic problems with the finite element method (FEM) has been used since many years ago [1], where a domain is discretized into triangular or quadrilateral elements for two dimensions problems and tetrahedrons or cubes for three dimension regions. In the case of electromagnetic problems, it is proposed to use triangular elements for 2D problems [1]. There are several methods for mesh generation which in turn can be even classified according to various factors [2]. In this paper, a method is proposed to solve electromagnetic problems by means of the automatic generation of reluctance meshes. A method for the automatic generation of reluctance meshes is proposed to create a set of reluctances according to the region they represent. The modeling of electromagnetic devices which use reluctance meshes are recently becoming popular but they have the drawback of being time consuming to implement due to the lack of a reluctance mesh generator [3]. Here, a software is proposed for the generation of reluctance meshes which uses methods initially designed by the authors to generate the initial sizing for finite element analysis or optimization studies. The results presented in this paper correspond to the mesh reluctance generator.

II. Software Methodology

The proposed software has been developed using C++ together with Qt framework to create the user interface and OpenGL as the display engine to show the generated reluctance meshes, Qt gives the possibility that the resulting software will be multiplatform. Qt it is a modular system of classes and tools that makes easier for the programmer to develop software in C++. Mesh visualization uses more advanced technology such as OpenGL, which is mainly integrated by a set of libraries written in C and C++ and it makes possible to interact with the hardware responsible of graphics visualization on the computer and in this way all the overhead that is needed for mesh visualization is processed by video card and not by the CPU. Within the software, there are two ways to define an electromagnetic problem domain, the first way is through the reading of a text file which contains the fundamental information to create the domain where the reluctance mesh will be created. The second way is based on predefined models where it is only necessary to provide values such as height, length and other factors, as it shown in Fig. 1.

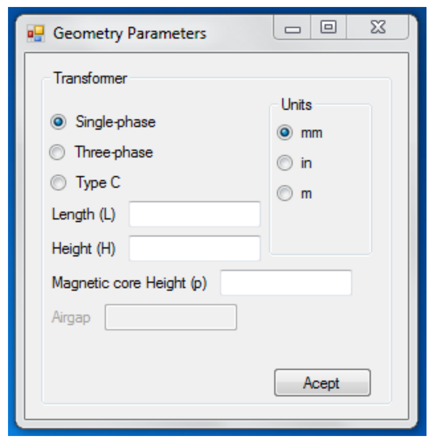

Fig. 1. Input data to define the domain outline.

III. Reluctance Mesh Generation Algorithm

To illustrate the mesh generator, two of the generated reluctance meshes for simple structures are shown in Figs. 2 and 3. The first mesh corresponds to a type-c core and the second one corresponds to a magnet. The first step of the software is to evaluate the domain in order to implement the most suitable method to the mesh generation, in the full paper, a more complex domain will be presented.

Figure 2 shows a type-c core mesh generation for this geometry the generator creates nodes and elements simultaneously like advancing front, such as the type of methods implemented for mesh generation for finite element. On this occasion the method does not create a triangular element, such as the advancing front does [4], in this case it is calculated to create a node that will be part of the union of an element, either reluctance or source.

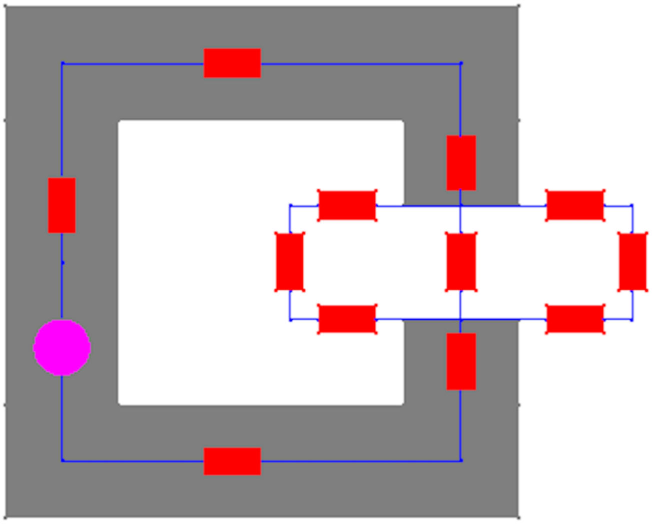

Fig. 2. Reluctance mesh of an electromagnetic C core.

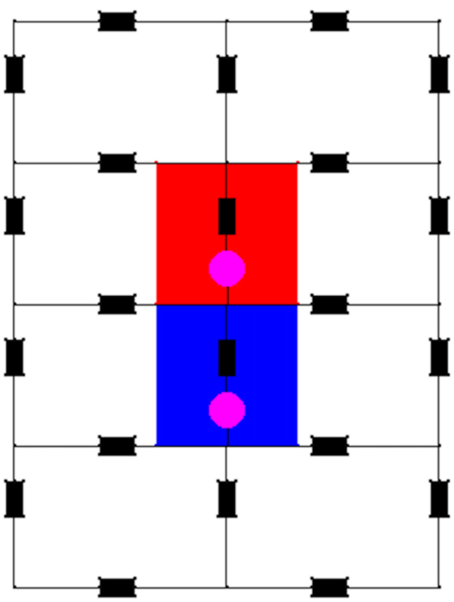

Fig. 3. Reluctance mesh of a magnet.

The reluctance mesh generated for a permanent magnet is shown in Fig. 3. The method for the generation of the reluctance network is different to the method used to generate the reluctance mesh shown in Fig. 2. The difference lies in that it was considered that the geometry is symmetric, so a method similar to based-grid was used [5]. The method consists in generating a grid mesh over the domain and based on that, the elements are created, in this case, reluctances and sources.

IV. Reluctance Networks

The key idea in modeling an electromagnetic device by reluctance networks is to generate elements named reluctances to represent all leakage and mutual magnetic flux paths. The method of reluctance network is based on magnetic Law of Kirchhoff (1) for nodes and Law of Ohm for magnetic circuits (2) [6].

$$\sum_{i=1}^{n} \emptyset_i = 0 \quad (1)$$

$$\emptyset_i = \frac{F_{ij}}{R_{ij}} \quad (2)$$

where ϕ_i is the magnetic flux at node i, F_{ij} is magnetic potencial between i and j, n is the number of nodes, and R_{ij} is the reluctance between nodes i and j.

The reluctances are defined accordingly to the domain they represent and to the dimensions of the region as indicated in (3).

$$R_{ij} = \frac{L}{\mu A} \quad (3)$$

where R_{ij} is the reluctance, L is the mean length, μ denotes the permeability and A is the area.

The reluctance mesh generator must take into account the topology of the network and the dimensions need in (3). Afterwards, a set of simultaneous equations are then built and solved for the magnetic flux.

V. Conclusions

This paper has presented the development of a software for generating reluctance networks that represent the different domains within an electromagnetic device. The data structures designed contains all information needed by the solver. More results will be given in the full paper.

References

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