Modelling of punching influence on magnetic properties of non-oriented electrical steels used in the magnetic core of a PMaSynRM motor

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In this analysis, the damaging effect of mechanical cutting on the magnetic properties of non-oriented silicon iron strips was incorporated in the finite element model of a PMaSynRM. A comparison between the undamaged magnetic properties of the motor core material and a model that considers a hyperbolic function behaviour of magnetic polarization versus strip width will be presented. Attention will be devoted to the most important motor functional features.

Keywords: non-oriented electrical steels; permanent magnet assisted synchronous reluctance motor; finite element analysis; magnetic properties; cutting procedure

1. Introduction

It is well known that investigating the influence of different manufacturing steps on the magnetic properties of non-oriented electrical steels is considered an important domain of study. Cutting the electrical strips in a desired shape and giving them geometrical dimensions to fit the commercial requirements for electric motors has a great effect on the overall efficiency of the motor. Usually, methods such as punching, waterjet cutting, laser, and wire electric discharge machines are involved. From these, mechanical punching and laser stand out. However, mechanical cutting has important drawbacks, such as the appearance of plastic deformation near the cut edge characterized by the presence of an affected zone with unsatisfactory magnetic properties.

The permanent magnet-assisted synchronous reluctance motor (PMaSynRM) is considered one of the most promising electrical machines due to its high torque density energy. Although many models are based on rare earth (RE) magnets, in the context of a global crisis and increased price of raw materials, solutions are continuously searched to replace the most expensive parts, such as RE magnets. We have modelled and analysed a prototype of a PMaSynRM motor with six poles that was characterized by an important reluctance torque component generated by the rotor anisotropy and a lower torque attributed to the permanent magnets. In our study, we chose ferrites (Y30H-2 - $SrO_6Fe_2O_3$) magnets. Our main goal was to include the effect of cutting technology in the model of the prototype mentioned above based on a method that considers the deteriorated zone as a multi-slice pattern [1], in which we introduced experimental data of 7 normal curves measured on the electrical steel strips with various widths ranging from 5 mm to 60 mm as described in [2]. This method was implemented in the free software FEMM 4.2 based on our prototype geometry and magnetic materials used in the practical solution presented in [3].

2. Results and discussion

The PMaSynRM model uses as material for the rotor the M300-35A electrical steel with three magnetic paths per pole as flux barriers that support the Y30H-2 magnets having two magnetic directions: radial for the circularly placed magnets and tangential to the rotor. For the stator, we have used NO20 Hi-Lite silicon iron material with 36 slots for a 3-phase power system. Each coil has 7 turns with 39 copper strains of AWG 22. Starting from the phenomenological model based on hyperbolic functions described in [2], the width of the strain-hardened lateral band was estimated at 2 mm (M300-35A) and 1.75 mm (NO20), respectively. The normal magnetization curves for the fully damaged and undamaged strips were computed. They were introduced together with the other seven experimentally measured dependencies in the electrical motor model, exhibiting a multi-slice contour implemented near the cut edge. Each slice follows the cut edge of the motor magnetic circuit having a variable width of 2 mm, 0.5 mm, 0.5 mm, 0.75 mm, 1.25 mm, 2.5 mm, 7.5 mm, and 15 mm. Figure 1 shows one-pole motor geometry with the multi-slice pattern and a comparison between the magnetic polarization for the undamaged and multi-slice cases.

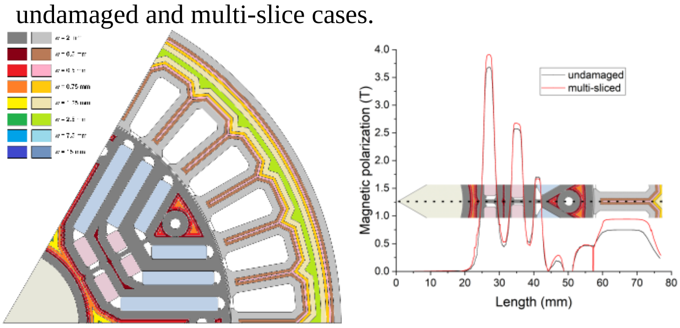

Figure 1: One-pole motor geometry exhibiting a multi-slice pattern (left) and magnetic polarization versus length in two analysed cases (right).

References

[1] N. Alatawneh et al., IET Electric Power Applications, **14** (2020), 2355-2361.
[2] V. Manescu (Paltanea) et al., J. Magn and Mater., **499** (2020), 166257.
[3] G. Paltanea et al., 2023 ISFEE Conference, 16-18 November, Bucharest, Romania

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