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Contribution to iron losses decrease in AC motor: a new shifted non segmented Grain Oriented magnetic circuit

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Abstract— This paper deals with iron losses computation in a new and original AC electric motor magnetic circuit made of shifted non-segmented grain oriented steel laminations. This structure has been recently developed and prototypes have been tested. The latter showed significant core loss decrease compared with motors made of non oriented sheets. In order to evaluate the contribution of different iron losses components in the global decrease, a Finite Element analysis is performed, exploiting experimental Epstein frame loss curves.

I. INTRODUCTION

Increasing the performance of electrical rotating machines, has always been a major challenge. This is even more the case nowadays considering the present environmental issues. From this perspective, several solutions have been developed in the past few years. Recently, a new AC stator magnetic circuit for low and medium power machines, based on the stacking of shifted non-segmented Grain Oriented (GO) steel sheets, has been developed [1]. It has been experimentally shown that the latter allows decreasing iron losses compared with a machine built with Non Oriented (NO) sheets of same thickness [2]. The aim of this study is to better understand the contribution of the different iron losses components (quasi-static, classic and excess) on the global decrease in order to define the most appropriate steel quality and the β - the shifting angle (Fig. 1) - value.

Empiric models to predict the core losses of soft magnetic materials exist [2][3]. Nevertheless, in order to allow performing a loss separation (quasi-static, classic and excess) these models require the b magnetic flux density to be known in the whole structure, which is not experimentally possible for the particular magnetic circuit presented in this paper.

So, the use of a finite element (FE) modeling makes it possible to evaluate the b magnetic flux density distribution inside each lamination. Hence, the iron losses components can be computed *a posteriori* by exploiting experimental Epstein frame loss curves.

II. NON SEGMENTED SHIFTED GO STEEL SHEETS STACK

The studied structure is a yoke made of GO sheets (Fig. 1) whose Rolling Directions (RDs) are shifted from each other by a constant β angle (Fig. 1). An unidirectional excitation is provided by a winding laid out regularly around the yoke and supplied by sinusoidal current. The principle of energy minimization will lead naturally to the concentration of the magnetic flux in the sheets whose RD are the most adapted to its circulation. Hence, in every single point of the studied structure, the b magnetic flux density and RDs define an angle

noted α in the following.

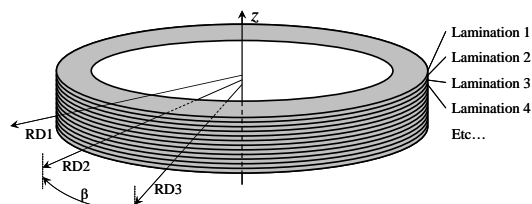


Fig.1 Yoke composed of shifted laminations

III. LOSSES COMPUTATION

In our approach, the FE method is used considering only the first magnetization curves $b(h)$ in the x , y and z directions (Fig. 1), and the iron losses component determination is only introduced at the post processing level, following the method introduced in [4]. The presented developments consist in the extension of this method in order to be able to distinguish the contribution of the iron losses components in the shifted yoke, where the flux distribution is specific and not trivial. For a given β , the following steps are used:

1. characterization of the material on Epstein strips in order to obtain the component losses curves for different α values
2. FE computation of b in each element of the structure
3. iron losses component computation interpolating the curves obtained at step 1

The numerical results obtained will be validated by considering, for specific values of β , the global iron losses measured on existing prototypes. Moreover, this method will also allow defining the best value of β compatible with the magnetic circuit building techniques.

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