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Analysis of the magnetic flux distribution in a new shifted non-segmented Grain Oriented AC motor magnetic circuit

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Abstract – This paper deals with a new AC electric motor magnetic circuit structure made of shifted non-segmented grain oriented steel laminations. The aim is to understand with a finite element approach the local distribution of the magnetic flux density inside laminations as well as in the air-gaps between them. It is shown that the air-gap flux distribution is not trivial at all and very difficult to appreciate differently.

I. INTRODUCTION

Usually, most of the low and medium power AC electric rotating machine magnetic circuits are made of Non Oriented (NO) steel. Grain Oriented (GO) steel laminations, as for them, are used in transformer cores. Nevertheless, recently, a new AC stator magnetic circuit, based on the stacking of shifted non-segmented GO sheets, has been developed [1]. Previous works showed that such a structure decreases iron losses compared with NO sheets of same thickness [2]. In a certain way, this structure presents some similarities with transformer core corner joints (step-lap). In such configurations, the b magnetic flux density has to pass from one lamination to another in order to satisfy the principle of energy minimization. Nevertheless, the path thus taken by b is not trivial at all. Moreover, due to the very thinness of the air-gaps between laminations, measuring b experimentally is quite a difficult task. Hence, using numerical methods, such as the Finite Element (FE) method, is the most appropriate approach for the understanding of this kind of phenomena.

II. NON-SEGMENTED SHIFTED GO STEEL SHEETS STACK

The studied structure is an annular yoke made of GO laminations whose Rolling Directions (RDs) are shifted from each other by a constant β angle (Fig. 1).

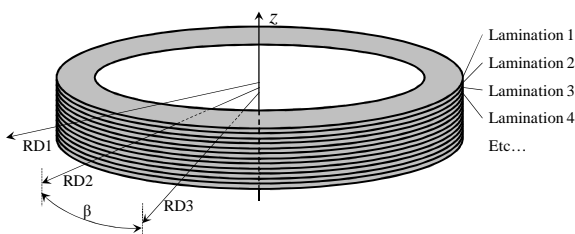


Fig. 1. Yoke composed of shifted laminations

An unidirectional excitation is provided by a winding regularly laid out around the yoke and supplied by a sinusoidal current. It results that the path of the magnetic flux follows rather the sheet whose RD is the most adapted to its circulation (minimizing the magnetic energy) and, depending on the

reluctance of the air-gaps, crosses the latter.

In this abstract, only the case $\beta=90^\circ$, which corresponds to one of the best configurations [1], [2], is presented.

III. FINITE ELEMENT SIMULATION AND RESULTS

As the spatial periodicity along z axis corresponds to two sheets, Fig. 2 presents the distribution of b in two stacked sheets. As expected, b is concentrated in the sheets that are best adapted to its circulation. However, the path taken in the air-gap to pass from a sheet to another is more original (Fig. 3). Indeed, two particularities can be noticed. First, the distribution presents a sinusoidal evolution along the longitudinal direction, with a periodicity directly linked to β . Second, the flux crosses the air-gap in the two directions. Experiments confirm this result.

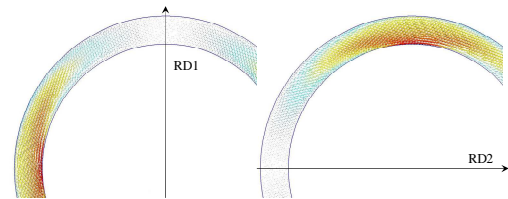


Fig. 2. Distribution of b in stacked laminations

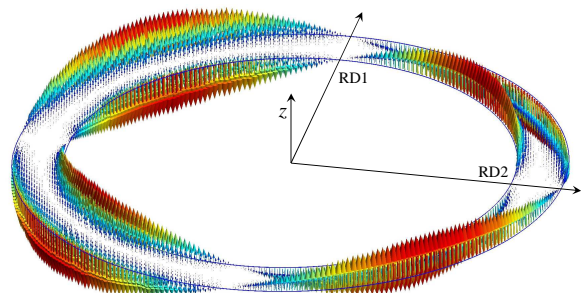


Fig. 3. Distribution of b in the air-gap between two stacked sheets

In the final paper, the influence of β , of the dimensions and the shape of the sheets, and of the magnetic permeabilities on the magnetic flux distribution in the sheets and in the air-gaps will be presented, analyzed and discussed.

IV. REFERENCES

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