



HAL
open science

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

Guillaume Parent, Remi Penin, Jean-Philippe Lecoïnte, Jean-Francois Brudny, Thierry Belgrand

► To cite this version:

Guillaume Parent, Remi Penin, Jean-Philippe Lecoïnte, Jean-Francois Brudny, Thierry Belgrand. Analysis of the magnetic flux distribution in a new shifted non-segmented grain oriented AC motor magnetic circuit. The Fifteenth Biennial IEEE Conference on Electromagnetic Field Computation (CEFC 2012), Nov 2012, Oïta, Japan. hal-04260604

HAL Id: hal-04260604

<https://hal.science/hal-04260604>

Submitted on 26 Oct 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

G. Parent¹⁻², R. Penin¹⁻²⁻³, J.P. Lecoïnte¹⁻², J.F. Brudny¹⁻², T. Belgrand³

¹Univ. Lille Nord de France, F-59000 Lille, France

²UArtois, LSEE, F-62400 Béthune, France

³ThyssenKrupp Electrical Steel, F-62330 Isbergues, France
guillaume.parent@univ-artois.fr

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).

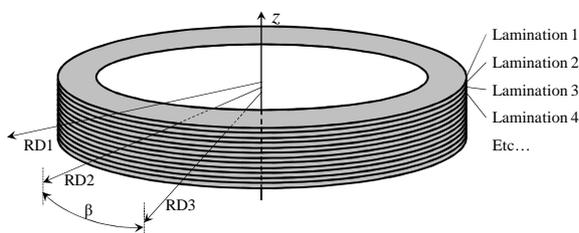


Fig. 1. Yoke composed of shifted laminations

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.

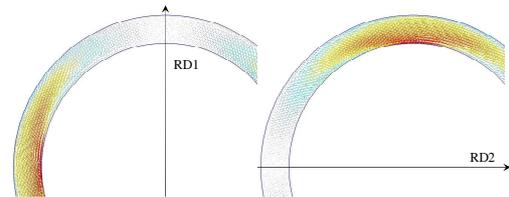


Fig. 2. Distribution of b in stacked laminations

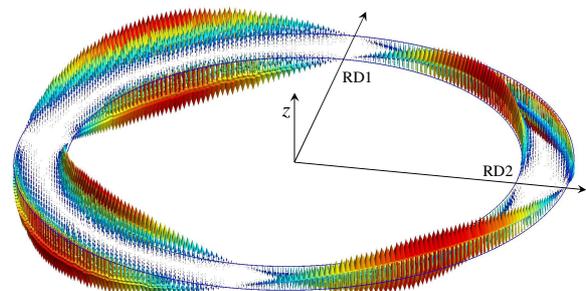


Fig. 3. Distribution of b in the air-gap between two stacked sheets

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

- [1] J.F. Brudny, B. Cassoret, R. Lemaître, J.N. Vincent, "Magnetic core and use of magnetic core for electrical machines", International Patent PCT/EP2008/061884, March 2009.
- [2] S. Lopez, B. Cassoret, J.F. Brudny, L. Lefebvre, J.N. Vincent, "Grain oriented steel assembly characterization for the development of high efficiency AC rotating electrical machines", *IEEE Transactions on Magnetics*, Vol. 45, Issue 10, pp. 4161-4164, October 2009.