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Hybrid Modeling Method for the Analysis of a Linear Flux Switching Machine

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***Abstract*—A fast hybrid modeling method is proposed for the 2D analysis of a linear flux switching machine. A magnetic equivalent circuit in conjunction with the boundary element method is applied to the geometry to accurately determine the airgap permeances. The model can also take into account the non-linear behavior of the soft magnetic parts of the machine. The force response obtained by the hybrid method is compared to those obtained by 2D finite elements. The force response shows good agreement in terms of amplitude and shape.**

***Index Terms*—linear machine, flux switching, boundary element method, magnetic equivalent circuit.**

I. Introduction

For the analysis or design of machines comprised of non-linear soft-magnetic material with a complex geometrical airgap shape, usually finite element (FE) method and magnetic equivalent circuit (MEC) modeling are applied, because they can take saturation effects into account. FE and MEC are on the opposite sides of the speed-to-accuarcy spectrum; MEC is fast but inaccurate whereas FE is accurate but slow. Furthermore, for complex geometrical shapes, the permeances in the MEC are difficult to determine and often require a priori knowledge of the flux distribution. Especially, the calculation of the dominant airgap permeances can be troublesome. To improve the MEC a hybrid modeling technique is proposed that enables the airgap permeances to be calculated fast and accurately by using the boundary element method (BEM). Moreover, no a priori knowledge of the flux flow in gap is required. The topology of the analyzed linear flux switching machine (LFSM) is shown in Fig. 1. It can be seen that both stator and translator have a slotted structure, which makes an accurate determination of airgap permeances difficult.

II. The hybrid modeling method

To calculate the airgap permeances accurately only a part of the complete airgap is considered. The local magneto-static scalar potential field distribution due to a constant scalar potential distribution of 1 A-turns along the line segments of the contour that defines the shape of a tooth is calculated using BEM. Simultaneously, the scalar potentials of all other line segments are set to zero. The permeances between the tooth and all the line segments can be easily calculated once the value of the flux entering those line segments is known.

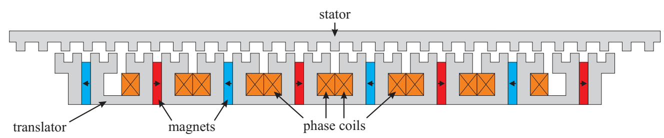

Fig. 1. Topology of the analyzed LFSM.

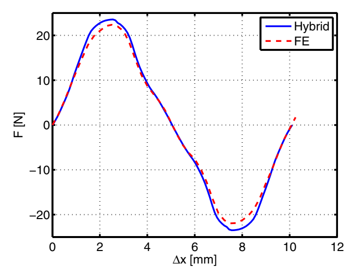

Fig. 2. Cogging force obtained by the hybrid method compared to FE.

In [1] a similar approach was presented using FE instead of BEM. However, BEM is more suitable in terms of accuracy and computational effort due to its formulation, because it immediately gives the solution for flux distribution on the boundary of the airgap and no meshing of the internal domain is required [2].

III. Results

The calculated cogging force of the LFSM including end effects compared to 2D FE is shown in Fig. 2. The maximum error in amplitude between the curves is 7%.

IV. Conclusion

A hybrid method that is a fast and accurate modeling technique for actuators comprised of soft magnetic materials has been proposed. The validity of the hybrid model for has been confirmed by 2D FE simulations. In the full paper the performance of the LFSM will be further elaborated on.

References

[1] V.A. Kuznetsov and P. Brochet,"Numerical Modeling of Electromagnetic Process in Electromechanical Systems," Compel, Vol 22, No. 4, 2003.
[2] L. Gaul, M. Kögl, M. Wagner, "Boundary Element Methods for Engineers and Scientists," Berlin, Springer, 2003, ISBN 3540004637.

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