DOI: https://doi.org/10.15407/ techned2017.05.018

COMPUTATION OF PERIODIC MAGNETIC FIELD IN FERROMAGNETIC CONDUCTIVE MEDIUM AND SUPPLY CURRENT HARMONICS BY USING HARMONIC BALANCE FINITE ELEMENT METHOD

Journal	Tekhnichna elektrodynamika
Publisher	Institute of Electrodynamics National Academy of Sciences of Ukraine
ISSN	1607-7970 (print), 2218-1903 (online)
Issue	No 5, 2017 (September/October)
Pages	18 – 22

Author
I.S. Petukhov
Institute of Electrodynamics National Academy of Sciences of Ukraine,
pr. Peremohy, 56, Kyiv, 03057, Ukraine,
e-mail: igor_petu@mail.ru

Abstract

The harmonic balance finite element method for two dimensional periodic magnetic field in a conductive ferromagnetic medium is formulated. To convert of partial differential equation system into the system of nonlinear algebraic equations the weak formulation of Galerkin method is used. Structural steel and silicon steel with different magnetic properties and various electrical conductivity are studied. It is described how to take into account the nonlinear properties of medium in mathematical model. The spectrum of supply current and flux density on the surface and inside the medium were computed provided the sinusoidal voltage fed. The dependencies of the amplitudes of high harmonics versus the steel properties and amplitude of

the first harmonic of magnetic flux density at the surface of medium are presented. References 14, figures 5.

Key words: harmonic balance method, finite element method, ferromagnetic medium, magnetic field spectrum, current spectrum.

Received: 03.02.2017
Accepted: 24.04.2017
Published: 17.08.2017

References

1. Antonov A.E., Petukhov I.S. Identification of the magnetic field of the rotor of a two-axis electrical machine. *Tekhnichna Elektrodynamika*. No 1. 1999. Pp. 64–68. (Rus)
2. Bruskin D.E., Zorokhovich A.E., Khvostov V.S. Electrical machines. Moskva: Vysshaia shkola, 1987. 319 p. (Rus)
3. Cherepin V.T., Olykhovskiy V.L., Petukhov I.S. Optimizing the deflecting magnetic system of the mass spectrometer type of spheretron. *Tekhnichna Elektrodynamika*. 1997. No 4. Pp. 3–7. (Rus)

4. Development of the methods for symmetrization and calculating the parameters of linear induction machines (Parameter – 7): 2002 year. Report: № State registration 0198U007472; National academy of science of Ukraine, Institute of electrodynamics. Kiyv: Institute of Electrodynamics, 2002. 105 p.
5. Gyselinck J., Dular P., Geuzaine C., Legros W. Harmonic-Balance Finite-Element Modeling of Electromagnetic Devices: A Novel Approach. *IEEE Trans. on Magnetics*. 2002. Vol. 38. No 2.

Pp. 521–524. DOI:
https://doi.org/10.1109/20.996137
6. Lu J., Yamada S., Harrison B. Application of Harmonic Balance-Finite Element Method (HBFEM) in the Design of Switching Power Supplies. *IEEE Transactions on Power Electronics.* 1996. Vol. 11. No 2. Pp. 347–355. DOI:
https://doi.org/10.1109/63.486185
7. Lu J., Zhao X., Yamada S. Harmonic Balance Finite Element Method: Applications in Nonlinear Electromagnetics and Power Systems. Wiley-IEEE Press, 2016. 304 p. DOI: https://doi.org/10.1002/9781118975770
8. Petukhov I.S. Simulation of alternating electromagnetic field in a conducting ferromagnetic medium by finite element method. *Tekhnichna Elektrodynamika*. 2008. No 4. Pp. 18–26. (Rus)
9. Petukhov I.S. Simulation of alternating electromagnetic field in a conducting ferromagnetic medium. *Pratsi Instytutu Elektrodynamiky Natsionalnoi Akademii nauk Ukrainy*. 2004. No 2(8). Pp. 15–16. (Rus)
10. Reklaitis G.V., Ravindran A., Ragsdell K.M. Engineering Optimization: Methods and Applications. New York: Wiley, 1983. 667 p.
11. Silvester P.P., Ferrary R.L. Finite Elements for Electrical Engineers. Cambridge: Cambridge University press, 1983. 494 p.
12. Stefan Ausserhofer, Biro O., Preis K. An Efficient Harmonic Balance Method for Nonlinear Eddy-Current Problems. *IEEE Trans. on Magnetics*. 2007. Vol. 43. No 4. Pp. 1229–1232. DOI:
https://doi.org/10.1109/TMAG.2006.890961
13. Zhao X., Li L., Lu J., Cheng Z., Lu T., Huang H., Liu G. An Efficient Fixed-Point Harmonic-Balanced Method Taking Account of Hysteresis Effect Based on the Consuming Function. ICCP Proceedings. 2010. Pp. 179–181.
14. Yamada S., Bessho K. Harmonic field calculation by the combination of finite element analysis and harmonic balance method. *IEEE Trans. on Magnetics*. 1988. Vol. 24. No 6. Pp. 2588–2590. DOI: https://doi.org/10.1109/20.92182

PDF