A Study on Iron Loss Analysis Method Considering the Harmonics of the Flux Density Waveform Using Iron Loss Curves of Epstein Samples

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Abstract — **In this paper the distribution and changes in magnetic flux densities of the single-phase line-start permanent magnet motor are computed by using 2-D finite element method. Iron loss is evaluated by the frequency analysis of flux density waveforms using Discrete Fourier Transforms and iron loss curves tested on Epstein samples at frequencies.**

INTRODUCTION

The analysis of losses such as copper loss, iron loss is one of the most promising technologies to design electrical machines for energy saving [1]. And iron loss can account for a significant part of the total losses. Therefore, it is important to increase the accuracy and reliability of the simulation for the iron loss.

In general, under alternating flux conditions the iron loss is represented by Steinmetz [2]. This conventional method assumes sinusoidal variation of the magnetic fields and the iron loss is viewed as being caused mainly by the fundamental frequency. Therefore, this equation is not sufficiently accurate because the waves are non-sinusoidal [1,2]. Instead of the equation, iron loss curves of Epstein samples according to frequencies are used for iron loss analysis in this paper. In order to take into account the harmonic effects of the magnetic fields on the iron loss, a precise prediction of the magnetic flux densities needs to be performed. Therefore, the flux density distribution and waveforms are obtained using 2-dimensional finite element method (2-D FEM).

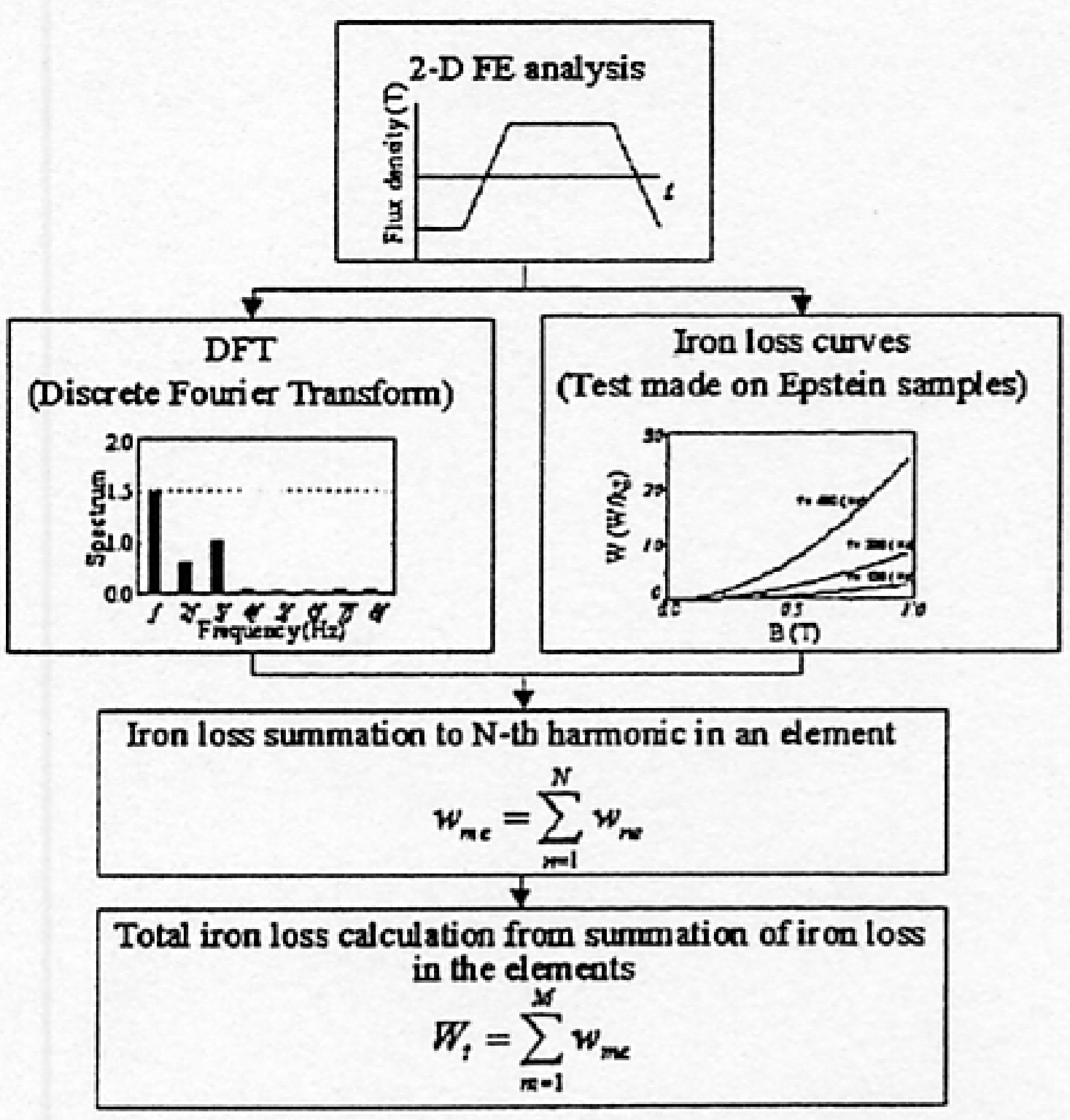
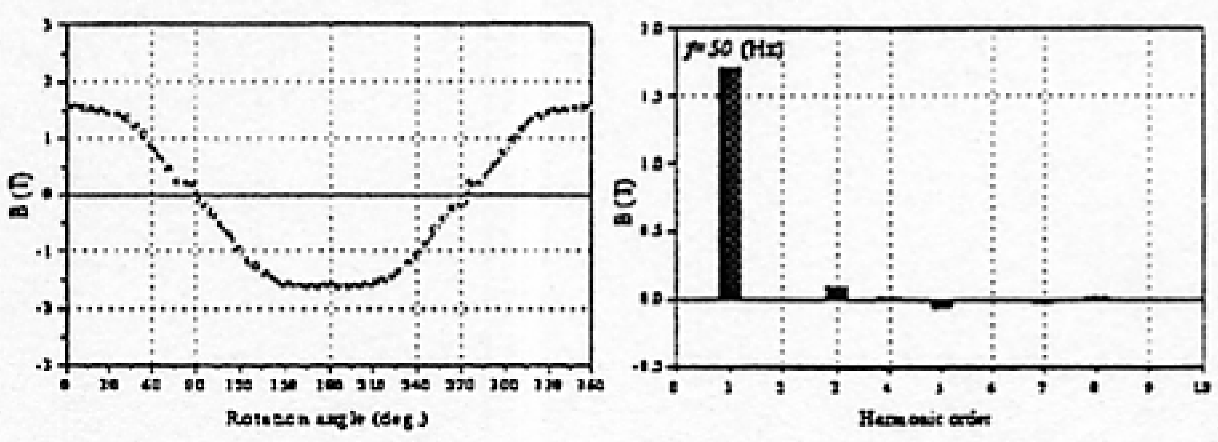


Fig. 1 Flow chart for iron loss calculation

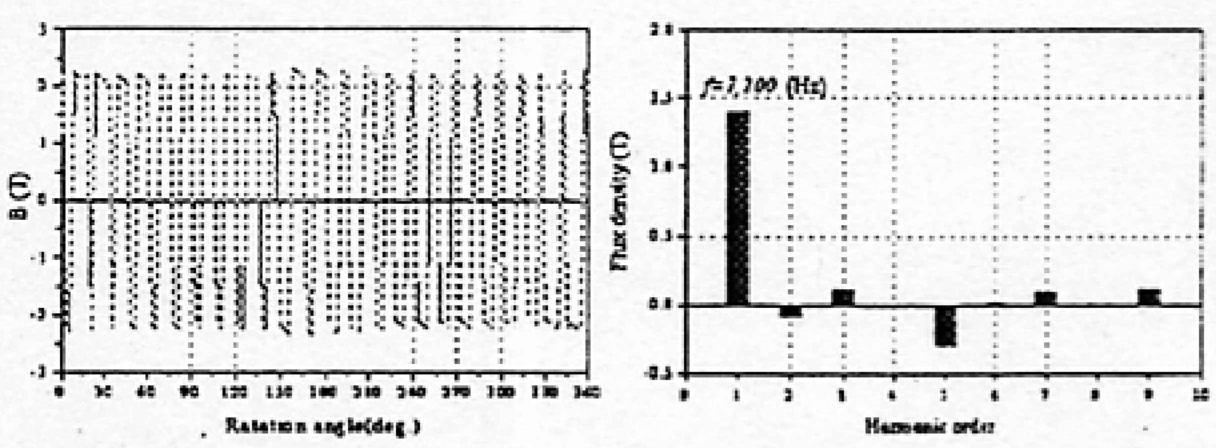
The variation of flux density with the rotor position is analyzed from Discrete Fourier Transform (DFT) [1]. The iron losses considering harmonic components in each element are calculated from iron loss data sheet and the results of frequency analysis using DFT. Finally, The total iron loss can be calculated by the summation of the iron losses in all the elements. The flow chart of the method described in the paper is shown in Fig. 1.

THE RESULTS

The analysis model is the single-phase line-start permanent magnet motor (LSPM). The flux density waveforms and the harmonic analyses in elements of the stator yoke and the rotor slot bridge are shown in Fig. 2. Table 1 indicates iron losses in each element.



(a) Stator yoke



(b) Closed slot bridge at the rotor

Fig. 2 The flux density waveforms and the results of harmonic analysis

Table I. The results of iron loss calculation in the elements

Position	Frequency	Flux density	Iron loss
Stator yoke	50 (Hz)	1.7 (T)	0.00350 (W)
Closed slot bridge	1,200 (Hz)	2.3 (T)	0.00998 (W)

REFERENCES

[1] S. Inamura, H. Shibayama and K. Sawa, "A simple estimation method of iron loss in switched reluctance motor," Trans. COMPUMAG, pp. IV-62-IV-64, July, 2001.

[2] F. Deng, "An improved iron loss estimation for permanent magnet brushless machines," IEEE Trans. on Energy Conversion, Vol. 14, No. 4, pp. 1391-1395, December, 1999.