1928
K N Toosi University of Technology
Faculty of Electrical Engineering
Center of Excellence in Computation and Characterization of Devices and Subsystems

The Second Iranian Conference on Engineering Electromagnetics (ICEEM 2014), Jan. 8-9, 2014

Iranian Scientific Society of Engineering Electromagnetics

A Comparison between Two Dimensional Finite Element Method Analysis of Eddy Currents and Analytical Results

Vahid Badeli*, Esmael Fallah

Department of Electrical Engineering, University of Guilan, Rasht, Iran

***Corresponding author: Badeli.vahid@yahoo.com**

ABSTRACT—Eddy currents are one of the main loss components in the core of electrical machines. While calculating eddy current using conventional methods, flux density is assumed to be distributed uniformly. Considering a uniform flux distribution is not a valid assumption. According to Lenz's law, eddy currents oppose to their causes and consequently by producing flux skin effect, cause a non-uniform distribution of flux density. In this paper a new finite element method has been proposed to analyze the effect of eddy currents in a more accurate manner in which the diffusion equation is solved in a circular cross section and results in different frequencies are compared.

KEYWORDS: eddy currents, finite elements, skin effect, two dimensional.

I. INTRODUCTION

According to Faraday's law, when conductors are placed within a time-variant magnetic field, an electro-motive-force is induced in them that make the electrical current flow in circular paths. These currents, which are called eddy currents, are the origin of the Ohmic loss in the magnetic cores. In conventional method of calculating eddy current loss, flux density is assumed to be distributed uniformly on the core cross section area and by this assumption, following, well known formula is resulted for calculating eddy current loss [1, 2]:

$$P_e = \frac{\pi^2 \sigma d^2}{6} f^2 B^2{}_{\max} \qquad (1)$$

In which, P_e is the eddy currents loss in the unit volume, σ is special electrical conductivity, d is the thickness of the lamination, f is the frequency of the magnetic flux variation and $B_{max}$is the amplitude of the magnetic flux density. Due to eddy currents, assuming a uniform distribution of flux is not accurate because according to Lenz's law, eddy currents oppose to their causes and force the flux to flow along the skin of the conductor. This effect is known as flux skin effect [3]. In low frequencies this effect is significantly weakened by laminating the core. But if the flux variation frequency increases, for instance in a case with a voltage containing harmonics which results into the flux having harmonics as well, the flux skin effect could not be neglected [4]. In such cases estimating eddy current losses that were calculated using Eq. (1) is not exact and in order to have a more accurate analysis, the effect of eddy current shall be taken into account. On the other hand, modeling eddy