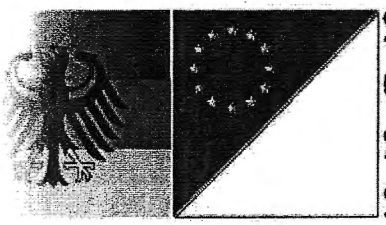

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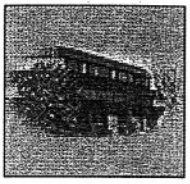

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Regular paper

CALCULATION OF CURRENT DENSITY DISTRIBUTION IN THE CONDUCTOR WITH RECTANGULAR CROSS-SECTION IN THE FERROMAGNETIC BLOCK GROOVE

Milan PLAZINIĆ, Jeroslav ŽIVANIĆ [1]

Abstract: This paper represents the results of calculating current suppression in the conductor with rectangular cross-section in the groove of ferromagnetic block. The calculation is carried out by applying simplified analytical formulas, loop method and FEMM programme package. When applying loop method, the effects of ferromagnetic block will be determined by means of mirror image theorem. Then the obtained results are compared.

Keywords: Loop method, Current density distribution, Ferromagnetic block groove.

INTRODUCTION

Current in the conductor with rectangular cross-section, which is situated in the ferromagnetic block groove, creates magnetic field in its own surrounding. Ferromagnetic material has considerable influence on the lines of magnetic field intensity. The lines of magnetic field intensity tend to close along the path of lower magnetic resistance, so their distribution is asymmetric regarding the horizontal symmetry axis of the conductor shown in Figure 1.

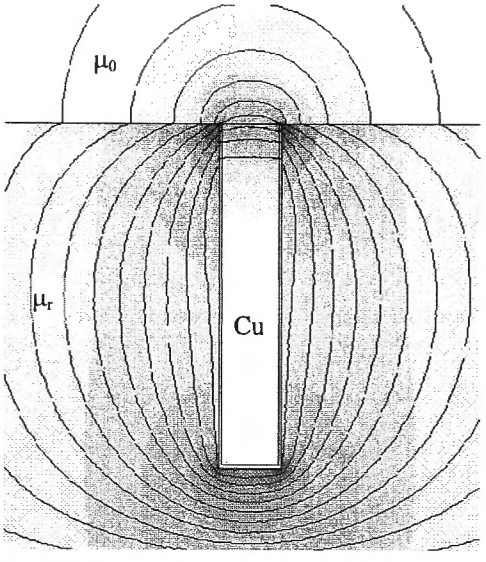

Fig. 1 – *Field lines in the surrounding of rectangular cross-section conductor in the groove of ferromagnetic block*

If alternate current is established in the conductor, it will lead to uneven distribution of electric filed caused by self-inductance along the conductor cross-section, which will, consequently, lead to uneven current distribution.

The current is distributed in the way that its density should rise when approaching the groove hole. This phenomenon leads to the increase of effective resistance of the conductor and to the increase of loss due to Joule's effect. If the conductor height has considerably higher values than its width, and since μ_{Fe} is higher than μ_0, the lines of magnetic field intensity in the groove are approximately perpendicular to the side face of the groove and they can be presumed to be parallel to axis y. Following the path of lower resistance, the lines close through ferromagnetic material by-passing the groove from the lower side, as it is shown in Figure 1.

According to Ampere's Law, circulation of the vector $\boldsymbol{H}$ along the closed contour which is in concordance with the field line is approximately

$$\oint_l \boldsymbol{H}\mathrm{d}\boldsymbol{l} \approx H(x)b$$

Approaching the groove hole, the total current involved in circulation line increases, so the intensity of magnetic field increases.

If there is only one conductor in the groove, the intensity of magnetic field and current density are determined on the basis of the simplified analytical equations shown in [1].

$$\underline{H} = \frac{\underline{I}}{b\,\mathrm{sh}\underline{\gamma}h}\,\mathrm{sh}\underline{\gamma}x$$

and

$$\underline{J} = \frac{\underline{I}}{ah}\,\frac{\underline{\gamma}h}{\mathrm{sh}\underline{\gamma}h}\,\mathrm{ch}\underline{\gamma}x$$

The modules of magnetic field intensity and current density are determined on the basis of:

$$H = \frac{I}{b}\sqrt{\frac{\mathrm{ch}2kx - \cos 2kx}{\mathrm{ch}2kh - \cos 2kh}}$$

and

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