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SLOT HARMONICS IN CAGE MOTORS DUE TO SATURATION OF A MAIN MAGNETIC CIRCUIT

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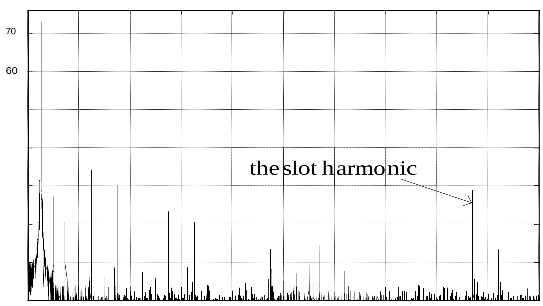
Abstract
This study discusses how saturation of the main magnetic circuit by the fundamental MMF harmonic affects the Fourier spectra of phase currents in cage motors. The concept of a magnetic current's equivalent is used. As a result, we can understand when and why new bars form in stator current spectra by taking into account the effect of all currents on the permeability of the main magnetic circuit. Measurements corroborate the conclusions of our thinking.

I. INTRODUCTION
Currently, Fourier spectra of stator current are used to diagnose problems with cage motor rotors. Accurate measurements and predictions of those spectra are crucial to making an accurate diagnosis. This implies that the predictive mathematical model
This motor's pole-pair number 'p' and rotor slot number 'N' determine the position of this supplementary bar [6]. This bar may be determined using a model that takes magnetic saturation into consideration [4, 6]. In this research, we propose a model and the numerical test results that prove it is capable of identifying these supplementary slot harmonics.

I. CAGE MOTOR
Saturation Modeling Using the Primary Magnetic Field A cage motor model is created using the co-energy function, which is segmented as Eco > Emp > Emh > E to account for magnetic non-linearity. The and the precision of the measurement tools is essential. There magnetic circuit by the p-harmonic, which introduces non- includes the full spectrum of the MMFs of motor windings higher harmonics that disrupt the primary magnetic circuit. In the third There are still discernible quantitative distinctions between spectra. symbolizes the combined energy of potential leaking areas. It is
model-based predictions and experimental motor measurements. Fig.1



$$\Theta = \frac{2}{\pi}\frac{i_\mu}{p}\cos p(x-\alpha)$$

Assuming magnetic linearity, a mathematical model of this motor predicts just two bars, one at the main frequency of 50 Hz and the other at a slip-dependent frequency of (35 + 34) 50 Hz (s - rotor slip), as shown in Fig.1 for s=0,004. Saturation is what causes the bars in a true spectrum, and their frequencies are multiples of wherein the stator voltages and currents are described using their 3-phase symmetrical components, and the cage mash currents are described using their N-phase symmetrical components. The non-linear inductance arises in these equations.

50Hz, but there's also a rather tall bar out in the distance

$L = \frac{3}{}(w\,k)^2 \cdot \Lambda$,

$\Lambda = \frac{1}{}\frac{\partial E_{mp}}{}$ (4)

100Hz with respect to the slot harmonic. The existence and

(w_s , $k_{s,p}$ - stator phase turn number and winding factor) at the following positions: in the matrix $\mathbf{L}^s$ at (1, 1) and (2, 2), inthe matrix $\mathbf{L}^r$ at (p, p) and (N – p, N – p) . In the matrix $\mathbf{M}^{rs}$

components appear. Beside a "classical" slot harmonic $(35 - 34 \cdot s) \cdot 50$ Hz, the new bars appear in the Fourierspectrum $(37 - 34 \cdot s) \cdot 50$Hz and $(31 - 34 \cdot s) \cdot 50$Hz , shown

appear non-linear terms: L at the position

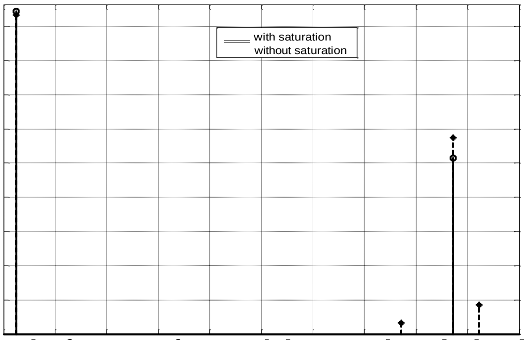
(1, p and in Fig.3 (at s=0,004).

he positions

(2, N – p) . The other elements of

Matrix representations of inductance in (3) are analogous to those in the magnetic linearity model [5

I. Statistical Results



The function of permeability must be calculated.

p = 30 Co-Energy

MagNet6.0 20 has been used to compute the function.

Example motor FEM with a Fourier spectrum of 10 in Fig.1, we may use the function as a close approximation to the co-energy,

Fig3. Calculated Fourier spectrum of a phase current up to 2,5 [kHz]of a motor P_N=2MW, U_N=6kV/Y, p=1, N=34 at s=0,004

$$E = 1.0635 \cdot (i)^2 - 0.0635 \cdot (i)^4 \qquad (5)$$

VI. CONCLUSINS

To conclude the consideration in this paper, the following can be stated. Additional slot harmonics can arise due to saturation of the main magnetic circuit by the fundamental component of total MMF. A model presented in this paper allows to predict these harmonics quantitatively, but qualitative difference to measurement still exist. However, harmonics with frequencies being multiple of 50Hz cannot be predicted from the presented model.

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